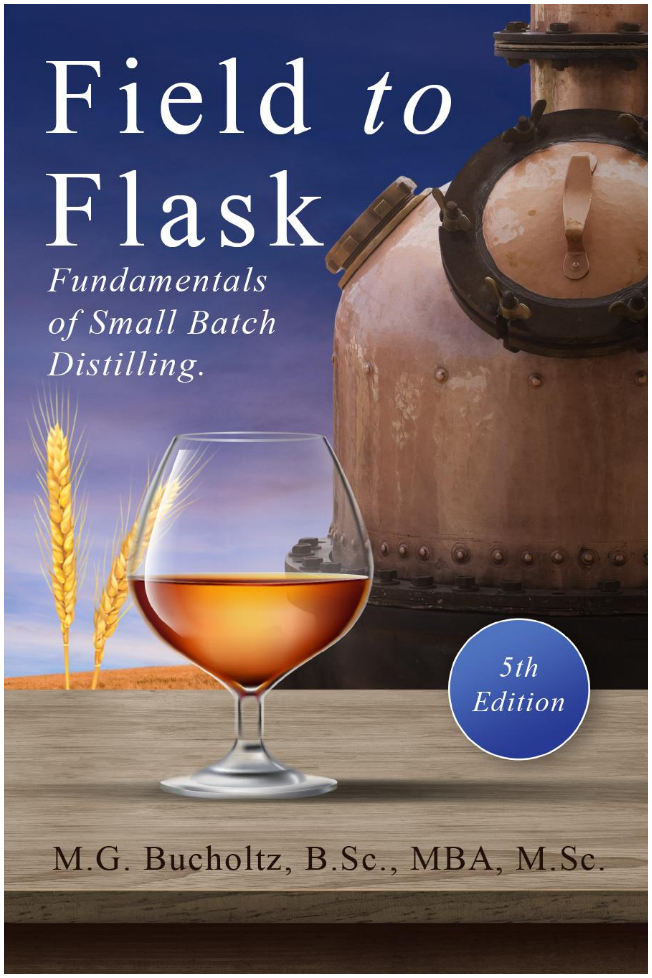
Field *to* Flask
Fundamentals of Small Batch Distilling.
5th Edition
M.G. Bucholtz, B.Sc., MBA, M.Sc.

Praise for Field to Flask 4th edition

For 30 years, Malcolm Bucholtz was a homebrewer and winemaker, and in 2013, he was bit by the craft distilling bug and decided to leave his job working for a mineral exploration company. Dissatisfied with the available materials for those entering craft distilling, Bucholtz wrote Field to Flask: Fundamentals of Small Batch Distilling to use in his 5 day distilling workshop which he has been instructing in Kelowna British Columbia since October 2014.

In 22 chapters Field to Flask is comprehensive in its scope as its name implies. Starting with a brief history of alcohol, Bucholtz covers regulatory requirements, marketing and business plans, but the core of the book it is focus on the science of converting agricultural products into distilled spirits. Here is where the book shines with detailed discussions on the yield of various raw materials as well as basic information on microbiology, yeast, fermentation, distilling, aging and proofing spirit. Field to Flask aims to be the starting point for those with the passion to start distilling as a hobby or to start a licensed small batch craft distillery. To that end, Bucholtz has done an excellent job. There are plenty of more detailed books on the history or marketing or individual styles of spirits, but it is no small feat that Bucholtz has condensed so much useful information in to a book of this size. Overall, it is one of the best serious introductions to the science and business of craft distilling.

— Eric Zandona

American Distilling Institute

Winter 2019/2020

Field to Flask: Fundamentals of Small Batch Distilling is an arsenal of knowledge for anyone seeking to begin or perfect the art of distilling spirits. Whether you are a DIY enthusiast looking to try a new business endeavour during the pandemic or a wide-scale distiller with years of experience in the industry, there is something for everyone to learn in this book. Bucholtz is a B. Sc. and an MBA who has been crafting alcohol for over 30 years. In 2014, he went on to complete his General Certificate in Distilling from the Institute for Brewing and Distilling to fully pursue his passion for entrepreneurship and crafting quality spirits. This expertise shines through from cover to cover of this comprehensive guide, which Bucholtz distributes to budding and experienced distillers during his 5-day workshops that he conducts across the nation.

It was through Bucholtz and this fantastic book that I was fully able to appreciate the value and intricacies of society's favourite intoxicant. I was most impressed by the extent of Bucholtz's research to explain the history of spirits as a whole and the history of each individual spirits including but not limited to whiskey, vodka, gin, and rum. This penchant for scientific rigour is also applied to other facets of the distilling process such as the molecular, mechanical, physical, and biological nature of crafting spirits and various distilling techniques. The same scientific meticulousness is applied in later chapters that detail the local legalities regarding the distillation, sale, and distribution of liquor in each Canadian province and U.S. state, as well as the entrepreneurship skills and consumer psychology that goes into running a successful distillery. As I read this book, I could not help but think that a historian, a mechanic, a business person, a lawyer, and a microbiologist could all read this book and get the same amount of enjoyment out of it.

— SaskBooks Review

Field to Flask

The Fundamentals of Small Batch Distilling

5th Edition

M. Bucholtz, B.Sc, MBA, M.Sc.

A Wood Dragon Book

Field to Flask

The Fundamentals of Small Batch Distilling

Fifth Edition

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Special acknowledgement goes out to the Institute for Brewing & Distilling in London, England. I would not be teaching others about the art and science of distillation, I would not be consulting to start-up craft distillers, and I would not have written this book were it not for having successfully written your General Certificate in Distilling exam which launched me on this most unusual trajectory in late 2014. An extra special acknowledgement goes out to Dr. Annie Hill of Heriot Watt University in Edinburgh, Scotland who accepted me into the Master's Degree (M.Sc.) program in Brewing & Distilling in 2017. In late 2020, I was granted my M.Sc. degree. The knowledge gained from this rigorous curriculum of study has prompted me to do this 5th edition of Field to Flask.

DEDICATION

This book is dedicated to existing craft distillers as well as entrepreneurs who are thinking about starting a craft distillery. Although craft distilling has shown robust momentum around the globe over the past several years, its ability to gain a bigger market share going forward will depend on craft distillers solidly embracing the science that underpins raw materials, mashing, fermenting and distilling. With a deeper understanding of the fundamentals will come more innovative products and vastly improved product quality.

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Note From The Author

Deregulation

The word deregulation is broadly defined as ‘an elimination of regulations that hinder the competition of goods and services’. Deregulation, according to economic thought, will result in market forces driving the economy. Entrepreneurial animal spirits will be awakened.

Remember when taking an airplane flight meant booking fare on a large carrier that was in large part government owned? When making a phone call meant utilizing technology that was owned by large telco companies with strong ties to government? When a beer was a beverage only obtained from one of a handful of large mega-corporations like Molson’s, Labatt’s, Anheuser Busch, or Coors? Or when getting a ride from the pub to your house meant riding in a car licensed through your local taxi commission?

Many industries in our economy have now been deregulated. Laws have been rescinded and rules relaxed. Market forces are at the helm of the economy. Taking an example from the beer industry, the website

www.beveragedaily.com reports there are nearly 9000 craft breweries in North America and over 2200 in the U.K..

Starting around 2010, for the first time in nearly 100 years, distilled alcohol production began to be deregulated. A decade later, distilled alcohol is no longer the solitary domain of a handful of big multi-national corporations. Individual entrepreneurs can now get a license to manufacture and sell alcoholic beverages in Canada, the US, the U.K., Australia and other locales.

There are just over 1800 craft distillers licensed to do business in America according to 2020 data from the American Craft Spirits Association. Canada has about 180 craft distilleries and the UK almost 250 according to the website www.thedrinksbusiness.com. Even Australia with some of the highest alcohol taxes on the planet has just shy of 300 craft distilleries.

My Journey

In 2013, I was managing a small publicly-traded mineral exploration company, but I was tired of the travel and the constant stock promotion gimmicks. I thought long and hard about what I wanted to do next.

Sometimes when you open yourself to new possibilities, the Universe will unexpectedly deliver. In mid-2013, my wife and I were visiting some good friends who offered me a taste of an imported South Korean spirit type called Shoju. The subtle smoothness, elegant flavor and seriously intoxicating powers of this product distilled by a 6th generation Master Distiller so intrigued me that I decided my next career journey would have to be in the area of distilled spirits. I reasoned that with my near three decades of home brewing and home wine-making experience, I would be able to at least understand the basics of distilled spirits. Little did I know that what was about to unfold would be prolific.

In early 2014, with my curiosity piqued, I registered to write the General Certificate in Distilling exam through the UK-based Institute for Brewing & Distilling (IBD). It took me nearly nine months of reading and research to prepare for this exam. The British education system is famous for its brutally tough exam formats.

Early in my studies, I attended a 5-day Distilling workshop in Gig Harbor, Washington presented by the Artisan Craft Distilling Institute. I was profoundly disappointed at the lack of math, science and hands-on learning opportunities built in to the program. Sitting in the classroom in Gig Harbor listening to the boring presenter drone on about how to market with

Facebook, I thought to myself, what if I were to establish a consulting organization in Canada to offer hands-on distillery courses to people interested in learning about the art and science of fermentation and distillation? What if I were to use my IBD exam preparation materials as the basis for these courses?

The Universe was apparently listening. Several weeks later, I found myself in the right place at the right time. During a business trip to Kelowna, British Columbia, I ended up at a small craft distillery for a tasting. The owner was present behind the tasting bar that day and after listening to my idea for a properly designed 5-day Distilling workshop, he suggested that his distillery would be a good venue for holding workshops.

The first 5-day workshop was unveiled in October 2014 and it marked the beginning of a wave of momentum that would continue for the next 5 years. By the end of 2019, 520 people had come through the 5-day workshops, from as far away as England, Australia, Central America, South America and the Caribbean Islands. This book you hold in your hands is the learning material I provide to participants in these workshops.

But, running a craft distilling business is not easy. Sadly, the Kelowna distillery ceased operations in late 2019. I was then invited to shift my workshops to the newly opened Two Rivers Distillery in Calgary, Alberta.

Delivering workshops is challenging in itself. External ‘black swan’ events surely do not help. As I was wrapping up my first event in Calgary in March 2020, an invisible enemy called the corona virus was sweeping its way across North America. The Calgary small business community was subsequently hit hard with mandated shutdowns and health precautions. Hosting of events was suddenly impossible. As the corona virus eased slightly, we delivered a workshop in September, and one in November, 2020. But, as I sit at my desk in late 2020 penning the updates to this book, mRNA vaccines are being made available in countries around the world. I am confident that once the global economy gets back on track, craft distilling will experience further growth.

As for the people who have taken my workshops, some have now ventured forth to start their own craft distilleries. Others have found work at craft distilleries. In your travels, if you happen to visit any of the following, you will find a connection of some sort to one of my 5-day workshops.

StillHead Distillery in Duncan, BC

Tumbleweed Spirits in Osoyoos, BC

Roots & Wings Distillery in Langley, BC

After Dark Distillery in Sicamous, BC

Monashee Spirits in Revelstoke, BC

Jones Distilling Company in Revelstoke, BC

Lost Boys Distilling in Fernie, BC

Fernie Distillers in Fernie, BC

Island Shiners in Sooke, BC

Bespoke Spirits in Parksville, BC

Okanagan Crush Pad in Summerland, BC

Wynndel Craft Distillery in Creston, BC

Trench Brewing & Distilling in Prince George, BC

Bruin Wood Distillery in Robert’s Creek, BC

The 101 Brewhouse & Distillery in Gibson’s, BC

Krang Distillery in Cochrane, Alberta

Burwood Distillery in Calgary, Alberta

Hansen Distillery in Edmonton, Alberta

Rig Hand Distillery in Nisku, Alberta

Two Rivers Distillery in Calgary, Alberta

Section 35 Farm Distillery in Viking, Alberta

Broken Oak Distillery in Grand Prairie Alberta

Pivot Spirits in Rolling Hills, Alberta

Grit City Distillery in Medicine Hat, Alberta

Park Distilling in Banff, Alberta

Lone Pine Distillery in Edmonton, Alberta

Outlaw Trail Distillery in Regina, Saskatchewan

Errington Lake Distillery in Kindersley, Saskatchewan

Sperling Distillery in Regina, Saskatchewan

StumbleTown Distilling in Saskatoon, Saskatchewan

Doucette Distilling in Big River, Saskatchewan

Kinsip Spirits in Prince Edward County, Ontario

Crosscut Distilling in Sudbury, Ontario

Viritus Spirits in Toronto, Ontario

Freshwater Distillery in Collingwood, Ontario

Black’s Distilling in Peterborough, Ontario

Dairy Distillery in Almonte, Ontario

Laneway Distillers in Toronto, Ontario

Distillerie Puyjalon in Havre-St. Pierre, Quebec

Distillerie Grande Derangement in Lanaudiere, Quebec

Distillerie Shefford in Shefford, Quebec

Distillerie Vent du Nord in Baie Comeau, Quebec

McAuslan Malting & Distilling in Montreal, Quebec

La Societe Secrete in Perce, Quebec

Cirka Distillerie in Montreal, Quebec

Still Fired Distillery in Annapolis Royal, Nova Scotia

Halifax Distilling Co. in Nova Scotia

Raging Crow Distillery in North River, Nova Scotia

Sussex Craft Distillery in Sussex Corner New Brunswick

Dungeons Distillery in Cape Bonavista, Newfoundland

Belfour Spirits in Little Elm, Texas

Patagonia Spirits Co in Santiago, Chile

If you are thinking that this list represents a small percentage of the total number who have taken the workshops, you are correct. There are many barriers to entry when it comes to craft distilling including municipal zoning issues, fire and building codes, obtaining capital investment, and of course acquiring the scientific knowledge of the brewing and distilling process.

But, not everyone came to a workshop with the intention of launching a craft distillery. Many attendees have now taken up the art of home distilling. Many others who were already home distillers have forged ahead to become much better home distillers. Unquestionably, all of the workshop participants have become more discerning consumers of distilled spirits.

My journey into distilling took another unusual twist in mid-2017 when I decided to apply for admission to the M.Sc. Degree program in Brewing & Distilling at Heriot Watt University in Edinburgh, Scotland. This idea had been formulating in my mind for several years. With my IBD studies behind me and having done copious reading to keep improving the 5-day Distilling workshop curriculum, I thought the time was right to take the next leap. Thankfully Dr. Annie Hill saw fit to accept me into the M.Sc. program. She evidently believed that an old dog could be taught new tricks. And, she was correct in her reasoning. In October 2020, I was advised that the Board of Progression had granted me my M.Sc. degree. My thesis project focused on the use of Saskatchewan-grown CDC Prime Purple wheat as a new raw material for making beverage alcohol. Was this a tough program? Yes, without a doubt. In fact, brutally tough is an apt descriptor for the professors, the term papers, and the exams. This was the most arduous challenge I have undertaken since I completed my MBA degree 20 years ago at Heriot Watt University. But, I am not complaining. In fact, I am grateful for the demanding standards set out by the British educational system. My MBA degree 20 years ago set me on a path of new adventures I never thought would be possible. I am sure the M.Sc. degree in Brewing & Distilling will do likewise.

Why This Book?

The past several years have impressed on me that although entrepreneurs in the craft distilling movement are abundant with passion, many lack scientific knowledge. If craft distilling is to evolve and grow, it is vital that craft distilling entrepreneurs acquire a deeper understanding of what is physically happening during mashing, fermenting, distilling, and oak ageing. Without this knowledge, the craft movement will stall and fade away into insignificance. Consider the craft brewing movement that started in the late 1980s. Entrepreneurs starting craft breweries did it right. They were either already very skilled home brewers who understood the science, or had studied at a brewing college or had hired people who had studied at a brewing college. Soon, craft breweries were making remarkable expressions of beer and taking significant market share from the big commercial brewers. The craft distilling industry must follow this paradigm. There is precious little room in the market for mediocre expressions of distilled spirits. This 5th edition contains the deeper knowledge that craft distillers will need going forward. My message is simple: Embrace the science. Raise the bar.

A Disclaimer

This book contains knowledge that one will need in order to become a competent home distiller. It has thrilled me over the past 6 years to meet people attending my workshops who were keen to learn how to make whisky, gin and vodka at home. Making alcohol at home has a way of inflating one's ego and stirring up one's inner rebel. I ask that readers of this book be fully aware that home distilling may be illegal in most jurisdictions. Engaging in home distilling can land you in a heap of trouble. So, dear reader, set aside your rebel instincts and proceed sensibly and cautiously.

Welcome to the world of small batch craft distilling. I do hope your journey will prove to be as rewarding as mine has been.

Cheers!

Malcolm

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A Brief History Of Alcohol

The Drunken Monkey Hypothesis

In 2004, researchers Stephens and Dudley(1) advanced the Drunken Monkey Hypothesis. Their hypothesis suggests that modern man evolved from wild primates. It proposes that in the era of wild primates, fruit was the food of choice. Competition for fruit was intense. Those who got enough fruit to eat, survived. Those who did not get enough to eat, failed to survive. This was Darwinian natural selection at work.

Fruit ripening on trees is exposed to natural airborne yeast. As the fruit ripens to maturity, the yeast can cause fermentation to occur. One result of fermentation is the production of ethanol. To the wild primates, the odor of ethanol was a sure sign that ripe, edible fruit was close at hand.

Over time, primates evolved into different genera. Some primates evolved into the genus ‘homo’, from whence we come. Stephens and Dudley argue that those that evolved into the genus ‘homo’ developed an appreciation for the aroma and taste of ethanol. Members of the genus ‘homo’ were able to eat the alcohol-bearing, ripe fruit and tolerate its alcohol content. This ability to tolerate alcohol is related to two bodily enzymes, alcohol dehydrogenase and aldehyde dehydrogenase. Modern man, genus ‘homo’, species ‘sapiens’, is the evolutionary progeny of the alcohol tolerant wild primate species.

As time marched on, the homo sapiens diet turned to one richer in meat, plants and tubers. Fermented fruit was no longer key to survival. But eventually, around 7000 BC, mankind would re-discover fermentation and the enjoyment of alcohol would be rekindled.

Has our reacquaintance with alcohol been a good thing? The line of reasoning involving bodily enzymes, at first glance, suggests alcohol consumption is acceptable to the human body which enzymatically breaks down the alcohol molecules. So, why then is alcohol labelled by health practitioners as a potential health problem? The answer rests with the scientific reality that yeast fermentation will generate up to about 15% alcohol by volume in a fermented mash of raw material. This level of alcohol, the bodily enzymes can digest. But, in the 15th century mankind learned how to efficiently concentrate the alcohol content of a fermented solution by way of distillation. Distillation can concentrate alcohol to as high as 96.5% by volume. This content, the bodily enzymes cannot efficiently digest. Bodily organs come under duress and express cellular damage which manifests as disease. As a home distiller or as a craft distiller, I urge you to bear this all in mind. Distilled alcohol is to be savored and enjoyed. It should not be mass-consumed for intoxicative effects.

Phoenicians, Greeks, and Romans

Seth Rasmussen, in his book The Quest for Aqua Vitae, presents a riveting history of alcohol. Archeological evidence supports wine production around 7000 BC in an area of the world that today includes the lands bordered by the Black Sea and Caspian Sea (modern-day Georgia, Azerbaijan, Armenia, Turkey and Iran). Evidence also supports the fermentation of bee honey in 6000 to 8000 BC in what is today modern day Spain. (2)

In reading Rasmussen's book, my imagination turned to hunter-gatherer inhabitants of these ancient lands eating the flesh of grapes and other fruits and drinking the juices squeezed from these fruits. One day, probably by accident, somebody left some crushed apples or grapes in an earthenware vessel. Bubbles began to form on the fruit and a gentle hissing sound could be heard coming from the vessel. Although not immediately understood in detail at the time, this was fermentation. After several days, when the juice from the earthenware container was sampled, a most peculiar observation was made. The juice now imparted a mild feeling of happiness to all those who sampled it. Intoxication and its pleasant effects had been re-discovered.

Over the thousands of years that followed, mankind learned how to concentrate the level of alcohol in a fermented liquid. In a 1907 paper presented in England at an annual meeting of the Yorkshire and Eastern section of a brewing society, the author, Mr. T. Fairley, notes that history books contain descriptions of ancient societies placing fermented liquid in an earthenware vessel and gently heating the vessel to bring off vapors. Animal skins were placed above the heated vessel to absorb and capture the rising vapors. (3)

My imagination sees people squeezing the captured liquid from the animal skins, drinking it and making a startling observation. The pleasant feeling of happiness and euphoria obtained from a fermented beverage was intensified thanks to vaporizing and condensing the vapors from the liquid.

Over the ensuing centuries, as hunter-gatherers increased in number, they extended their reach into surrounding regions. They took with them the seeds of the grape and other fruits. By 1200 BC, civilization had spread as far south as the Mediterranean Sea. The dominant civilization in that part of the world was the Phoenicians who lived in a series of city states called Tyre, Sidon and Biblos (modern day Cyprus, Sardinia and Sicily also owe their existence to the Phoenicians). (4)

As Fairley (3) describes, as well as being skilled artisans and seafarers, the Phoenicians were accomplished at wine making and simple distillation. They had a linguistic expression for distilled alcoholic spirits that roughly translated into water of life. The Phoenicians are thought to have travelled through what is now modern day Spain, France, Ireland and Scotland. They took with them their knowledge of distilled alcoholic beverages. The Phoenician expression water of life remains with us to this day in the Spanish agua de ardiente, the French eau de vie, and the Gaelic usque beatha.

Rivalling the strength of the Phoenician civilization was the power and reach of the Greek culture. The ancient Greeks ascribed sacred powers to distilled beverages and incorporated distilled spirits into religious

rituals. (5)

This ancient Greek knowledge of distillation remains with us to this day. A mixture of grape pomace (skin and pulp) and wine is distilled to make a spirit beverage called Zivania. Grape pomace alone is fermented and then distilled to make Tsipouro and Tsikoudia. An anise infused version of these spirits remains with us today in the form of Ouzo. (6)

By about 200 BC, the Phoenician empire had collapsed and the Roman empire had usurped the former glory of Phoenicia. By about 150 BC, the Greek empire had faded into the hands of the Romans. We know the Romans were involved in distillation. The Latin expression de-stillare, meaning to drip or trickle down, is the root of our modern English word distillation. (3)

For the next several hundred years, the Roman empire ruled supreme. However, like so many empires before it, the Roman empire eventually collapsed. From about 400 AD onwards, the world, as it existed at that time, lapsed into a period of negligible advancement called the Dark Ages. (7) However, the knowledge that mankind had accumulated to date concerning the art and science of distillation was not lost.

Maria The Jewess

Sometime prior to 100 AD, a figure by the name of Maria the Jewess is said to have developed an apparatus that today we would recognize as a still. Her design had three components. The curcurbit was the vessel of the still, the ambix was the still head and attached to it was the solen which connected to the third part, the bikos, which we would recognize as the receiver (condenser) portion of a still. Maria's design eventually found its way to Islamic scientific thinkers in the period 700 to 800 AD. These scientific thinkers made incremental improvements to her design and ambix eventually became the expression for the improved still design, the al-Ambic still. (2)

A typical al-Ambic still consists of a copper pot with an onion-shaped dome mounted on top. Alcoholic vapors flow up from the pot, through the onion dome, down the gooseneck-like tube and into a water-cooled condenser. To ensure no alcohol vapors escape at the junction where the onion dome mounts to the pot, the join is sealed with a paste made of rye flour.

The al-Ambic still design would remain the technology of choice into the mid-1800s when Anneas Coffey introduced his column still design. But, despite the introduction of a column still, pot stills that resemble the al-Ambic design remain in fashion to this day in places like Ireland and Scotland.

The al-Ambic still design is illustrated in Figure 1. Travel to France, Spain and Portugal and you will see distilled spirits artisans plying their craft using various configurations of the al-Ambic still to make brandy distillates.

Figure 1 – al-Ambic still

Let's now turn our focus to a brief look at the history of some of the types of spirits we typically see on liquor store shelves. This history might inspire you, whether you are home distilling or whether you are intent on launching a craft distillery.

Le Cognac

In the 3rd century AD, Roman Emperor Probus extended privilege to a few select citizens to grow grapes in the area around the modern day Cognac region of France. In the centuries that followed, wine production escalated and to ease over-supply situations, some of the wine was exported to Holland where it was distilled into brandwijn (brandy). By the 1600s, the French had started doing their own distilling using al-Ambic stills and were soon exporting barrel aged brandy (called Cognac) to Holland, England and northern Europe. (8) The French may have learned the art of distillation in the mid-1200s from Arnaud de Villeneuve after his return from Crusades in the Holy Land. Chevalier de Croix Masson is credited with advancing the art of double distillation in the early 1600s. (9)

Today, brandy produced in the Cognac region of France is by legal definition a Cognac. In fact, Cognac can only be produced in the Cognac region of France. As author Simon Difford notes, this region in the western part of the country is divided into six sub-areas that denote the quality of Cognac produced therein. At the top of this designation list is the Grand Champagne region with its reputation for the very best Cognac. Bringing up the bottom of the list is Bois Ordinaire. (10)

The production of Cognac is tightly regulated. The white wine distilled to make Cognac derives from 95% Ugni Blanc grapes with the remainder being Folle Blanche and French Colombard. (8) An ideal wine for making Cognac will have a moderate alcohol content (8-9% abv), crisp acidity, no SO2 added, and the grapes will have been picked early. When crushing the grapes, care must be taken to afford only minimal contact between the skins and the juice. Contact between the two will extract polyphenols from the skins which will impair the wine quality when the polyphenols oxidize to aldehydes. Aldehydes in excess will then impair the quality of the distillate.

Cognac is tightly regulated as to ageing and production. It must be distilled twice on traditional charentais al-Ambic copper stills. The first distillation run yields what the French call brouillis. All of the ethanol, higher alcohols and volatiles present in the wine are captured in the brouillis. The strength of the brouillis will be around 30% abv. The volume of the brouillis obtained will be about 1/3 of the original wine volume. The brouillis will then be re-distilled to further refine it. On the second run, the desirable distillate is divided into two categories. The first portion emerging from the still is termed le cognac and the second portion is termed le seconds. The strength of these portions cannot exceed 72% abv. The undesirable final portion of the run yields distillate

(tails) which is collected separately to be re-distilled with the next brouillis run.(9)

The collected le cognac distillate is then placed in oak casks after having been diluted with water to between 55 and 70% abv. The filled casks are aged for a regulated period of time. The casks are made of French oak sourced from the Limousin or Troncais regions of central France. The ageing process involves the use of new oak barrels, medium aged barrels, and very old barrels, each being in contact with the ageing spirit for various intervals of time. Distillers may only distill le cognac and le seconds following the autumn grape harvest for a five month window which runs from November 1 through to March 31 of the immediately following calendar year.

The time clock for cask ageing commences on April 1. As to the age denominations of Cognac products, VS means the youngest distillate in the blend has been aged for at least two years, VSOP means the youngest distillate in the blend has been aged for at least four years and XO contains distillate that is at least ten years old. (11)

Some le seconds distillate is removed from the oak casks after three years and cold filtered. It is then blended with neutral spirit (95% abv) and water to obtain a final strength of around 43% abv. This is the French brandy you see at cheaper price points on your liquor store shelves.

L' armagnac

If you have ever had a French brandy from Gascony in the foothills region of the Pyrenees Mountains in south-west France, then you have had an Armagnac. History books suggest that this was the first brandy ever distilled in France, as early as 1411.

This region of south-west France was delineated in 1909 to distinguish it from the better known Cognac region. This area was not as economically successful as the Cognac region and local farmers could not afford the expensive al-Ambic stills. As a result, the quality of alcohol produced differed from the Cognac region. The region was then further divided into three sub-regions: Bas Armagnac, Tenareze, and Haut Armagnac. This decision was based on the fact that differing soil conditions between the sub-regions were resulting in grapes of differing quality and hence spirits of varying quality. Grape varietals used in making Armagnac are: Baco, Ugni Blanc, Folle Blanche and French Colombard.

In the early 1800s, Eduard Adam conceived the design for a distillation apparatus containing multiple chambers. In 1813, inventor Jean Baptiste Cellier adapted Adam's ideas and produced a distillation apparatus containing two columns. Wine was fed into the top of one column. The wine flowed down through a series of plates in the column, and up into the top of the next column where it then flowed down through more plates into a pot. Meantime, additional wine in the pot was heated to cause alcohol vapors to rise through the apparatus and up the plated columns. To ensure the process was continuous, the still operator would periodically remove some liquid from the still pot and replenish the pot with fresh wine. Where Cognac is pot distilled twice on a variant of the al-Ambic still to at least

67% abv (but definitely less than 72% abv), Armagnac distillate emerging from the Cellier column design will have an alcoholic strength of around 52% abv. The distillate is put into new oak casks sourced from the Gascony region. Once the distillate has acquired sufficient character, it is transferred to used oak casks that are about 400 liters in volume and left to age for a number of years. A finished product that sells as ‘Armagnac’ is between two and six years old. ‘Veil Armagnac’ is over six years old. ‘Millesimes’ is over ten years old. (9)

Usque Beatha

Historians reckon that by the late 1400s, whisky production in Scotland was well underway. The first record of distillate being made in Scotland appears in Exchequer documents from 1494 where it was written: “To Friar John Cor, by order of the King, to make aquavitae, VIII bolls of malt.” Eight bolls of malt in today’s measure would be about 870 kgs. The fact that this brief written phrase mentions malted grain shows how advanced the knowledge of alcohol production was by 1494.

By the 1600s, the Scottish Parliament had taken note of whisky production and had moved to impose a harsh tax of ¼ shilling per pint (in today’s money that would be over 30 Pounds Sterling per pint). This tax grab caused the distillers of the day to go underground to escape the long arm of the tax man. The Act of Union between England and Scotland in 1707 sought to raise the tax rates further and with that the game of catching illicit distillers was on in full force. Despite efforts to nab them, by the latter part of the 1700s, illicit distillers continued to outnumber legitimate ones by a huge margin. Clearly the policy of tax grabs by government bureaucrats was not working. The Wash Act of 1784 allowed for two stills of up to 180 liters size in each parish provided the stills were run by respectable men. (9) In the 1823 Excise Act, government authorities opted for a different stance. Distilling was fully sanctioned in exchange for a reduced amount of taxation. The success of the legitimate whisky industry was now better assured. But, it was not to be smooth sailing. Over the ensuing decades, the whisky industry experienced periods of rapid growth but also periods of contraction during economic downturns. The industry also faced periodic attempts by politicians to raise the level of excise taxes. But, survive it did and today Scotch Whisky (both single malt and blended) continues to be a global phenomenon. For an deeper dive into the history of Scotch, I highly recommend the writings of Charlie MacLean. (12)

Single Malt Scotch

If you are uncertain as to the distinction between single malt and blended Scotch, please do not feel bad. You are not alone.

A single malt Scotch is made from malted barley at a single distillery in Scotland using copper pot stills. The stills are divided into two categories, namely wash stills and spirit stills. The latter are usually smaller in volume, although don't let the word 'smaller' throw you. In my travels in Scotland, I have seen pot stills as big as 20,000 liters in volume.

The first part of the single malt process is not unlike that of beermaking. Malted barley in a mash/lauter vessel (tun) is brought into contact with hot water. Malted barley these days is obtained from massive-scale malting plants run by the likes of Crisp Malting, Baird's Malting, and Simpson's, three heavyweight players in the U.K. malting business. Only a small handful of single malt distilleries malt barley anymore, and even if they do, the quantities are minor.

The heat from the hot water contacting the malt barley helps to re-invigorate the naturally occurring enzymes in the grain. The net result is a breaking down of long starch molecules into smaller molecules (fermentable sugars). The bed of grain in the mash/lauter tun is then flushed three or four times with more hot water to separate the fermentable sugars from the bed of grain. This flushed, sugary, sweet liquid is then cooled and directed to a fermenter vessel (the washback) where either dried yeast or slurry yeast is added. Many distilleries obtain their yeast from a company called AB Mauri, located near Inverness. Fermentation takes between about

55 and 96 hours, with different distilleries having different protocols. Each single malt distillery is required to repetitively produce distillate having a particular taste profile to satisfy the needs of the blenders who create the various blended Scotches. Once a fermentation time has been established for a given distillery, there is no room for future variance.

The fermented wash is next moved into a steam-heated wash still. Distillation continues until practically all the alcohols, acids and flavor compounds have been captured. What is left in the still at that point is effectively water. The alcoholic strength of the collected wash still distillate will be in the range of 25% to 35% abv.

This distillate is then transferred to the spirit still. Distillation in a spirit still will proceed until the strength of the distillate coming off the still is about 50% to 55% abv. Again, this parameter is driven by the blenders who will be purchasing the malt whisky. This parameter is also driven by the size and unique shape of the still. Depending on still size, still shape and final cut point, distillates obtained will average anywhere from 68% to 74% abv.

Distillate obtained from the process is then loaded into oak casks where it will rest for several years. There was a time when each distillery would age its own distillate. Today, with the Scotch industry being largely corporately owned, the distillate is picked up by tanker truck and taken to large centralized ageing warehouses.

The oak casks used in Scotland are mostly sourced from the US. By law, a whisky (bourbon) maker in America must start with a new, charred white oak cask when ageing distillate. Once ageing is complete, the cask can no longer be used for ageing whisky in the US. Used casks are shipped to Scotland, sometimes direct to distilleries, sometimes to Speyside Cooperage near Craigellachie. In 2018, I had the pleasure of spending a half-day on the floor at Speyside Cooperage. Whereas the oak ageing protocols in the US are clearly defined and unequivocal, what I took away from my cooperage experience is just how opaque the Scottish barrel ageing subject is. While on site, I witnessed coopers taking ex-bourbon barrels and inspecting them for cracked staves, which were replaced. These repaired barrels were then sent on to distilleries. I witnessed coopers taking ex-bourbon barrels and even used barrels from Scottish distilleries (1st fill casks) and re-charring the barrels. When I inquired as to who the various distilleries were for the barrels being worked on that day, I was politely told such information was secret.

The next time you come face-to-face with a bottle of single malt Scotch, study the color. If it appears to be a light straw hue, you can assume it was aged in either an ex-bourbon cask or a refurbished Scotch cask that has seen multiple uses. If the hue of the whisky appears darker, you can assume ageing was done either in a re-charred ex-bourbon cask or in a re-charred Scotch cask. The details of the ageing process are driven by the creators of the various blended whiskies who have strict parameters as to color and oaky taste of the product. The Scotch industry also brings in oak casks from Spain that once held sherry. When you travel around Scotland, you will quickly learn that the hallmark of Scotch Whisky made in the Speyside region (along the River Spey) is its ageing in ex-sherry casks made of European oak. The next time someone tells you that they really enjoy a good Speyside Scotch, what they are really telling you is their taste buds have come to enjoy the notes of plum and jam that can only come from ageing in an ex-sherry cask. Some distillers even source ex-port casks (called ‘port pipes’). Towards the end of the ageing process, whisky might be transferred to these ex-port casks for perhaps six months, just long enough to impart some sensuous port notes to the whisky. I shall be watching the ex-sherry process closely in years to come. Global sherry consumption is trending down, meaning fewer ex-sherry casks are available. In fact, Macallan distillery is now sourcing European oak casks and filling them with their own fortified wine (sherry) so as to ensure an uninterrupted supply chain.

Blended Scotch

The main driver of the Scotch whisky industry is blended Scotch. A typical bottle of blended Scotch is comprised of: 95% abv base alcohol and a series of single malt whiskies. The 95% abv base alcohol is made at one of about seven grain alcohol distilleries in Scotland. The raw material of choice these days for grain alcohol is usually corn or wheat. These facilities employ continuous Coffey stills (or some manner of continuous still) and will run 24/7. The still will be modulated so that the distillate being produced is at a strength of around 95% abv. When I visited Simpson's Malting at Berwick-Upon-Tweed, I saw the production of green malt, which is sprouted grain that has not been kiln dried. The still-moist grain kernels, roots and shoots intact, was being loaded onto a truck for express delivery to one of the nearby grain distilleries. It was explained that 2/3 of the cost of producing malted barley is the cost of fuel to fire the driers that generated the blasts of hot air to heat the drying kiln. By sourcing green malt, the grain distilleries are saving significant sums of money. After all, it is not the base grain alcohol that defines the flavor of a blended Scotch. It is the choice of single malts used to build the blend.

To sum up the process, put yourself for a moment in the shoes of a blended brand, such as Johnnie Walker Black Label. Your blending team will have a desired selection of single malt whiskies that they use to build the taste profile of Black Label. The single malt distilleries supplying to Johnnie Walker must operate their processes to deliver a consistent profile. Their grain mashes must all be done to tight specifications. Their fermentation times must be tightly controlled. And barrel ageing must be strictly regimented. The base grain alcohol will then be sourced as cheaply as possible to maximize the profit margin in the finished bottle of blended whisky.

And lastly, if you have heard occasional rumors of pending single malt shortages, there might be substance to those rumors. But, any shortages are not being driven by individual consumers buying so much single malt that the supply chain is stressed. Any shortages of single malt whisky are being driven by the fact that the global market for blended Scotch is massive and getting bigger as developing nations warm up to the consumption of blended Scotch. You don’t even have to keep your ear to the ground for rumors. All you need do is visit your local liquor store. Look at how many single malts are now sporting no age statements. This is due to the blenders not being able to wait until single malts have attained a specific number of years in the cask. Consider a blender who has typically used a 12 year old single malt in his formulation. If he can create his blended formulation using single malt that is only nine years old, he will pressure the single malt maker to abandon the 12 year age statement. As a Scotch drinker who cherishes the age statement number, I find this to be disturbing.

Make the Trip

Once global travel gets back to normal after the corona virus has been resolved, I urge you to make a visit to Scotland. The September timeframe is ideal, as the tourist rush will be over. From Edinburgh, a 30 minute bus trip will take you to Glenkinchie distillery. From Edinburgh, a train ride and bus ride will land you at Glengoyne distillery near Stirling. Also from Edinburgh, a train ride will take you to Pitlochry and Scotland's smallest distillery, Edradour. A longer train ride to Inverness and some help from either a bus or hired car will put you in the tiny village of Craigellachie. The local petrol station had a more elaborate inventory of Scotch Whisky than my local liquor store here in Canada! In Craigellachie, stay at the Highlander Inn. It is owned by a Japanese gentleman who worked for many years in the Scotch Whisky industry. The array of whiskies available for tasting was stunning. I conducted intensive tasting research each evening while seated at the bar. From Craigellachie, you can walk to Speyside Cooperage. A short bus ride will take you to Glenfiddich Distillery. Dufftown is just a bit further along the road. A beautiful walk along the River Spey will take you to Aberlour distillery. And of course, your trip will not be complete without a tour of the uber-expensive, shiny, new, visitor center at Macallan distillery. If seeking to start a craft distillery, I further argue that a trip to Scotland is essential before you get too deep into the planning stages. The knowledge you will take away from your trip will help you immensely.

Gorzatka and Voda

The knowledge of distilling eventually found its way to modern day Poland and Russia. The exact timeline remains a topic of intense debate. Polish people will proudly argue that in the early 1400s the term gorzatka (meaning burning water) was recorded in official records. By the 1500s, the common man had learned the art of distillation as evidenced by repeated written mention of the word gorzatka. In the 1600s, Peter the Great and later Catherine the Great in the mid-1700s embraced vodka, calling it voda – meaning little water.

In 1818, with vodka still strongly in fashion in Russia, Ivan Smirnov founded a distilling company to produce vodka. By 1886, his nephew Pyotr Smirnov had taken over the reins of the organization. Pyotr, however, wanted to set the company apart from the other vodka makers in Russia. He is rumored to have travelled to Europe and purchased a Coffey Still from Anneas Coffey. This design of still was a radical departure from the traditional pot stills of the era. The design was based on two columns and the resulting distillate was much cleaner that anything produced in a pot still. So good was the resulting vodka that Czar Nicholas III formally endorsed Smirnov Vodka and set in motion its future brand success.

Pyotr died in 1898 and his son Vladimir took over the company. Corporate success, however, came to a sudden halt in 1917 with the Bolshevik Revolution which heralded the introduction of Communist rule. In quick order, the Communist government seized Smirnov’s assets and Vladimir fled the country with just the shirt on his back. After settling in France, he tried to re-establish the Smirnov brand but the French wanted nothing to do with this clear spirit, opting instead for their much-loved brandies, Cognacs and Armagnacs. In 1934, with his health failing, Vladimir sold the worldwide rights and trademarks for Smirnov Vodka to a fellow Russian political refugee, Rudolph Kunett, for 54,000 Francs ($45,000 US dollars). Kunett set up shop in his adopted country of America in the small town of Bethel, Connecticut. He soon ran into the same problem that had plagued Smirnov in France. No-one wanted this clear spirit called vodka. Prohibition had just ended and Americans were resuming their consumption of whisky. In 1939, Kunett admitted defeat and sold the Smirnov trademarks and rights to food and drink distributor G.F. Hublein Company (the maker of A-1 Steak Sauce) for US$14,000 US plus a small per-bottle royalty.

Had Kunett held on for just one more year, his fortunes would have changed. World War II saw men head off to the battlefields and women take up jobs in the munitions factories. After a hard day in the factory, women wanted to relax with a drink at their local bar. But they did not want harsh tasting whisky. Bartenders were quick to realize that vodka was the answer. Colorless and odorless, it would not corrupt the flavor of a drink made with juices or sodas.

The vodka cocktail revolution was born. Bloody Marys, Screwdrivers, and Moscow Mules were soon all the rage. Cocktails proved more than just a passing fancy. In the decades that followed, cocktails fluctuated in popularity, but never went out of fashion. This is a critical fact for every start-up craft distiller to bear in mind.

In the 1970s, the Swedish government was in dire need of money and began looking for products it could sell on the world market. The Swedes were quick to realize they had an asset in the form of their government-owned company, Absolut Rent Branvin. The English translation of this name aptly says what this company made – Absolute Pure Vodka.

In 1979, after granting creative freedom to ad agencies in New York, what emerged was the brand name, Absolut Vodka. With clever artwork playing on the name ‘Absolut’ and on the unique bottle shape, this upstart new brand soon caught serious attention from cocktail-loving consumers. The big corporate spirits makers took notice too. In 2008, drinks giant Pernod Ricard bought the exclusive rights to Absolut Vodka for a cool $8.3 billion. Absolut Vodka, made from winter wheat, remains strong as a brand name and an image to this day. But recent data shows that sales, although still robust, are tapering off as the consumer continues to be presented with innovative vodka product offerings from a multitude of other vodka brands.

Dutch distilling concern, Nolet, also took notice of the Absolut brand success. In 1983, Nolet launched its Ketel One Vodka onto the world stage. Nolet took a more laid back approach with Ketel One. No glitzy ads from high-powered agencies in New York. Just a clean, smooth vodka that was a pleasure to sip neat. In 2008, drinks giant Diageo paid Nolet $1 billion for a 50% interest in the brand name.

For a most excellent read on Vodka and its history, I highly suggest a book called Vodka, written by Victorino Matus. (13)

In the story of Tito’s Vodka, Matus alludes to what could be best called the dirty little secret behind vodka. That secret is something called bio-fuel. Matus claims that vodka has taken a wrong turn in the road and I am in agreement.

High energy prices over the past 15 years have created the bio-fuel movement. Pull up to your local gas station and you will see a small sticker on the pump that advises you that ethanol has been blended into your gasoline. This ethanol will have come from a bio-fuel plant somewhere near your community. Or, as I like to call them, ethanol factories. But wait, you say, isn't vodka ethanol? In fact, isn't ethanol at the heart of all alcoholic spirit drinks? Yes, dear reader it is. Welcome to Vodka 2.0 where ethanol factories sell 96.5% abv strength ethanol to beverage alcohol companies. The only difference between the stuff in your gas tank and the stuff in your martini glass is the fuel ethanol has been passed through a molecular sieve to draw off residual water and get the strength to 99.5% abv which is suitable for gasoline blending. In the North American marketplace, the vodka that you buy could very well have been sourced at a massive ethanol factory somewhere in the middle of Indiana. If it is Monday, the factory is making Brand A. If it is Tuesday, this same ethanol factory is making Tito's. If it is Wednesday, it is making ethanol for the gasoline industry. Whoa! you say. Tito's is handcrafted in Texas by a man and his faithful dog on a pot still. Sorry, folks. Sorry to shatter your dream and rain on your parade. Vodka has now been well and thoroughly commoditized.

In Saskatchewan, there is an ethanol factory in the tiny town of Unity, located west of Saskatoon. I have toured it, in all its jaw-dropping magnificence. Fermenter tanks that hold 200,000 liters. A distillation system that includes a total of eight columns, some of which are stories high and several feet diameter. A mere handful of people sitting at a digital console with keyboards run the entire show with clicks of a mouse. Impressive! But, also sad. I have tasted what comes off this process. Ethanol at 96.5% abv purity. Clean, smooth. Almost devoid of texture on the tongue and certainly absent of any finish at the back of the palate. This ethanol is now finding its way into vodka both in Canada and the US. While the plant manager was not willing to name specific end users located outside of Saskatchewan, he hinted very succinctly that there are many craft distillers in Canada buying his product along with some very 'big names' in the US, no doubt taking advantage of the weaker Canadian dollar. He hinted very strongly that a good amount of it is particularly finding its way into the craft distilling scene in California. If you are a resident of that state and are reading this chapter, maybe it is time to question where your local craft distillers are getting their ethanol for their vodka.

As Matus further points out in his book, American entrepreneur Sydney Frank was of the first movers to take advantage of product from an ethanol factory. Frank made his deft move in 1996. Capitalizing on 30 years of experience working with his father-in-law in the liquor distribution business, Mr. Frank knew what to do and where to turn. His experience told him that consumers would pay a premium for food or drinks that were from France.

He turned to a commercial contract distiller in France (that's a pleasant way of saying he went to an ethanol factory) and asked them to concoct a mash bill based on soft wheat. At a time when vodka was sold in clear bottles, he decided that a frosted glass bottle bearing the colors of the French flag would better grab the attention of the consumer. He further opted for a bottle that was slightly taller in the neck than the bottles of his competitor's. Taller than the standard shelf spacing meant that retailers would be forced to place the bottles on the top shelf. Taller in the neck and frosted grey. Sounds like a goose, doesn't it? How about Grey Goose? Being a clever marketer, Frank took matters one step further. He retained the Chicago-based Beverage Tasting Institute to conduct a blind tasting of 40 different vodkas from around the globe. Frank agreed to cover all the costs of this exercise. Not surprisingly, Grey Goose was awarded a composite score of 96/100. With that one data point in his pocket, he extrapolated wildly and began proclaiming Grey Goose to be the world's best vodka. Apparently people were paying attention. In 2004, Bacardi paid Mr. Frank $2.4 billion for the Grey Goose brand name.

When I get together with my wife's family, often the topic of conversation turns to alcohol. A few of my wife's family members drink vodka from big-box retailer Costco, specifically its Kirkland Vodka. I am reminded very pointedly that their cherished Kirkland Vodka is surplus Grey Goose. On many occasions I have tried to explain that there is no such thing as a Grey Goose distillery with a white picket fence and manicured lawn that sells its surplus inventory to Costco. The harsh reality is, vodka is ethanol and the Grey Goose and Kirkland ethanol both come from an ethanol factory somewhere near La Vallee de l'Oise in France. If it is Monday, the factory is making Grey Goose. If it is Tuesday, the factory is making Kirkland Vodka. I have about given up trying to get my point across. My wife's family who are so endeared to Grey Goose are also victims of marketing. The glitzy ads in magazines have thoroughly convinced these folks that Grey Goose is an important brand and nobody is going to convince them otherwise.

At times I think back to the early days of craft beer and how within a handful of years consumers became savvy and aware of the different beer styles being brewed. I wonder when the consumer will get savvy and realize that an ethanol factory in the middle of the stark Saskatchewan prairie could be making their craft vodka? If this realization one day dawns, the craft distillers who are sourcing this factory ethanol and not being honest with the customer might face some severe backlash. In fact, in early January 2021, the Saskatchewan government revamped its craft distilling definitions. Now, a craft distiller who is sourcing material from an ethanol factory will be labelled a Type 2 operator. A distillery grinding its own grain and making its own vodka will receive preferential tax treatment and be called a Type 1 operator. The winds of change are starting to blow.

While, for the moment, vodka may have taken a wrong turn in the road, all hope is not lost. In his 1991 classic, A History of Vodka, author William Pokhlebkin (14) notes that in the early 1900s, it was common for Russian upper class folk to sip vodka straight up, with food. He laments how the vulgar people in North America started to mix vodka with sodas and juices starting around World War II.

I happen to agree with Pokhlebkin. Next time you cook yourself a nice dinner, pour a 2 ounce shot of good vodka (craft distilled from grain and not sourced from an ethanol factory) and as you eat, take occasional sips. You will find the vodka cleanses the palate and adds a new dimension to your meal. Expand your research and try sampling different vodkas neat at room temperature. There is a world of difference between a vodka made from wheat versus one made from rye grain versus one made from potato versus one made from barley. Some time ago, I made an acquaintance with a vodka that I have come to quite enjoy. Yes, it likely comes from a big commercial distillery, but the raw material of choice makes this vodka really stand out from others. The vodka I speak of is Spud. This product of Poland is made from potatoes and the silky texture on the tongue will amaze you. I sip it straight up at room temperature.

If you are contemplating starting a craft distillery, take ample time to reflect on the fact that vodka has been commoditized. While you skin your knuckles grinding grain and executing 14-hour rectification runs, a craft distillery down the road might be bringing in cheap ethanol from a factory and putting it in a fancy looking bottle with a cleverly worded label that says something about 7 times distilled. If you want to make vodka, consider encouraging people who visit your tasting room to start sipping vodka straight up at room temperature, the way the Russian nobility used to consume it over 100 years ago. Make a few different recipes from different grains. Educate the consumer about the world of ethanol factories. Let them gently know that products like Grey Goose are just names and nothing more. It is time to get vodka back on the right track.

And to finish this brief examination of vodka on a lighter note, have you ever wondered why vodka (and many other spirits) are typically bottled at 40% alc/vol? The answer extends back to the mid-1800s in Russia to a scientist called Dimitri Mendeleev, who also invented the Periodic Table of the Elements. He was tasked by the government to come up with standardized weights and measures. Mendeleev observed that when vodka and water were mixed, the resulting volume of the mixture was smaller than the sum of the parts. He observed that one part vodka and three parts water gave the greatest volume reduction. Mathematically, he considered 1 mol of ethanol (46.1 grams per mol) and 3 mols water (54 grams per 3 mols). At room temperature of 20ºC he knew the density of ethanol to be 0.789 kilograms per liter and the density of the

alcohol/water mix to be 0.923 kilograms per liter. The ratio

of (46.1)*(0.789) / (100.1)*(0.923) calculates to 0.3937. Rounding up to an even 0.40, he concluded that vodka should be bottled in Russia at 40% abv strength. (15) This figure has obviously remained popular. Now you know why.

The Rise of Rum

The late 1400s heralded the start of the age of global commerce. The Portuguese, being skilled mariners, found their way around the tip of Africa and onwards to Madagascar and India. One plant that was collected from these seagoing ventures was the sugar cane. Native to modern day New Guinea, by 325 BC, the sugar cane plant had been brought to India where it flourished. The army of Alexander the Great, marching through India, called the sugar cane honey from reeds. Arab invaders circa 620 AD called the plant sukkur, from whence our modern word sugar is derived. In the late 1490s, this reed-like species found its way across the Atlantic ocean on Portuguese vessels. Christopher Columbus is generally credited with introducing the plant to Hispaniola (modern day Dominican Republic) where it quickly took root and flourished. From the Dominican, sugar cane soon spread into South America and to the other Caribbean islands.

The islanders followed the old methods of the Indian sugar merchants and began cooking the juice squeezed from the sugar cane to produce crystals of sugar. The remaining sludge left over from the sugar extraction process, molasses, also proved of value to the islanders who understood that leaving the molasses exposed to the air would induce fermentation. Allowing the molasses sludge to ferment and then distilling the resulting alcoholic liquid with crude equipment produced a substance that came to be called rum. Rum remains hugely popular around the world to this day.

As author Dave Broom notes in his book Rum-The Manual, (16) some of the earliest rum-making took place in the early 1600s, and by 1640, rum-making had spread to Demerara (the present day South American nation of Guyana). One of the first islands to start growing cane in abundance for rum purposes was Barbados in the early 1600s. By 1655, rum-making had reached Sugar Colony Number One (present day Jamaica).

As trading vessels from Europe concluded business in the Caribbean islands and continued on to the American colonies, they often landed in places like Boston, laden with barrels of molasses. Settlers began distilling copious amounts of rum, or as it was often called in those days kill-devil or rhum-bullion. By 1661, rum had become so commonplace that a court in Boston declared it to be a menace to society. But, a court ruling be damned. Rum was not to be defeated. In response to an ongoing conflict with France, William of Orange, who was sitting on the British Throne, banned the import of French brandy in 1713, making rum imported from the American colonies a hot commodity. By 1750, there were 25 rum distilleries in Boston, 20 in New York and 17 in Philadelphia.

This growth led to envy within the British government. The British overlords felt they were not getting their tax cut and they created the Sugar Act of 1764 which placed a tax on molasses. This tax grab is deemed to have been one of the root causes of the American Revolution.

War also played a role in the rise of rum. Between 1755 and 1763, the Seven Years War saw alliances between European nations severely tested and fought over. During this tumultuous period of world history, Britain occupied Cuba. With this occupation came the knowledge of sugar cane growing and rum making. By 1799, Cuba was exporting annually to Britain 1.2 million gallons of rum from a reported 300 small distilleries. Even the British Navy eventually adopted rum and began distributing daily rations called tots to its sailors.

In the early 1800s, a Spanish businessman Don Facundo Bacardi Masso found his way to Cuba where he became a reasonably successful merchant. He eventually started dabbling in the art of making rum, employing techniques like charcoal filtration and barrel ageing to make the drink more palatable to the consumer in Europe. By the late-1800s, his company was a flourishing success and its distilled product highly sought after in Europe. Today, Bacardi is a global force in the production of rum and owns many other brands of spirit beverages including Bombay Sapphire Gin and Grey Goose. For a more thorough treatment of the history of rum, I suggest getting a copy of Dave Broom's book, Rum-The Manual. (16)

As an interesting aside, in mid-2018 when I was thinking about my eventual M.Sc. thesis project, I was encouraged by one of my Heriot Watt professors to consider a thesis project on rum. I managed to make contact with a rum distillery in Barbados and for a time it looked as though a thesis project on rum would be possible. After some discussion back and forth, I was told all that remained was the customary approvals from head office. Much to my shock, head office in France denied my request. A 2011 article in the publication French History has now clarified why this likely happened. The 2011 article tells of a time in the late 1780s when a request was made for details on how the various rum makers on French-colonized Caribbean islands were plying their trade. The response to the request was that "each Distiller or Rum Producer manufactures this commodity according to techniques that vary depending on the plantation, the seasons, the syrups, the sugar skimmings…and the capacity of his equipment. Almost all Rum Producers keep their practices secret." (17) Evidently things have not changed much. Rum making techniques to this day remain carefully guarded and are not the stuff thesis projects are based on.

Rum is distilled using either the pot still method or the continuous still method. The original method was double pot distillation, not unlike the technique used to make whisky in Scotland. This method was modified in Jamaica (likely in the late 1700s) such that three pots were placed into the process. The first pot produces distillate vapors at about 30% abv strength.

These vapors flow into a second pot. As they emerge from that pot, they are at about 75% abv strength. Vapors pass into the third pot and as they emerge from it they are at 80-85% abv strength. Lower strength material (about 75% abv) coming off this final step in the process is collected and returned to the second pot. Yet lower strength material (about 30% abv) is collected and returned to the first pot. Rums made using this pot/retort process are heavy bodied and aromatic. Rums made on a Coffey still (or any sort of continuous still) will exit the process at something closer to 95% abv strength. These rums will be lighter bodied. When you go to your local liquor store and peruse the various rums on offer, bear in mind that the various products on offer could very well be blends of base alcohol made on a continuous still and pot distilled alcohol.

The entire subject of ageing is rather opaque when it comes to rum. Unlike the European Union, the Caribbean islands do not seem to have a legally codified methodology for spirits ageing. When I spot a modestly-priced 12-year-old rum on my local liquor store shelf I have to question whether that rum is all 12-year or whether the recipe is a blend containing other younger rum. I closely examine rum bottle labels for ageing details. I am apt to buy only those brands that clearly disclose their ageing parameters. My favorite rum is a product called Dos Maderas (meaning two woods). This rum starts from a blend of up to five different distillates sourced from the Caribbean region. Some of these are no doubt made by continuous distillation. After ageing for five years in ex-bourbon casks, the distillate is emptied from the barrels and transported to Spain where it is loaded into older ex-sherry casks for three years and then slightly younger ex-sherry casks for two more years. The plummy, jam notes of this nectar quickly send my senses into nirvana. Another rum that I am liking very much is Admiral Rodney Rum from Saint Lucia. It too is a delight to sip. The packaging label fully discloses that it is a blend of rums that have been brought off the lower portion of the column on a Coffey still, aged for between five and nine years in oak and then blended.

Whisky, Tax and Bourbon

The early 1600s marked the start of what would be many waves of migration to the New World. The brave settlers coming from afar brought with them their domestic grains. The Dutch and Germans brought rye grain. The English brought barley and wheat. It was quickly discovered that these grains were capable of growing in the fertile soils of the New World. But, these hardy souls brought with them more than just grain. They brought their brewing and distilling equipment as well. This equipment consisted of likely nothing more than crude metal pots and wooden barrels. Rudimentary to be sure. But very effective nonetheless. Before long, beer and distilled alcohol were being made from surplus grains remaining from the autumn harvests.

There is a curious connection between rum and whisky. Author Reid Mitenbuler describes in his book Bourbon Empire (18) how in 1764 the British government imposed a tax on the importation of molasses from the Caribbean (The Sugar Act). This prompted the now famous cry ‘no taxation without representation’ and the War of Independence soon followed. With the sourcing of rum a declining possibility, American settlers started turning towards whisky distilled from domestically grown grain. But, whisky would very soon attract political attention.

In 1789, newly elected President George Washington found himself leading a nation deeply mired in post-Revolution debt. Some $54 million (about $5 trillion in today’s money) had been borrowed from France to finance the War of Independence. To pay this debt, Washington and his Treasury Secretary Alexander Hamilton imposed a Whisky Tax on the settlers. So vigorous was the backlash that by 1802 the tax had been repealed. Many settlers in the wake of this disastrous attempt to tax whisky headed west into present day Kentucky and Tennessee to get away from the reach of the government. This wave of migration westward is what set the stage for the modern day Kentucky Bourbon and Tennessee Whisky industries. The names of many of these settlers are with us yet today. Elijah Pepper (Old Crow Bourbon), Jacob Beam (Jim Beam brands), Robert Samuels (Maker's Mark Bourbon) and Basil Hayden (Basil Hayden's Bourbon) to name a few. For a more thorough read about this pivotal part of American history, there is an excellent article on the TTB website by Michael Hoover. (19) I have become quite enamored with Bourbon, with my favorite being Makers 46. Bourbon is a product made using at least 70% corn in the recipe. The balance of the recipe can veer in a couple directions. Wheat will create a smoother product, whereas the use of rye grain will add some complex spiciness.

During my trips to Edinburgh for school, I was taken aback when I heard my professors alluding so highly to Kentucky Bourbon. The production process generally used to make bourbon is a 2-step affair. The first step involves the use of a column still to obtain distillate that is about 50% abv strength. One enough of this material has been collected, it is distilled again in a pot type still to create distillate that by law must be less than 80% abv strength. This double distilling method, which is not unlike the Scotch Whisky distilling approach, might explain why my professors spoke highly of bourbon.

For more fascinating reading on the American alcohol story, I highly recommend Dead Distillers by authors Spoelman and Haskell written in conjunction with Kings County Distilling from Brooklyn, New York. (20)

Genever and Gin

By the early 1600s, the Dutch were distilling alcohol of modest quality and blending it with barley wine. In 1602, the Dutch East India Company was formed. Dutch vessels soon began sailing around the tip of Africa much like the Portuguese had done in the late 1400s. But the Dutch pressed farther afield to the Indonesian Spice Islands in search of exotic fare. A spice called juniper (juniperis chinensis) soon found its way into Dutch distilled alcohol and the new creation was a product called Genever.

In 1638, in England, Charles I granted exclusivity on grain distilled spirits production for a 21 mile radius around London to his political friends at the Worshipful Company of Distillers. Politics entered into the fray again, in 1689, when Charles' son James II was driven from the throne. English parliament turned to Holland for help and asked William of Orange to assume the English throne under the title William III. Dutch Genever soon found its way into English social circles along with grain alcohol from the 21 mile radius around London. What emerged from this Dutch-British political combination was a product called Gin.

England was at odds with Louis XIV of France and to destroy demand for French brandy, William III enacted legislation to allow anyone to distill grain spirit. He also encouraged the importation of rum from the American colonies. The excise duties collected on this increased volume of spirits production further helped finance the conflict with France. In a further bid for funds, the English Parliament imposed steeper duties on beer. This in turn led to even more people taking to gin drinking.

For the next 50 years, gin consumption grew smartly, as did the attendant social problems. As quickly as government enacted legislation to curb the legal production of gin, illicit distillers sprang into action to feed demand. Things got so bad that gin came to be known as Mother's Ruin – a reference to its dire effects on the health of new-born babies.

In 1736, the British House of Commons passed the Gin Act which imposed a 20 shilling per gallon tax on gin. It was asserted that "the drinking of gin had excessively increased amongst people of inferior rank". This excessive consumption had "destroyed thousands and rendered great numbers of others unfit for labour, had debauched their morals and had driven them into every vice." But soon businesses popped up under the guise of being "chemists". They began offering liquid to ease a baby's colick and they offered medicine under names such as Tom Row, Make Shift, and Ladies Delight. Of course, all of these products were gin in disguise. (21)

While gin was perceived as a spirit for the working class, the government enforced the notion that beer was the beverage of choice for successful folk and for people who wanted to be successful. To drive home the point, artist and social activist, William Hogarth, was engaged to create two pencil sketches in 1751: Beer Street and Gin Lane. The Beer Street work depicts erudite, successful people holding mugs of beer. Companion piece Gin Lane depicts a lower class of folk, debauched, inebriated and emaciated from having consumed too much cheap and easy gin. But Hogarth's message did not resonate immediately. It took a grain crop failure in 1757 to make for a temporary ban being placed on alcohol production. Being forced to go without a product for a while can evidently lead the consumer to not desire the product as eagerly. The ban on grain alcohol distillation saw sobriety return to the streets of London. Sobriety, in turn caused people to consider Hogarth's message about the evils of gin. London's gin-drinking ways were soon reformed.

In 1760, distillation was again approved, but at much higher excise rates. With the benefits of sobriety now appreciated and with a growing moral movement providing added impetus, gin production was soon restored but with a new respect for moderate consumption. The next 100 years would see the creation of many gin producers, the names of whom are still with us today, such as Tanqueray, Gordon's, Boodles, Beefeater, and Gilbey's.

As the 1800s neared an end, gin found its way to the US and into cocktails. The gin cocktail movement continued right into the 1900s with World War I even failing to put a dent in consumption. Drinks like the Ramos Gin Fizz, Pink Lady, the Negroni, and the Singapore Sling became wildly popular.

Today, the gin movement remains strong with craft distillers leading the charge. Moreover, craft distillers in North America have made a hard right turn on the gin road by veering away from the juniper-forward, London Dry style. Whereas in the U.K. juniper must be the predominant flavor in gin, there are no such requirements in North America.

Again, Dave Broom to the rescue. If you want to delve deeper into the history of gin, I highly recommend his book Gin-The Manual. (22) Broom's book reviews a vast array of gins from the U.K., Canada and the USA. In each review, he lists the botanicals (not the quantities) that the distiller used to create the gin. This book is a great way for the gin-loving consumer to educate his/her palate. I make it a point to sample as many different gins as I can when I travel and I usually have Mr. Broom's book with me as I sit at a bar. The following gins are some of my favorites:

For a gin oozing with luscious notes of lavender and citrus, try to find Wallflower Gin made by Gordon Glanz and his team at Odd Society Spirits in Vancouver. A wallflower by definition is something shy and retreating.

This gin is anything but, which reflects the odd irony that so very much defines Odd Society Spirits. Mr. Glanz, by the way, is a graduate of Heriot Watt University – Brewing & Distilling program. His various excellent creations underscore the benefits of acquiring scientific knowledge if contemplating a craft distillery venture.

If your travels take you to London, look for a gin by French distiller Audemus Spirits called Pink Pepper Gin. The pink peppercorn imparts some gentle citrus notes to the gin. But, what made me flip head over heels in love with this gin is the use of the tonka bean which imparts a finish of coconut and vanilla, two flavors that one's palate does not expect from gin.

Also in your adventures, look for Bathtub Gin from Ableforth's Spirits. The subtle earthiness of this product was like a magic elixir to me. The bartender at the bar in the Edinburgh airport was beginning to think I was going to sit there all day inhaling the aromas instead of drinking the gin.

If in Edinburgh, look for some gin liqueurs from the Edinburgh Gin distillery. My favorite is Raspberry Gin Liqueur. The raspberry notes are front and center but the gin notes are singing along in perfect harmony.

I am impressed with what craft distilling has done to gin. I have no doubt that gin will remain a popular spirit for a long time to come. However, as I will discuss later in this book, making a good gin is not something that is accomplished in one afternoon. Dozens of small scale iterations will be necessary to arrive at your perfect recipe.

Canadian Whisky

Canada has a rich tapestry of stories pertaining to the development of whisky. The stories start in the late 1700s with waves of immigration landing on the shores of Upper and Lower Canada.

In 1783, the Molson family arrived from England and settled in Montreal. John Molson opened a brewery and the seeds for the future success of the Molson's Beer brand were planted. During one of his return visits to England, Molson acquired a pair of copper pot stills. In 1820, his eldest son Thomas Molson began distilling whisky. By this time there were an estimated 70 distilleries located up and down the St. Lawrence River, all producing product for export back to a thirsty English marketplace.

By 1845, this export market dried up as railways made it possible for people in England to more easily source whisky from Scotland. Many of the small distilleries along the St. Lawrence River faded into memory. In 1867, the year Canada became a country, the Molson family made the decision to exit the spirits business and concentrate full time on beer. The next time you are enjoying a cold glass of Molson-Coors beer, remember that the Molson family was not always just about beer.

In 1832, a pair of English immigrants, James Worts and his brother in-law William Gooderham, arrived in Toronto where they set up a grain milling operation. In 1845, looking to expand their business, they decided to venture into the production of whisky using a mash made of wheat. Their timing was otherwise perfect as the American Civil War erupted in 1859 and wreaked havoc on the many distilleries that dotted the landscape from

New York to the Carolinas. Gooderham and Worts seized the opportunity and by late 1860 were making 2.5 million gallons of whisky a year, much of it destined for a thirsty, war-torn America.

Gooderham and Worts were unwavering British imperialists. In 1916, after having amassed huge wealth from making whisky, they decided to idle their production facility in Toronto as a show of support for the efforts of Britain in World War I. They reasoned that alcohol could distract people’s attention from the worry over the war. So, why make it any longer? In 1923, upstart whisky entrepreneur Harry Hatch purchased their Toronto facility for $1.5 million.

Another very colorful figure who left his mark on Canadian Whisky was American-born Hiram Walker. Walker was born in Massachusetts in 1816. In 1846, he landed in Detroit where he set up shop providing dry goods to settlers heading west. He also began experimenting with rectification. In those days, a rectifier was one who purchased raw alcohol distillate from a larger distiller. The raw distillate was then charcoal filtered and doctored with caramel burnt sugar and prune juice to make a palatable spirit drink. When US laws changed and rectifiers came under duress, Walker scarcely blinked. He packed up his equipment and headed across the border to Canada and settled in present day Windsor, Ontario. In 1858, with assistance from his brother Harrington, he set up shop making whisky from a mash of what is reported to have been a mix of 80% corn, 14% rye, 3% barley and 3% oats. This recipe was the forerunner of the recipe now used to make the popular a brand of spirit drink Canadian Club Whisky.

Another colorful figure who left a mark on Canadian Whisky was John P. Wiser. Wiser was born in 1825 in Utica, New York into a family of successful industrialists. The family eventually established a distillery in Prescott, Ontario and young J.P. was put in charge of operations. His mash recipe apparently was based on corn and rye, but with a twist. Wiser also added hops to his mashes. By the early 1900s, Wiser was exporting his product around the world. Whisky historians suggest that Wiser's may have been the first whisky brand to label itself as a 'Canadian Whisky'. In 1911, J.P. Wiser died. His children lacked the interest to continue running the business. Company Treasurer, Albert Whitney, took over running the operation, but in 1927 he passed away as well. The Wiser's Distillery and brand name were then acquired by Montreal businessman Sir Mortimer Davis.

In 1926, the Canadian government struck a committee (the Smuggling Committee) to investigate how distillers had managed to evade paying Excise Tax during the Prohibition years. What was revealed was a complex web of corruption that involved distillers and senior level bureaucrats. With alcohol prohibition (the Volstead Act) still in force in America, Hiram Walker realized that as an American citizen he faced possible incarceration in the US if he were ever called to testify (confess) under oath in front of the Canadian government's Smuggling Committee. In December 1926, a hurried deal was consummated that saw Harry Hatch purchase the assets of the Hiram Walker Distillery for $14 million. No longer associated with the distillery, Walker was no longer under any duress to appear before any government committees. Today, the distillery is still in Windsor, Ontario, bigger and better than ever, but it is owned by spirits giant Pernod Ricard.

Two massive acquisitions were made inside of three years. Who was this upstart Harry Hatch? The Hatch family was already in the liquor business when Harry was born in 1884 near Belleville, Ontario. As a young man, alongside with his brother Herb, he worked in various bars and hotels in the area. In 1911, he set out on his own and established a package liquor store in Whitby, Ontario. Success followed and two years later Hatch moved his business into downtown Toronto. In 1916, when the Ontario government ushered in the Ontario Temperance Act, Harry and his brother barely blinked. They packed up shop and re-located to Montreal where they established a mail-order business selling whisky to their former clients in Toronto and surrounding area. Their success soon attracted the attention of

Montreal businessman Sir Mortimer Davis, head of both the Canadian Industrial Alcohol Company and Imperial Tobacco. The Volstead Act in America had created a thirsty marketplace. Harry Hatch partnered with Davis and wasted little time in assembling a fleet of motor boats. By 1923, 50,000 gallons of whisky a month (purchased from places like the Gooderham and Worts Distillery in Toronto) was finding its way by boat across Lake Ontario into upstate New York. Harry Hatch had become a very wealthy man. Mortimer Davis became even more wealthy than he already had been.

It is fascinating that history records Wiser's Red Letter Rye from the early 1900s as being 'dark in color and smooth'. In late 2015, the J.P. Wiser brand launched its Wiser's Hopped Whisky. With its dark color and smoothness, this was a page taken right out of the corporate history book. I further suspect this move was to counter the early success of the craft distilling movement. As an aside, Vice-President of Operations for Pernod Ricard, Don Livermore holds a Ph.D. from Heriot Watt University, is a microbiologist, and has years of experience in the world of whisky. A lethal combination to be sure. I am impressed with the innovative expressions coming out of Dr. Livermore's operation. Craft distillers will need to have their head in the game and their sticks on the ice, to use an old hockey cliché, if they are to even remotely keep up with Dr. Livermore. And while on the subject of Wiser's, I would be remiss to omit a short personal story. My 87 year old mother-in-law has always enjoyed a wee tipple of whisky. A few years back, I offered her a dram of some of my home-distilled whisky. She took a sip, placed the glass on the table and pushed it in my general direction. "It's not bad", she stated. "But it's not Wiser's." I did not know it at the time, but Wisers is the only brand she has ever consumed in 60-plus years of whisky drinking. How's that for brand loyalty?

In 1837, the Seagram family arrived from England and settled in the town of Galt, near Toronto. Octavius Seagram and his wife had two boys, Joseph and Edward. Young Joseph proved quite talented with pencil and paper and in 1864 the Waterloo Distilling Company hired him to be their bookkeeper.

Some 20 years later, he engineered a deal to buy out the company which he re-named the Joseph E. Seagram Distilling Company. Annual production was soon nearly one million gallons a year. His secret to success was apparently ageing his whisky in ex-sherry casks for four years. Where he learned this technique remains uncertain but this ageing technique remains popular today in the Speyside region of Scotland.

By 1880, social pressures, however, were mounting. The evils of alcohol were coming under scrutiny and politicians were under pressure to act. These same politicians were also feeling pressure from the large distillers who had been donating money to fund re-election campaigns. In 1883, with large distillers feeling the sting of softening sales and social backlash, the Canadian government returned past favors and passed the Bottled In Bond Law which stipulated that no taxes would be due on whisky until such time as it had been bottled and sold.

In 1885, the Canadian government went one step further with amended legislation stating that whisky had to be aged two years in order to be formally called Whisky. This proved disastrous to the many small distillers who relied on quick product turnover to generate cash flow. But, this legislation proved fortuitous to the large distillers who quietly solidified their grip on the spirits industry as smaller players closed up shop. With small distillers fading out of business, politicians argued that the evils of alcohol were being kept in check. Start-up craft distillers today should remain ever mindful of this symbiotic relationship between government and the big commercial distillers. This relationship still quietly exists and could rear its ugly head at any time. As a case in point in the Province of Ontario in late 2016, the then Premier Kathleen Wynn suddenly and without warning passed Bill 70 which called for the imposition of a 61% tariff on every bottle of distilled spirits sold by a craft distiller from a retail tasting room. This nasty piece of legislation never came to be formally implemented, but it serves to illustrate how politicians bowing to pressure from the big distillers can turn against the small entrepreneur.

In 1898, with social pressures continuing to mount, the government of Prime Minister Wilfred Laurier made provision for a national referendum on the subject of implementing a prohibition ban on alcohol. 51.3% of people voted in favor of banning alcohol. But Laurier, ever the clever and calculating politician, decided not to impose a ban on alcohol after seeing that only 44% of eligible voters had cast a ballot. Clearly, this was a man who knew how to walk the walk and talk the talk all while quietly looking after his big distiller friends.

Prohibition did eventually come to Canada between 1901 and 1921. Prince Edward Island was the first province to implement a prohibition ban on alcohol in 1901. Ontario and Alberta followed in 1916. Saskatchewan, British Columbia and New Brunswick followed in 1917. Nova Scotia was the last to ban alcohol in 1921. Quebec, interestingly enough, adopted a prohibition ban on alcohol in 1919, but repealed the ban some two months later.

One of the most fascinating families in the history of alcohol in Canada is the Bronfman family. They are synonymous with the prohibition of alcohol. The Bronfman family arrived in the tiny farming community of Yorkton, Saskatchewan in 1889 with three boys in tow, Abe, Harry and Sam. Four daughters were eventually born into the family as well. This family was entrepreneurial in every sense of the word. If there was a dollar to be made, whether selling horses, chopping firewood, running hotels or selling cars, they figured out a way to make that dollar.

Back in 1878, the Canadian government had passed the Canada Temperance Act. Those lobbying in favor of this Act at the time were certain it would be damning to the alcohol trade. But, the government of the day was clever and on the lookout for its big distiller friends. The Act stated that it would be illegal to ship alcohol into any province, but only if that province first held a referendum to ratify the Canada Temperance Act. Individual provinces were not interested in having time-consuming and expensive referendums. The Bronfman family was aware of this and planned accordingly. The temperance efforts lost strength in 1914 as societal focus shifted to Canadian efforts in World War 1.

Deciding that temperance in general and the Act in particular lacked any teeth, the Bronfman family swung into action, setting up a booze mail order business. Consumers across the country with money and means could now obtain a bottle of whisky through the mail. World War I had created a huge surplus of whisky in Scotland. The Bronfman clan also figured out that it was legal in Canada for a person to obtain whisky by way of a doctor's note. The Canada Pure Drug Company was then set up to begin importing boatloads of bottled Scottish grain alcohol distillate into the port of Montreal. From there, the Canadian Pacific Railroad transported railcar loads of it to Yorkton, Saskatchewan into the waiting arms of the then 28-year-old Sam Bronfman. Sam worked up to 22 hours a day charcoal filtering the grain alcohol and adjusting the flavor with caramel and prune juice. He also had acquired aged rye whisky, likely from Harry Hatch. A typical blend of Bronfman's product consisted of 100 gallons of aged rye whisky, 318 gallons of 65% grain alcohol and 382 gallons of water. Labels bearing names such as Gold Label and Special Vat Whisky were then glued over top of the existing labels on the bottles. Before long, the Canada Pure Drug Company became the supplier of choice to medical practices and retail druggists across the prairie provinces and into Ontario, earning a reported $390,000 a month in gross revenues.

But, the Canada Pure Drug Company needed bonded warehouses to properly distribute its merchandise. With some financial encouragement from Harry Bronfman, certain officials at Excise Canada bent the rules, looked the other way and allowed the Bronfman family to build a series of warehouses from Ontario to British Columbia. These facilities soon became known as boozoriums. There were at least 25 of these facilities in Saskatchewan alone.

From Yorkton, some of the Canada Pure Drug Company merchandise found its way south to Moose Jaw, Saskatchewan thanks to a handshake deal that Harry and Sam Bronfman had made with a mysterious figure in a wheat field near the village of Bienfait, Saskatchewan. That mysterious figure was none other than Chicago gangster Al Capone. Moose Jaw was the terminus for the Soo Line Railroad which ran down through Estevan, Saskatchewan on into Fargo, North Dakota and eventually into Chicago. No exact figures are available, but there is no doubt that a considerable amount of product found its way from Moose Jaw into Al Capone's hands and then into the thirsty American market.

In early 2017, I met an elderly gentleman in Regina who at the age of 94 had vivid childhood memories of whisky running. As a wee lad of four or five years of age, he would pull his wagon to the local train station in the small village of Ituna, Saskatchewan. The stationmaster would offload boxes of cargo from the train. Some of these boxes, labelled 'Motor Oil', would be placed on his little wagon. This wee lad would pull his wagon up and down Main Street making deliveries to designated people who in turn would pay him 25 cents per box (the equivalent of about $3 in today's money). Except, the boxes did not contain motor oil. They contained something far more tasty and intoxicating. No doubt these boxes were in some way connected to the Bronfman clan.

In late 2015, I visited Prichard's, a small craft distillery just outside Nashville, Tennessee. Apparently the exploits of the Bronfman family are still talked about in the US. When a couple of gentleman at the tasting bar realized that I was Canadian, their first comments were "ya'll up there in Canada made a lot of money supplying America with whisky during Prohibition". Indeed we did and there are many colorful figures from that era who shall be remembered in the history books as having played leading roles.

As Prohibition wound down and society came to again accept alcohol, the Bronfman family bought a distillery in Kentucky. They disassembled it piece by piece and moved it to Montreal where they set up shop as legalized distillers under the corporate banner Distillers Corporation Limited. Their success continued with the purchase of Joseph E. Seagram Distilling Company in 1928.

Prohibition was still in force in the US. The Bronfman family fed its now legal Canadian alcohol into a complex web of underworld distribution to satiate a hungry market south of the border. In 1935, court proceedings began in what the RCMP thought would be a certain conviction against the family on liquor smuggling charges. But, the Bronfman clan remained untouchable with the judge very strangely ruling that although the Canada Export Act prohibited liquor exports to the US, the Bronfman family could not be indicted. By 1971, the Bronfman empire had grown to include some 39 distilleries worldwide. Some of the Scotch distilleries I visited in Scotland were at one time Bronfman-owned. Sadly, the Bronfman empire faltered under the watch of Edgar Jr., the third generation of the family. Edgar Jr. certainly epitomizes the adage ‘rags to riches to rags in three generations’. Today drinks giant Diageo owns the spoils of this former grand empire. For a riveting read of the liquor exploits of this era, I highly recommend the book Whisky King by Trevor Cole. (23)

The post-Prohibition era was also profitable for Mortimer Davis and Harry Hatch. The distilling assets that made this duo so much money were folded into a legalized entity called Consolidated Distillers Ltd. Today, global spirits heavyweight Pernod Ricard owns this former success story.

I could continue on for many more pages detailing the history of Canadian Whisky. Instead, I refer you to the very excellent treatment of the subject by author and esteemed whisky expert Davin deKergommeaux in his book aptly entitled Canadian Whisky, The Portable Expert, now available in its second printing. (24) Two other good reads on the history of Canadian Whisky are Booze, by author James Gray (25) and Booze, Boats and Billions by C.W. Hunt. (26)

I stated earlier that my professors in Scotland were proponents of bourbon. I believe this is because of its manufacturing process. The same cannot be said for Canadian Whisky and trust me, they made that very clear. Canadian whiskies are mainly column distilled. When exactly this methodology was adopted, I am not certain. As you will learn later in this book, column distillation removes the higher alcohols, leaving largely ethanol in the distillate stream. A 1999 paper written (26) by a scientist at a western-Canada distillery (thought to be Alberta Distillers) states the distillate coming off the still is at 95% abv strength. In other words, de-facto a vodka. As you will read in the next chapter, Canadian distillers are allowed by law to adulterate their product with up to 9.90% by volume of other ‘stuff’. (27) This ‘stuff’ is sometimes referred to as ‘distillers wine’. Its composition remains undisclosed, but is thought to be perhaps a mix of wine and possibly even some brandy. In 2016, I attended a Spirits Conference in London, U.K. The keynote speaker, a major liquor importer, preached a message of damnation for Canadian Whisky stating that Canadian Whisky makers were nothing more than a bunch of barking mad organic chemists. At issue was the addition of 9.09% of other stuff. Now I understand why my professors at Heriot Watt expressed disdain for Canadian Whisky. The particular taste profile of Canadian whiskies likely explains why Canadian consumers have learned over the decades to mix their whisky with cola or ginger ale.

I still have faint memories of my Dad in the late 1960s mixing coca cola into a product called Seagram’s 5 Star. Each bottle came affixed with a five-pointed, plastic star glued onto the front face of the bottle. Sometimes I would be given the plastic star which I would affix to my cap and I would pretend to be a military 5-star general. My point in all of this is, Canadian consumers are mixers. As a craft distiller in Canada, one must be cognizant this. A consumer intent on mixing is not going to pay top dollar for a craft product. Craft distillers must further be cognizant of what Canadian Whisky really is. I have met far too many craft operators who do not understand distillation. They feel that by utilizing the 4-plate ‘whisky column’ on their stills, they can magically make whisky. They fail to grasp that the big commercial operators use multiple types of grain and blend different steams of aged product together to make a typical Canadian Whisky. Whisky is not what the majority of craft distillers think it is. I have also run into far too many craft distillers who adamantly tell me it takes only three years to make a Canadian Whisky. Historical material I have read makes it clear that back in the late 1960s when Seagram’s ran their distillery in Weyburn, Saskatchewan, old Sam Bronfman dictated that all Whisky would be aged minimally 5 years in oak casks.

Tequila

I will conclude this brief look at the history of spirits with a look at a beverage alcohol that has seen a resurgence in popularity – Tequila. Long before the arrival of the Spanish colonizers in Mexico, the agave cactus was held in high esteem by native peoples as a food source. This dietary practice of cooking and eating agave is said to date back to 9000 BC. The agave plant was so revered it was often called "Mayahuel" who in Mexican folk lore was the Goddess of nourishment and also the Mother of 400 rabbits who were the gods of drunkenness. When the Spanish arrived in Mexico in the 1600s, they observed the local natives cooking and eating the stalks and leaves of the agave plant. The local natives were also allowing the cooked agave to ferment into wine. When the Spaniards introduced rudimentary stills to the situation, it was soon learned that this fermented wine could be distilled into a drinkable spirit.

In the 1800s, distilling of agave began in the city of Tequila. The species of agave used in the city of Tequila has since come to be called agave tequiliana and as of 1974, (28) distillate made from this species of agave in the State of Jalisco (where the city of Tequila is located) can be called Tequila. In addition, agave tequiliana grown in the States of Nayarit, Michoacin, Guanajuato and Tamaulipas can also legally be used to make Tequila. Distillate made outside of these areas is to be called Mezcal. In fact, distillate made from any of about 40 agave species in Oaxaca, Durango, Zacatecas, San Luis Potosi, Guanajuato, Guerrero, Puebla, Michoacan and Tamaulipas can be called Mezcal. (29)(30)

Tequila reached a fevered pitch in 2013 when actor George Clooney and partners started sourcing distillate from distillers in Jalisco State and bottling it under their brand Casamigos Tequila. In June 2017, drinks giant Diageo bought the brand for $700 million. (31)

It takes about 10 years for an agave tequiliana plant to reach maturity. Once it is harvested, it is no more. With the resurgence in Tequila popularity, the industry is having trouble keeping up with demand. To combat the raw material shortage, some distillate is now made from a 50/50 mixture of sugar and agave plant material. If you are wanting a genuine product, study the bottle label carefully. Only a product made from 100% agave is the real deal. The white Tequila made from a sugar/plant material mix is akin to white dog or white lightening in North America. White Tequila that has been made today, will be bottled tomorrow and will appear at your local liquor store next week. Gold-colored Tequila is white Tequila adulterated with food colorant. If you see a 100% agave product termed ‘reposado’, that is distillate that has been aged for a short time in ex-bourbon barrels. A product termed ‘anejo’ has been aged for up to three years in oak. A product termed ‘extra anejo’ has been aged longer than three years.

For the record, my favorite sipping product from Mexico is Don Julio Extra Anejo. With no let-up in sight on the Tequila demand front, look for a new product called Raicilla which is made in Jalisco State from the maximiliana varietal of cactus. This product is said to be more tropical and fruity than a typical Tequila. Watch for another called Bacanora from Sonora made from agave pacifica cactus. Pine nuts and almonds are added to a Bacanora distillation run to lend more character to the distillate. Watch too for Sotol made from a cactus plant called Desert Spoon (dasylirion wheeleri). This plant grows in northern Mexico, New Mexico, west Texas, and the Texas Hill Country. It is known as the state drink of Chihuahua, Durango and Coahuila. (28) It would not surprise me to soon see a craft distiller from the south-west USA take a serious look at this expression.

The Lure of History

My travels and observations over the past several years have shown that the consumer is fascinated with the history of alcohol. Nowhere was this more apparent to me than in late 2015 in Paducah, Kentucky at a craft distillery called the Moonshine Company. Stepping inside this craft distillery was like taking a step back in time. The entire front part of this operation was a veritable museum dedicated to that iconic American spirit, Moonshine. From the collection of old stills, old posters and old photographs, there was something for everyone. By the time visitors reached the tasting bar, their emotions were so stoked they could hardly wait to make a purchase. Any time I consult to a craft distillery that is about to open, I am quick to remind them about the power and lure of history. If you are intent on building a small craft distillery, perhaps incorporate history into your marketing efforts. Search out old stills, photographs and posters from bygone eras. Make your distillery and your products a complete emotional experience for the customer. That emotional experience will give you a good chance at retaining that customer.

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3

Spirits Definitions

The products that distillers can and cannot make are tightly regulated by government. It is prudent to follow these definitions at all times. Getting caught deviating from them can have dire consequences for the future viability of your craft distillery business and can reflect poorly on the overall image of the craft distilling movement.

Canada

The following are the alcoholic spirit definitions in Canada as prescribed by the Consolidated Regulations of Canada, section 870 (CRC 870): (1)

Grain spirit: In Canada a craft distiller can make a mash of cereal grains (wheat, corn, rye, barley, oats etc.) and ferment that mash with yeast to produce alcohol. Distilling the alcohol from the fermented mash to a sufficiently high proof so that all or nearly all of the naturally occurring flavor substances have been removed will then allow a distiller to call the product a grain spirit.

A grain spirit will have a slight grainy profile on the palate and might not hold wide appeal with customers. Unfortunately, many craft distillers have not stopped to fully contemplate this. The desperate thought of generating quick cash flow by taking distillate fresh from the still, proofing it to 40% abv and trying to sell it has proven too alluring. If white distillate was so popular, the big commercial distillers would have been making it in mass quantity for many years now. The fact that they have not, suggests that it lacks wide appeal. One example of white spirit that I saw in 2016 was at a craft distillery in Alberta that was selling a product called WD-40. The bottle came with an oak stick attached to it. I guess the consumer was supposed to place the oak stick in the bottle and make the product turn brown. An un-sophisticated, gauche approach detrimental to the image of craft distilling.

Vodka: The strict definition of vodka up until 2019 stated it was a potable alcoholic spirit obtained by filtering a grain spirit or potato spirit through charcoal so as to render it without distinctive character, aroma or taste. In 2019, this definition was brought into alignment with that of the USA. Now a Canadian distiller can make vodka from practically any material.

To make vodka, a craft distiller will initially distill a fermented mash of raw material to produce a distillate (grain spirit). That distillate will then get re-distilled. Following the re-distillation, the distillate will either be exposed to granulated activated charcoal and then filtered through a plate filter, or run through a filter device equipped with charcoal impregnated cartridges.

Despite the words in this definition calling for no distinctive taste or aroma, many of the vodkas made by the large commercial distillers will still have some slight aroma or taste to them. In workshops, I have noted that participants can distinguish between the slight aromas and back-of-the-tongue finishes of Smirnoff Vodka, Grey Goose, and Absolut Vodka. These tastings tend to be a moment of enlightenment for many people. Vodka is something that is typically consumed in cocktails which cover up any of a vodka's subtle characteristics. Very few people have experience evaluating vodka at straight-up at room temperature. In these tastings, I take matters one step further. I dilute the vodka samples to 30% abv. I encourage you to try this technique at home, not only with vodka, but with any spirit you are evaluating. It is amazing how sampling a distilled alcohol straight-up, at room temperature, diluted to 30% abv strength will reveal its more subtle characteristics.

In my opinion, craft distillers should be making vodka while assuming the consumer will drink it straight, or at best with a splash of water. Making a vodka of mediocre quality that demands using it only in a mixed drink is a dangerous game that will likely see the consumer gravitate back to a big name commercial brand. In his book, A History of Vodka, referenced in the previous chapter, author William Pokhlebkin reminds us of the late 1800s period in Russian history when Pyotr Smirnov was producing his much-loved vodka. In those days, it was common practice to drink vodka straight-up at room temperature in small quantities while dining. In 2007, when my wife and I were in New York city, she took me to the Russian Tea Room on W 57th Street, next to Carnegie Hall. Although I did not fully appreciate it at the time, the various vodka samples I tried that evening while dining was exactly how vodka would have been enjoyed in Smirnov's day. Pokhlebkin stresses how lamentable it is that today when the consumer sees vodka, he or she instinctively reaches for something to mix with it. I believe with some encouragement and education, the consumer can be convinced to start enjoying vodka straight up, in small quantities much as one would enjoy a wee dram of single malt Scotch straight up. We don't have to go as far back as pre-Revolutionary Russia to see evidence of vodka being consumed un-mixed. In the James Bond movie, Dr. No., Bond can be seen adding ice to a glass and pouring himself a generous dram of vodka.

To further assist the consumer in learning to enjoy vodka straight up, a craft distiller may want to give thought to producing several different vodka recipes. Perhaps a lighter profile version with wheat, a spicier version with rye grain, and a sweet, creamy version with triticale grain.

To illustrate this point, I often blind sample a wheat based vodka next to barley-based Three Point Vodka made by Eau Claire Distilling in Turner Valley, Alberta. Without fail, people immediately recognize the difference between the two grains. The suggestion that a craft distiller ought to make a couple different vodka products then comes into clearer focus.

The definition of vodka makes a further reference to potato spirit. I am aware of only a few craft distilleries in Canada that are making spirits from potato. In Ontario, a former potato farmer who grew tired of selling potatoes to large food processors now has turned his farm into a distillery where he makes Beattie's Potato Vodka. This vodka is a delight to sip straight up. Potato vodka does not have to be made from the North American variety of potato used in food processing. High starch potato varietals from eastern Europe make amazing vodka. The Polish vodka called Spud, that I referenced in the previous chapter is made from a higher starch potato varietal. The silky texture on the tongue is divine.

Distillation of surplus wine to make vodka is something else to be considered. Prior to 2019, a distiller in Canada could not assign the name vodka to a distillate made from wine, because wine was obviously not a cereal grain or a potato. For example, prior to 2019 the Diageo-owned brand Ciroc sold in Canada as a 'Spirit Drink'. Dillons Distilling in Ontario, Canada called their Method 95 product a 'Liquor', even though one could always find it on liquor stores shelves in the vodka section. If you have never tried either of these products, I suggest doing so. The silky texture on the tongue, makes a wine-derived alcohol spirit a pleasure to sip straight up.

If you have spent any time at all in your local liquor store you have noticed the proliferation of flavored vodka courtesy of the big commercial distillers. The consumer is slowly catching on that these vodkas are chemically flavored. Many of these chemical flavors already legally appear in our food system. Adding the flavors post-distillation nicely side-steps the requirement for no distinctive taste or aroma in the vodka. With the consumer starting to lean more intently towards real food, can a shift towards real flavored spirits be far behind? In my opinion, the days of chemically flavored vodka are numbered. There is a huge opportunity for a craft distiller to flavor vodkas with all-natural fruit syrups, real fruit, cream emulsions or even natural flavor concentrates. One craft distiller that is having good success at natural infusion flavoring is Legend Distilling in Naramata, British Columbia. Their Honey/Rhubarb Vodka released for the 2015 season was excellent. The big hit in 2016 was their Naramata Sour Cherry Vodka. Their 2017 release was an orange-sumac creation called Manitou that was delicious. 2019 saw a Farm Berry creation. It need not even be fruit juices that provide the flavor. I have seen craft vodka with coffee beans in the bottle and even vanilla pods. Craft distillers should think creatively as to how they can set their vodka apart from plain, ordinary commercially distilled vodka.

To cite a few examples, a few years ago I was treated to a sample of vodka from Poland that had been aged ever so briefly on walnut wood. There was only a slight straw-yellow hue to the product, but the walnut taste sent my tastebuds into overdrive. Monashee Distilling in Revelstoke, British Columbia has taken flavor to new heights with its 23% alc./vol Mountain Creamer which is vodka flavored with organic cream, chocolate, caramel, almonds, vanilla, honey, maple syrup and locally roasted coffee.

Craft distillers should become acquainted with Canadian-based company FoodArom and its portfolio of nearly 9000 flavors. Many of these flavors are natural which means the starting point in extracting the flavors was the real ingredient. Many craft distilleries are now using these natural additions. A classic example is Equineox from Turner Valley, Alberta craft producer Eau Claire Distilling. This product is flavored with natural prickly pear cactus concentrate. Truly a masterpiece to sip slowly over ice on a hot day. Keep it real, keep it natural, make it different, and the consumer will take notice.

Whisky: Whisky is an alcoholic distillate or mix of such distillates made from cereal grain. The distillate is allowed to contain caramel and flavoring. This definition contains no reference to barrel ageing. This verbiage collides with the definition of grain spirit. A craft distiller could, in theory, make a distillate from a grain(s) of his or her choice and sell the distillate un-aged to the consumer at a suitable alcoholic strength under the grain spirit definition. Regulatory authorities are trying to eliminate the incongruence across these definitions. For example, a craft distiller trying to call a clear distillate product by the name Whisky will now incite an argument from government officials.

In my view, this is a good thing. Whisky has been around for over 500 years. It is a beautiful thing. It is an art. Trying to bottle clear distillate coming off a still and insinuate that it is whisky does little to bolster the image of craft distilling

However, regulators must go further. Consider White Owl Whisky from Century Distillers in Calgary, Alberta. This product is almost ubiquitous in Canadian liquor stores. While a large operator like Century Distillers can release a white product called Whisky, a craft distiller aiming to release a similar type product will encounter opposition from authorities. The playing field must be levelled.

Malt Whisky: Take the above definition of whisky and alter it slightly to read that malted grain must be used and Malt Whisky comes into focus. The definition tightens up matters further with the requirement that Malt Whisky must have the taste and character generally attributed to a Malt Whisky.

But, this definition, just like the definition for Whisky, contains no age requirement. This is where craft distillers need to pause for some careful thought. Even though the definition makes no reference to age, this does not mean that shortcuts should be taken.

I have seen craft distillers use malted grains to make distillate and then cleverly expose the distillate to oak chips for a few weeks to infuse some oaky notes and brown color into the product. At bottling time, some of these distillers have furnished each bottle with a tiny piece of French oak barrel stave to provide more pickup of oaky flavor as the bottles sit on a customer’s liquor cabinet shelf. In many cases the consumer is being offered insinuations that the product was aged in oak casks for a period of time. This kind of snake-oil-salesman deception has no room in craft distilling. The next time you see a bottle of Malt Whisky at a craft distillery, ask some tough questions and see what answers you get. There is an entire science behind ageing distillate in oak. This is a science to be embraced, not side-stepped.

Canadian Whisky, Canadian Rye Whisky, Rye Whisky: Produce a whisky or a malt whisky as per the previously stated definitions. Barrel age that whisky or malt whisky in small wood (a wood container less than 700 liters in volume) for a minimum of three years. This will allow a distiller to call the resulting product a Canadian Whisky, a Canadian Rye Whisky, or a Rye Whisky.

The definition further stipulates that the product must be mashed, distilled and aged in Canada. The bottling strength must not be less than 40 % alcohol by volume. Caramel coloring may be added as can flavor preparations. As far as the ageing period is concerned, three years is the minimum, so a distiller could age it for longer. It is critical to note that this three-year period was originally created in the late 1800s to give the large distillers of the day an advantage over smaller operators who could not afford to sit on inventory for any length of time. I have had craft distillers adamantly tell me that a Canadian Whisky can be made in three years. No it cannot. As you will learn later in this book, there are a myriad of complex reactions that take place in an oak barrel. It takes time to create a whisky. In the cooler climate of Scotland I have seen 10-year-old product for sale. In the warmer climate of North America, I maintain that it will take perhaps seven or eight years to properly barrel age a whisky.

The definition further states that no person shall make any statement concerning the age of a Canadian Whisky other than for the period during which the whisky has been held in small wood. I find these definitions very loosely worded and amenable to abuse. In 2017, I saw a product called

Century 21 Reserve in my local liquor store. At first glance, this appeared to be a 21-year-old Canadian Whisky. But when I looked at the price tag, some suspicion entered my mind. The price tag at around $38 per bottle was too low for something 21 years old. The high prices for 21-year-old Scotches confirmed my suspicions. What likely happened in this case is the company had some 21-year-old product in inventory. They likely blended this older whisky with a much younger, cheaper distillate. The attendant color was then tweaked by the addition of some caramel coloring. So, there are no lies here. There is 21 year old product in the bottle, just not all of the product is 21 years old.

To add to the complexity, there is an archaic bit of wording in Canadian law that allows distillers to add up to 9.09% by volume of other 'stuff' to whisky to presumably soften any harshness on the palate. What this 'stuff' is, remains an industry secret. I suspect it is a mix of white wine and brandy. And, there is nothing in Canadian definitions concerning the amount of rye grain that must be used in a Rye Whisky. A distiller could make a distillate from wheat and add only a tiny amount of rye distillate and call the resulting product Canadian Rye Whisky. Such seems to be the case with Highwood Distillers Canadian Rye Whisky which is made primarily from wheat. I maintain it is high time for a review of these decades-old definitions. The confusion must be cleared up.

I encourage people interested in launching a craft distillery to critically evaluate whisky from around the world. Gather data on the raw materials used, the types of stills used, and the ageing parameters used. Explore 10, 12, and 15 year old single malt whisky products from Scotland. Explore aged expressions from Ireland. Sample the various blended products from these areas. Explore some of the expressions from small companies like Broger and Telser in Germany and Austria. Find some of the expressions coming from Iceland, and the Scandinavian countries. Don't forget about Taiwan, Australia, and now even Israel. The craft distilling movement has a unique, time sensitive opportunity to make a positive mark on whisky in Canada. This opportunity should not be allowed to pass by unexploited.

As a craft distiller, do not be afraid to blend different distillates. You do not have to necessarily make up a complex mash recipe comprising a litany of grains. You can distill batches of fermented mash made from individual grains and then blend those distillates. You will likely find a blended product will be well received by the consumer's palate. After all, that palate has been unknowingly sipping blended distillates for decades now. A complex example of blending is that of Crown Royal which is made by Diageo in Gimli, Manitoba. There are reportedly dozens of different distillates (different ages and different raw materials) that are blended together to create Crown Royal. Another financial success story that involves blending is the brand 40 Creek Whisky. This brand pioneered by John Hall is based on corn, rye and barley. In 2015, Italian company Gruppo Campari paid a reported $182 million to acquire the 40 Creek brand.

As an example of what can be possible with blending, I have explored the making of gluten-free whisky. I prepared corn distillate, oat distillate and buckwheat distillate. These grains are all gluten free. I then blended various small quantities of these distillates. I found that the blends with a high proportion of buckwheat distillate had the best flavor.

Flavored Whisky: Some time ago, the large commercial distillers approached the government regulators seeking a way to shave time off the three-year ageing regimen. The concession that was granted stated that a Canadian Whisky can be given a flavoring preparation and then aged for only two years. Now you know why Crown Royal Maple Whisky and Crown Royal Apple Whisky were created. One year less of ageing means cash flow one year sooner. But, the natural flavoring argument rears its head again. Do these Crown Royal expressions contain natural maple syrup or natural apple juices? Try some the next time you are at your favorite bar and decide for yourself. For craft distillers wishing to incorporate flavor into their whisky products, the

sky is the limit thanks to vendors such as FoodArom. Keep it real, keep it natural and get creative. Whisky magazines that I read are now mentioning coffee-whisky products.

This discussion of definitions next leads into non-standard definitions. What if a person wanted to create a moonshine? Nowhere in the CRC 870 verbiage is there mention of moonshine. Such a product is regarded as a non-standard offering.

Somewhere on the label a distiller will have to state the ingredients used in making the product. To avoid entanglement with the ageing requirements, a distiller would be wise to include in small print on the label the words 'Grain Spirit' or 'Spirit Drink'.

Adding flavoring to a non-standard product is also a possibility to consider. A 2017 craft start-up in Sicamous, British Columbia is offering a full suite of flavored moonshine products. After Dark Distillery is using natural flavors to create corn-based moonshine. The product that has received top reviews at the 5-day workshops is the Apple Pie Moonshine. Instead of buying flavor preparations, consider the idea of going totally natural like the team did at Tumbleweed Spirits in Osoyoos, British Columbia. Their Fireweed product relies on real cinnamon and real chili peppers. This product easily surpasses the chemically flavored FireBall Whisky from commercial operator Sazerac Company.

Rum: In Canada the definition for rum states that product must be made from sugar cane, or sugar cane products. Sugar cane products are generally accepted to mean molasses. Molasses is the remaining sludge from the sugar extraction process. Sugar cane products do not encompass table sugar or brown sugar.

The rum definition goes on to state that rum must be aged for one year minimum in small wood. If ageing in wood is required, and if wood ageing imparts some coloration to the distillate, how then do the large distillers make white rum? The answer is by legal bobbing and weaving. Captain Morgan Rum is made in the US Virgin Islands. Bacardi is made in Puerto Rico. There is no ageing requirement for rum made in the USA or associated territories. Lamb's Rum is made in the U.K., where there is no ageing requirement. These products are imported into Canada and bottled, thus sidestepping the ageing requirement.

Another question that arises is, can one make rum from sugar beet molasses sourced from the Roger's Sugar factory in Taber, Alberta? Unfortunately, because the sugar factory in Taber, Alberta extracts sugar from sugar beets (and not sugar cane), the use of their molasses will place a distiller at odds with the CRC 870 rum definition. Rum made from sugar beet molasses would have to be called a 'Rum Flavored Spirit Beverage' or something similar in order to remain compliant with the CRC 870 definitions. There is one craft distiller that I am aware of that uses the sugar beet molasses product from Taber, Alberta. The flavor in their product is lacking because sugar beet is a far different material than sugar cane. Sugar beet molasses comprises mostly sucrose and not the more complex sugars and complex organic acids found in sugar cane. I do not encourage craft distillers to go down the sugar beet road.

If you are looking for an example of a very good craft distilled rum made from sugar cane molasses, try to find Leatherback Rum from North of 7 Distilling in Ottawa, Ontario. The darker color and slight smoky notes derived from barrel ageing in charred oak make this rum a divine inspiration. Ask yourself, how hard was it for the North of 7 Distilling crew to make rum from molasses and give it time in charred oak barrels? The answer is, not very hard. The point is, they took the time to get innovative and displayed patience as the product aged. The end result is winning them accolades. This is what craft distilling is meant to be.

As a craft distiller, you can help the image of the entire craft movement by doing your level best to follow the CRC 870 definitions. An example of a distiller that is flaunting the definitions is Wayward Distillation House in Courtenay, British Columbia. On their website they explicitly state: Traditionally, Rum is made from sugarcane byproduct, usually molasses. Never one for tradition, Wayward's Drunken Hive is crafted from molasses made from caramelized BC honey instead. Although Wayward may be deriving some weird satisfaction from thumbing their nose at the CRC 870 definitions, such actions hurt the image of the craft movement.

Gin: In Canada, the definition of a gin states that one must start with alcohol from food sources. This means alcohol distilled from grains, potatoes, grapes or fruit. To that alcohol, a distiller will add juniper berries and then re-distill the alcohol. There are jurisdictions in the world that simply allow botanicals to be soaked in alcohol to create a gin. In Canada, the definitions clearly state the alcohol must be re-distilled.

Juniper is the only mandated botanical additive in gin. A distiller can add a wide range of other botanicals, a sweetening agent or even flavoring preparations to create unique flavor profiles. I have seen craft distillers add up to a dozen different botanicals to their gins. If no sweetening agent has been added, the gin maker has the privilege of calling the product London Dry Gin. Most craft distillers will however opt to just call their product gin. London Dry Gin seems to be something best suited for those classic gins from the U.K. including Gordon’s, Bombay Sapphire, and Tanqueray.

One evolution in craft-made gin is that of barrel resting. Craft distillers are obtaining ex-sherry casks, ex-port casks and ex-cognac casks. They are resting their gins in these casks for various lengths of time and then bottling. Some of the end results I have tasted are truly exceptional. In your travels in the US, if you ever come across barrel rested Port Cask Reserve Gin from Golden Moon Distilling in Golden, Colorado prepare to be impressed. In 2015, I met Golden Moon's proprietor Stephen Gould at a distilling trade show in London where he was offering samples of his Port Cask Rested Gin. As I sipped a small sample, I am sure I could hear choirs of angels singing. However, take note that wood can be a cruel mistress. I am aware of one Saskatchewan-based craft distiller that has a barrel rested gin product on the market. The hand-written verbiage on the back label says the gin spent 6 months in new oak. I routinely offer this product in workshops and without fail the response is that it tastes too woody. Perhaps this product would have been better served by ageing it in a used oak cask for a shorter time.

Another evolutionary twist gaining traction is infused gin. To experiment with this technique, take any gin, add loose-leaf Earl Grey tea and let the mix steep for 3 days. Filter the gin through a coffee filter to remove the tea leaves and then add a small amount of honey or simple syrup to sweeten the infused gin. This style of gin was all the rage in England 100 years ago. (2) Another variant that was all the rage years ago was Rhubarb Gin. Take gin and pour it into a glass jar. Add rhubarb plus sugar and let steep for 3 days. Filter through a coffee filter and return the gin to its original bottle. The tartness of the rhubarb has been brought to heel by the sugar and the gin botanicals are still evident in the background.

Yet another twist that I hope will make its way to North America is the concept of a gin liqueur. Take gin distillate at 60% abv strength. Dilute it down to 30% abv strength by adding a mixture of sweetener and fruit syrup flavoring. The only variable you need to pin down is the ratio of sweetener to fruit flavoring. In my travels to Edinburgh for school, I came to enjoy both the Raspberry and the Rhubarb Ginger expressions of gin liqueur offered by Edinburgh Gin.

Think of gin as a blank artistic canvas. As a craft distiller, you can use your paint brush and create a masterpiece. My experiences have shown that lavender can impart a delicious taste profile to gin. Grapefruit peel is also another of my favorites. As an extension of the standard 5-day workshop, I also offer a 1-day Gin Master Class in which participants devise botanical recipes and then distill those botanicals with alcohol on a small al-Ambic still. Participants have discovered that additives such as apple, grapefruit, hibiscus flower and even black cardamom can add unique twists to the taste of a gin. The sky is the limit. As a craft distiller, think outside the box. Think creatively.

To experience what a multitude of botanicals can do for a gin, try to find the German product Monkey 47. If you spot some, don’t flinch at the price. Just dig deep into your wallet and make the purchase. It is indeed made with 47 different botanicals. As for the Monkey part of the name, I will leave it to you to research the quirky story behind that one.

To experience what the addition of an unusual botanical can do for Gin, consider Aviation Gin, the American success story associated with actor Ryan Reynolds. The unusual ingredient subtly present in this gin makes my taste buds jump for joy. The unusual ingredient is sasparilla root, from whence root beer derives its flavor. Perhaps the reason this gin appeals to me is I drank a lot of root beer as a kid.

Canadian Brandy: In Canada, if one obtains grapes and ferments them in Canada and subsequently distills the resulting wine, the distillate can be termed a Canadian Brandy. There is no requirement as to where the

grapes must come from. They just have to be fermented in Canada. Brandy is not a big seller, probably because the handful of commercial distillers that make the stuff have never aggressively marketed the product. The definition goes on to stipulate that one can add fruit, botanicals and flavor preparations to brandy. In Canada, a brandy must be aged 6 months in small wood (casks less than 700 Liters) or 12 months in wood (meaning casks greater than 700 Liters).

My small scale research has demonstrated that brandy, after ageing in oak, can be given a further unique twist by macerating grapefruit peel and orange peel in it and then adding honey for a bit of sweetness. This variation, called Forbidden Fruit Brandy, was hugely popular in England over 100 years ago. (1) I have had similar successes with the maceration of mandarin orange pieces in the brandy.

As a craft distiller, think outside the box and come at the consumer with a brandy they have never seen before and you might be surprised at what happens.

Dried Fruit Brandy: take the above definition for brandy and adjust it so that a distillate is produced from a fermented mash of dried fruit and you have the basis for a dried fruit brandy.

Fruit Brandy: take fruit wine or a mixture of fruit wines and distill. Alternatively, take a mash of sound, ripe fruit (other than grapes) or a mixture of such fruits. Ferment the mash and then distill. The resulting product can be called Fruit Brandy. Caramel color, botanicals and flavoring preparations may be added under this definition. If the product has been made from 100% of a given fruit, then the name of that fruit can appear in the product title. In early 2021, I was contacted

by a group interested in starting a craft distillery to make Schnapps. After much discussion, they came to the realization that there is no type of beverage alcohol called Schnapps. This German expression is akin to a Scotsman or Irishman asking for a dram. Technically, a fruit brandy would envelope the concept of Schnapps.

Grappa: when a wine maker presses grapes, the remaining mass of skins and seeds is termed pomace. Take pomace, rehydrate with water and add yeast to ferment whatever remaining bits of fermentable sugars are in the pomace. Distill the resulting product and the resulting distillate is Grappa.

There is one hitch, however. The name Grappa is firmly trade protected by Italy. In Canada, thanks to concessions made in recent trade agreement negotiations with the European Union, the name Grappa cannot be used in the product name at all. If contemplating making a grappa, please consult with authorities to get clarification on the naming protocol. Typically not a big seller in all parts of Canada, grappa is something that a craft distiller might want to offer seasonally in limited quantities. The key will be having the relationship with a winemaker so as to get the pomace in a timely fashion.

Liqueur: take alcohol from food sources and mix it, infuse it or macerate it with fruits, flowers, leaves or botanicals. Alternatively, take alcohol from food sources and re-distill it with fruits, flowers, leaves or botanicals. To complete the process, add a minimum of 2.5% sweetener and ensure that the end product contains not less than 23% alcohol by volume. Most liqueurs on liquor store shelves will be in the 25 to 30% abv range.

One efficient way of producing a liqueur is to take alcohol, mix it with fruit syrup concentrates and liquid invert sugar. Fruit syrups are readily obtainable from a vendor called Pacific Fruit Concentrates. Drums of liquid invert sugar are sold by any of the sugar makers that supply the baking industry. An invert sugar, by the way, is a sugar that has been heated and exposed to acid to hydrolyze the sucrose molecules and to kill off any bacteria. A liquid invert sugar will stay as a liquid in its container and will not harden up and crystalize over time.

A style of liqueur that is gaining popularity in Canada is Amaro. Think bitter oranges, rhubarb, grapefruit peel, cinchona bark (the stuff that gives tonic water its flavor) and other herbs macerated in alcohol with a sweetener added and you will have an Amaro style of liqueur. In 2018, I had a liquor distributor in western Canada tell me that their wish was for more craft distillers to start making Amaro to help keep up with surging demand. A craft distillery in North Vancouver, The Woods Spirit Company, is turning heads with its Amaro-type products made using rhubarb, gentian, wormwood, bitter orange, grapefruit and fir tree needles.

Another product that nicely fits this liqueur definition is Amaretto. Think apricot pits and dried apricots macerated in alcohol for a time and then that alcohol sweetened. Sons of Vancouver Distillery in North Vancouver, British Columbia is turning heads with its portfolio of Amaretto-type expressions that have been variously barrel aged in ex-rye barrels and ex-bourbon barrels.

Vermouth: Take alcohol from food sources, add botanicals, aromatics or flavoring preparations. Add white wine and ensure that the alcoholic strength is no higher than 20%. This is the definition of a vermouth. When a consumer sees the word vermouth, he or she no doubt instinctively thinks of the commercial stuff that one adds to martinis. Perish the thought. A craft-made vermouth is another of those blank

artistic canvasses where the distiller is the artist making a masterpiece. For an example of a brilliantly crafted vermouth, Odd Society Spirits in Vancouver, British Columbia makes Bittersweet Vermouth that quite frankly makes my knees weak – it is just that deliciously good. A splash of their vermouth over ice is a libation I could sip all day long, in considerable quantity.

Restrictions: There are many product names that we cannot use in Canada. As noted above, naming a spirit just as Grappa is in violation of trade agreements with Italy. Grappa di Ticino is a name protected by Switzerland. The names Jagertee and Jagatee are protected by Austria. Spirits named Korn and Kornbrand are protected by the Germans and Austrians. The name Ouzo is protected by Greece. Pacharan is a name protected by Spain. Scotch and Scotch Whisky are the sole domain of Scotland. Irish Whiskey is likewise sole domain of Ireland. Brandies by the names Armagnac and Cognac are the property of France only. Bourbon and Bourbon Whisky are names closely protected by the United States. I have seen Canadian craft distillers making products named Urban Burban and BRBN. I suggest these operators ought to be more careful. Similarly, Tennessee Whisky is the domain of the State of Tennessee. Tequila is to be made in Mexico and even then only in a certain part of Mexico. Mezcal is also protected by the Mexicans. Caribbean Rum can only be sold under that name if it is fermented and distilled from cane sugar in a Commonwealth Caribbean country. But, in a bizarre twist, a Canadian distiller can import rum in bulk quantity from a Commonwealth Caribbean nation and blend it with other rum and sell it as Caribbean Rum. The Caribbean Commonwealth nations are Anguilla, Antigua, Barbados, Bahamas, Belize, Bermuda, British Virgin Islands, Cayman Islands, Dominica, Grenada, Guyana, Jamaica, Montserrat, St. Kitts and Nevis, Saint Lucia, St. Vincent and the Grenadines, Trinidad and Tobago, and Turks and Caicos.

The US

The following are the alcohol definitions as laid down by the United States Alcohol and Tobacco Tax and Trade Bureau (TTB). (3)(4)

American spirits definitions are tightly structured. Unlike Canada, these definitions leave no ambiguity in the mind of the reader.

Grain Spirit/Neutral Spirit: In the US, a craft distiller can make neutral spirits and grain spirits. Grain spirits are made from a mash of cereal grains and distilled to 95% alcohol or above (190 proof). Neutral spirits are made from any material (ie. grains, sorghum, wine, fruit) and are distilled to 95% alcohol or above (190 proof). If bottled, these spirits must have a minimum of 40% alcohol (80 proof).

Vodka: In the US, vodka is defined as grain spirit or neutral spirit filtered through charcoal so as to be without distinctive character, aroma, taste or color.

Whisky: In the US, a whisky is defined as an alcoholic spirit made from a fermented mash of grain and distilled to less than 95% alcohol by volume (190 proof) having the taste, aroma and characteristics generally attributed to whisky, and bottled at not less than 40% alcohol by volume (80 proof). If a distiller wanted to just make a non-descript product that lacked complexity, this is the definition that would be

used. But, a craft distiller most certainly would aim for a higher standard. Under this basic whisky definition are several sub-categories:

Bourbon Whisky: Whisky produced in the U.S., at a distilled strength not exceeding 80% alcohol by volume (160 proof), from a fermented mash of not less than 51% corn and stored at not more than 62.5 % alcohol by volume (125 proof) in charred, new oak containers.

Rye Whisky: In the bourbon definition, replace the word corn with the word rye.

Wheat Whisky: In the bourbon definition, replace the word corn with the word wheat.

Malt Whisky: In the bourbon definition, replace the word corn with the expression malted barley.

Rye Malt Whisky: In the bourbon definition, replace corn with the expression malted rye.

Corn Whisky: Is similar to the definition of bourbon, except that a corn whisky must not be exposed to ageing in a charred wood container. New oak and used oak containers can be used so long as they have not been charred.

Straight Whiskies: In the TTB definitions, special treatment is afforded to whiskies that have been aged for a minimum prescribed time.

Straight Bourbon Whisky: A bourbon whisky as per the above definitions that has been aged for two or more years.

Straight Rye Whisky: A rye whisky aged for two or more years.

Straight Wheat Whisky: A wheat whisky aged for two or more years.

Straight Malt Whisky: A malt whisky aged for two or more years.

Straight Rye Malt Whisky: A rye malt whisky aged for two or more years.

Straight Corn Whisky: A corn whisky as per the above definition aged for two or more years.

Straight Whisky: TTB definitions allow for a Straight Whisky which is a whisky containing not more than 51% of any one type of grain.

For the above listed products (except corn products) an age statement is required if the ageing period has been less than four years. Ageing periods greater than four years do not require a statement on the label, but some distillers choose to add an age statement regardless.

For the above listed products (except corn products) the statement “Bottled in Bond” shall reflect a product aged a minimum of four years, made by a single distiller in a single season and bottled at 50% alcohol (100 proof).

Blended Whisky: A minimum of 20% by volume Straight Whisky mixed with any other whisky or with grain spirit/neutral spirit.

Blended Bourbon Whisky: A blend containing not less than 51% Straight Bourbon Whisky.

Blended Rye Whisky: A blend containing not less than 51% Straight Rye Whisky.

Blended Wheat Whisky: A blend containing not less than 51% Straight Wheat Whisky.

Blended Malt Whisky: A blend containing not less than 51% Straight Malt Whisky.

Blended Rye Malt Whisky: A blend containing not less than 51% Straight Malt Whisky.

Blended Corn Whisky: A blend containing not less than 51% Straight Corn Whisky.

For the above listed blended products (except the blended Corn Whisky), age statements must reflect the youngest component of the blend.

The Moonshine and White Dog Question: If whisky is to be stored in oak containers, how then is it possible for distilleries to make white spirit at less than 190 proof? The answer rests with the executives at Jim Beam. When launching their Ghost White Whisky several years back, they exercised some apparent sway over the TTB officials. The TTB is now allowing white whisky products, but in the label approval process do not be shocked if asked to revise your label to place the word 'White' on a separate line from the word 'Whisky'. Jack Daniels deftly dodges all controversy by calling their Unaged Tennessee Whisky a Neutral Spirit. Similarly, a moonshine can be a white whisky or it could even be a grain spirit distilled to 190 proof or higher.

Other Grains: What if a distiller did not wish to use the standard grains of corn, wheat, rye or barley? For example, Corsair Distilling produces an oat whisky and a quinoa whisky. Dry Fly Distilling produces a triticale whisky. Deviation from using the standard grains points back to the umbrella definition of whisky as being an alcoholic spirit distilled from a fermented mash of grain at less than 95% alcohol by volume (190 proof) having the taste, aroma and characteristics generally attributed to whisky. Use of non-grains will incur a discussion with the TTB. For example, quinoa is often termed a superfood and it is rarely thought of as a grain. Buckwheat is biologically a fruit and not a grain at all. In these cases, the TTB could insist that your mash bill

recipe have a goodly amount of one of the standard grains corn, wheat, rye or barley.

Gin: In the US, gin is defined as an alcoholic spirit with a main characteristic flavor derived from juniper berries and produced by distillation or mixing of spirits with juniper berries and other aromatics or extracts derived from these materials and bottled at not less than 40% alcohol by volume (80 proof).

Under this umbrella definition are some sub-categories.

Distilled Gin: A spirit made by distilling a mash with or over juniper berries and other aromatics or their extracts, essences or flavors.

Re-distilled Gin: A gin produced by re-distillation of distilled spirits with or over juniper berries and other aromatics or their extracts, essences or flavors.

Compounded Gin: A gin produced by mixing neutral spirits with juniper berries and other aromatics or their extracts, essences or flavors.

Brandy: In America, a brandy is defined as a spirit distilled from the fermented juice, mash or wine of fruit or from its residue to less than 95% alcohol by volume (190 proof) having the taste, aroma and characteristics generally attributed to brandy and bottled at not less than 40% alcohol by volume (80 proof). Brandy aged for less than two

years must bear an age statement to that effect. Under this definition are some sub-categories.

Fruit Brandy: Brandy distilled solely from the fermented juice or mash of whole, sound, ripe fruit. Pomace (not more than 20% by weight) or spent yeast lees (not more than 30% by volume) may be added to the material being distilled.

AppleJack: A brandy made from apples.

Kirchwasser: A brandy made from cherries.

Slivovitz: A brandy made from plums.

Dried Fruit Brandy: A brandy distilled from sound, dried fruit. The name of the product must contain the name of the fruit (ie dried apricot brandy)

Pomace or Marc Brandy: A brandy distilled from the skin and pulp of sound, ripe grapes after the withdrawal of the juice. If fruit other than grapes is used, the name of that fruit must be reflected in the name of the product (ie. apple pomace brandy).

Rum: In the US, rum is a spirit distilled from the fermented juice of sugar cane, sugar cane syrup, sugar cane molasses or other sugar cane

by-products to less than 95% alcohol by volume (190 proof) having the taste, aroma and characteristics generally attributed to rum and bottled at not less than 40% alcohol by volume (80 proof). An age statement is not required on rum.

Liqueur: in the US, a liqueur is a flavored spirit product containing not less than 2½% by weight of sugar, dextrose, levulose or a combination thereof made by mixing or redistilling any class or type of spirits with or over fruits, flowers, plants or pure juices therefrom or other natural flavoring materials or with extracts derived from infusions, percolation or maceration of such materials. Under this umbrella definition, there are a few noteworthy sub-categories.

Rye Liqueur: A liqueur made with not less than 51% Rye Whisky, Straight Rye Whisky, or Whisky distilled from rye mash bottled at not less than 30% alcohol by volume (60 proof).

Bourbon Liqueur: A liqueur produced in the U.S. with the predominant characteristic flavor of Bourbon Whiskey made with not less than 51% Bourbon Whisky, or Straight Bourbon Whisky, and bottled at not less than 30% alcohol by volume (60 proof).

Gin Liqueur: A liqueur with the predominant characteristic flavor of gin made with gin as the exclusive distilled spirits base, bottled at not less than 30% alcohol by volume (60 proof).

Brandy Liqueur: A liqueur with the predominant characteristic flavor of brandy made with brandy as the exclusive distilled spirits base,

bottled at not less than 30% alcohol by volume (60 proof).

European Union

The following is a brief look at the spirits definitions as laid down by the European Parliament. Until such time as Brexit is completed, these definitions will apply to a craft distiller seeking to operate in the United Kingdom. Regulation (EC) No 110/2008 contains the definition, description, presentation, labelling and the protection of geographical indications of spirit drinks. (5)(6)

The ethyl alcohol used in the production of spirit drinks and all of their components shall be of agricultural origin.

Ethyl alcohol of agricultural origin: Ethyl alcohol of agricultural origin possesses the following properties:

no detectable taste other than that of the raw material;

minimum alcoholic strength by volume: 96.0%;

maximum level of residues:

total acidity, 1.5 grams of acetic acid per hL of 100% vol. alcohol esters - 1.3 grams of ethyl acetate per hL of 100% vol. alcohol

aldehydes – 0.5 grams of acetaldehyde per hL of 100% vol. alcohol

higher alcohols – 0.5 grams of methyl-2 propanol-1 per hL of 100% vol. alcohol

methanol – 30 grams per hL of 100% vol. alcohol,

dry extract – 1.5 grams per hL of 100% vol. alcohol,

volatile bases - 0.1 grams of nitrogen per hL of 100% vol. alcohol

furfural: not detectable.

This tight definition explains why so many gin craft distillers starting up in the U.K. are purchasing NGS (neutral grain alcohol) rather than attempting to make their own alcohol to 96%.

Sweetening: Sweetening means using one or more of the following products in the preparation of spirit drinks:

semi-white sugar, white sugar, extra-white sugar, dextrose, fructose, glucose syrup, sugar solution, invert sugar solution, or invert sugar syrup;

rectified concentrated grape must, concentrated grape must, fresh grape must;

burned sugar, obtained exclusively from the controlled heating of sucrose without bases, mineral acids or other chemical additives;

honey as defined in Council Directive 2001/110/EC of 20 December 2001 relating to honey;

carob syrup;

any other natural carbohydrate substances having a similar effect to those products.

Rum: In the E.U., rum is a spirit drink produced exclusively by alcoholic fermentation and distillation, either from molasses or syrup produced in the manufacture of cane sugar or from sugar-cane juice itself and distilled to less than 96% vol. so that the distillate has the

discernible specific organoleptic characteristics of rum, or a spirit drink produced exclusively by alcoholic fermentation and distillation of sugar-cane juice which has the aromatic characteristics specific to rum and a volatile substances content equal to or exceeding 225 grams per hL of 100% vol. alcohol.

Rum shall not be flavored and the minimum alcoholic strength of rum shall be 37.5%. Only caramel color may be added to rum to adjust color.

Whisky: In the E.U., a whisky takes on a definition similar to that of Canada. Whisky is an alcoholic distillate made from a mash of grain. It shall be subject to one or more distillations so that the distillate has an aroma and taste derived from the raw materials used. The final distillate shall be aged in wooden casks not exceeding 700 liters in size for three years. The minimum alcoholic strength shall be 40%. Whisky shall not be sweetened or flavored. Only E150a caramel coloring may be added for color adjustment.

Grain Spirit: In the E.U., a grain spirit is an alcoholic distillate made from a mash of cereal grains and having organoleptic characteristics derived from the raw materials used. The minimum alcoholic strength shall be 35%. The distillate may not be flavored. Only caramel may be added for color adjustment.

Wine Spirit: In the E.U., wine spirit can be produced exclusively by the distillation of wine to less than 86% alc/vol. The volatile substances in a wine spirit shall be equal to or exceeding 125 grams per hL of 100% vol. alcohol. The maximum methanol content is 200 grams per hL of 100% vol. alcohol. The minimum alcoholic strength of a wine spirit

shall be 37.5%. No flavoring may be added except caramel for color adjustment.

Brandy: In the E.U., brandy shall be produced from wine spirit, distilled to less than 94.8% vol., provided that that distillate does not exceed a maximum of 50% of the alcoholic content of the finished product. Brandy shall be matured for at least one year in oak receptacles or for at least six months in oak casks with a capacity of less than 1,000 litres. The minimum alcoholic strength shall be 36%. The volatile substances in a wine spirit shall be equal to or exceeding 125 grams per hL of 100% vol. alcohol. The maximum methanol content of 200 grams per hL of 100% vol. alcohol. No flavoring may be added except caramel for color adjustment.

Grape Marc Spirit: in the E.U., grape marc spirit is produced exclusively from grape marc fermented and distilled either directly by water vapor or after water has been added. A quantity of lees may be added to the grape marc that does not exceed 25 kg of lees per 100 kg of grape marc used. The quantity of alcohol derived from the lees shall not exceed 35% of the total quantity of alcohol in the finished product. The distillation shall be carried out in the presence of the marc itself at less than 86 % vol. alcohol. Re-distillation at the same alcoholic strength is authorized. Marc contains a quantity of volatile substances equal to or exceeding 140 grams per hL of 100% vol. alcohol and has a maximum methanol content of 1,000 grams per hL of 100% vol. alcohol.

The minimum alcoholic strength by volume of grape marc spirit or grape marc shall be 37.5%. No addition fortification with alcohol shall take place. Grape marc spirit or grape marc shall not be flavored. This shall not exclude traditional production methods. Grape marc spirit or grape marc may only contain added caramel as a means to adapt color.

Fruit Marc Spirit: in the E.U., a fruit marc spirit is obtained exclusively by fermentation and distillation at less than 86% vol. of fruit marc except grape marc contains a minimum quantity of volatile substances of 200 grams per hL of 100% vol. alcohol; the maximum methanol content shall be 1,500 grams per hL of 100% vol. alcohol; the maximum hydrocyanic acid content shall be 7 grams per hL of 100% vol. alcohol in the case of stone-fruit marc spirit. The minimum alcoholic strength shall be 37.5%. No flavoring shall be added. Caramel can be added to adjust color.

Fruit spirit: In the E.U., a fruit spirit is a spirit drink produced exclusively by the alcoholic fermentation and distillation of fleshy fruit or must of such fruit, berries or vegetables, with or without stones, distilled at less than 86% vol. so that the distillate has an aroma and taste derived from the raw materials distilled, having a quantity of volatile substances equal to or exceeding 200 grams per hL of 100% vol. alcohol, in the case of stone-fruit spirits, having a hydrocyanic acid content not exceeding 7 grams per hL of 100% vol. alcohol.

The maximum methanol content of fruit spirit shall be 1,000 grams per hL of 100% vol. alcohol. However for the following fruit spirits the maximum methanol content shall be:

1,200 grams per hL of 100% vol. alcohol obtained from the following fruits or berries: plum, quetsch, apple, pear, raspberries, blackberries, apricots, peaches.

1,350 grams per hL of 100% vol. alcohol obtained from the following fruits or berries: Williams pears, redcurrants, blackcurrants, rowanberries, elderberries, quinces, juniper berries.

The minimum alcoholic strength by volume of fruit spirit shall be 37.5%. No addition of alcohol as defined in Annex I(5), diluted or not, shall take place. Fruit spirit shall not be flavored.

Vodka: In the E.U., vodka is a spirit drink produced from ethyl alcohol of agricultural origin obtained following fermentation with yeast from either:

potatoes and/or cereals, or

other agricultural raw materials, distilled and/or rectified so that the organoleptic characteristics of the raw materials used and by-products formed in fermentation are selectively reduced.

This process may be followed by re-distillation and/or treatment with appropriate processing aids, including treatment with activated charcoal, to give it special organoleptic characteristics. Maximum levels of residue for ethyl alcohol of agricultural origin shall meet those laid down in Annex I, except that the methanol content shall not exceed 10 grams per hL of 100% vol. alcohol.

Flavored Vodka: flavored vodka is vodka which has been given a predominant flavor other than that of the raw materials. The minimum alcoholic strength by volume of flavored vodka shall be 37.5%. Flavored vodka may be sweetened, blended, flavored, matured or colored. Flavored vodka may also be sold under the name of any predominant flavor with the word 'Vodka'.

Gin: in the E.U., gin, is a juniper-flavored spirit drink produced by flavoring ethyl alcohol of agricultural origin with juniper berries (Juniperus communis). The minimum alcoholic strength by volume of Gin shall be 37.5%. Only natural and/or nature-identical flavoring substances shall be used for the production of Gin so that the taste is predominantly that of juniper.

Distilled Gin: a juniper-flavored spirit drink produced exclusively by re-distilling ethyl alcohol of agricultural origin of an appropriate quality with an initial alcoholic strength of at least 96% vol. in stills traditionally used for gin, in the presence of juniper berries (Juniperus communis) and of other natural botanicals provided that the juniper taste is predominant. The minimum alcoholic strength by volume of distilled gin shall be 37.5%.

London Gin: London Gin is a type of distilled gin obtained exclusively from ethyl alcohol of agricultural origin, with a maximum methanol content of 5 grams per hL of 100% vol. alcohol, whose flavor is introduced exclusively through the re-distillation in traditional stills of ethyl alcohol in the presence of all the natural plant materials used. The resultant distillate shall contain at least 70 % alcohol by volume. Where any further ethyl alcohol of agricultural origin is added it must be consistent with the characteristics listed in Annex I(1), but with a maximum methanol content of 5 grams per hL of 100% vol. alcohol. London Gin must not contain added sweetening exceeding 0.1 gram of

sugars per litre of the final product. No colorants are allowed. London Gin shall not contain any other added ingredients other than water.

The minimum alcoholic strength by volume of London Gin shall be 37.5%. The term London Gin may be supplemented by the term ‘dry’.

Liqueur: Liqueur is a spirit drink having a minimum sugar content, expressed as invert sugar, of:

70 grams per litre for cherry liqueurs the ethyl alcohol of which consists exclusively of cherry spirit,

80 grams per litre for gentian or similar liqueurs prepared with gentian or similar plants as the sole aromatic substance,

100 grams per litre in all other cases;

Liqueur can be produced by flavoring ethyl alcohol of agricultural origin or a distillate of agricultural origin or one or more spirit drinks or a mixture thereof, sweetened and with the addition of products of agricultural origin or foodstuffs such as cream, milk or other milk products, fruit, wine or aromatised wine as defined in Council Regulation (EEC) No 1601/91 of 10 June 1991.

The minimum alcoholic strength by volume of liqueur shall be 15%.

Only natural flavoring substances and preparations as defined in Article 1(2)(b)(i) and Article 1(2)(c) of Directive 88/388/EEC and nature-identical flavoring substances and preparations as defined in Article 1(2)(b)(ii) of that Directive may be used in the preparation of Liqueur.

Nature-identical flavoring substances and preparations as defined in Article 1(2)(b)(ii) of that Directive shall not be used in the preparation of the following Liqueurs:

Fruit liqueurs:

blackcurrant, cherry, raspberry, mulberry, bilberry, citrus fruit, cloudberry, arctic bramble, cranberry, lingonberry, sea buckthorn, pineapple;

plant liqueurs:

mint, gentian, aniseed, génépi, vulnerary.

(d) The following terms may be used in the presentation of Liqueurs: prune brandy, orange brandy, apricot brandy, cherry brandy, solbaerrom, (also called blackcurrant rum).

Sloe Gin: Sloe Gin is a liqueur produced by maceration of sloes in gin with the possible addition of sloe juice. The minimum alcoholic strength by volume of Sloe Gin shall be 25%. Only natural flavoring substances and preparations as defined in Article 1(2)(b)(i) and Article

1(2)(c) of Directive 88/388/EEC may be used in the preparation of Sloe Gin. The sales denomination may be supplemented by the term 'Liqueur'.

Scotch Whisky: The European Union has permitted the UK to introduce a specific definition covering Scotch Whisky.

Scotch Whisky means Whisky (distilled and matured in Scotland) as conforming to the The Scotch Whisky Act 1988.

For the purpose of the Scotch Whisky Act 1988 "Scotch Whisky" means Whisky:

which has been produced at a distillery in Scotland from water and malted barley (to which only whole grains of other cereals may be added) all of which have been -

processed at that distillery into a mash;

converted into a fermentable substrate only by endogenous enzyme systems; and

fermented only by the action of yeast;

which has been distilled at an alcoholic strength by volume of less than 94.8% so that the distillate has an aroma and taste derived from raw materials used in, and the method of, its production;

which has been matured in an excise warehouse in Scotland in oak casks of a capacity not exceeding 700 liters, the period of that maturation being not less than 3 years;

which retains the color, aroma and taste derived from the raw materials used in the method of its production and maturation; and

to which no other substance other than water and spirit caramel has been has been added.

The Scotch Whisky Regulations (SWR) of 2009 replaces the Scotch Whisky Act of 1988.

The requirements for making Scotch Whisky remain unchanged from the 1988 wording.

Single Malt Scotch Whisky: means a Scotch Whisky produced from only water and malted barley at a single distillery by batch distillation in pot stills.

Single Grain Scotch Whisky: means a Scotch Whisky distilled at a single distillery but which, in addition to water and malted barley, may also be produced from whole grains of other malted or un-malted cereals.

Blended Scotch Whisky: is defined under the SWR as a combination of one or more Single Malt Scotch Whiskies with one or more Single Grain Scotch Whiskies.

As from 23 November 2012 it is not possible for Single Malt Scotch Whisky to be exported from Scotland other than in a bottle labelled for retail sale.

Irish Whiskey: The European Union has permitted a definition for Irish Whiskey as per the Irish Whiskey Act of 1980. There are three varieties of Irish Whiskey:

Pot Still Irish Whiskey/Irish Pot Still Whiskey: is defined as a spirit distilled from a mash of a combination of malted barley, un-malted barley and other un-malted cereals. The mash must contain a minimum of 30% malted barley and a minimum of 30% un-malted barley and be:

saccharified by the diastase of malt contained therein, with or without other natural enzymes;

fermented by the action of yeast;

distilled (double or triple) in pot stills in such manner that the distillate has an aroma and taste derived from the materials used.

Malt Irish Whiskey/Irish Malt Whiskey: is made from natural raw materials, 100% malted barley, water and yeast. Other natural enzymes may also be used at the brewing and fermentation stage. Malted barley is produced to individual specification by dedicated malting companies, which may be un-peated or peated in character. By using 100% malted barley, "Malt Irish Whiskey/Irish Malt Whiskey" will have a distinctive smooth, velvet, full and oily texture with a malty and sweet taste. The Whiskey must be:

saccharified by the diastase of malt contained therein, with or without other natural enzymes;

fermented by the action of yeast;

distilled (double or triple) in pot stills in such manner that the distillate has an aroma and taste derived from the materials used.

Grain Irish Whiskey/Irish Grain Whiskey: is produced from malted barley (not exceeding 30%) and includes whole un-malted cereals,

usually maize, wheat or barley. Other natural enzymes may be used at the brewing and the fermentation stage. The Whiskey must be:

saccharified by the diastase of malt contained therein, with or without other natural enzymes;

fermented by the action of yeast;

distilled (usually triple) in column stills in such manner that the distillate has an aroma and taste derived from the materials used and the column distillation method.

Australia

Alcohol definitions in Australia (and New Zealand) are regulated by Food Standards Australia New Zealand (FSANZ), a statutory authority in the Australian Government Health portfolio. The Code is enforced by state and territory departments, agencies and local councils in Australia and New Zealand.

The following spirit definitions are taken from the Australia and New Zealand Food Standards Code 1.12.

Brandy:

a spirit obtained from the distillation of wine, or fermented preparations of grapes or grape product; or

such a spirit with any of the following added during production:

water;

sugars;

honey;

spices;

grape juice;

grape juice concentrates;

wine;

prune juice

Liqueur:

Liqueur means an alcoholic beverage that is a spirit, flavored by or mixed with other foods, which contains more than 15% alcohol by volume, measured at 20°C.

Spirit:

Spirit means an alcoholic beverage consisting of:

a potable alcoholic distillate, including whisky, brandy, rum, gin, vodka and tequila, produced by distillation of fermented liquor derived from food sources, so as to have the taste, aroma and other characteristics generally attributable to that particular spirit; or

such a distillate with any of the following added during production:

water;

sugars;

honey;

spices

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4

Microbiology Basics

Having discussed the history aspect of alcohol and having discussed the legal definitions of spirit types, the next consideration is the microbiology basics that underpin the creation of alcohol.

One does not need formal training in microbiology in order to be a craft distiller. But, a seriously tight grip on microbiology will heighten one's appreciation for the alcohol creation process.

Cell Types

All living organisms can be classed as either prokaryotic, eukaryotic or archea. The latter are highly specialized organisms that exist in extreme environments. As such, they do not play a role in alcohol creation and will not be mentioned further.

The difference between prokaryotic and eukaryotic organisms rests with the structure of their cell wall and their internal organelles.

Eukaryotic cells are more complex in design and have a nucleus and other organelles each bound by membranes. Eukaryotic cells divide by budding, in which a daughter cell is produced that breaks away from the parent cell. A parent cell can produce several daughter cells. Each daughter then becomes a parent to several daughter cells. Eukaryotic cells are found in plants, animals and fungus. Yeast is of the fungus family and has the eukaryotic cell structure.

Prokaryotic cells are simpler in design, have a nucleoid instead of a proper nucleus, and have no membranes around the organelles. Prokaryotes are known otherwise by their more common name of bacteria. Prokaryotes divide by binary fission in which the cell splits in half. Prokaryotes exist in three general shapes: rods, spirals and cocci. They often have a tail attached to them called a flagellum that they use to move around. The outer layer of the cell has tiny pili, hair-like attachments to allow the cell to grab onto other cells, including the healthy cells in your body or the yeast cells in a fermenter vessel.

Figure 2 illustrates the basic construct of a prokaryotic bacteria cell.(1) The small bit of DNA material in a bacterial cell is present in its cytoplasm area in a feature called a nucleoid. A bacteria cell wall contains peptidoglycan which is comprised of acetylglucosamine, acetylmuramic acid and peptides of amino acids. Yeast cells and the cells in our bodies do not contain peptidoglycan. As an aside, when drug makers are creating antibiotics to help cure us from bacterial infection, they often engineer a form of peptidoglycan into the antibiotic so that it will attach itself to the bacteria cells and proceed to neutralize them.

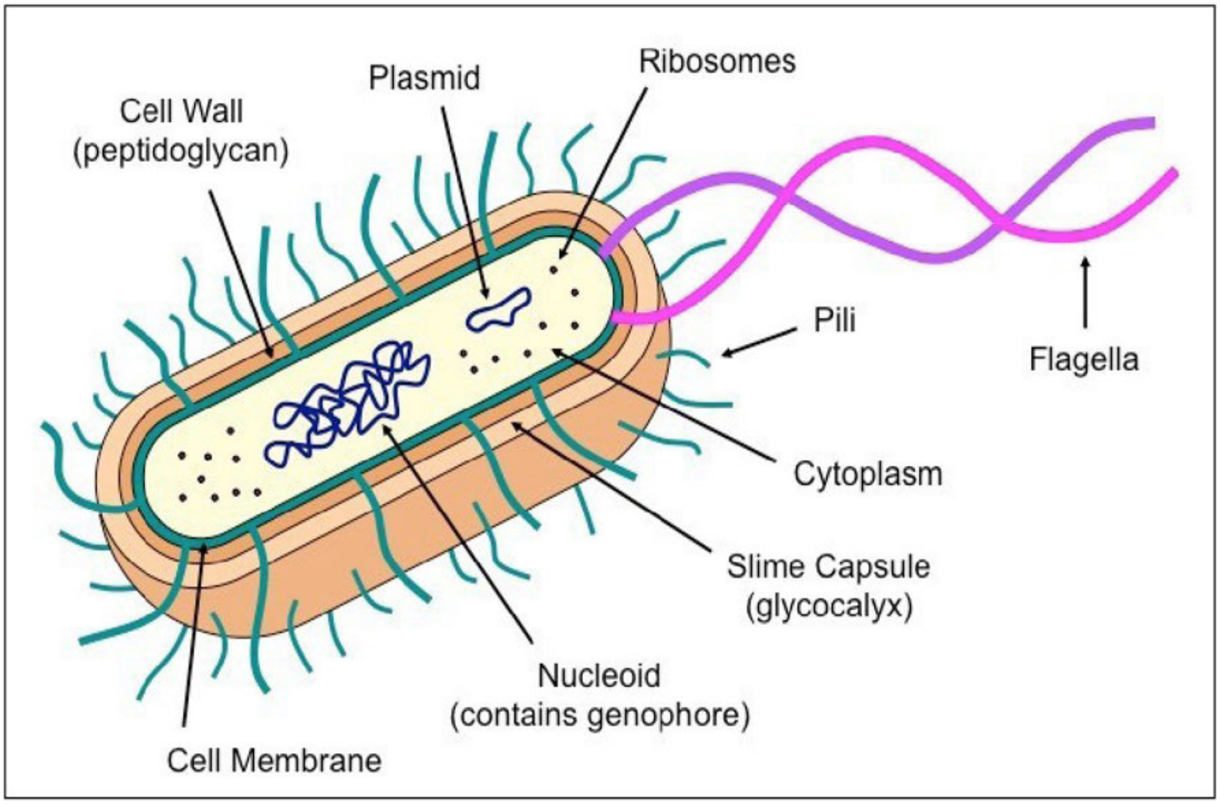

Figure 2 – Prokaryote structure

Also in the cytoplasm are plasmids, which contain extra DNA coding that is not immediately essential. Plasmid DNA is often used when the bacteria seeks to transfer genetic coding data to other bacterial cells, sometimes with dire results. It is this plasmid DNA that can make healthy cells in our bodies become antibiotic resistant. (2)

A eukaryotic cell is more complex in its structure. It has a well-defined nucleus. Its various organelle parts all have a membrane structure around them for protection. Figure 3 illustrates a eukaryotic cell. (3) The individual cell components will be detailed in a later chapter.

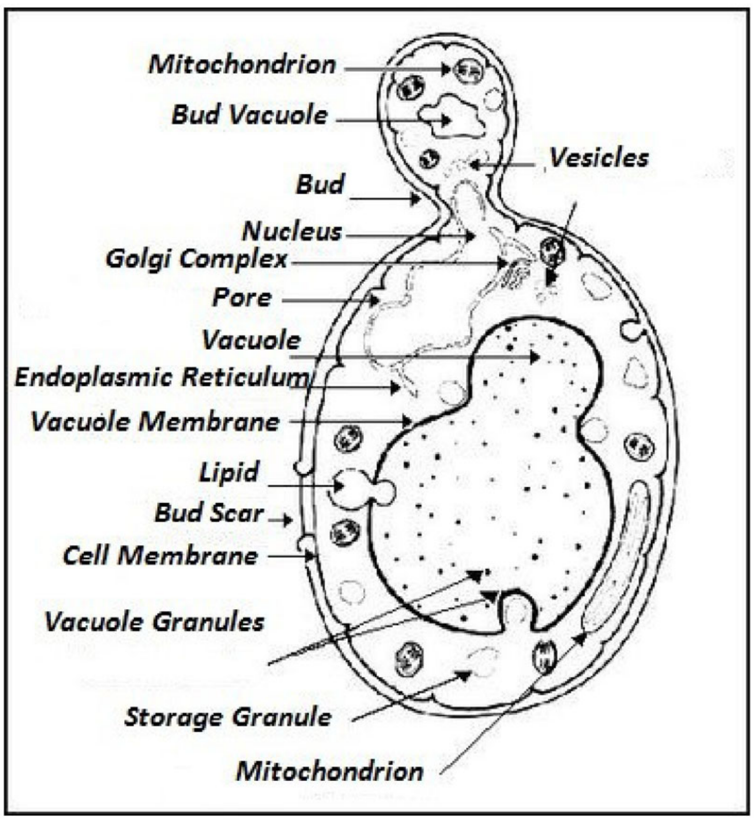

Figure 3 – Eukaryote structure

Gram Staining

In 1882, Danish scientist Hans Gram determined that some bacteria, when stained with dye and then examined under a microscope, would retain the color of the dye while other bacterial cells would not retain the dye color. This class division came to be known as Gram positive and Gram negative bacteria.

Gram staining detects peptidoglycan, which is present in the relatively thicker cell wall of Gram-positive bacteria. The dye stain will be retained by the peptidoglycan and will appear violet in hue. Gram-negative cells also contain peptidoglycan, but in a very small layer that is insufficient to retain the dye added to the bacteria sample. As a result, the stained color will appear reddish in hue.

Gram positive bacteria are generally catalase negative, meaning that they do not need oxygen to survive. Distillers and brewers, need to be aware that Lactobacillus bacteria (LAB) are the Gram positive variety that will be most apt to appear in a brewery or distillery. LAB bacteria will consume the fermentable sugars that are otherwise meant for the yeast and will produce lactic acid and carbon dioxide. LAB have negative consequences for brewers in that LAB infected beer can turn hazy. For distillers, the significant drawback to a mash infected with LAB will be a reduction in the amount of alcohol obtained from the ferment. Less alcohol obtained means a hit to bottom line profit. If using grain as a raw material, bear in mind that un-malted grain will likely have a species of LAB called Lactobacillus brevis present in the tissues of the kernels. If using raw materials like agave cactus syrup or perhaps fruit to make alcohol, a LAB species called Leuconostoc might make an appearance.

Gram negative bacteria are generally catalase positive, meaning that they require oxygen to multiply. Two gram negative bacteria in particular that a distiller could encounter are Acetobacter and Gluconobacter. Both cause a souring effect in the fermented raw materials because bacterial cells have consumed fermentable sugars and have generated sour acids.

There are a couple of Gram negative bacteria that do not need oxygen to grow, namely are Megasphaera and Pectinatus. The former can leave a fermented mash with rancid aromas. The latter will leave aromas of rotten eggs. To beer brewers, these two bacteria are a disaster. To a distiller, they could also be a disaster if the acids creating the foul aromas manage to follow through the distillation process.

To eliminate these unwanted microbes from a distillery setting, one must undertake a rigorous cleaning cycle on all equipment prior to starting a mash or a ferment. More details on cleaning will be provided in a coming chapter.

Amino Acids

Amino acids rest at the very apex of cellular life. Cell structure and cell nutrition both depend on amino acids. There are 20 amino acids known to mankind as follows:

Alanine

Arginine

Asparagine

Aspartic acid

Cysteine

Glutamine

Glutamic acid

Glycine

Histidine

Isoleucine

Leucine

Lysine

Methionine

Phenylalanine

Proline

Serine

Threonine

Tryptophan

Tyrosine

Valine

The basic construct of an amino acid is shown in Figure 4. (2) An amino acid comprises an NH2 molecule attached to a central carbon atom. Appended to that central atom is a hydrogen atom, a carboxyl structure and a complex R functional group.

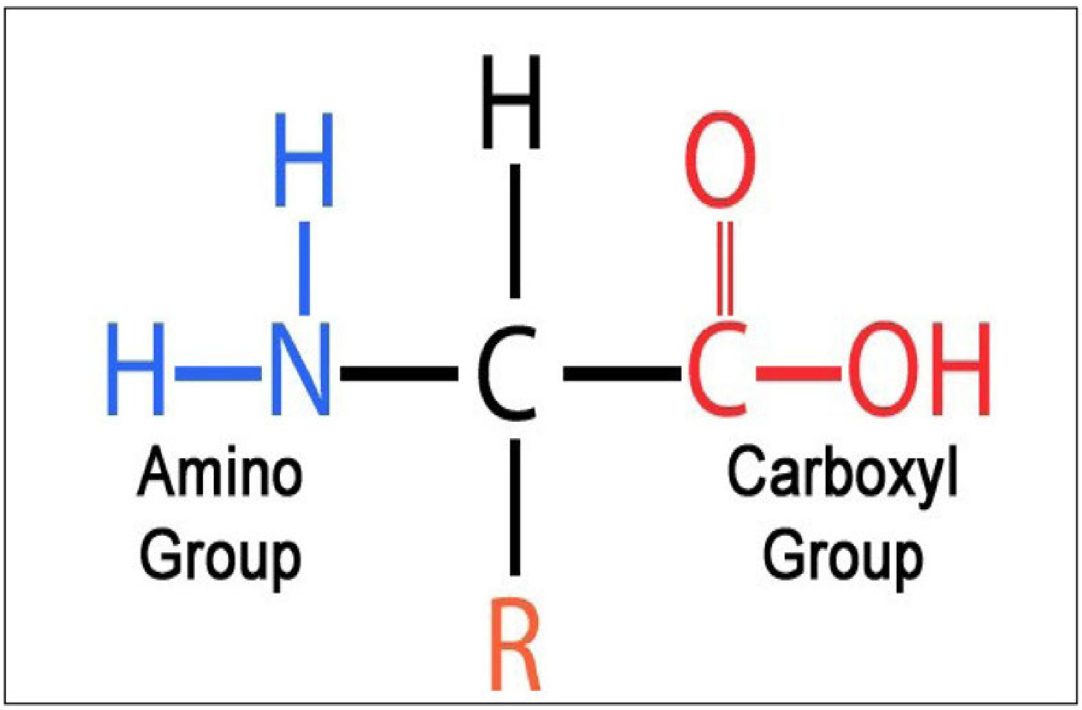

Figure 4 – Amino acid structure

Proteins

It is possible for two or more amino acids to link together. The NH2 group of one amino acid will hook to the carboxyl group of another with the net result being a water molecule ejected from the playing field. Such a linkage of amino acids is called a peptide. If between two and ten amino acids link together, this is termed an oligopeptide. More than ten aminos hooking up creates a polypeptide.

If a long series (50 to 2000) of amino acids all hooked up in a chain, the resulting polypeptide would be called a protein. Proteins can be very complex as there are 20 amino acids that can be used. Think of the combinations and permutations, especially in a large polypeptide!

Proteins get even more complex when structure is considered. The sequence of arrangement of amino acids in a protein is called the protein's primary structure. Take that chain and twist it into a helix pattern and the result is the secondary structure. A secondary structure could also be obtained by laying primary structure chains beside each other in a pleated sheet format. This name derives from the fashion industry where fabric can be folded back onto itself to create folds (pleats). Imagine taking chains of protein, laying them side by each and then doing some folding to create a wrinkled pattern. If a bend were applied to these secondary structures so that the R attachments hooked to each other, the result would be a tertiary structured protein. At the root of structural alignment are the variables of electric charge and pH. Positive and negative charges attract. If the functional R groups on various amino acids in the protein have opposite charges, there is a tendency to create the secondary and tertiary structures. The pH of the protein chain will also help determine whether or not the functional groups carry a positive or a negative charge.

If multiple tertiary structures are linked together, the result is a quaternary structured protein. Think of the permutations and combinations. The subject of protein is a daunting one indeed.

The structure of a protein is important when one considers enzymes. An enzyme is a protein that facilitates the expediency of a chemical process. A good analogy is to think of the cartoon character Wiley Coyote. Imagine Wiley has a big rock and he wishes to push it over the edge of a cliff. But, between him and the cliff edge there is a small hump of earth that he will have to push the rock up and over. The energy he needs to complete this pushing task is called the activation energy. Imagine if Wiley had a stick that he could use as a lever to help him move the rock. The lever would not break or be compromised in any way. In fact, he could re-use his stick lever over and over for several rock pushing exercises in a row. The stick and its leverage would make the rock pushing event proceed easier and smoother. The stick would in effect reduce the activation energy Wiley needs. The stick is an enzyme, or in more technical language a proteolytic enzyme.

Proteolytic enzymes play a role in breaking down starches in raw materials, proteins in raw materials as well as cell wall structures of raw materials.

If a proteolytic enzyme is to break down starch (amylase type enzyme), or protein (proteinase type enzyme), or a grain endosperm cell wall (glucanase type enzyme), the proteolytic enzyme must have a particular shape so that it can fit onto the substrate material that is to be broken down. This concept of proper fit is called the lock and key model and will be discussed in greater detail in a future chapter.

Exposing an enzyme to a pH it is not entirely comfortable with will affect the electrical charges on its functional R groups which will influence the secondary and tertiary structural shape. A change in shape means the lock and key model will not work. The enzyme will not perform its desired duty. The same argument holds for temperature. Expose the enzyme to temperature extremes and the shape of the enzyme molecule might change to the point where the lock and key model no longer works.

Enzyme manufacturers will give a distiller specific temperature ranges and pH levels for adding the various enzymes to a grain mash. Amylase type enzymes are tolerant of temperature up to about 90ºC. Glucanase type enzymes are tolerant of temperature up to about 65ºC.

Protein shape also influences the ability to attract other substances. For example, in the beer making process, a brewer will add hops to the boil kettle. Certain parts of the hop alpha acids will be attracted to the proteins in the boiling wort with help from a metal ion such as magnesium. Providing the brewer has used proper water chemistry and fresh hops, this interaction will give the beer drinker a nice foamy head on the resulting pint of beer. But, not all protein attraction is desirable. The interaction between the polyphenols in hops and an amino acid in beer called proline can generate sediment which becomes evident to the eye of the beer drinker in the form of visible haze. (4) Large commercial brewers seek to avoid this situation. Craft brewers have learned to add extra hops to the recipe to induce haze to create the New England IPA style of beer.

A living cell is capable of assimilating amino acid molecules from its surroundings. In the case of yeast cells exposed to a mash of grain or fruit or molasses, the yeast cells will demonstrate a preferential order of amino acid uptake uptake. Glutamic, Aspartic, Asparagine, Glutamine, Serine, Threonine, Lysine and Argenine are taken across the cell wall in quick order. Valine, Methionine, Leucine, Isoleucine, and Histidine are taken up next at a slower rate. Glycine, Phenylanaline, Tyrosine, Tryptophan, Alanine are lastly taken up. (5) A living yeast cell will use the amino acids to help create new cell material for daughter cell growth. A yeast cell will also use the amino acids to manufacture its own internal proteolytic enzymes to help assimilate fermentable sugars across its cellular membrane.

Glucose and Friends

In brewing and distilling, one molecule to become well acquainted with is the sugar molecule, glucose. Mother Nature also relies on other sugar type molecules as well.

In a kernel of grain, inside the individual cells of the endosperm (main body of the kernel), Mother Nature has placed coiled-up molecules of starch. The basic structure of glucose (2) is shown in Figure 5. Repetitively joining glucose units so that carbon atoms 1 and 4 are close together (1-4 linkage) will generate an amylose starch.

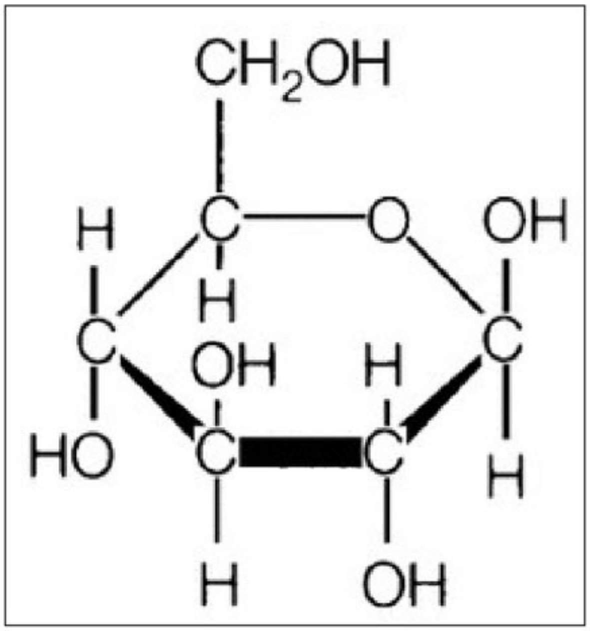

Figure 5 – Glucose

(Note: the atom numbering sequence begins at the right side of the molecule and proceeds in a clockwise direction. The carbon atom at the extreme right is number 1 and the carbon atom at the extreme left is number 4).

Joining glucose units so that carbon atoms 1 and 6 are close together (1-6 linkage) gives an amylopectin starch. An amylose starch resembles a linear chain. An amylopectin type starch resembles a complex branched structure. Figure 6 illustrates these starch types. (6) About 1/3 of starches in Nature are amyloses and 2/3 are amylopectins. In the mashing process, the heat imparted to the mash during heating will, over an extended period of time, break down the linkages between glucose molecules in the starch. But, brewers and distillers do not have infinite amounts of time. Thankfully, Mother Nature has provided enzymes which lower the activation energy, which allows the heat energy to break the linkages quicker. Starches will break down (hydrolyze) into glucose, maltose, maltotriose, as well as more complex structures called dextrins. A maltose is two glucose units attached together. A maltotriose is three glucose units together. In a fruit and molasses, Mother Nature has made use of glucose and a close structural variant called fructose to create the sucrose molecule. The next chapter will examine in more detail the various raw materials for distilling.

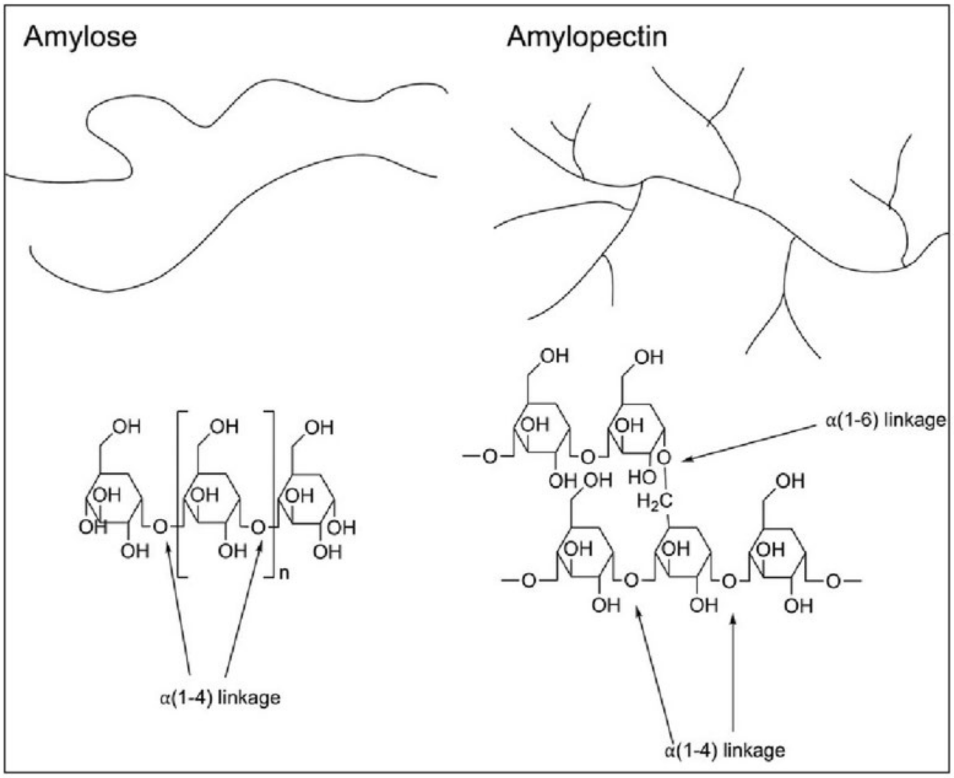

Figure 6 – Starches

Notice in Figure 5 that the OH group at the right side of the glucose molecule is facing upwards. If it were facing downwards and if between 7000 and 15,000 such units were joined together using 1-4 linkages, the result would be a material substance called cellobiose. Join together thousands of such units and the resulting material will be cellulose which is a major constituent of wood.

If Mother Nature did some further re-arranging of the structure in Figure 5 so that the H-OH structures at carbon atoms 2 and 3 were flipped around, the result would be a six carbon sugar called mannose.

If Mother Nature removed one of the carbon atoms from the glucose structure to leave a 5-carbon product, the formula of the 5-carbon structure would be HOCH2(CH(OH))3CHO. This is termed a xylose.

If Mother Nature assembled a chain of xylose, mannose and glucose molecules together so that there were a total of between 500 and 3000 molecules, this would be termed a hemicellulose, which is another major constituent of wood.

The individual cells in the grain endosperm have a cell wall structure associated with them. Sugar type molecules are used in making that structure. Suppose Mother Nature took two or maybe three glucose units and joined them with 1-4 linkages (in the fashion of an amylose). Next, she inserts a glucose unit bonded to the other glucose units at the 1-3 location. Next she adds a couple more glucose units using 1-4 linkages and then adds this construct to a series of similar units. With a multitude of such repetitions, the overall result is what is termed a beta glucan. These structures are an integral part of the endosperm cell wall structure in grain kernels. Chains of beta-glucans arranged in parallel can bind together. Some grains, notably rye grain, are notorious for their stickiness during mashing. The stickiness is the parallel conjoined beta glucan chains.

The other constituent of the endosperm call wall is arabinoxylan. If Mother Nature takes a repetitive chain of xylan and every now and again inserts a 5-carbon sugar molecule (arabinose) using 1-3 and 1-2 linkages, the result is arabinoxylan, otherwise called pentosan. (4)

DNA and RNA

Every living cell contains DNA, which is short for deoxyribonucleic acid. Humans look the way we do because we inherited 23 chromosomes (strands of DNA material) from our father and 23 chromosomes from our mother. A yeast cell is less complex than humans and has only 16 chromosomes. A bacterial cell is even less complex yet with one chromosome. DNA is contained in the nucleus of a living eukaryotic cell and in the nucleoid of a prokaryotic cell.

DNA is best envisioned as a ladder construct as shown in Figure 7. This diagram of a ladder has been annotated with the letters p and s alternating down one side at each rung. On the opposite sides of the ladder, notice that the order of P and S is opposite. The sequence on one side of the ladder is PSPS and SPSP on the other. The letter P denotes a phosphate group and S denotes a 5-carbon deoxyribose sugar molecule.

The rungs of the ladder are comprised of nitrogenous base pairs. One base molecule is half of a rung. The nitrogenous base molecules are attracted to one another by weak hydrogen bonds. The individual bases consist of either a single-ring nitrogen unit called a pyrimidine or a double-ring unit called purine.

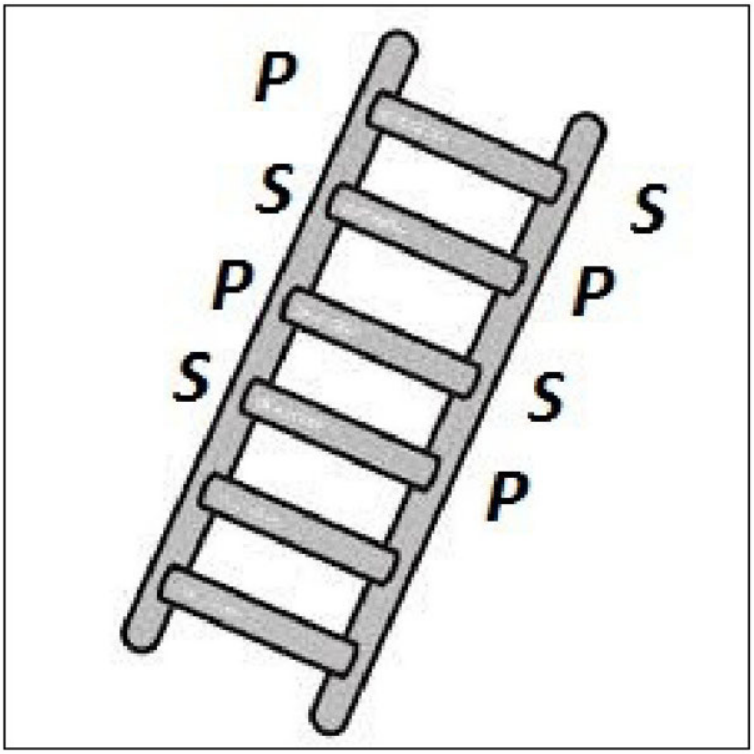

Figure 7 – The DNA ladder

There are 4 expressions of nitrogenous bases involved with DNA and RNA: purines called adenine (A) and guanine (G) and pyrimidines called thymine (T) and cytosine (C). To make a base pair, Mother Nature has an definite order for creating the rungs of the ladder. A purine will always pair with a pyrimidine. That is, (A) will always pair with (T) and (C) will always pair with (G). In the case of RNA, there is a nitrogenous pyrimidine base called uracil (U).

Figure 8 illustrates the structures of these nitrogenous bases. (7)

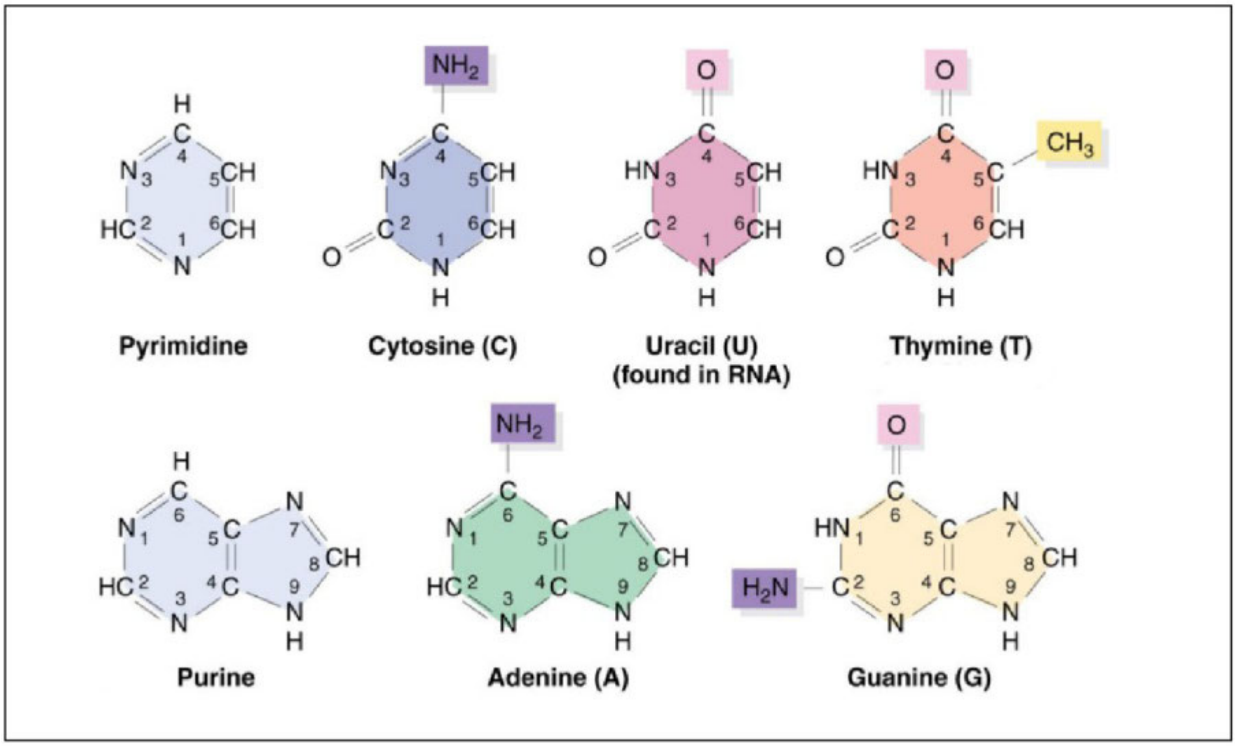

Figure 8 – Nitrogenous Bases

A phosphate group, a nitrogenous base and a 5-carbon ribose sugar together comprise a nucleotide. Thus, the long staves of the DNA ladder are comprised of a multitude of nucleotides. The nucleotide sequence along one side of the ladder is opposite to that on the other side. The ends of the ladder staves are termed the 3-prime (3’) and 5-prime (5’) ends. A 3’ end will have the number 3 carbon atom of the ribose sugar molecule open and available for bonding. The 5’ end will have the number 5 carbon atom in the ribose sugar attached to a phosphate group.

Think of a train with an engine at one end and a caboose at the other. The long nucleotide staves of the ladder are like two trains on parallel tracks, with each train headed in a different direction. And if this was not complex enough consider what it all would look like if the ladder was twisted into a helix. The DNA helix structure was first written about by researchers Watson and Crick in 1953. (8)(9)

Genes and Chromosomes

A gene is a linear sequence of nucleotides. String together various genes and the net result is a chromosome. A chromosome is not just a random assembly of genes. A chromosome, by definition, must contain all the necessary coding instruction for cellular survival. (9)

Cell Division

Prokaryotic bacterial cells multiply by splitting themselves in half. The chromosomal material in the cell nucleoid replicates itself and the replicated bit is passed onto to the break-away cell material.

Eukaryotic cells grow by budding off a daughter cell. An individual parent cell will create (grow) a daughter cell that has received growth instructions from the parent cell DNA. RNA information from the parent will assist with protein synthesis to make the various cell organelles. Once grown, the daughter cell will detach from the parent.

Making New DNA

The making of new DNA will commence at a specific location on the nucleotide strand. The basic steps are:

An enzyme called helicase will break the hydrogen bonds between the nitrogenous bases, unwind the helix structure and stabilize the unwound portion.

With the individual nitrogenous bases exposed, an enzyme called DNA polymerase will create new nitrogenous bases, deoxy ribose sugars and phosphates to compliment those exposed. An exposed (A) will result in the creation of a new (T). An exposed (C) will result in the formation of a new (G), and so on in accordance with the pairing rules set down by Mother Nature.

The DNA polymerase enzymes will double check (edit) the work being done. The rate of formation of the new bases is rapid at about 1000 per second. Mistakes will occur typically at the rate of one mistake in 10 new bases formed. The polymerase enzymes will be kept busy editing and fixing the mistakes.

Growth of new nucleotide material in the 3’ and 5’ directions proceeds differently. In the 5’ direction, the polymerase enzyme jumps just a bit ahead of itself, and then works backwards making short pieces (100 to 1000 bits long) of the correct nitrogenous bases, sugars and phosphates. These short pieces are called Okazaki fragments, named after the scientist who recognized them in 1968.

Eventually, in the unwound DNA section, there will come to exist a new strand of 3’–5’ nucleotides (that is a complement to the old 5’– 3’ strand) and a new strand of 5’–3’ nucleotides (that is a complement to the old 3’–5’ strand).

The strand of new 3’–5’ material will join with the old existing strand of 5’–3’ material. This will break away and become a new piece of helix wound DNA.

An enzyme called ligase then arrives on scene to re-helix the remaining strands and stabilize matters

Making RNA

RNA (ribonucleic acid) is essential in the creation of new protein material for cellular growth. The creation of proteins involves taking the linear coding of nucleotides in the DNA and using that information to create a linear assembly of amino acids. A linear assembly of amino acids is by definition a protein.

The basic steps in RNA creation are:

An enzyme called helicase breaks the hydrogen bonds, and unwinds the helical DNA structure.

An enzyme called RNA polymerase binds to only one of the exposed lengths of DNA. What will result will be new RNA material.

A nitrogenous base of (A) which in DNA creation would be complemented by (T), is instead complemented by a base called Urasil (U) in the RNA creation process.

There will be regions of the DNA strand that give rise to newly created RNA material, even though that particular bit of coding is not needed to create the desired protein. These regions are called introns. After the complementary bases are made, an enzyme arrives on scene to splice out the introns and re-connect the sections (exons) that do code for protein creation.

The RNA strand then moves out of the nucleus area of the cell to get on with the work of making protein. Ligase arrives on scene to rewind the unwound DNA section.

Not all RNA is the same. There are three variants of RNA, namely ribosomal RNA (rRNA), messenger RNA (mRNA), and transfer RNA (tRNA). Each has a specific function:

Once outside the nucleus, rRNA material binds to certain proteins in the cell structure to create sites called ribosomes.

tRNA material has the job of transferring amino acids from the cell cytoplasm to the ribosome area where the amino acids will be used in protein creation. Think of tRNA as a shuttle bus moving amino acid passengers.

The mRNA has the job of dictating which amino acids go in which order to create the needed proteins for cellular growth. For example, if a cell needs to create a new cell organelle, a certain structure of protein will be needed versus the structure of protein needed for new cell wall material. Every 3 units of nucleotide on the mRNA fragment is termed a codon. Sequencing of codons drives the sequencing for protein creation. (9)

ATP, ADP, NAD, NADH, FAD and FADH2

It takes energy to create proteins. Living cells contain electron energy. Electron energy is often abbreviated as ATP, which stands for adenosine tri-phosphate. It is essentially a bit of RNA material with adenine and a ribose sugar at its core. Three phosphate structures are then attached. Figure 9 illustrates the structure of ATP.

When one of these phosphate units is cleaved off, there is a net release of energy. The resulting two-phosphate structure is called adenosine di-phosphate, or ADP. (10)

Figure 10 illustrates ADP and ATP in the context of ethanol formation. Cellular energy in a yeast cell is moved via electron transfer, either as oxidation or reduction. Oxidation is a net loss of electrons, while reduction is a net gain. In brewing and distilling, the living yeast cells obtain energy from the raw material food sources. In fact, the formation of ethanol from glucose fermentable sugar involves the oxidation of glucose.

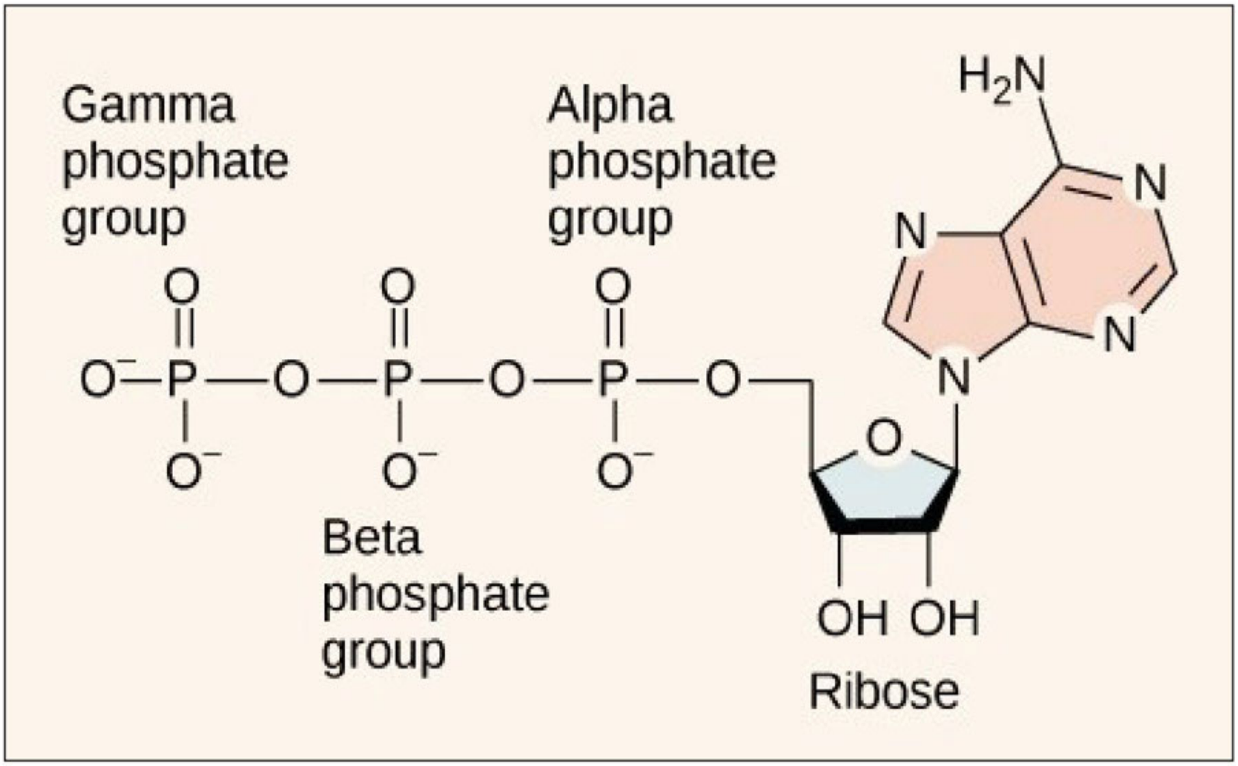

Figure 9 – ATP structure

In Figure 10, note also the features NAD and NADH. NAD stands for nicotinamide adenine di-nucleotide. NAD acts as an electron agent, sometimes called an electron carrier. It can accept electrons from other molecules and it can then donate these electrons to other molecules. An electron carrier is also to be thought of as a coenzyme. Coenzymes are non-protein, organic molecules that have been synthesized from vitamins. A vitamin is an organic compound that has been synthesized from amino acids. For example, a material called coenzyme A, is synthesized from pantothenic acid which has been synthesized from the amino acid alanine. The coenzyme NAD is synthesized from the vitamin niacin, which is synthesized from the amino acid tryptophan.

NADH is NAD material that has been reduced (meaning it has gained an electron). Both NAD and NADH are critical to the functioning of the glycolysis process that sees glucose converted to pyruvic acid. An electron carrier that is closely related to NAD is that of FAD which is flavin adenine di-nucleotide. When FAD receives (reduced) two hydrogen atoms, the result is $FADH_2$. (11) Earlier in this chapter, it was noted that enzymes fit to binding sites on a molecule (substrate). A co-factor is a mineral substance such as calcium, magnesium, or zinc (each obtained from the water used in brewing or distilling) that helps the enzyme better fit to the substrate binding site.

Catabolism and Glycolysis

Cells need material to work with, just as a construction builder needs raw material to make a structure. A living cell will utilize catabolism which involves the tearing down of complex foodstuffs. In other words, a cell will utilize the raw materials surrounding it to sustain itself and to grow.

A yeast cell will absorb a molecule of glucose across its cell wall and then, through a complex multi-step procedure, transform the glucose into ethanol which has a practical use for a brewer or distiller. As part of this glucose transformation, the cell creates energy to drive the creation of new cellular material.

Glycolysis refers to the multi-step procedure in which molecules of glucose are transformed into ethanol after being assimilated (absorbed) into the cytoplasm (interior) of a yeast cell. If faced with a sucrose molecule from fruit, a yeast cell will dispatch an enzyme to cut the sucrose into its constituent parts. If faced with maltose (two glucose units) or maltotriose (three glucose units), a yeast cell will dispatch an enzyme to sever the molecules into glucose units.

Through the multi-step glycolysis process, the glucose is converted to pyruvic acid (pyruvate). Figure 10 illustrates the glycolysis steps. Another name for this process is the Embden Myerhof Parnas Glycolytic Pathway. This process provides a yield of 2 ATP energy units per each molecule of glucose processed. Through this process, NAD acts as an electron acceptor and becomes NADH.

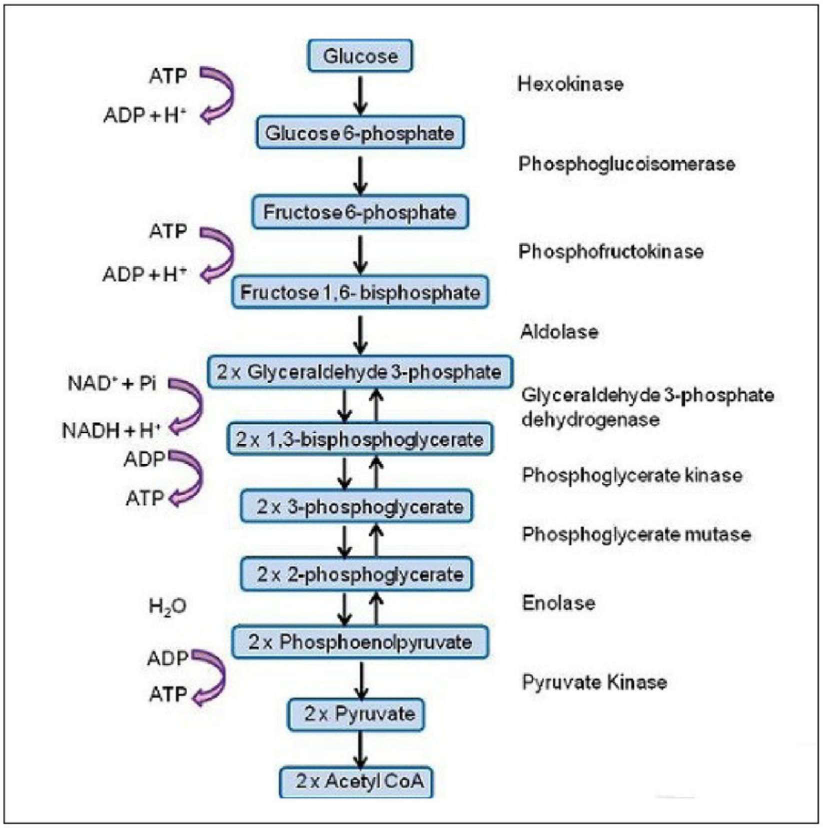

Figure 10 – Glycolysis pathway

Understanding of this process was not arrived at overnight. In the 1920s, researcher Otto Meyerhof made advances on earlier work that had been done in the 1890's. In the 1930s, Gustav Embden better defined the multi-step process. In the 1940s, work by Jakub Parnas helped to complete the picture.

Ribose Sugars

A yeast cell will further utilize glucose to manufacture additional 5-carbon ribose sugars necessary for creating new DNA nucleotide material to share with daughter cells. Glucose molecules will be converted into glucose 6-phosphate, similar to the initial step of the Glycolysis pathway. The 6-phosphate structure is converted into 6- phosphogluconate format and ultimately into ribose sugar for use in creating new DNA material.

These steps are reduction reactions with electrons gained causing NAD to become NADH. In the final step, CO_2 is released. Figure 11 illustrates this pathway.

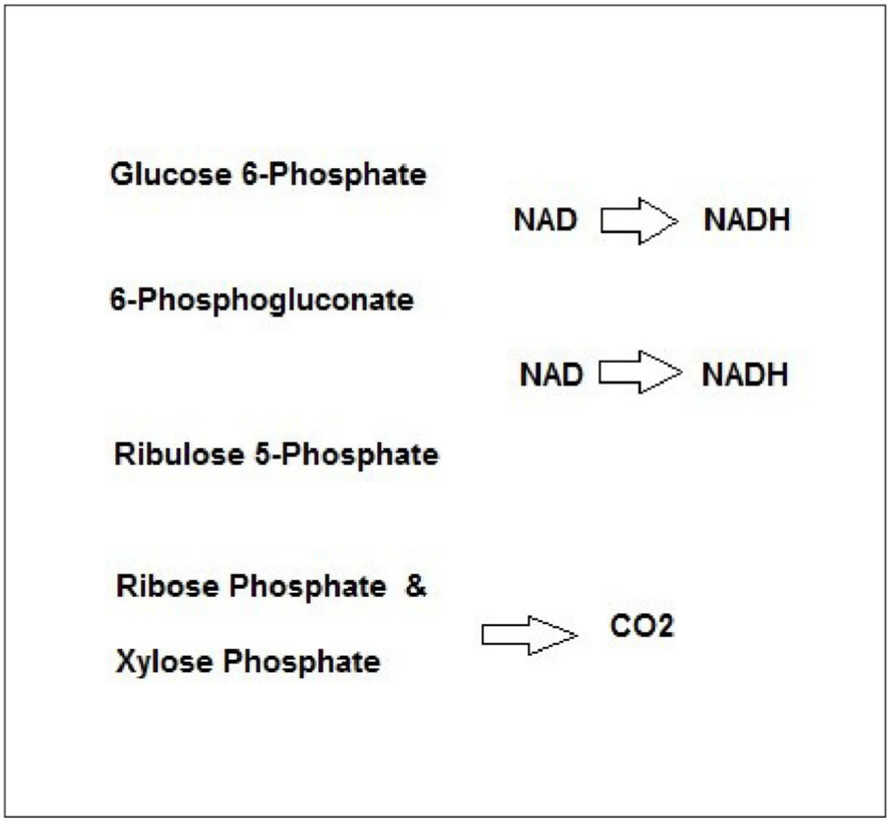

Figure 11 – Ribose sugar pathway

Pyruvate…So What Now?

At the end of the glycolysis reactions, NAD has accepted electrons to become NADH. In order to keep the glycolysis reactions going, the NADH must oxidize (lose electrons) to revert back to the NAD format so it can acquire more electrons. The oxidation occurs with assistance from an enzyme from the yeast cell called pyruvate dehydrogenase. This enzyme causes pyruvate to give up a carbon dioxide molecule to form acetaldehyde. Acetaldehyde will then oxidize to form ethanol. Ethanol is what brewers and distillers are seeking.

To more fully appreciate the oxidation of pyruvate, consider the following non-yeast examples:

An athlete goes for a workout at the gym. The cells in his body are using the glycolysis pathway to rapidly convert glucose to pyruvate. The energy generated (2 ATP per molecule of glucose) gives him strength to conduct his workout. The pyruvate then oxidizes (loses an electron) and becomes lactic acid thanks to the presence of trace amounts of lactobacillus bacteria in the bloodstream. The lactic acid builds up on his muscles and he will feel stiff and sore after the workout.

A person accidently cuts themselves with an unsterile object. In the presence of chlostridium perfringens bacteria in the cut or wound, pyruvate can oxidize into gangrene which is detrimental to living tissue.

Milk contains lactose which is a molecular construct involving glucose and galactose. Cheese making is actually a fermentation process and the glycolysis steps will occur. Pyruvate in the presence of an added bacteria called lactobacillus lactis will oxidize to help to produce cheese with a flavor that consumers recognize as cheddar.

Similarly, pyruvate in the presence of an added bacteria called streptococcus salivarius thermophilus, will oxidize to help to produce cheese with a flavor that consumers recognize as Swiss cheese.

If one thinks of ATP energy as a currency, then in the context of amassing wealth, more energy is better. At least this is how a cell of yeast looks at the situation. If there is dissolved oxygen in the fermentation vessel, a cell of yeast will try to enrich its future prospects by generating more energy. Instead of directing the pyruvate to oxidize into ethanol, the yeast cell will direct the pyruvate through an energy-creating process called the Krebs cycle, named after 1930s German biochemist Hans Krebs.

Before pyruvate can enter the Krebs cycle, it must shed a CO2 molecule, give up electrons (NADH becomes NAD so that glycolysis can continue) and then join with coenzyme A (present in the yeast cell mitochondria, having been synthesized from pantothenic acid) to form acetyl CoA.

Oxaloacetic acid (present in the yeast cell) reacts with acetyl CoA to form citric acid and thence isocitric acid.

The isocitric acid transfers a pair of electrons to NAD and in so doing oxidizes to alpha-ketoglutaric acid. This acid gives up a pair of electrons and oxidizes to succinyl CoA.

This material transfers energy to ATP and ends up forming succinic acid. This acid in turn gives a pair of electrons to FAD (which becomes FADH2) and oxidizes to fumaric acid.

The fumaric acid becomes malic acid with the uptake of a water molecule. The malic acid gives a pair of electrons to NAD and oxidizes to oxaloacetic acid. The cycle then begins anew. The net result of one ‘turn’ of the Krebs cycle is the creation of 2 units of ATP. Figure 12 illustrates the Krebs cycle.

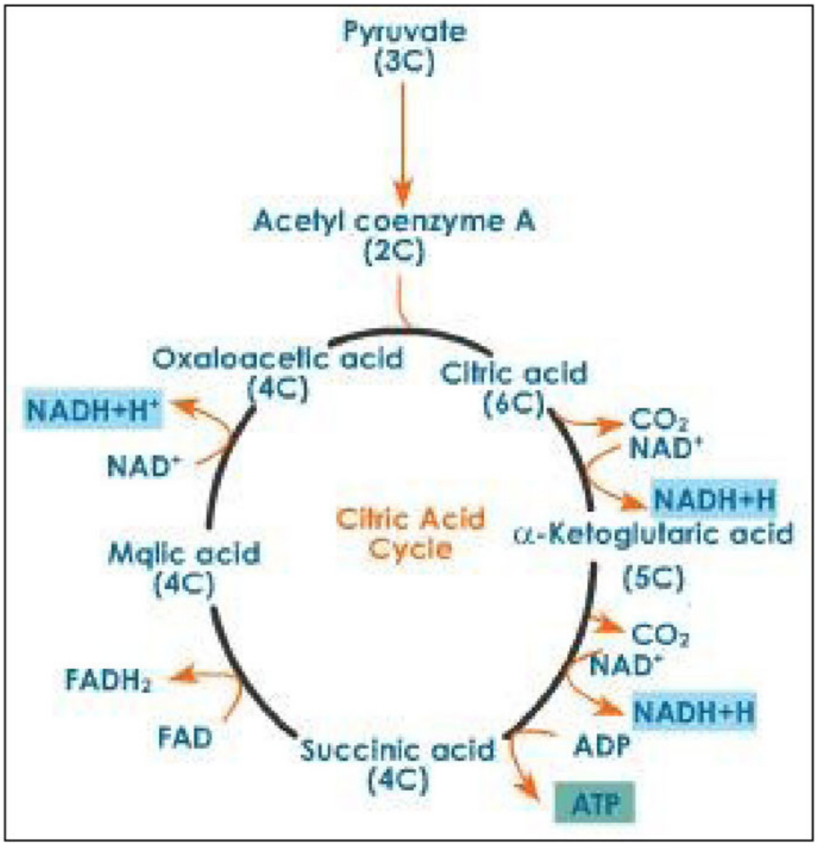

Figure 12 – Krebs Cycle

The electrons transferred to NAD during the Krebs cycle are moved via a chemiosmosis electron transport chain. This transport chain occurs in the mitochondrial membrane of the yeast cell.

On one side of the mitochondrial membrane will be a surplus of H+ ions compared to the other side. This generates a proton motive force. The action of moving the electrons across the membrane is likened to a waterfall. The waterfall is equipped with a series of carriers which are NAD, a derivative of vitamin B2, iron sulfide, coenzyme Q, and cytochromes a, b and c. As the H+ ions move across the membrane, energy is released and ATP is formed from ADP and inorganic phosphate which the cell obtains from DNA nucleotides.

A total of 32 units of ATP are created in this transport chain. Combine this with the 2 units from the Krebs cycle itself and the 2 units from glycolysis and the total is 38 ATP units. As stated earlier, if thought about in terms of a currency, one can now see why a yeast cell will follow this energy enriching pathway. A yeast cell has a maternal desire to propagate and the energy gained in the Krebs cycle will be used to help create new progeny (daughter) cells. Figure 13 illustrates the Electron Transport Chain which physically takes place at the inner surface of the mitochondrion. (12)

To reiterate, this pathway is only possible if there is dissolved oxygen in the fermentation medium. When the dissolved oxygen runs out, the ability to create progeny cells is diminished and the oxidation of pyruvate to ethanol will occur.

Higher Alcohols

The primary alcohol of interest to distillers is ethanol which has a 2-carbon atom backbone structure and a formula C_2H_5OH. However, alcohol molecules with additional carbon atoms in their structures are also created by yeast cells. These structures are called higher alcohols and could have up to six or eight carbon atoms in their structures.

Valine, methionine, leucine, isoleucine and phenylanaline amino acids when taken up by a yeast cell will have their NH_2 grouping cleaved off (refer back to Figure 4). The remaining portion of the amino acid molecule is converted to an aldehyde format and then reduced to a higher alcohol which is excreted from the cell. This mechanism is the Erlich Pathway, named after German scientist Felix Erlich who discovered it in 1907.

A yeast cell will scavenge NH_2 groups off of amino acids as a matter of survival. As a yeast cell generates ethanol and excretes it from the cell structure, the surrounding environment becomes toxic to the cell. Any leaks of ethanol through the cell wall will mean certain death for the cell. The cleaved NH_2 molecules are used to fortify the cell wall to ensure cell survival.

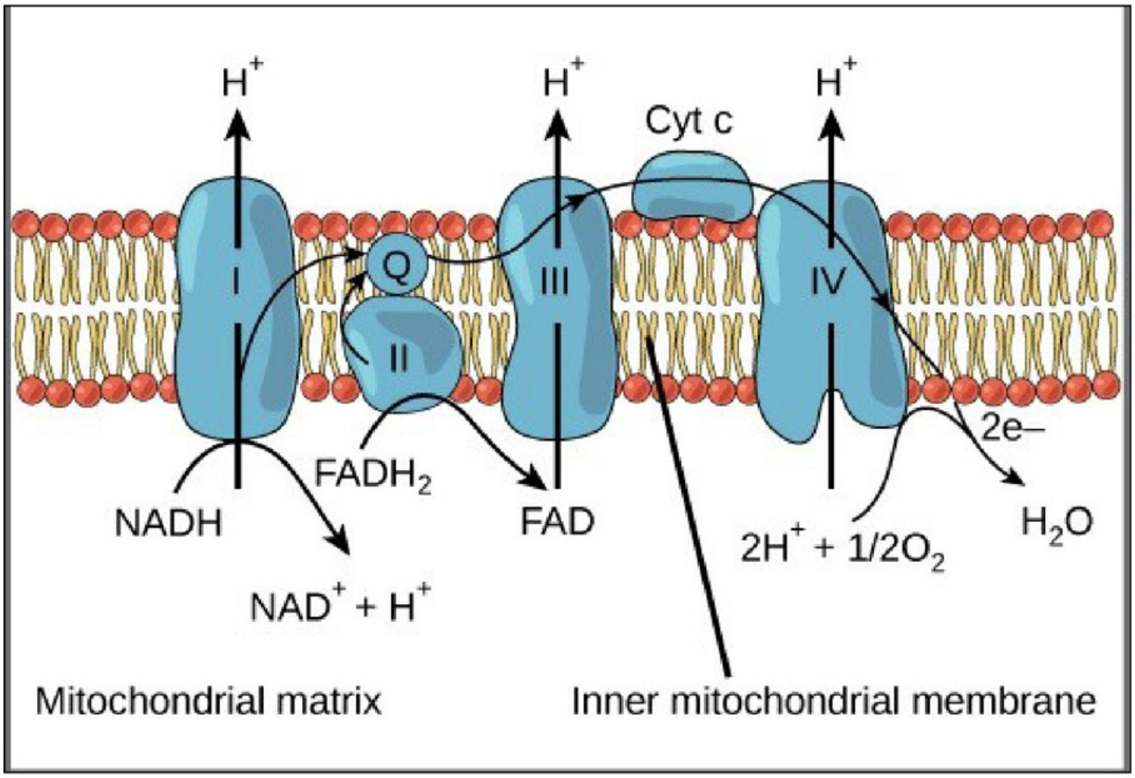

Figure 13 – Electron Transport Chain

The cell's valiant efforts at survival yield substantial benefits to the distiller. The mouthfeel, body and texture of a distilled spirit are all a function of the longer molecular chains of the higher alcohols produced by the yeast cell.

Esters

Esters are physically experienced by consumers of food and beverage as aromas in the nasal sensory system or as fruity tastes on the palate. For example, whenever I sip a Japanese Malt Whisky such as Hibiki, I marvel at its fruity character. These notes of fruitiness are esters.

One way that esters can be created for brewers and distillers is through decarboxylation. The raw materials used in brewing and distilling can contain fatty acids. The basic structure of a fatty acid is shown in Figure 14. The end group on a fatty acid is called a carboxyl group. Bacteria present in the fermentation medium can sever all or part of the carboxyl OH grouping. An alkyl structure of the general format CnH2n+1 can then move in to take the place of the severed bit and an ester will be created.

Normally, I advise distillers to focus intently on fermenter vessel cleaning and sanitation. However, there is a small margin for the introduction of bacteria into the fermenter vessel. In Scotland, I came across many distilleries using the traditional wooden fermenter vessels (washbacks). These vessels are built from staves of pine and larch wood. Bacteria (likely lactobacillus types) reside in the small cracks in the wooden staves. During the fermentation, these bacteria help to create esters by severing the fatty acid carboxyl groups.

There are other ways esters can be formed. In the Krebs cycle, it was noted earlier that acids are generated. Leading up to the start of the Krebs Cycle, a material called coenzyme A is formed. If coenzyme A combines with an acid the net result will be a structure called acyl CoA. When oxidized, acyl

CoA will form acetyl CoA. If an alcohol molecule joins to acetyl CoA, the net result will be an ester.

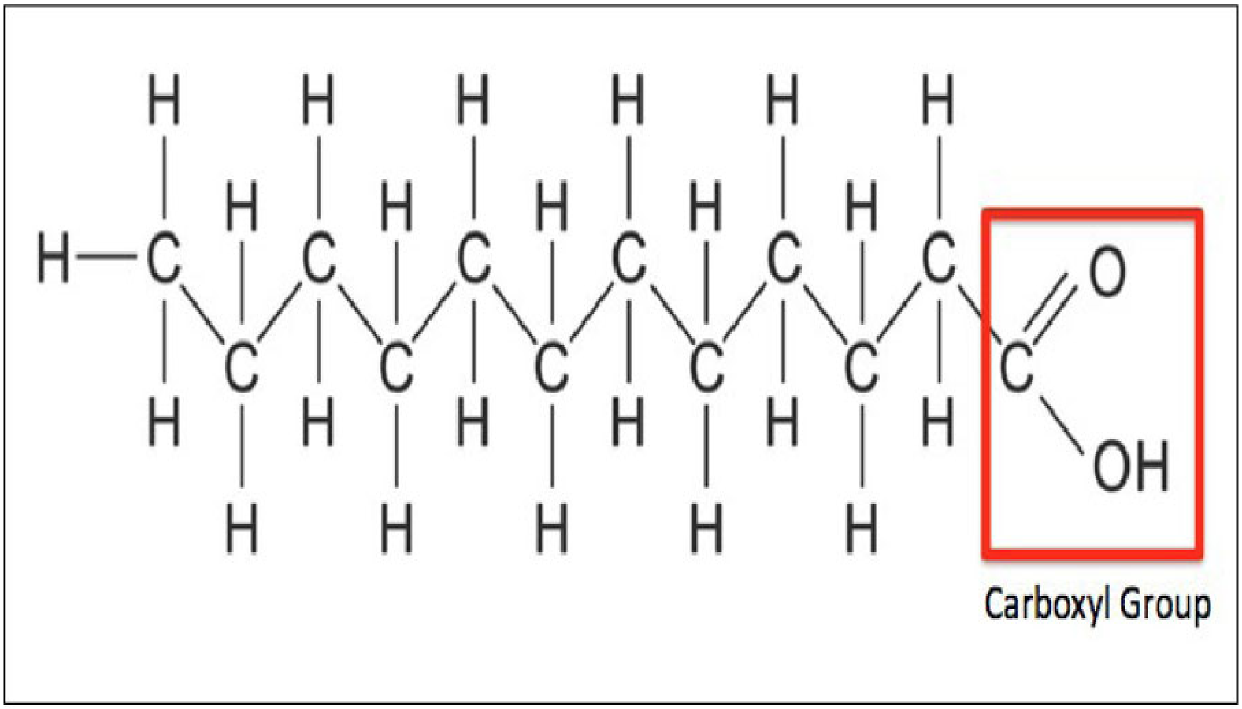

Figure 14 – Fatty acid structure

Esters can also be formed from pyruvate. In a yeast cell, there are two variants of an enzyme called acetylalcoholtransferase. These enzymes enable the decarboxylation (removal) of all or part of the OH unit in the pyruvate structure. The net result is acetyl CoA and when appended with an alcohol molecule an ester forms. (13)(14)(15)

On a couple occasions in 2018 and 2019, I experimented with the addition of lactobacillus plantarum to my mashes for making bourbon style whisky. My goal was to have the bacteria decarboxlate either some fatty acids in the mash or perhaps the pyruvate to generate esters. I doubt it is my imagination, but I sense some slight fruity notes in the end product. Lactobacillus plantarum is commercially available from yeast supplier Lallemand as a product called Sour Pitch which has been designed for craft brewers to make their hideous (my not so humble opinion) sour beers. In early 2020, one of my professors co-authored a paper in the Journal of Food Chemistry. Their study involved the deliberate addition of Lactobacillus plantarum to a mash of malted barley. Sensory evaluation panels were able to differentiate between the control distillate and the distillate with the added bacteria. (16)

Gluten Free

Gluten-free food and beverage has grown into a huge, multi-billion dollar business. Gluten-free has also found its way into distilled spirits. In Canada and the USA, the threshold for determining if a beverage alcohol is gluten free is 20 parts per million (ppm) gluten. Inside a kernel of grain, as previously discussed, the endosperm cells contain starch molecules cemented in place by proteins.

In wheat, these proteins are called gliadin and glutenin. Collectively, they are known as ‘gluten’. It is this elastic gluten that gives bread its spongy form. These wheat proteins cause some people with sensitive stomach linings to develop cramps and general gut upset.

In rye grain, the main intra-cellular proteins are called secalins. In oats, the term avenins applies and in barley the term hordein applies. In corn, the storage intra-cellular proteins are zeins and in buckwheat the term 13S globulin applies. Grains like corn, oats and buckwheat which are free of gliadin and glutenin are not going to cause gut upset.

Stolichnaya has monetized gluten-free grains and created a vodka product made from 88% corn and 12% buckwheat that is marketed as

gluten-free.

Where confusion enters the discussion is: the complex protein molecules from wheat, rye and barley should not be able to travel through the distillation process because they have a high molecular weight and will not be able to attain enough heat energy to rise through the distillation column. Therefore, all distilled spirits should be gluten free. But they are not. In past 5-day workshops, I have had gluten-sensitive people in attendance. It is amazing to see how quickly they react adversely to various distilled spirits. Some of these attendees with gluten sensitivities have even claimed that they can drink certain brands of distilled alcohol while other brands cause gut upset issues.

What likely is happening is small bits of gluten protein break loose and attach themselves to alcohol molecules. These small bits of gliadin and glutenin protein travel through the distillation process and end up in the final spirit.

More puzzling yet is how the US Government in 2020 declared whisky to be gluten-free. Having seen people react to various distilled alcohol products, I remain perplexed at the decision of the US government.

There is a test that can be applied to a beverage alcohol to determine if it contains gluten. The test is the ELISA Test, where ELISA is an acronym for Enzyme Linked Immuno-Sorbent Assay. An enzyme is added to a sample of the beverage alcohol being tested. The enzyme will bind to any gluten present. A second enzyme is then added which will bind to the first enzyme/gluten combination. In so doing, this second enzyme will exhibit color. Comparing the degree of color intensity to a standardized color chart will allow a scientist to determine how many parts per million (ppm) of gluten are present. The problem is, this determination is a visual one and subject to the lab technician’s ability to make a visual chart determination. For example, does the visual chart interpretation indicate the amount of gluten present to be 19 ppm or is it 21 ppm? Scientists are working to design a more accurate enzyme linked test for gluten.

What the Canada Food Inspection Agency has suggested is that a craft distiller can label a finished product as being a gluten-free spirit. But, a person being offered a taste in a distillery tasting room should first be asked out of courtesy if they are gluten intolerant. If they are, the advice is to offer them a wee sip to determine if they are having a reaction to the product. A tiny sip will immediately tell a sensitive person if there is going to be a problem. US craft distillers may also want to exercise caution. Put gluten-free on your label, have someone experience a reaction and you will find yourself on the receiving end of a lawsuit. Proceed cautiously on this gluten-free subject matter.

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5

Raw Materials

Having examined some of the principles behind Microbiology in the previous chapter, an examination of some of the raw materials that a distiller can use in the making of alcohol is next in order.

If craft distilling is to command a larger portion of the beverage alcohol market, it is imperative that craft distillers obtain a more thorough grasp of where various raw materials come from and what they are comprised of. Before a person commits to launching a craft distillery they should engage in at-home, small-scale, recipe development so as to become cognizant of the characteristics of various raw materials.

If a raw material product contains starch or simpler fermentable sugars, that material can be used to make alcohol. Fruit, sugar cane, molasses, potato, wheat, corn, barley, rye, millet, sorghum, oats, triticale, lentil, quinoa, rice, agave cactus, and even whey are all examples of raw materials that can be used to create alcohol. Before deciding on a particular raw material, a distiller must be sure to verify that the raw material is in alignment with the legal definitions that define the various spirit types. For example, In North America, rice is generally regarded as a cereal grain. In theory, one could make a rice whisky. But, rice may not be afforded the same cereal designation in jurisdictions outside of North America.

A discussion of raw materials extends to materials that can impart flavors to beverage alcohol. For example, products such as juniper, coriander, orange peel, lemon peel, lavender, grains of paradise, angelica root, and cinnamon are some of the botanical materials that a distiller could use in imparting flavor to gin, vermouth, and amaro type products.

Plant Growth Basics

When considering cereal grain, fruits, sugar cane plants, or agave cactus plants, a brief look at how a growing plant develops is helpful in better appreciating that raw material. What follows is a basic overview of how photosynthesis and the Calvin Cycle combine to help create plant starch.

In photosynthesis, photon energy from sunlight hits the leaves of a growing plant. The photon energy excites electrons in the plant cells, raising the electrons to a higher energy state. As the excited electrons return to their equilibrium lower energy state, ATP energy is released.

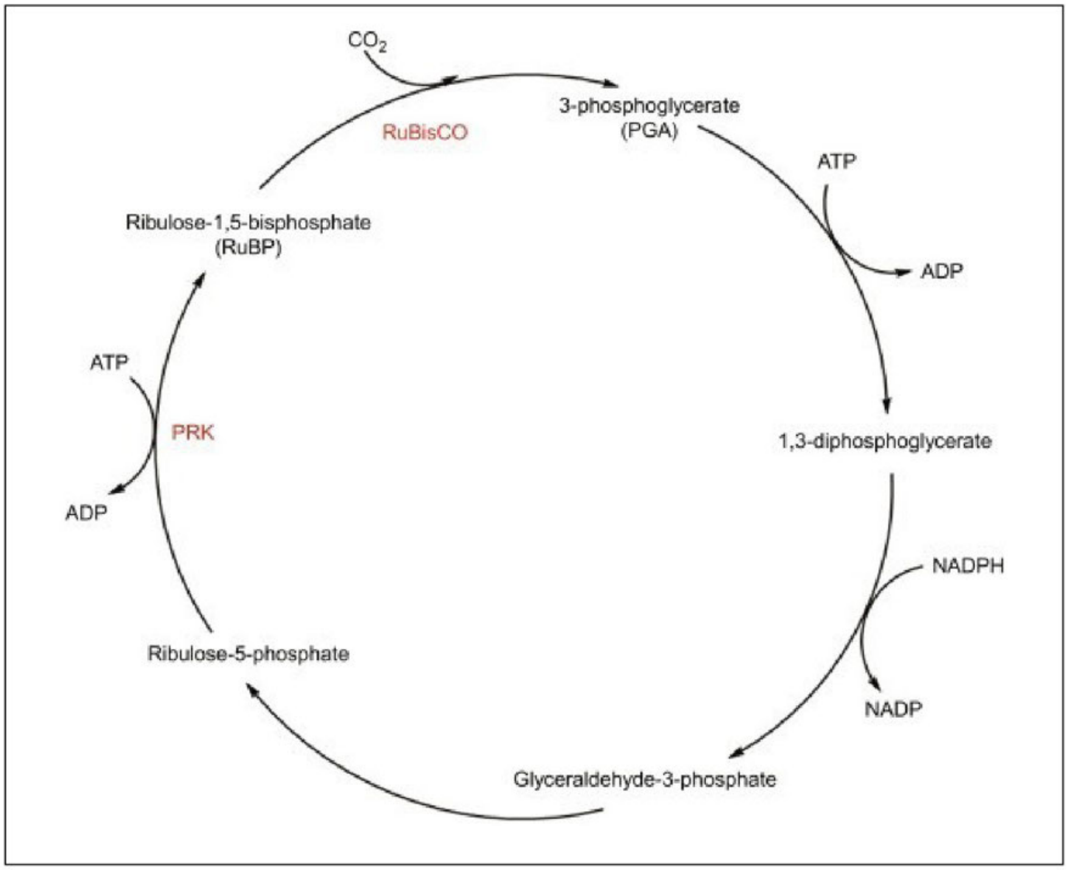

Figure 15 – Calvin Cycle

In the Calvin Cycle, carbon dioxide (CO2) is absorbed into the chlorophyll-bearing cells of the plant. With help from an enzyme (present in the plant) called RuBisCo, the ribulose 1,5 bi-phosphate present in the plant fibers is converted into two, three-carbon molecules of 3-phosphoglyceric acid. Energy from ATP, along with assistance from electron carrier coenyzme NADPH (both created in the photosynthesis process), removes a phosphate group from the 3-phosphoglyceric acid to make diphosphoglycerate which is in turn reduced to produce the three-carbon sugar, glyceraladehyde-3-phosphate. This three carbon sugar is turned into fructose diphosphate which the plant uses to create various formats of sugar-type molecules which are used in creating new plant structure. Figure 15 is taken from The Energy Dictionary, and illustrates the basics of the Calvin Cycle. (1)

Pomes, Berries, and Drupes

Fruit as a raw material class encompasses pomes, berries and drupes. In each of these sub-divisions, the physical structure of the fruit comprises an exocarp (outer portion), a mesocarp (the part we eat) and the endocarp (the inner part we throw away).

A pome is a fruit in which the endocarp consists of small seeds and a structural core. Examples include apples and pears.

A berry could be a blueberry, a raspberry, a haskap berry, a currant, and even a grape.

A drupe is distinguished from pomes and berries because its endocarp is a hard stone that we discard. Drupes are otherwise referred to as stone fruits. Think peaches, apricots and plums.

When working with fruits, one must take note of picking ripeness and consumption ripeness. In the case of berries and drupes, these two degrees of ripeness are practically the same. If it is ready to eat, it is ready to work with to make alcohol. But not all fruits make desirable alcohol distillate. As a case in point, consider peaches. While delightful to eat, the aroma and flavor that follows through into a distillate is weak. Apricots, on the other hand, make a remarkable tasting distillate. If making distillate from plums, look for the damson varietal from which prunes are made. With pomes, such as apples, over-ripeness can cause a loss of delicate flavors and aromas in the distillate. If contemplating pears, the most desirable varietal is the Williams pear flavor. However, literature suggests that the Williams pear has a high tannin content. Structurally, a C_6H_5 entity bonded to an OH^- entity in a ring-like structure is called a phenol. A series of phenols strung together in a chain is a polyphenol. Tannins are of the polyphenol structure. Prior to using these pears, they should be allowed to sit in a cool place so the tannins have a chance to break down. The result will be a smoother, more elegant distillate coming off the still.

As an aside, polyphenols have an affinity to bind with proteins. When we drink a young red wine and notice a drying sensation on the tongue, that is the tannin polyphenol interacting with the protein in the saliva on our tongue (a bit of scientific wisdom to take to your next wine tasting social event).

One berry worthy of serious consideration as a raw material is the grape. If you have been to a vineyard, or if you have seen pictures from a vineyard, you can appreciate that the flowering part of a grapevine is attached to a larger, almost tree-like, structure that has roots in the soil. This is called the trunk. From bud points on the trunk, there emerges shoots. Along the shoots there are more bud points, leaves and flower clusters. Some plant species will produce a terminal bud point where further growth halts. Not so with the grapevine. It will continue to grow as long as conditions are favorable. The flower clusters grow on the opposite side of the shoot from the leaves. Depending on growing conditions and varietal species, one to three flower clusters will form on a shoot.

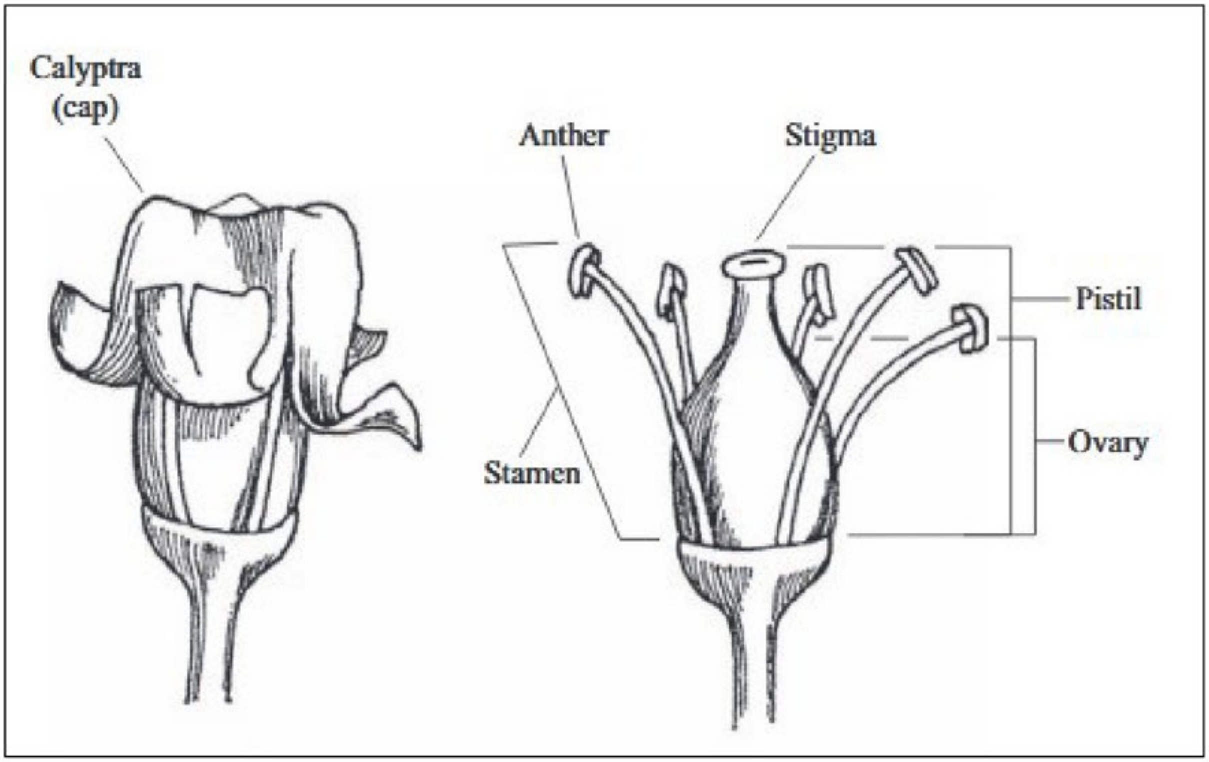

Figure 16 – Basic grapevine physiology

Figure 16 illustrates the basic grapevine physiology. (2) According to author E. Hellman in Oregon Viticulture, a flower cluster will contain many, individual flowers. These flowers are covered by a cap-like structure called the calyptra. This cap structure encloses the reproductive organs and other tissues within the flower. A flower consists of a single female organ called the pistil and five stamens, each tipped with a male organ called an anther. At the base of the pistil is the ovary which consists of two internal compartments, each having two ovules containing an embryo sac with a single egg. The surface of the ovary contains stigmas. The stigmas are a landing spot for the pollen grains produced by the anthers. The pollen grains land on the stigmas and proceed to penetrate the ovary. The time during which pollination occurs is called bloom (also anthesis) and can last from one to three weeks depending on weather. Viticulturists refer to full bloom as the stage at which roughly one-half to two-thirds of the caps have loosened or fallen from the flowers. The subsequent growth of the grapes from the fertilized ovaries will then be a function of weather and soil condition.

With pomes and drupes, the general physiology as just described for grapes applies, but with a key difference. For the most part, pomes and drupes are not self- pollinating. They have stamens, stigmas and ovaries, but transfer of the pollen from the anther to the stigma depends on bees or gusts of wind.

Bees are under duress in many parts of the world thanks to neonicotinoids, nasty chemicals with close structural links to nicotine. These chemicals are widely used by farmers for crop insecticide control. A 2014 article in the journal Science points out that neonicotinoids were developed 40 years ago in response to the chemical DDT being banned. Neonicotinoids are absorbed into all parts of a plant’s stem and leaf system, including the nectar on the flowers. Neonicotinoids damage the central nervous system of bees to the point where the bees can no longer function, nor navigate their way around to pollinate plants. As little as 5 nanograms transported by a bee back to a hive can kill off 50% of an entire bee colony. Lesser dosages can impair the colony’s ability to feed and to navigate. (3) As a craft distiller, give some thought to throwing your weight behind efforts in your community to help save the bees.

One of the essential building blocks of pomes, drupes and berries is the glucose molecule, C6H12O6. Figure 17, taken from a 2001 article by Charles Bamforth, (4) illustrates the glucose molecule assemblage which comprises six carbon atoms, twelve hydrogen atoms and six oxygen atoms. Chemists have a system for numbering the atoms that make up molecules which commences at the right side of a molecule. In glucose, the carbon atom at right is carbon atom number one, the oxygen atom at right is number one and the two hydrogen atoms are number one and two respectively. Progress around the ring-like structure in a clock-wise fashion counting incrementally to assign numbers to the other atoms. In Figure 17, I have numbered the carbon atoms to better illustrate the numbering methodology.

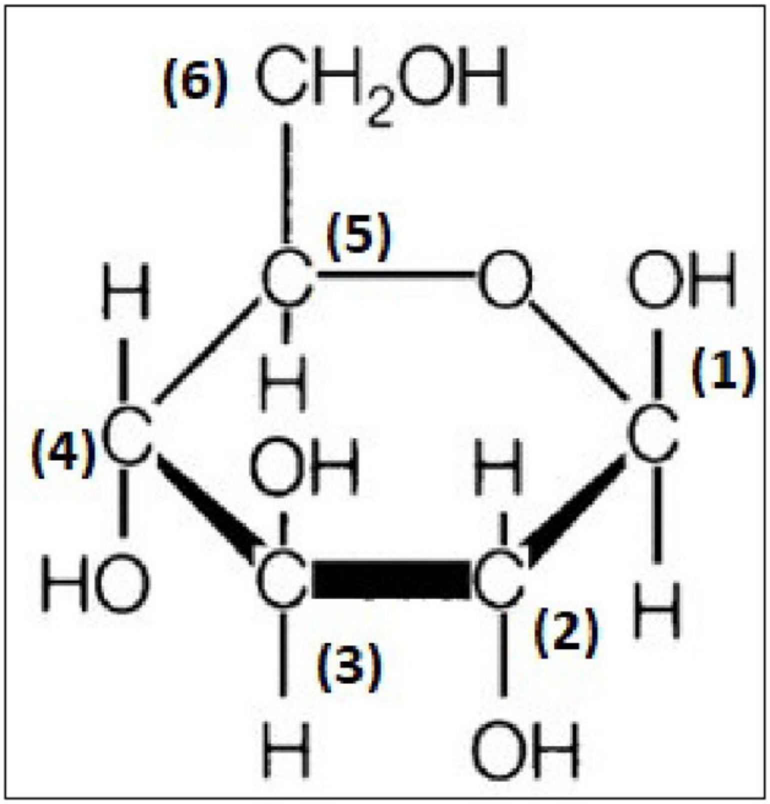

Figure 17 – Glucose molecule structure

In fruits, glucose molecules chemically bond to fructose molecules. Fructose is also C6H12O6 but the chemical links between the atoms and the angular displacements of atoms are slightly different than in glucose. Glucose and fructose will join together after each gives up a hydrogen ion. The resulting combination of glucose and fructose is termed a sucrose molecule. When we bite into a ripe piece of fruit and taste its sweet goodness, we are tasting sucrose. Figure 18, taken from an article by author Steve Curtis (5) illustrates the sucrose molecular assemblage. As fruit progresses towards complete ripeness, the oxygen bond between the two molecules breaks down. Yeast will then be able to consume each molecule individually during fermentation.

Literature suggests that fruits contain between 5% and 12% sugar by weight, with sugar comprising glucose, fructose and sucrose. The wide variation in sugar content amongst fruits is a function of the type of fruit (pome, drupe, berry), the varietal, the soil and climate as well as the seasonal growing conditions.

Apples contain about 12% sugar, apricots about 9% sugar, blueberries about 7% sugar, cherries about 11% sugar, mangoes about 14% sugar, papayas about 8% sugar, peaches about 8% and plums about 10% sugar.

These numbers do not bode well for a craft distiller seeking to use fruit as a raw material. The fruit will have to be sourced at low or no cost to compensate for the low alcohol yields.

Wine grapes have higher sugar content than pomes and drupes, with on average about 18% sugar. The type of grape, the climate and seasonal factors all will play a role in determining sugar content.

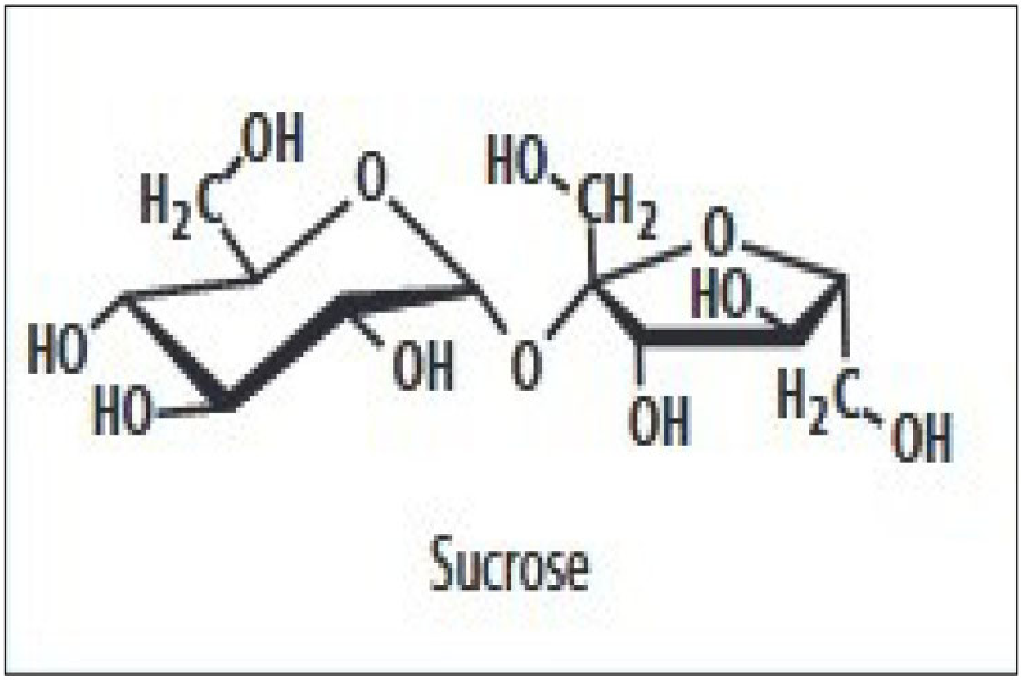

Figure 18 – Sucrose molecule assemblage

When using fruits, it is vital to ensure the products are free from mold and rot that can interfere with the yeast and the fermentation cycle. It is further essential to use products that are ripe enough so that the yeast can properly consume both the glucose and fructose molecules that comprise the sugar content.

The sugar content in fruits is stored in the cells that make up the fruit mesocarp. In order for the yeast to access the sugars, the cellular structure of the fruit must be broken down through crushing of the fruit. Care must be taken to avoid crushing the stones in drupes.

Inside a typical stone is a small pit. You can investigate this for yourself at home by taking the stone from an apricot or peach and giving it a crushing blow with a hammer. As the stone breaks, the small white pit inside the stone will become apparent. If this pit is allowed to be exposed to the fermentation process, a resulting by-product called ethyl carbamate (urethane) will synthesize. Ethyl carbamate is regarded by health authorities as being potentially carcinogenic.

When working with fruit, opinions vary as to whether or not to add water to the crushed material. My personal approach is to add ½ liter of water to each 1 kg of mashed fruit. In my experience with fruits, I have found the starting pH acidity of the mash will be lower than that of a typical grain mash. I have had my best fermentation success using a wine type yeast that is suited to a lower pH environment. Standard distillers yeasts may exhibit sluggish behavior due to the low pH. If using a wine yeast, the temperature of the mash at the time of yeast pitching can be around 20ºC.

As will be discussed in a future chapter, yeast needs amino acids and short peptide chains to create new cellular material in order to propagate daughter cells. Fruits, by virtue of their high water content, have low levels of protein. Care must be taken to ensure that adequate dosages of yeast nutrient are added to a fruit mash so that the fermentation properly goes through to completion. A yeast cell starved for nutrients cannot make DNA and RNA to facilitate daughter cell growth. For small scale, home recipe development, consider using a product called Fermaid-K, available at any local home brewing store. Follow the dosage recommendations on the package. For craft distillers, speak with your yeast supplier. Yeast suppliers such as Lallemand will have their own proprietary nutrient blends that will be sold in larger quantities.

Sugar Cane

The basic physiology and chemistry of fruits also extends to an examination of sugar cane and its by-products. Sugar cane is a perennial grass of the genus Saccharium Officianarum.

Sugar cane grows between north latitude 37 degrees and south latitude 31 degrees at altitudes up to 1,000 meters above sea level provided such areas have significant rainfall and temperatures that range from 25ºC to 35ºC. To illustrate this geographic range, picture the entire globe with a horizontal line drawn through the southern tip of Italy and another horizontal line drawn through the southern tip of Africa. The areas around the world that fall between these lines are potential sugar cane growing regions provided they meet the elevation, rainfall and temperature parameters listed above.

While plants in general are efficient at utilizing solar energy, sugar cane is regarded as an extremely efficient convertor of solar light energy. There are four stages to the growth of a sugar cane plant. (6)

At the start of the growth season, the cane plant will sprout. Two cotyledon leaves will appear on the stem as it emerges from the soil. Beneath the ground, the root mass will have buds on it.

About 20 days later, the second stage of growth, tillering, gets underway. During this stage, new shoots form every three or four days from the underground buds. Not all of these new shoots will survive. The tillering phase will see the cane gain height over about four months.

The next stage is the grand growth phase which commences about 120 days after planting. This stage sees the plant form vegetative mass that eventually is recognized as cane. This phase will last five to eight months.

The final stage is the maturation stage and it will last three months. During this stage, the cane stalk will develop sucrose material in its fibers. A sample of juice extracted from the ripening cane stalk will indicate a Brix reading of 12-16° Brix. This unit of measure describes the amount of fermentable sugars present in 100 grams of raw material.

After the cane plantation has ripened, the canes are cut as close to the ground as possible as the lower part of the canes has the highest sugar content. The harvested canes are taken to a processing plant where they are fed between rollers that press the juice out. Lime (CaOH) is added to the juice to help precipitate out any plant matter. The juice is heated to 80-85ºC and as it heats, CO2 is bubbled into the vessel to further encourage solids to drop out of solution. A vacuum is then applied to the cooking vessel to draw off liquid and to help concentrate the sugars. The concentrated liquid is centrifuged to recover the crystals of sugar. The remaining liquid left after sugar crystal extraction is called molasses.

In terms of process efficiency, 100 tonnes of cane will produce eleven tonnes of sugar and three tonnes of molasses. Not all molasses is the same. With the high price of sugar on global markets, it is common for sugar processors to do a repeat extraction of sugar from the remaining molasses. This then gives rise to the various grades of molasses a distiller will find for sale. Hi-Test, also called Fancy grade, will have the most available fermentable sugar. At the bottom of the list will be Blackstrap with a sharp taste and little residual sugar. Choose wisely. I personally gravitate towards the top-of-list Fancy Molasses.

Molasses can be sulphured or un-sulphured. During processing, sulphur is added if the producer is aiming to obtain white crystals of sugar. Residual sulphur in molasses could inhibit proper functioning of yeast during fermentation.

A tablespoon of molasses can provide the average person with up to 20% of their daily mineral requirement. This robust mineral content will also benefit yeast cells during fermentation. The sugar content of molasses (complex combinations of sucrose, glucose and fructose) is about 50%, which makes molasses a valuable raw material for distillers to use. 100 kgs of good quality molasses will generate about 30 liters of alcohol.

However, caution is warranted. Molasses can contain bacteria strains such as Leuconostoc Meserentoides and Zymomonas Mobilus. Leuconostoc converts sucrose into non-fermentable dextrans. The 1-6 linkages in the dextrans make assimilation by yeast difficult, so a distiller obtaining infected molasses might find low yields of alcohol after a ferment. Zymomonas produces unwanted H_2S rotten egg type aromas which can carry through the distillation process. To kill off any bacteria, a distiller should consider diluting the molasses slightly and then heating it to just over 75ºC. Holding at that temperature for as little as 30 minutes will kill off bacteria. Another option is to add sulfuric acid to lower the molasses pH to near 4, where bacteria can no longer survive. Such a low pH might then create difficulties for the yeast, so some upwards adjustment of pH to the 5.5 level will be required. Prior to adding yeast to start a ferment, the molasses should be further diluted with water to just under 17º Brix otherwise the yeast cells will be extremely unhappy because of the osmotic pressure placed on them from the dense molasses. (7)

Sugar Beet

In parts of western Canada and neighboring American states like Montana and Idaho, sugar beet is a common crop. Not far away from a sugar beet growing area, one will usually find a processing plant that buys the sugar beets. In western Canada, there is a processing facility in Taber, Alberta owned by Roger’s Sugar. The harvested sugar beets arriving at the facility are cleaned, cut and heated in water to about 70ºC. The resulting sugary sweet liquid is further cooked in the presence of chemicals such as lime to precipitate out sugar crystals.

The remaining sludge at the end of the process is too called a molasses, but it differs in taste and viscosity from molasses left over from sugar cane processing. The reason it differs is the make-up of the sugar content. The sugar in sugar beets is mostly sucrose and thus lacks the complexity of the sugars in cane molasses. Using the less expensive sugar beet molasses is generally favorable economically, but the resulting product does not have the depth of flavor that a sugar cane molasses spirit has. This is an important consideration for craft distillers.

Cereal Grain

When considering cereal grain as a raw material for alcohol creation, it is important to examine seed structure, and plant physiology. Figure 19, taken from the textbook Biochemistry of Foods, illustrates the key parts of a grain kernel.

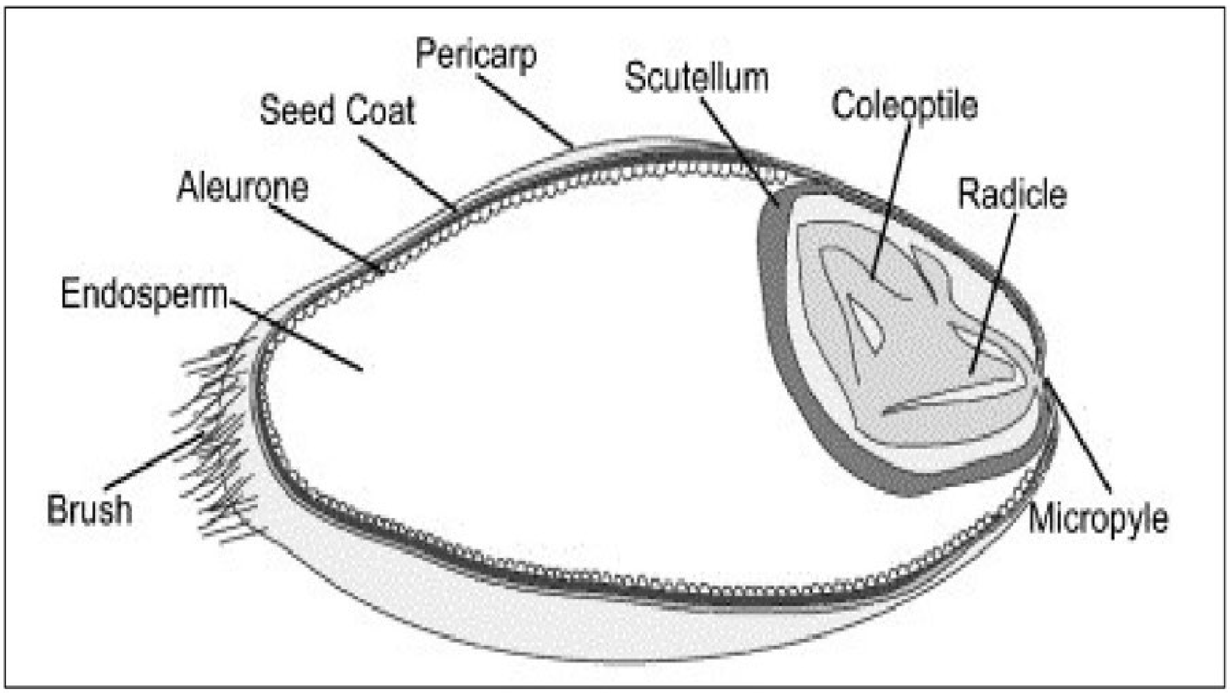

Figure 19 – Basic structure of a grain kernel

A kernel of grain, if healthy, is a living, respiring entity. The kernel is divided into two components with the scutellum membrane acting as a divider. The end of the kernel near the scutellum is called the micropyle end. This is the end through which the kernel will absorb moisture if exposed to water. The scutellum is also where a hormone called gibberellic acid (GA) is synthesized. Located at the micropyle end are the coleoptile and the radicle (sometimes called the coleorhiza). The coleoptile is what will emerge from the kernel as the acrospire (the shoot) during kernel germination. In the case of a kernel that gets planted in the ground by a grain farmer, the coleoptile will eventually emerge above the soil as a culm which will grow into a stem. The radicle (coleorhiza) will emerge from the kernel as the root which will anchor into the soil to act as a conduit of nutrients and moisture to the growing plant. Other roots called seminal roots will follow in the process. (8)

Once the culm emerges from the soil it becomes subject to photosynthesis and the Calvin Cycle. A cereal grain plant will then develop auxiliary shoots called tillers. As the culm (now called a stem) grows higher, leaves develop. Approximately five weeks after seeding, the final leafing stage is reached. The final leaf is called the flag leaf and its formation signals the end of the plant growth phase and the start of the reproductive phase.

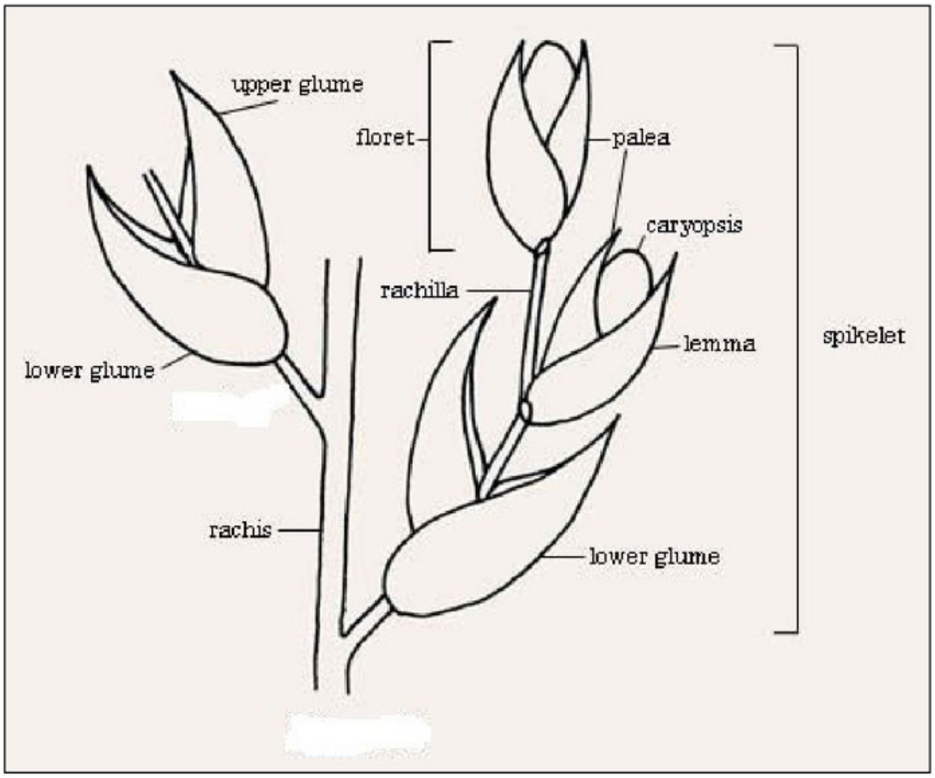

Figure 20 – Kernel development

In the reproductive phase, a grain head structure starts to take shape within the sheath (called the boot) of the flag leaf. A grain head structure comprises a main structural linear axis feature called the rachis. Branching off the rachis in alternating fashion side to side are several rachilla structural features. Each rachilla hosts florets. The rachilla-floret structures are called spikelets. Figure 20 illustrates further. (9)

Each floret is a potential flowering unit and will consist of an upper glume and a lower glume. Inside the glumes are the lemma and the palea. Within the lemma and palea structure is found the embryo from whence a new kernel of grain will be formed.

A fertile floret will yield a flower which will develop into a grain kernel. Barley has three spikelets (flowering units) at each rachis node. If all flowering units are fertile, then groupings of three kernels will form. Three kernels on one side of the rachis and three on the alternating side made a total of six. This is what a plant breeder would call a 6-row barley. If only the middle floret is fertile, the result will be one kernel on one rachis side and one kernel on the opposite side. This is a 2-row barley.

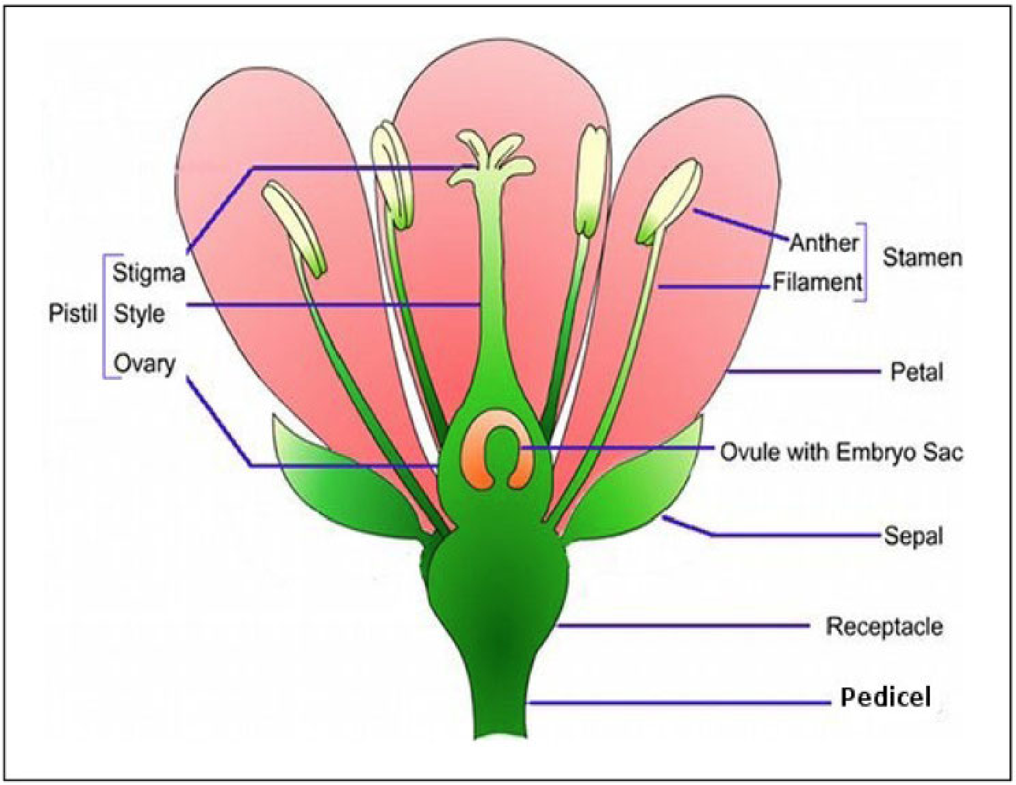

Figure 21 – Cereal Grain Reproduction

As Figure 21 shows, (10) a fertile floret comprises stamen which are each tipped with a male organ called an anther. The pistil comprises the stigma, the style and the ovary. The ovary contains an embryo sac with a single egg.

The stigmas are a landing spot for the pollen grains produced by the anthers. The pollen grains land on the stigmas and proceed to penetrate the ovary. In the case of wheat, rye and oats there are no 2-row or 6-row delineations. Wheat and oats will have between three and five florets at a spikelet of which two or more will be fertile. Rye will have three to five florets at a spikelet of which only two will be fertile. Corn will have two florets at a spikelet of which one will be fertile. After pollination, a grain kernel will start to grow at each pollinated floret. Grain kernels will mature fully over about 40 days.

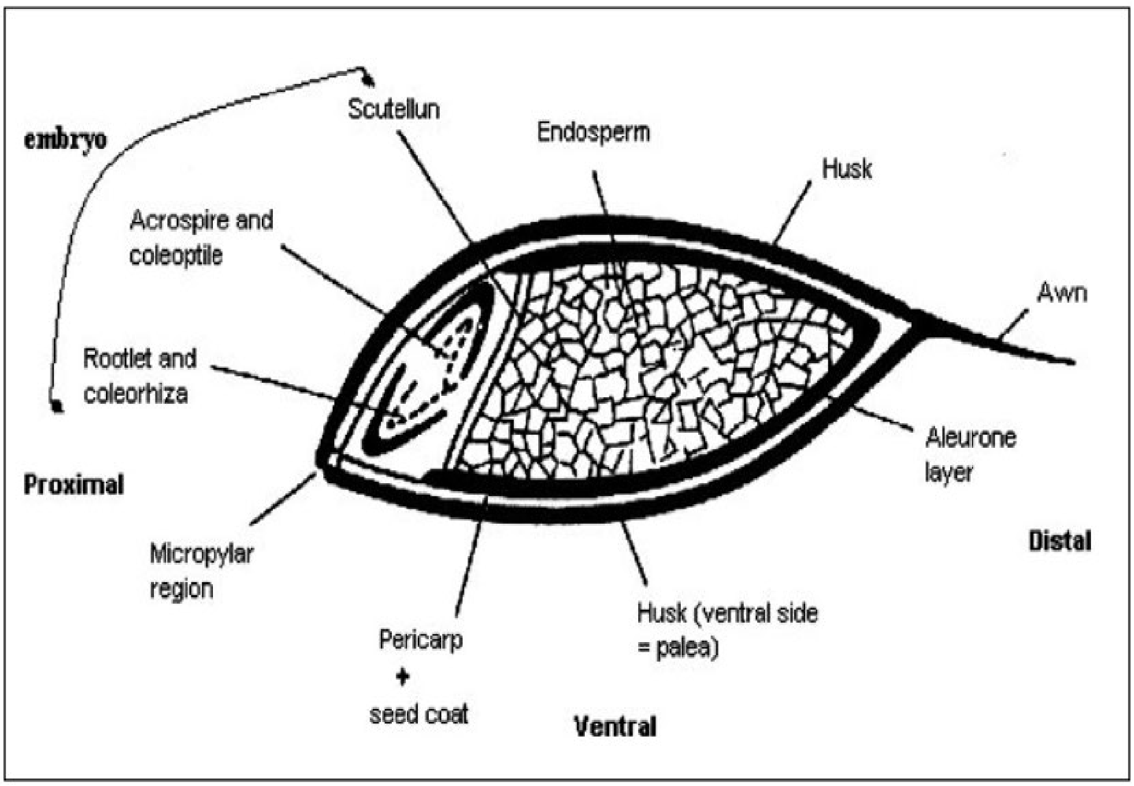

Figure 22 – Detailed structure of a grain kernel

As the newly created kernel matures and starts to grow, the cells that comprise the glumes will fuse to the cells that comprise the lemma and palea. In a mature grain kernel, these fused tissues are recognizable as the husk, the pericarp-testa as shown in Figure 22. Immediately underneath the pericarp-testa is the aleurone layer. Also in this figure, note the top part if the kernel is called the dorsal side (think of a fish with its dorsal fin on top). The bottom part of the kernel is the ventral side. The collective bits found in the micropyle end are classed as the embryo. (11)

Not all harvested grains retain their husks. Barley is one grain that will retain its husk all the way through harvesting and handling. Rice and oats are two others. Wheat and rye will shed their husks as the grain is threshed in the farmer's combine.

The bulk of a mature kernel's mass is the endosperm. The endosperm cells contain starch globules cemented in place by proteins. Both are desired by brewers and distillers to make alcohol.

To grow a crop of grain, a farmer will plant grain seeds in the soil. Exposing the kernel to moisture and warmth (the farmer's field has warm moist soil during spring planting) will trigger the coleoptile and coleorhiza into action.

A rootlet will start to make its appearance at the micropyle end of the kernel. This event is called chitting. This rootlet will soon be joined by other rootlets. This main root is the radicle and the others that form are the seminal roots. All of these roots will anchor themselves into the soil.

Next, the coleoptile will start to grow, but it does not emerge from the grain structure. It prefers to remain close to the kernel and will progress under the husk availing itself of protection from the elements as it grows. Eventually though, it will emerge from the awn end of the kernel and from there progress vertically upwards to emerge above the soil. This event is what the farmer calls emergence and it signals that the seed planting efforts have been a success. The emerged coleoptile at this point is termed a culm. The culm transitions into a stem. Leaves grow until the flag leaf develops. The cycle of life involving florets, stamen and stigma then repeats itself.

Where has the grain kernel managed to find the energy and the nutrition to put on this burst of growth? The answer rests with the generation of giberellic acid (GA) which was synthesized in the scutellum area. The GA migrates towards the aleurone layer where it triggers the synthesis of a series of enzymatic proteins. These enzymatic proteins will start to degrade (tear apart) the cell walls of the endosperm as well as the interior of the cells. This degraded material along with starch and protein from the cell interior is the source of food energy for the kernel to develop its root and shoot.

In the previous chapter, the structure of cellulose, hemicellulose, glucan and pentosan were described. Mother Nature uses these constructs to create the internal endosperm cell structure of a grain kernel. Recall that if the OH group at the right side of a glucose molecule is rotated 180 degrees, and if between 7000 and 15,000 such units are joined together using 1-4 linkages, the result will be cellobiose. Thousands of cellobiose units joined together creates cellulose.

If the H-OH structures at carbon atoms 2 and 3 in a glucose molecule were flipped 180 degrees, the result will be a 6-carbon sugar called mannose.

Removing one of the carbon atoms from a glucose structure to leave a 5-carbon structure is termed a xylose.

A chain of xylose, mannose and glucose molecules numbering between 500 and 3000 molecules, would be termed a hemicellulose. Two or maybe three glucose units joined with 1-4 linkages (in the fashion of an amylose) having other glucose units bonded to the 1-3 location in a repeating fashion is termed a beta glucan.

A repetitive chain of xylose with periodic insertions of a 5-carbon sugar molecule (arabinose) using 1-3 and 1-2 linkages is termed an arabinoxylan, otherwise called pentosan.

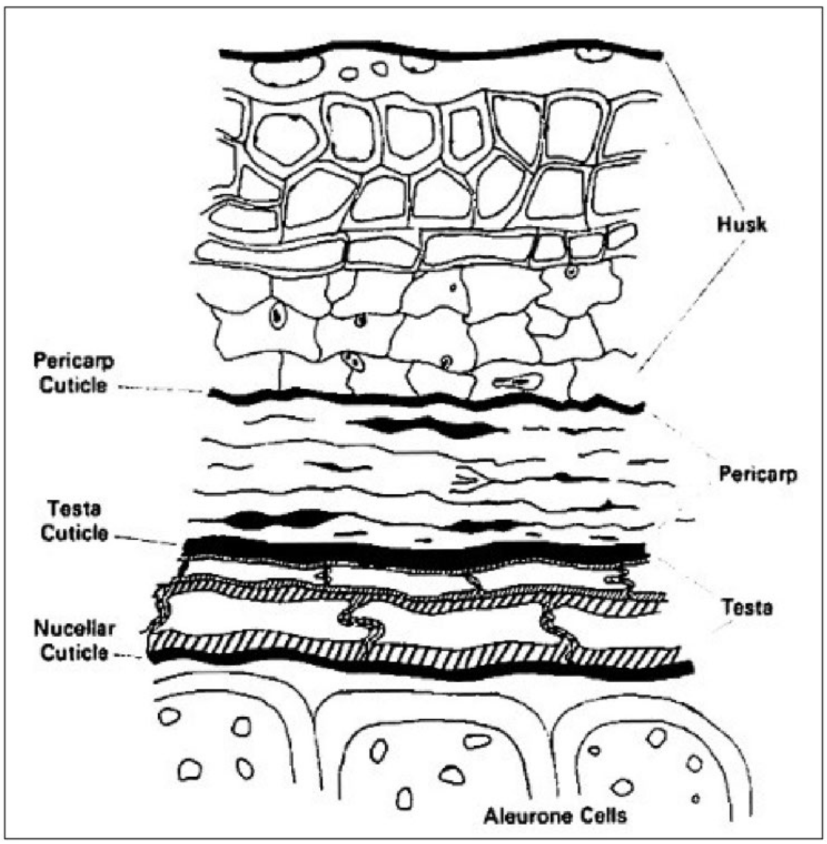

Figure 23 – Kernel outer layers

Figure 23, from a 1984 paper published by Heriot Watt University researchers Freeman and Palmer, (12) illustrates the cellular structures inside a grain kernel. The pericarp and testa cells comprise about 6% of the weight of a kernel of grain. The cell walls are made up of celluloses and pentosans (hemi-celluloses) which are linked 5-carbon sugar structures.

The aleurone cell walls are made up of roughly 60% pentosans and 30% celluloses with the balance being fats (glycerides) and minerals. The interior of the aleurone cells comprise lipids, minerals and proteins.

The endosperm cells comprise nearly 80% of the weight of a kernel. The cell walls are made of roughly 60% beta (1,3) and beta (1,4) glucans with the remainder pentosans (28%), phytic acid, carbohydrate and a small bit of protein (5%).

Each cell is a three-layer sandwich where a middle layer of protein is surrounded by two layers (one on each side) of the glucans and pentosans. There is currently some debate among leading scientists as to whether the pentosan is only on one of the layers or on both. There is further debate as to whether the outer layers of the wall structure are solid or perforated. Figure 24 illustrates the construct of the cell wall. (12)

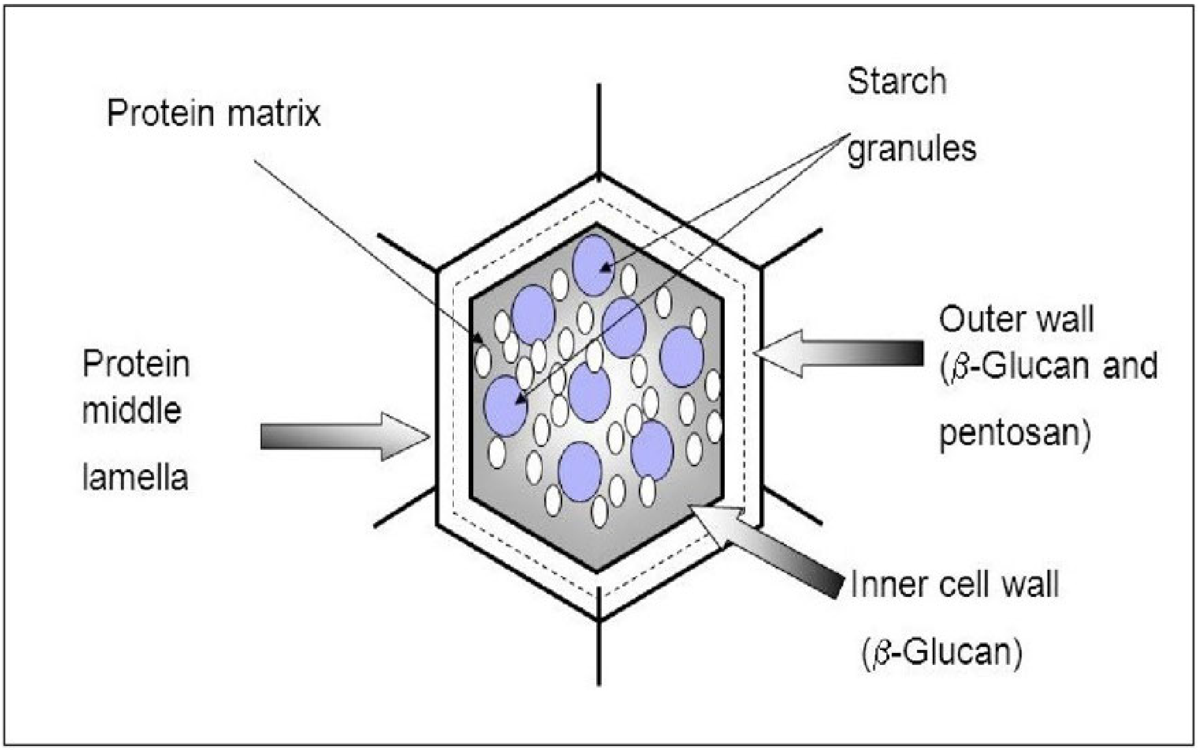

Figure 24 – Endosperm cell layers

The interior of an endosperm cell hosts granules of starch in both small and large sized formats. These are the starches that brewers and distillers are interested in for fermenting into alcohol. These starches are termed storage carbohydrates.

The starch molecules are cemented into place by protein molecules. These proteins are termed grain storage proteins. Think of this overall structure as starch being held prisoner in a 3-layer-thick maximum security jail. In rye grain the storage proteins are named secalins. In oats they are named avenins. In barley they are named hordeins. In corn they are called zeins. In wheat they are called gliadin and glutenin. If these latter two names sound vaguely familiar, they are collectively known in everyday language as glutens.

When using cereal grain as a raw material, yeast is not capable of digesting the long molecular chains of starch. A distiller must first break down the grain endosperm cell structure and then further break down the chains of starch contained within. Yeast is capable of digesting the smaller bits of broken-down starch. These bits will take the form of glucose, maltose and maltotriose. Two glucose molecules joined together creates a maltose. Three glucose molecules joined together creates a maltotriose.

There are two ways of accomplishing endosperm cellular breakdown: using the naturally occurring proteolytic enzymes in grain or using laboratory synthesized proteolytic enzymes in conjunction with heat energy. A proteolytic enzyme is a protein that has special binding sites in its structure.

Naturally Occurring Enzymes

An enzyme hastens a chemical process or reaction. An enzyme is not destroyed or altered during the chemical process. In an earlier description, I used the analogy of Wiley Coyote using a stick lever to help him push a rock over a cliff edge in a quicker, easier manner. Another way of thinking of an enzyme is as a piece in a jig-saw puzzle. It takes a certain piece (enzyme) to match up with another piece (substrate) of the puzzle. In the context of cereal grain being used as a raw material, the endosperm cells walls are a substrate to which an enzyme binds. The 1-4 linkage sites or the 1-6 linkage sites on a starch molecule are another example of a substrate. A two-molecule glucose structure or a three molecule glucose structure are further examples of substrates that an enzyme will bind to. In Figure 25, (13) a molecule of maltose attaches to the binding site on an enzyme molecule, just like two pieces of a jig-saw puzzle coming together. The energy of the enzyme severs the maltose into two bits which then leave the binding site. The enzyme is then free and available to visit with other maltose molecules. This substrate-binding site model was first conceived in 1894 by scientist Emil Fischer who termed it the lock-and-key model. The process of breaking a substrate is complex. In the previous chapter it was shown that a protein assembly contains a functional “R” group. Scientists have determined that proteolytic enzymes are proteins containing histidine, serine, or aspartic acid “R” group amino structures. The mechanism through which the enzyme breaks a substrate entails these amino acids facilitating increased flow of protons away from the active binding site. This flow of electric charge and reduction of proton numbers encourages the substrate bonds to break. (14)

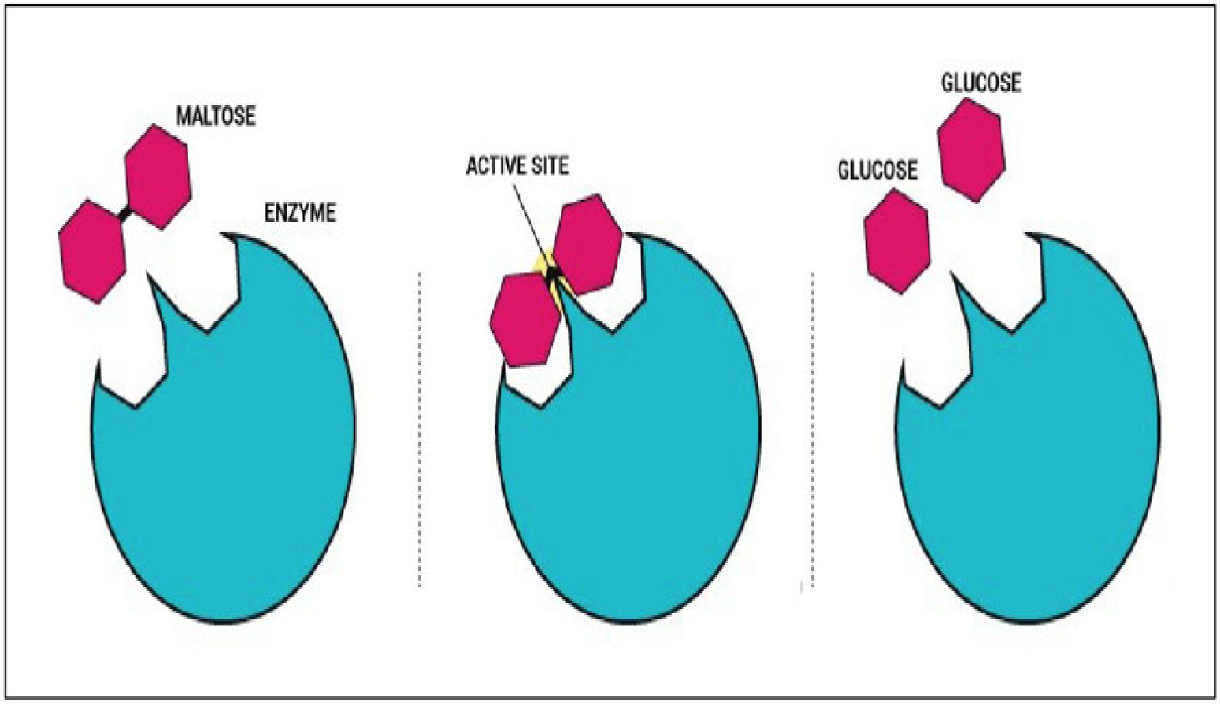

Figure 25 – Enzyme lock and key model

As a grain kernel starts to generate its root and shoot, the Giberellic Acid (GA) that was formed in the scutellum membrane is busy unleashing a series of enzymes in the aleurone layer. Scientists have mixed opinions as to whether the GA releases already-existing enzymatic proteins in the aleurone or if the GA causes the synthesis of new variants of protein that are enzymatic in behavior. What is known is that the enzymatic proteins that derive from the aleurone layer include: (15)

Phosphorylase, which degrades amylose starches, but not amylopectin starches.

Alpha-glucosidase, which breaks down both amylose and amylopectin starches.

Beta-amylase, which attacks amylose starches and cleaves off units of two glucose molecules (maltose). This enzyme also attacks 1-6 linkages, but not adjacent 1-4 linkages. The net result is short chains of 1-4 linked glucose molecules called limit dextrins. Beta-amylase is at its optimum performance level at around 64ºC. Its preferred pH range is 5.0 to 5.3. A group of German researchers (15) have voiced a strong opinion that the beta amylase already exists in the aleurone layer, but is linked to an inhibitor molecule. The Giberellic Acid (GA) severs this link and activates the beta amylase.

Alpha-amylase, which attacks 1-4 linkages at random locations in the starch chain (just not near 1-6 linkage spots). Its efficiency improves markedly when beta-amylase is also present. Alpha-amylase is at its best performance around 74ºC. It's preferred pH range is 5.0 to 5.3 and it is particularly stable in the presence of calcium ions (which derive from the water being used by the brewer or distiller).

Limit-dextrinase, which attacks 1-6 linkages and in so doing frees up more 1-4 linkages for the alpha and beta amylases to attack.

Beta-Glucan solubilase, endo (1,3) and endo (1,4) beta glucanse, which collectively attack the beta glucans in the endosperm cell wall and the links to the protein lamella layer (see Fig. 24).

Endo-peptidase, which attacks the storage proteins in the endosperm cell, breaking the proteins into smaller pieces.

Exo-peptidase, which in conjunction with endo-peptidase breaks the smaller protein pieces into individual amino acids.

Carboxypeptidase, which further attacks the storage proteins.

Collectively, all these enzymes working together will break down the endosperm cell structure of the grain kernel. The starches and proteins freed up from within the endosperm cell provide food energy for the grain kernel to develop its root and shoot. When the grain is mashed and used in a fermentation, the freed up starches and proteins will then be assimilated by the yeast cells to facilitate the formation of pyruvate and then alcohols. Grain that has been allowed to develop a root and a shoot is called malted grain. The malting process will be examined later in this chapter.

Synthesized Enzymes

It is possible for a distiller to use un-malted grains that have not been allowed to develop a root and a shoot. The addition of enzymes created in a laboratory will serve to break down the un-malted grain endosperm cell structure. It is common to hear these laboratory enzymes referred to as ‘artificial enzymes’. But there is nothing artificial about them.

Research into enzymes dates to 1913 and German scientist Otto Rohm who investigated the use of enzymes from the pancreatic tissue of slaughtered animals. But, enzymes do not just come from animals. A paper (16) from 1952 describes how researchers added Aspergillus Oryzae fungus to a 4% sucrose solution. The fungus could sense the osmotic pressure from the dense sucrose in solution and instinctively the fungus knew that it was surrounded by food. The fungus started secreting a milky liquid which was designed to break down the sucrose molecules into glucose and fructose so that they could be digested. The milky secretion was a proteolytic enzyme material. Today, large commercial enzyme makers utilize stainless steel reactor vessels into which they place fungus material plus nutrient food under controlled conditions. As the fungus secretes protein material, the material is filtered off and refined for packaging and sale to brewers and distillers.

Different enzyme types are generated under different process conditions. The fungal matter used will most likely be Aspergillus Oryzae or Aspergillus Niger.

If enzymes seem like a foreign subject, they ought not be. Although we consumers do not know it, our lives have been impacted by enzymes.

The next time you do a load of laundry, bear in mind your detergent contains amylase and glucoamylase enzymes which break down the proteins and carbohydrates in the food stains on your dirty shirt to be laundered.

As you reach for your wallet, consider that the leather has been made soft thanks to protease enzymes that have partly broken down the leather protein structure.

If you see a new pair of ripped, faded, denim jeans in the store, know that laccase enzymes have been used to partly degrade the denim (cotton) fabric.

When you drink a commercially-made lager style beer and wonder how it can be made so clear, the answer rests with alpha acetolactate decarboxylase enzymes that were used to break down any protein haze in the beer.

Every morning when you brush your teeth, there are a series of reactions that will occur in your mouth. Amylase and glucoamylase enzymes will break down the foodstuff on your teeth into glucose. A glucooxidase enzyme in the toothpaste will oxidize glucose to hydrogen peroxide. A lactoperoxidase enzyme in the toothpaste will then oxidize the thiocyanate in your saliva into hypothiocyanite which is an antibacterial, which keeps your mouth fresh.

Industry is also impacted by enzymes. Amylases, xylanases and lipases are used in the paper making industry. Phytases are now being added to animal feeds to help digestion and reduce animal flatulence, which is a greenhouse gas!

But not all enzymes are working in our favor. Look on many food packages in the grocery store and you will see high fructose corn syrup being used as a cheap additive. High fructose corn syrup is created by taking a mash of corn, heating it with an amylase enzyme to break down the starches. An enzyme called glucose isomerase is added to make the glucose sugar molecule re-arrange itself into a fructose molecule. (17) This re-arranged molecule tastes sweeter than ordinary sugar. Hence, food makers get away with adding less of it to get the same degree of sweetness. Problem is, our bodies do not like to digest high fructose sugar. Our cellular tissues store it in our system as fat. Fat in excess, can lead to disease.

There are a number of enzyme makers in the world. The largest is Novozymes, headquartered in Denmark. In North America, a California-based company called Gusmer Enterprises is the sales agency for Novozymes products. Another large concern is BSG (Brewer's Supply Group), a wholly owned subsidiary of German malting company Rahr. Yet another large player to bear in mind is Dupont Chemical. As a craft distiller, make contact with each of these entities. Each will no doubt argue that its enzymes are better than the competitor's enzymes. I have used enzymes from each of these suppliers and I am equally impressed by all. If there is a significant difference between these suppliers, it will be on price.

For entrepreneurs seriously contemplating a craft distillery project, the question arises as to where one might obtain enzymes for at-home recipe development purposes. It used to be that you would have to convince a craft distiller to sell you some enzymes. But in early 2020, enzyme maker BSG introduced enzymes for sale at the retail level. Visit your local home brewing supply shop and ask if they can sell you HiTempase, Bioglucanase, and

Amylo 300 from BSG. If they do not have these products in stock, they will be able to get them for you. When you get the enzymes, keep them in the refrigerator. They will maintain their viability for several years beyond the best before date stated on the container if kept cool. In late 2020, I used up the last bits of some still-viable BSG enzymes that were labelled as being best before July 2016. I had taken great care since 2016 to keep the enzymes in my refrigerator.

The significant differences between using sprouted (malted) grain with its naturally developed enzymes and non-sprouted grain with artificial enzymes are primarily time, pH, and temperature. Artificial enzymes and un-malted grains will demand a higher mash temperature and more attention to pH. The overall time required to complete the breakdown of the starch chains to smaller sugar units will be perhaps three times as long.

To illustrate the performance of laboratory synthesized enzymes, consider the following sketches of activity plots that I have created from data provided to me by Novozymes (USA).

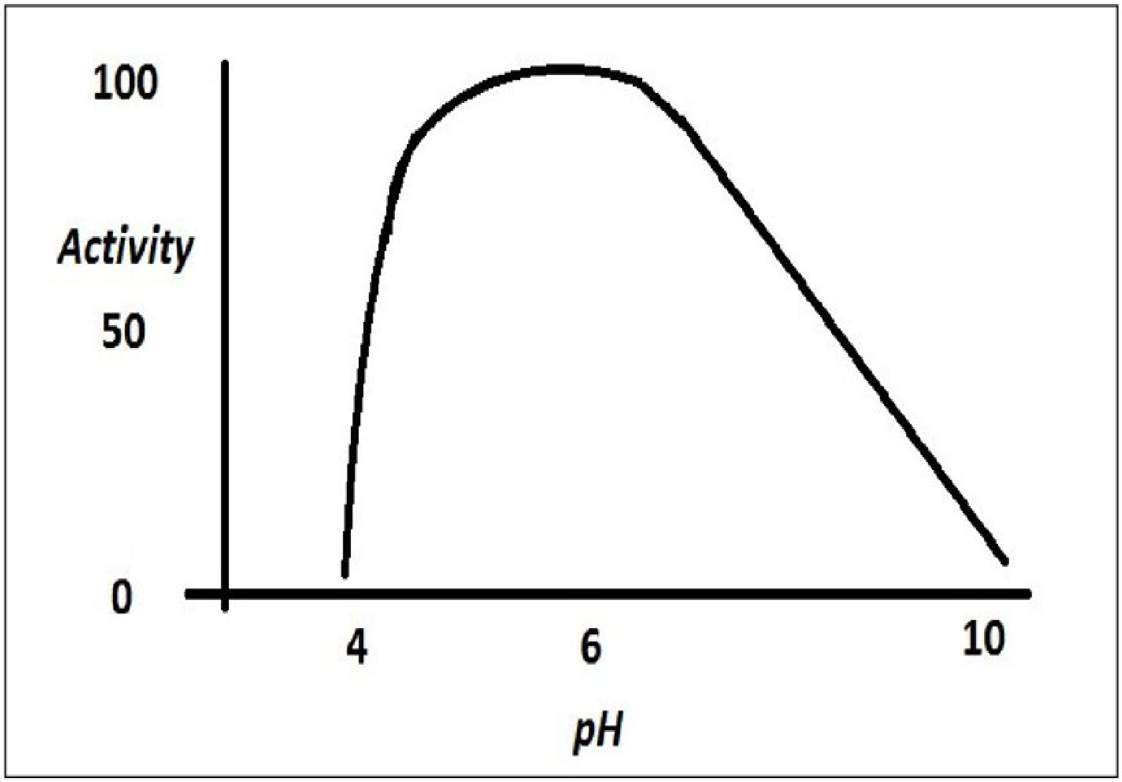

Figure 26 – Teramyl activity and pH

The first of the Novozyme products that a distiller will add to an un-malted grain mash is called Teramyl which is a thermostable alpha-amylase type enzyme. Figure 26 shows that the activity of Teramyl as a function of mash pH.

The peak activity will be seen at a mash pH of just under 6. Grain is naturally acidic. Starting a mash water at a pH of 7 (or slightly less), and then adding grain will result in the mash of pH falling to just under 6 where the Teramyl will perform at its best.

The second Novozyme product that will be added to a mash is called Viscoferm. This enzyme comprises xylanase which has the unique ability to cleave the glucan protein matrix structures in the grain endosperm to reduce viscosity. My experience using Viscoferm with otherwise sticky rye grain mashes has been highly favorable. Viscoferm is stable and active up to about 65ºC. It is fascinating to observe how quickly this enzyme will degrade a thick mash into something thin and soupy.

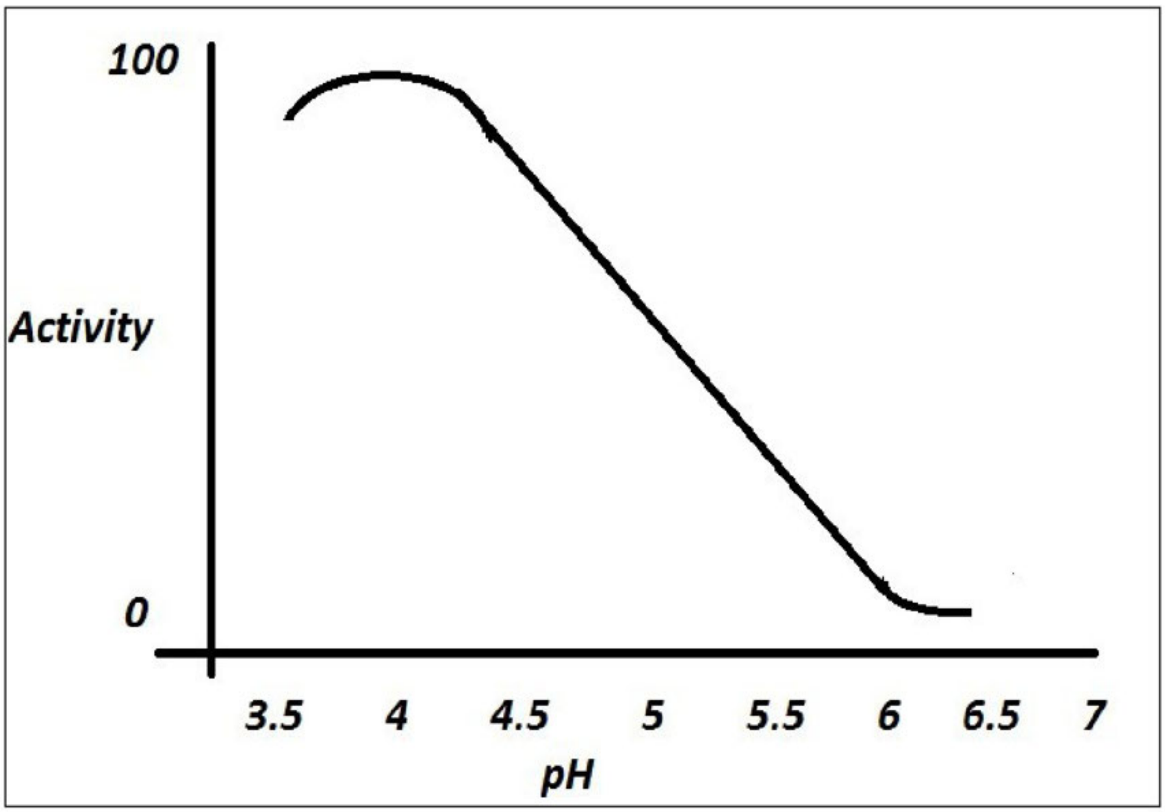

Figure 27 – San Extra activity and pH

The third Novozyme product that a distiller will add to a mash is called San Extra which consists of glucosidase. As Figure 27 shows, there is a certain pH sensitivity associated with San Extra.

Yeast performs best in a pH range that closely matches its internal cellular pH. This then sets up a conflict. The optimal pH for San Extra (around pH 4) is slightly less than the optimal pH range that yeast prefers. A distiller will have to experiment with the yeast strain being used to determine the best pH of a mash. In all likelihood, a decision will be made to aim for a final mash pH that will see the San Extra operate at 80% activity in order to keep the yeast performing optimally.

As far as application rates of enzymes are concerned, the manufacturer will supply this data with the purchased enzymes. The data will state an application amount per tonne of starch. For example, the directions might advise to add 0.50 to 0.70 kgs of a particular enzyme per tonne of starch. When computing a dosage, I always suggest to assume that cereal grain has 70% starch. This general assumption has never steered me wrong in any of my mashing efforts.

As a numerical example for an enzyme needing a dosage of 0.5 to 0.7 kgs per tonne of starch, suppose a distiller is doing a mash with 300 kgs of grain. At 70% starch, the grain will contain 210 kgs of starch. This is equivalent to 0.210 tonnes of starch. Picking the mid-point of the suggested dosage would imply the addition of 0.6 kgs per tonne. Mathematical calculation shows, 0.210 x 0.6 = 0.126 kgs of enzyme or 126 grams. The distiller could weigh out this amount using a digital scale. My personal experience has shown me that a gram amount of an enzyme is very close to the volume amount. In this example, the distiller would add 126 mls of the enzyme.

Sourcing Un-malted Grains

The primary advantage of using enzymes with un-malted grain is cost. Distillers can realize significant cost savings by sourcing un-malted grain directly from a grain farmer. It is advisable, though, to first have a look at a sample of the grain that is for sale. Examine the kernels closely for evidence of dark staining which is a sign of mold and bacteria that will be harmful to yeast during the fermentation process.

I source un-malted grain exclusively from Certified Seed Growers. Seed growers are carefully regulated by government agencies and will not (cannot) sell a sub-standard grain product. In addition, seed-quality grain has been passed through a cleaning plant so the grain will be free of dirt, debris and weed seeds.

In Canada, the Canada Food Inspection Agency regulates seed growers. Not far from where I live in southern Saskatchewan there is a certified seed grower (Hick Seed Ltd, Mossbank, Saskatchewan) offering some unique varietals of grain to local farm operators. I highly recommend craft distillers have a discussion with this company.

In the USA, each individual state will have an agency that certifies seed growers. This agency will provide a distiller with a list of compliant seed growers.

In the UK, the APHA (Animal Plant & Health Agency) can advise where approved seed growers are located.

Mashing with Un-malted Grains

When using un-malted grains, it is necessary to first grind the grain. The most efficient method of grinding is a hammer mill which comprises a shaft that rotates at high speed. Attached to the shaft are hardened pieces of metal called hammers. As the grain is fed into the mill, the action of the grain kernels hitting the hammers causes the kernels to shatter. Depending on the speed of rotation of the turning shaft, finer or coarser grains can be obtained. The resulting material from either a roller mill or a hammer mill is termed a grist. A hammer mill grind would typically be 100% passing a 0.250 mm screen size.

Grinding the grain will provide the maximum amount of surface area possible so that hot water added to the grain mash can quickly heat the grain and start to break the grain structure down in conjunction with the enzymes added. This structural breakdown is termed gelatinization. The gelatinization point of a grain is defined as that temperature where the starch molecules in the grain absorb water to the point where they burst, thus making it easier for the enzymes to continue doing their work of breaking apart individual chains of starch.

Once the grain is ground into grist form, the grist is loaded into a vessel called a mash tank. Water is added to the grist (3:1 water to grain ratio) and heat is imparted to the mash tank. Some distillers will employ hot steam injected right into the mash tank while others will have mash tanks with steam jackets built into the bottom portion of the tank. There is much debate around which method is best. I know of one craft distiller who will tell people that steam injection is the only way to go. No other system will work. I disagree. There are plenty of craft distillers using jacketed tanks where steam is confined to an external jacket around the tank. I personally believe this design allows a more exacting approach to controlling mashing temperature.

Heat the mash water to 50ºC. Then add in the first two enzymes making sure they are completely mixed into the water. Next, add the milled grain. Slowly continue heating while agitating/stirring the mash. It does not take long at all for the enzymes to begin tearing down the grain structure. It will quickly become evident that the viscosity of the mash is diminishing. Continue to heat the mash tank and its contents aiming for a temperature of 80ºC. Note, if using corn it is advisable to aim for a temperature of as high as 90ºC to break down the complex amylopectin starch structures in the corn endosperm.

Once at target temperature, stop applying heat and let the mash tank and its contents rest for up to 60 minutes. Each enzyme manufacturer will have specific recommended temperatures and times.

After this rest, cool the mash down to somewhere around 55-65ºC as recommended by the enzyme maker. At this point, a third enzyme will be added. This enzyme will be of the glucosidase variety and will complete the task of breaking starches into simpler, fermentable sugars. The mash will be held at this temperature level for a specified period of time, likely up to two hours. After this lengthy rest, the grain should resemble soupy mush and the starches and proteins from the cell endosperm will have been liberated and hydrolyzed into smaller pieces (fermentable sugars and amino acids respectively).

Malted Cereal Grains

Taking grain kernels and encouraging them to sprout is called malting and is the work of a maltster and the team at a malting plant. There are malting companies around the globe that cater specifically to the distilling and brewing industry by providing malted grains. Names like Cargill, Simpson’s, Crisp, Bairds, Great Western, Rahr, Malteurop, Boortmalt, Castle, Canada Malt, Prairie Malt, and Briess are some of the companies you might encounter on the world market.

Across North America, there are about 75 small-scale craft malting facilities that provide a wide variety of malted grains to craft brewers and distillers. One craft malting company that I purchase product from for my home-based efforts is Maker’s Malt located in Rosthern, Saskatchewan. The proprietor of this malting company grows his own grain and selects only the finest quality grains for his malting plant.

I am told key staff from a number of these craft malting facilities received training from the Canadian Malt Barley Technical Centre in Winnipeg, Canada. Training was provided by Dr. Yueshu Li, a world renowned authority on malting science. If you are interested in perhaps becoming a craft maltster instead of a craft distiller, contact Dr. Li for further discussion. (18)

Grain to be sold to a malting company must meet rigid criteria. The kernels must be plump, the total nitrogen content of the grain must be low, and the germinative energy (the ability to generate a shoot quickly) must be high. A farmer who produces a crop of grain meeting these criteria stands to gain additional revenue for his grain if it is selected for use by a malting company.

There are a series of tests that a malting company can employ to test the malting potential of grain. The first is called the Germinative Energy Test and it involves placing 100 kernels in a petrie dish with 4 mls of water at 18ºC for 72 hours. The number of kernels displaying formation of a root is then counted. The malting company will be looking for a number above 90%.

It is possible that some kernels of grain will display an adverse sensitivity to water. To check for this, a malting company will do a Water Sensitivity Test, taking a further 100 kernels of grain and placing them in a petrie dish with 8 mls of water at 18ºC for 72 hours. The number of kernels displaying root growth will then be counted. To illustrate, let's suppose in the first test with 4 mls of water 90 kernels showed root growth (90/100 = 90%). A maltster would then say the germinative energy is 90% and would buy the grain from the grower. In the 8 mls of water test, let's suppose that 75 kernels showed root growth (90-75 = 15 and 15/90 = 16.6%). Obviously some kernels are sensitive to too much water. Therefore, the malting company now knows that it will have to carefully regulate the malting process in order to get this batch of grain to malt suitably. Another test that is a bit quicker involves 200 kernels steeped in a dilute (0.75% v/v) solution of Hydrogen Peroxide for 24 hours. In this Germinative Capacity Test, the maltster is looking for 95% of the kernels to display root growth.

Upon receipt at a malting plant, the grain kernels are visually inspected for evidence of bugs that could chew up grain kernels during storage. Incoming grain loads are outright rejected if there is evidence of bugs. It is important to remember that the grain kernel is a living organism. A kernel of grain will survive through respiration. That is, it uptakes oxygen and slowly consumes its internal reserve of energy. In so doing, it respires carbon dioxide. The malting plant will accordingly do a Tetrazolium Test using 2,3,5 tetrazolium chloride at a 1% solution strength. A small sample of grain kernels is soaked in water for a couple hours. The kernels are then sliced longitudinally and exposed to the tetrazolium mixture. Kernels showing a red or pink hue mean the grain is healthy and respiring normally. A black hue means the grain is respiring rapidly due to tissue damage. A white color means dead tissue with no respiration. Incoming shipments of grain exhibiting damaged or dead kernels are rejected from the malting process.

Figure 28 – Steep Tank at Simpson's Malt

Grain is then cleaned to remove weed seeds and chaff material that is not malt-worthy. The grain is also passed through a vibrating screen sieve to remove any larger objects, such as stones that the farmer's combine harvester may have picked up. Grain could also be passed across a shaker table to remove these larger objects. Grain will then be passed by a magnetic separator to remove any metallic nuts and bolts that may have fallen into the grain from the farmer's equipment. Lastly, the grain is screened for size. Smaller kernels are typically sold off to the animal food industry while larger, plumper kernels are kept for malting.

There are three basic steps in malting of grain: Steeping, Germination, and Kilning. Every maltster will have his own proprietary technique for these steps which will be a function of the type of grain, the germinative capacity, and the varietal strain being malted.

In the steeping part of the process, grain is loaded into a steep vessel which could either be a flat-bottomed tank or a tank with a conical bottom, not unlike a fermenter tank in a brewery. Based on knowledge of the particular strain and the test results for germinative energy/capacity, the maltster will give the grain a water exposure, an air rest, a water exposure, and another air rest. According to the Malt Barley Technical Centre in Winnipeg a typical steep might be 8 hours long and the air rest segments 12 hours long. The temperature of the steep water will be in the range 14-16ºC. During this steeping and air resting, the kernels are slowly taking up moisture through the micropyle end of the kernel where the embryo is situated. The aim is to have the kernel become 45% saturated with moisture. The moisture is triggering the embryo to generate gibberellic acid (GA). The GA is gravitating towards the aleurone layer where enzyme proteins will be synthesized or released.

Figure 28 is a photo taken during my tour of the Simpson's Malt plant located at Berwick Upon Tweed, England in August 2018.

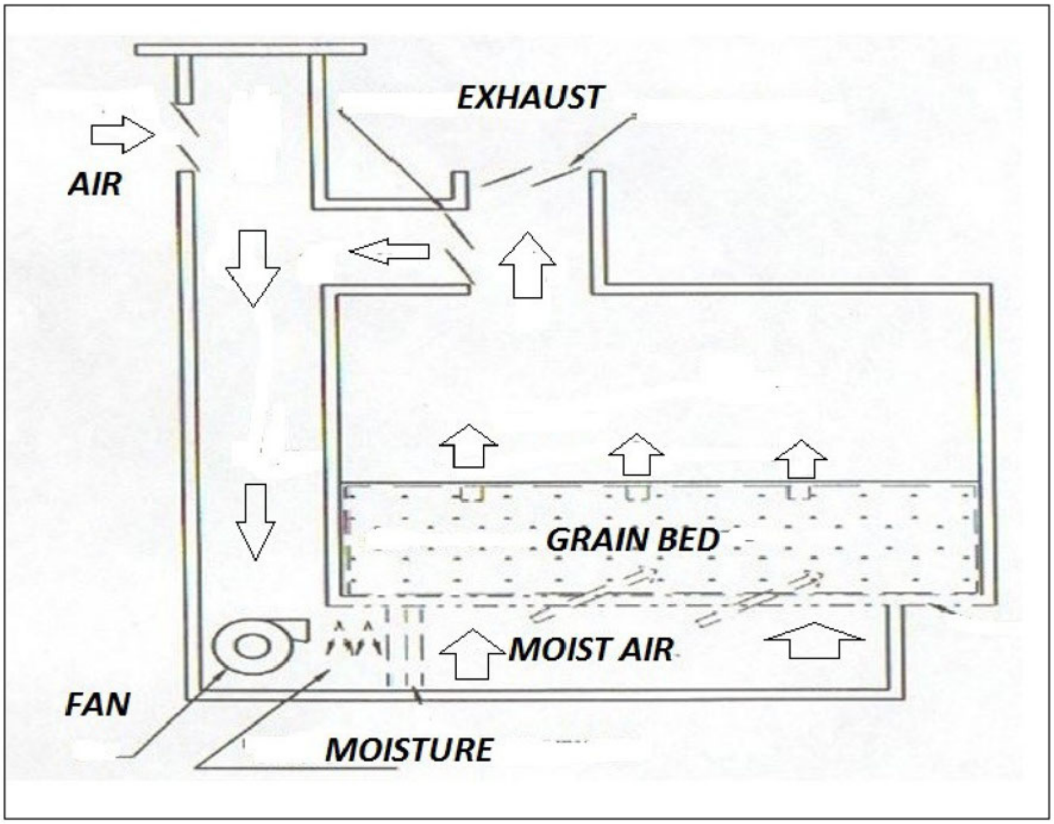

Figure 29 – Saladin Box

The steep tank that was being used was easily 20 feet diameter and 60 feet deep. At the time, the tank was being filled with steeping water in a turbulent manner to ensure thorough wetting of the kernels.

After steeping and air resting intervals, the grain was next transferred to a germination kilning vessel. (19)

The science of malting extends back to the late 1800s and to the design work of French scientist Charles Saladin. Saladin's design (the Saladin Box) is still used today by some malting companies. (20) In the Saladin Box, the steeped grain is spread across a perforated false bottom. Moist air at 100% relative humidity and a temperature of 16-18ºC is blown into the area beneath the grain bed. The air moves up and through the grain bed to exhaust from the top of the box. Figure 29 illustrates a Saladin Box construct.

The one feature missing from this drawing is the auger-like turning device that travels back and forth along the length of the box to turn the grain. The grain must be turned frequently so that the emerging shoots and rootlets do not become entangled with each other. A typical germination stage will last about 96 hours, but will depend on grain type and variety and the degree of root and shoot growth the maltster wants to obtain.

After germination, the grain is transferred from the Saladin Box to a kilning vessel. In the kilning vessel, the germinated grain is laid out in a bed and hot air at about 50ºC is blown through the bed. This air picks up the surficial moisture on the kernels and removes it through the exhaust vents. The maltster will be carefully monitoring the air hitting the wet grain (the air-on temperature) as well as the temperature of the air exiting the system (the air-off temperature).

When the air-off temperature starts to rise, the maltster knows that the surficial moisture has been removed. This point is called the break-point. The maltster then knows that in order to extract the moisture from the deeper tissues of the grain, the air flow rate must be slowed and the air-on temperature raised slightly. Over time, the maltster will gently raise the air-on temperatures and nudge up the temperature of the grain bed. In technical verbiage, the part of the process prior to the break-point is called ‘free drying’ and what comes after is ‘force drying’. Towards the final part of the process, the air temperature is raised to perhaps 80ºC for a short time to impart some coloration to the grain. This coloration comes about through Maillard reactions where sugars in the grain tissues react with protein in the grain tissues under the influence of heat energy to produce melanoidin pigments of a darker color.

To observe a Maillard reaction, take some onions in a fry pan and gently sautee them. The residual sugars in the onion tissue react with proteins in the tissue to impart a slight brownish hue to the onions. For another example, cook a steak and note that the meat takes on a brown color as the residual glucose sugars in the meat tissue react with protein to create darker coloration.

The overall kilning phase will take up to 30 hours. At the end of it, the maltster will aim to have reduced the moisture content of the grain to 4%. Following kilning, the grain is rapidly cooled down to room temperature. At the 4% moisture level, the malted grain can safely be stored at a brewery or distillery without worry of molds or spoilage.

Saladin Boxes are slowly being replaced by more modern technology. Malting companies (such as Simpson’s) using the latest technology will perform the germination and kilning of the grain all in one vessel. The name assigned to such a vessel is the GK vessel, where GK stands for ‘germination-kilning’.

Figure 30 – GK vessel at Simpson's Malt

Figure 30 is a photo taken inside of the combined germination-kilning vessel (GK vessel) at Simpson's Malt. As the grain germinates, it is turned slowly and continually by vertical augers on a rotating platform.

If you are wondering where your favorite Scotch Whisky picks up its smoky notes, the source is the kilning process. At Simpson's Malt in Berwick Upon Tweed, I was informed that kilned grain requiring smoke addition is taken from the germination/kilning (GK) vessel at a higher than normal moisture content and transferred to a separate smoking vessel where the drying process was completed under the influence of hot smoke derived from burning peat directed into the air-on stream. The smoke particles adhere to the grain kernels. Peat from different geographic locations was used for different customers as per their request.

In North America, it is my understanding that Briess Malting in Denver, Colorado still operates a small pilot plant for smoking barley. One craft distillery that has taken smoking to a new level is Santa Fe Spirits in Santa Fe, New Mexico.

Through an arrangement with Briess Malting, this distilling company is able to harvest mesquite wood from the high desert areas around Santa Fe. The harvested wood is sent to Briess Malting where it is used to smoke malt barley. If your travels take you to Santa Fe, I encourage you to visit Santa Fe Spirits. The flavors and aromas of the mesquite smoke are richly evident in the truly divine Colkegan Malt Whisky.

A craft distiller could even build a small-scale smoking apparatus. A fire box to burn wood or peat and a fan to blow smoke will be needed. Malted barley can be sprayed with water and then re-dried with the warm smoke. The amount of smokiness imparted to the grain will be a function of the time the grain is exposed to the smoke. The smoking apparatus and length of pipe extending from the fire box should be such that the temperature of the smoke reaching the grain is less than 50ºC.

As a reference point, I have used smoked barley imported from Simpson's Malt that smelled distinctly like a strong campfire when a brought a handful of it to my nose. The smoke content (phenol content) was only 27 ppm. A little smoke can go a long way.

Figure 31 – Green malt vessel at Simpson's Malt

I was intrigued to learn that not all of the germinated grain passing through the process at Simpson's Malt was ultimately kiln dried. Figure 31 is a photo of one of the rotary germination vessels used at Simpson's. Steeped grain is fed into a rotary vessel which slowly turns while the grain sprouts. Upon completion of sprouting, the grain with roots and shoots attached is hurriedly loaded onto a transport truck and whisked away to the Cameronbridge Distillery near Edinburgh. Upon receipt at Cameronbridge, the 'green malt' is immediately crushed up and added to a fermentation vessel. When asked why Cameronbridge would opt to use green, un-dried malt, the tour guide at Simpson's explained that 2/3 of the cost of making malt is the energy usage for the drying process. By taking green malt, Cameronbridge is saving itself a significant sum of money each year. The alcohol made at Cameronbridge is provided to Johnnie Walker as the base alcohol that is blended into the Johnnie Walker lineup of blended Scotches.

I have come across stories in trade magazines about craft distillers using green malt to make whisky. It is apparently advisable to blow un-heated air across the green malt after sprouting to dry it slightly. A meat grinder type of apparatus is said to work reasonably well in grinding the green malt. Depending on the varietal of cereal grain being used, the flavors and aromas in the distillate can apparently be quite unique.

Malt Specs

A malting company can provide a distiller with a spec sheet for the malted grain.

One of the data points on the spec sheet will be the Kolbach Index which refers to the percentage of nitrogen in the malt that is soluble as a percentage of the total nitrogen. In other words, to what degree has the protein in the endosperm cells been degraded. The number will vary from perhaps 30 to 45. The higher the number, the more protein degradation that has occurred. A higher number signifies a highly modified malt. A lower number represents an under-modified malt. Distillers should always aim to source malt that has been highly modified. The total nitrogen level in a grain sample is determined in accordance with the Kjeldahl method. This method entails a measured amount of grain being digested with strong sulfuric acid. The nitrogen in the grain is converted to ammonia ions (NH4-). An addition of NaOH turns the ions in to NH3 vapor which is distilled off and captured. Through titration, the total amount of nitrogen present in the grain can be calculated. The soluble nitrogen is otherwise referred to as the free nitrogen or FAN. The Ninhydrin assay is used to calculate FAN. Ninhydrin is a chemical of composition 2,2-dihydroxyindane-1,3-dione. It reacts with ammonia in amino acids and short peptides to induce a color change. A photospectrometer is used to assay the degree of color change and hence the amount of FAN.

Another number that might appear on a spec sheet is Friability. In a lab, a sample of malt is pressed against a roller with a standardized pressure applied. Some of the grain will crush, other kernels will not. Recall earlier in this section that the endosperm cell walls are made of glucans and hemicelluloses. A friability number of over 90% tells you that the endosperm cell walls have been good and well degraded.

Another number to look for is Extract. The malting company test lab will have taken a sample of malted grain and crushed it following a standardized method. The crushed malt is exposed to hot water following an industry standard technique called the Congress Mash. The sugary liquid that emanates from the crushed malt has its specific gravity measured using a density meter. A high number is desirable. For example, Cargill on its spec sheet for its 2-row malt made in Saskatchewan is reporting an extract value of 80. Gambrinus Malting (now owned by Rahr Malting) in Armstrong, British Columbia reports an extract of 82 on its 2-row malt. Some malt spec sheets might contain DBCG and DBFG values. These refer to the extract values of coarse and finely ground malt samples. Some spec sheets will report just the difference between these two values. It is important to use malt with a small difference (less than 1 percent). Some spec sheets will report Hot Water Extract values (HWE). HWE is based on how many liters of wort a kilogram of malt will yield with a specific gravity of 1.001 in water at a temperature of 20ºC using a 0.7 mm grind size for the coarse grind and a 0.2 mm grind size for the fine grind. Dividing the HWE values by 3.86 will convert them to DBCG and DBFG, respectively. Aim for a high HWE value if sourcing grain based on this parameter. (21)

When sourcing malted grains, I have developed a preference for Distillers Malt, from Cargill (USA) or from Simpson's Malt in the U.K. In my travels in Scotland, it was emphasized that the single malt distilleries are not using the standard pale malt that a beer maker would use. Distillers Malt has a higher extract value (HWE) which means more fermentable sugars from a quantity of the malt than from the same quantity of a standard 2-row brewing malt. I find that mashes from Distillers Malt have a more biscuit-like, more delicious flavor. The grains selected for being malted into Distillers Malt will have a higher nitrogen content (protein). During the malting of Distillers Malt, the kilning process is carried out at a slightly lower than normal temperature to ensure more of the naturally occurring enzymes survive the process to better modify the grain. A common Distillers Malt that I saw in use in Scotland was a brand called Concerto.

Mashing with Malted Grain

When a distiller receives a shipment of malted grain, the first step will be to grind the grain. Malted grain is more friable than un-malted grain, so a roller mill will be sufficient to get the task done. A roller mill comprises a pair of grooved rolls or perhaps four rolls. Larger commercial distilleries in Scotland use a six-roll configuration. The roller mill is designed so that one of the rollers in a pair turns at slightly higher speed than the other. The kernels of grain passing between the two rollers are then both compressed and sheared apart.

Grinding maximizes the amount of surface area available to interact with the hot water added to the grain mash. This has the effect of quickly heating the grain and re-energizing the proteolytic enzymes that have survived the kiln drying process. Even though the maltster heated the grain in the kilning phase, not all of the proteolytic enzymes were impaired by the heat. Alpha amylase, beta amylase, limit dextrinase and beta solubilase all have managed to survive to varying degrees. Exposing them to hot water will re-activate them. These re-activated enzymes will continue tearing apart the endosperm cell walls to further liberate the starch and protein molecules.

A typical ground malt grain at a Scotch distillery will have a size distribution in the order of 70% ground grain particles (passing a 1 mm screen size), 20% husk material (> 1.2 mm screen size) and 10% finer flour (passing a 0.125 mm screen size).

The process of heating malted grain to further tear down the kernel structure is termed gelatinization. The gelatinization point of a grain is that temperature where the starch molecules in the grain absorb water to the point where they burst, thus making it easier for the enzymes to continue doing their work of breaking apart individual chains of starch.

The grist is next loaded into a vessel called a mash tank.

Water is then added to the grist (3:1 water to grain ratio) and heat is imparted to the mash tank. Some distillers will employ hot steam injected right into the mash tank while others will have mash tanks with steam jackets built into the bottom portion of the tank. I personally believe this design allows a more exacting approach to controlling mashing temperature.

My studies at Heriot Watt introduced me to several excellent brewing books. One in particular, entitled Technology, Brewing & Malting, by Wolfgang Kunze (22) is the book Molson Coors uses to train it's brewers. Expensive, yes! Worth it? Without question. I highly suggest that all craft distillers get their hands on a copy.

One mashing technique used in Germany and explored in Kunze's book is called the fast mash. Grain and hot water are mixed, where the water was preheated to a calculated temperature such that upon mixing the temperature of the grist/water mixture is 62-64ºC. At this temperature the beta amylase and alpha amylase enzymes present in the grain are reactivated. They start attacking the starch molecules in the grain. The temperature range around 62-64ºC happens to also be the gelatinization point of malted barley. At the 62-64ºC temperature level, the beta amylase enzyme is operating at its most efficient. It attacks loose ends of the starch chains, nibbling off units of one or two glucose units (glucose and maltose respectively).

At the 62-64ºC temperature level, the alpha-amylase enzyme is also active, but it is not operating at peak efficiency. The alpha-amylase enzymes are busy attacking the linear amylose chains, cutting them at the 1,4 linkages in a random manner. As the amylose chains are cut, this creates more loose ends (non-reducing ends) for the beta amylase to feast on. Alpha-amylase is often called an endo-enzyme for its ability to attack starches in the mid-chain portion.

After a 20-30 minute hold time at 62-64ºC, the distiller employing a fast mash will then add more heat to the mash tank and raise the temperature to 72-74ºC. At this temperature, the activity of the beta-amylase is reduced significantly, but the alpha-amylase kicks into high gear and continues attacking the 1,4 linkage sites.

After 20-30 minutes at this temperature level, the starch chains have been ripped apart into smaller units of fermentable sugars. Most of these smaller units consist of two glucose molecules (maltose).

At this point, a critical distinction must be drawn. Travel around to craft breweries in your general area. You will note that the brewer is typically taking the malt barley mash to around 67ºC. What remains after holding the mash at this temperature level are small branches of 1-4 linked glucose units that were adjacent to 1,6 linkage sites. These small un-broken starch residues are termed dextrins and are what give an ale style of beer its sweet, mouthfeel that make your tastebuds cry out for more.

So, why is Kunze taking his fast mash temperatures to 74ºC? The answer is, Kunze is German. The dominant style of beer in Germany is lager. A properly made lager will not have excessive mouthfeel and body. Taking the mash at 74ºC will ensure the enzymes have thoroughly broken down all starch residues. This two stage temperature profile is critical when it comes to equipment selection. Distillers are not interested in residual body or mouthfeel. Distillers want to convert all the starches to fermentable sugars so as to maximize the alcohol yield during fermentation. If you are thinking that this argument is at odds with the fact that single malt distillers in Scotland still use a mashing procedure not unlike what beer brewers use, you are correct. Later in this chapter, this disparity will be laid bare.

What happens next will vary from between craft distilleries. It is a matter of personal preference. Some distillers will heat their mash to 78-80ºC to kill off any bacteria microbes that perchance have survived the mashing process. Doing this will assuredly disable all enzymatic activity in the mash. My personal preference is to not do this final heating stage. If there is any enzymatic activity left after the temperature rest at 72-74ºC, I prefer to leave the enzymes working and have them further tearing down any left-over starch residues.

The vast majority of malted grain available to brewers and distillers will have been well and thoroughly modified. However, there could be possible exceptions. I have encountered batches of malted wheat in particular that still were a bit tough and chewy. In a case like this, we need look no further than Kunze’s book and his slow mash method. It is similar to the fast mash, except at the start, the grain-water mixture is taken to 40-45ºC and held for 30 minutes. At this temperature you are taking advantage of an enzyme called beta 1,4 glucanase and also the various peptidase enzymes. All are active at 40-50ºC. If there are larger chunks of beta glucan or larger protein bits, they will soon be degraded. Then the mash will be heated to 62-64ºC and it will proceed as with the fast mash method. If you are a beer brewer and if this is sounding vaguely familiar to you, this method by another name would be called a protein rest.

Kunze's book also details the maltase mash, a method that I have never seen, but intend to start using. In the maltase method, about 2/3 of the grain is added to a pre-calculated hot water volume such that upon mixing the temperature of the water-malt mixture is 62ºC. Slowly over the next 40 minutes, the mash is heated to 70ºC. Then by adding the remainder of the water (cold) and the remaining 1/3 of the grain the mash temperature will fall to 45ºC. Letting the mash rest for 40 minutes will allow the enzymes to complete their work. The mash is then heated back up to 70ºC, given a short rest of 15 minutes and by then the process is done. Kunze asserts that this method will carve up the starches so that the yeast will generate a greater proportion of higher alcohols (flavor) during the ferment. More on higher alcohols in a later chapter, but suffice it to say here that those delicate, wonderful flavors and aromas in expensive Scotches, Rums and Whisky's are related to higher alcohols.

Water

The amount of water used in the mashing process is important as the amount will have an influence on the activity of the enzymes. A distiller should aim for 2.5 to 3 liters of water per kilogram of grain used in the mash. The analogy that was given to me by one of my professors was to think of the enzymes as being at the North Pole. If they are cold, they will be sluggish. If they can be kept warmer, they will be active. A thinner mash with more water will make for sluggish enzymes. A thicker mash with less water makes for a more insulated environment and more active enzymes.

Efficiency

Beer brewers like to quote efficiency numbers. Distillers, not so much. Consider the following basic example: Suppose a distiller uses 300 kgs of malted grain with an extract value of 79 (HWE= 3.86x79=305). This grain will occupy 300 x 0.7=210 liters of volume in a 1200 liter mash tank. The distiller will add 900 liters of water (3:1 ratio) thus leaving about 100 liters of head space in the mash tank. At the end of the mashing procedure the mash has a reading of 22ºBrix (more on this unit of measure later). 22ºBrix is the equivalent of a specific gravity (SG) of 1.092.

$$((1.092-1) * 1000 * 900 \text{ liters})/305 = 271 \text{ kgs.}$$

In other words, it should take 271 kgs of grain to give 900 liters of wort at 22ºBrix. But, a total of 300 kgs was added. Therefore the efficiency of the mash was 271/300 = 90%. Not bad, but it could be slightly better. Perhaps a slightly finer grind or a longer rest at each temperature stage would help. Even though craft distillers seldom speak of efficiency, it is important and with this example, you can now comfortably calculate your own efficiencies. (22)

To help you with calculations, 18ºBrix is a (SG) of 1.074, 19ºBrix is a (SG) of 1.079, 20ºBrix is a (SG) of 1.083, 21ºBrix is a (SG) of 1.088, 22ºBrix is a (SG) of 1.092, 23ºBrix is a (SG) of 1.097, and 24ºBrix is a (SG) of 1.101.

Mashing Vessels

The subject of mashing vessels is highly charged with controversy. I continue to run into craft distillery start-ups that have been convinced to buy beer brewing systems that consist of a hot water tank, a mash-lauter vessel, a plate chiller and a fermenter vessel.

Inside a mash-lauter vessel one will find a false bottom. That is, perforated panel sections where the perforations are sized to allow a mass of ground up grain to sit atop the panels without falling through. The operator will auger feed malted barley grain and hot water (at about 75ºC) into the vessel. Once the requisite amount of grain and water has been added for the recipe being made, the operator will let the system rest for about 60 minutes. The heat from the hot water will be sufficient to convert most (but not all) of the starches into smaller molecular bits (maltoses and maltotrioses). Next, hot water will be flushed through the bed of grain to wash away these fermentable sugars. The flow of sweet wort will be directed through a plate chiller to cool the temperature down. From the chiller, the flow will end of up in fermenter tank where yeast is added. Note that in the beer making process, the sweet wort is boiled for up to 60 minutes during which time bittering and aroma hops are added. The boiled wort is then cooled and fermented.

Sounds simple, right? By and large the equipment being sold to craft distillery startups is coming out of China. I have yet to see Chinese mash-lauter equipment function well. What I do see are plenty of craft distillers cursing and swearing that they will never again buy beer brewing equipment.

The solution to this problem and the question of what kind of process vessel to obtain was hinted at in Kunze's book. In parts of Germany and eastern Europe, beer brewers making lager style beer do not use a mash-lauter vessel. They use a separate mash vessel and a separate lauter vessel. The mash vessel is nothing more than a stainless steel tank equipped with either a steam-jacketed exterior or else a provision for steam injection directly into the tank. The requisite amount of ground-up barley and water are added to the mash vessel. The temperature of the vessel and its contents is raised to 64ºC and that temperature level maintained for about 30 minutes. Next, the vessel temperature is raised to 74ºC and held at that temperature for 30 minutes. The hot mash is then pumped to a lauter vessel with a false bottom where the sweet, fermentable sugars are flushed away and captured in a boiling vessel. After boiling and hop additions, the wort is cooled and directed to a fermenter vessel.

So, how does this all pertain to craft distilling? The answer is, all a craft distiller needs is the first half of this lager system. That is, a stainless vessel that is either steam jacketed or steam injected. The vessel will be designed to also include glycol cooling capacity. A craft distiller will grind up the required amount of grain and feed it into the vessel along with the required amount of water. The temperature will be taken through rests at the two temperatures stages (64ºC and 74ºC). The mash will then be cooled to 30ºC and pumped into a sanitized fermenter vessel where yeast is added.

In any start-up consulting I do, I strongly recommend this type of vessel be sourced. I have found a manufacturer that has now made several of them for various craft distillers. Speak to Ed Ripley at Ripley Stainless Steel in Summerland, British Columbia. Mr. Ripley and his team have over 30 years of experience making tanks for the beverage alcohol business.

If you are a Scotch afficionado and are following my argument, you are likely wondering why the Scotch whisky industry uses mash-lauter type vessels. The answer is, their vessels are specially designed for the rapid lautering of the grain beds. Their vessels are not beer brewing systems purchased from China. If this old school, Scottish approach appeals to you or if it fits with your brand image, contact a company like Edradour Distillery in Pitlochry and ask them who they retained to build the vessels for their 2019 expansion.

The question as to whether to have steam injection or a steam jacketed vessel is an easy one to resolve. If your incoming supply of water has a high mineral content to the point where you are adding harsh chemicals to prevent scaling in your boiler system, then you cannot use steam injection. If your water is such that you do not need to chemically treat your boiler water, then you can steam inject.

Theoretical Yield

How much alcohol can one expect to get from grain as compared to fruits, grapes or molasses? To address this question, a consideration of theoretical yield is in order.

100 kgs of good quality corn will in theory provide about 45 liters of alcohol.

100 kgs of good quality soft white wheat will provide about 42 liters of alcohol.

100 kgs of good quality hard winter wheat will provide about 44 liters of alcohol.

100 kgs of good quality rye will provide about 42 liters of alcohol.

100 kgs of good quality barley will provide about 42 liters of alcohol.

100 kgs of potato will provide between 8 and 13 liters of alcohol. The

species of potato will be the major determinant in the starch content. For example Idaho (Russet) potatoes have a higher starch content than Yukon Gold potatoes. The higher starch content of Idaho potatoes makes them ideal candidates for oven roasting. Yukon Gold potatoes with their lower starch content are ideal for traditional mashed potato dishes. The point, however, is that potatoes have a markedly lower starch content than grains. If you are intent on using potato as a raw material for making alcohol, you will have to source the potato for an extremely low cost in order to maintain some semblance of profitable economics. This explains why one does not see a lot of Potato Vodka on the liquor store shelves.

In the case of fruits and molasses,

100 kgs of good quality Plums will yield about 5 liters of alcohol.

100 kgs of good quality Peaches will yield about 4.5 liters of alcohol.

100 kgs of good quality Papaya will yield about 4.5 liters of alcohol.

100 kgs of good quality Mangoes will yield about 9 liters of alcohol.

100 kgs of good quality Apple will yield about 7.75 liters of alcohol.

100 kgs of good quality Apricots will yield about 6 liters of alcohol.

100 kgs of good quality Blueberries will yield about 4 liters of alcohol.

100 kgs of good quality Cherries will yield about 6 liters of alcohol.

100 kgs of good quality Wine grapes will yield about 10 liters of alcohol.

100 kgs of good quality molasses will yield about 32 liters of alcohol.

To understand how these theoretical yields are arrived at one must go back to the mid-1800s and to the work of French scientist Joseph Louis Gay-Lussac who was a pioneer in quantifying how sugars in the presence of yeast could create alcohol. Gay-Lussac's legacy to the world of distillation was the now famous Gay-Lussac equation:

$$\text{Sugar} + \text{Yeast} = \text{Alcohol} + CO_2$$

Expressed in chemical equation format, the Gay-Lussac equation is:

$$C_6H_{12}O_6 + \text{Yeast} = 2\ C_2H_5OH + 2\ CO_2$$

Next one must turn to the Periodic Table of the Elements and those distant memories of college and university chemistry class. The Periodic Table details data such as atomic number and gram molecular weight for the elements that comprise our known world.

From the Periodic Table of Elements, note that carbon has a gram molecular weight of 12.01 grams per mole, hydrogen a gram molecular weight of 1.007 gram per mole and oxygen a gram molecular weight of 15.999 grams per mole.

A mole (sometimes abbreviated mol) is defined by international chemistry regulatory bodies as that amount of material that contains as many atoms as there are in 12 grams of the isotope carbon C12. This number of atoms in carbon C12 is expressed by the Avogadro constant 6.022×10^{23}. I am sure that had my engineering school professors told me that someday I would be using this stuff to help me make Whisky, I would have paid better attention!

In other words, 6.022×10^{23} atoms of carbon will weigh 12.01 grams. A like number of hydrogen atoms will weigh 1.007 gram and a like number of oxygen atoms will weigh 15.999 grams.

Knowing the gram molecular weights of carbon, hydrogen and oxygen, one can quickly calculate the molecular weights of sugar, alcohol and carbon dioxide in the Gay-Lussac equation.

A molecule of C6H12O6 has a molecular weight of 180.13. The two molecules of C2H5OH have a molecular weight of 92.12 and the two molecules of CO2 have a molecular weight of 88.01.

Dividing the molecular weight of the 2 molecules of alcohol by the molecular weight of the sugar molecule yields 92.12/180.13 = 0.511

The general formula for density states that density = mass/volume.

The density of alcohol at 20ºC is 0.79 kgs per liter.

Consider this example. Take 100 kgs of hard winter wheat with a starch content of 70%. Assuming this starch all gets broken down into smaller units of glucose and all of that glucose ferments to produce alcohol and carbon dioxide, refer back to the Gay-Lussac equation. The 100 kgs of wheat will deliver 70 kgs of fermentable sugar. Multiplying this figure by 0.511 from the Gay-Lussac equation yields 70 x 0.511 = 35.77. That is, this amount of fermentable sugar will yield 35.77 kgs of alcohol. Inserting this figure into the general expression for density yields 35.77/0.79 = 45.27 liters of alcohol. Thus, the theoretical yield of 100 kgs of hard winter wheat with a starch content of 70% is 45.27 liters of alcohol.

Consider one more example, this time using fruit.

Take 100 kgs of good quality apples with a sugar content of 12%. Assuming this sugar ferments to produce alcohol and carbon dioxide, refer back to the Gay-Lussac equation. The 100 kgs of apple will deliver 12 kgs of fermentable sugar. Multiplying this figure by 0.511 from the Gay-Lussac equation yields 12 x 0.511 = 6.12. That is, this amount of fermentable sugar will yield 6.12 kgs of alcohol. Inserting this figure into the general expression for density yields 6.12/0.79 = 7.75 liters of alcohol. Thus the theoretical yield of 100 kgs of good quality apples with a sugar content of 12% is 7.75 liters of alcohol.

Neutral Grain Spirit

What if a distiller did not wish to use grains, fruits, or molasses? This leads to a discussion of the very sensitive issue of Neutral Grain Spirits (NGS). I addressed this topic rather bluntly in an earlier section of this book and I think you know where I stand on the matter. The only ground I will concede on the NGS front is for craft operators who seek to make nothing but gin or liqueur. I will not concede any part of my stance to operators seeking to use NGS to ‘make’ vodka.

Further to my story about the factory in Unity, Saskatchewan, there is another such factory in Ontario, Canada owned by Commercial Alcohols Ltd. I understand they also have a subsidiary in America. This organization owns four large scale ethanol distilleries in Ontario where it produces 95% alcohol using a feedstock of corn. Commercial Alcohols is also capable of providing a 95% rum distillate made from molasses and cane sugar. One vodka brand produced using distillate from Commercial Alcohols is Iceberg Vodka. The distillate is sent to St. John’s Newfoundland where it is proofed to 40% and bottled. Another, perhaps more famous, vodka brand based on distillate from Commercial Alcohols is Dan Akroyd’s Skull Vodka. The liquid in the skull is essentially the same liquid as in a cheaper bottle of Iceberg Vodka. Sorry to shatter your illusions, but as I have already stated vodka is a commercialized commodity.

In America, there are also companies such as Cargill and MGP Ingredients who have similar ethanol distilleries. A craft distiller can purchase grain alcohol from these vendors at around the $5.00 per liter price point (Canadian funds). However, I now can confirm that the factory in Unity, Saskatchewan can sell it for as little as $1.50 per liter. And it is odd how political forces can work. In Saskatchewan the rules for craft distillers clearly stipulate that 75% of the alcohol must be made on-site. But, if you take factory alcohol from Unity or from Commercial Alcohols and pass it through your still one time, it will be regarded as a raw material and you will not be deemed in contravention of the 75% policy.

Some people regard me as a snob when it comes to the subject of NGS used by craft distillers. I prefer to be thought of as a purist. The way I see it, the whole premise of craft distilling is for people to make genuine products from raw materials in small batches. If craft distillers want to behave as mini versions of the big boys, then what is the point? Sadly I am now seeing far too many other small distillers reach for NGS product from large ethanol distilleries. The Canadian craft distilling movement has missed its window of opportunity to draw a distinguishing line between grain to glass operators and NGS users.

In the USA, it now appears that the American Craft Spirits Association has adopted a code of ethics that demands craft distillers be open and honest about all facets of their process. In other words, disclose whether your alcohol is made on premise or sourced from a factory. I am not certain if the American Distilling Institute (ADI) has taken a similar ethical stance.

If you are contemplating starting a small distillery, the question you will have to ask yourself is – “do I intend to be a craft distiller where I craft my alcohol from raw materials or do I plan to shortcuts and acquire my alcoholic distillate from a large corporation”? Ponder this question carefully. I am not entirely sure how this whole craft distilling revolution will unfold in the next few years. Consumers may yet turn their back on so called ‘craft’ product sourced from large alcohol factories.

Agave

In Chapter 2, a brief discussion of the history of Tequila was provided. The raw material for Tequila is the blue agave (Agave Tequiliana), a subtropical lilly that grows in various forms throughout Mexico and on into South America. The blue agave is a slow grower and it can take 8 to 12 years to reach maturity. At maturity, the bulbous portion of the plant is harvested. Chopped up bits of the harvested bulb are then roasted to break down and free up inulin which is long molecular chains of fructose. The inulin is then fermented and the resulting alcoholic liquid distilled to produce a spirit that is gaining in popularity – Tequila.

However, this spirit can only be called Tequila if it is made in certain designated parts of Mexico. So, why talk about Tequila if we cannot make it legally in other parts of the world? It turns out there are commodity brokers who import agave syrup into North America and other countries. A craft distiller could ferment this syrup and distill it. It would have to be called something like Agave Spirit in order to remain within bounds of the spirit definitions. I am aware of one craft distiller in Canada – Sperling Distillery in Saskatchewan – that does just this. Sperling is now gaining serious popularity for its Agave Spirit. A couple years ago I had the pleasure of tasting their coffee-flavored expression. As the delicious liquid flowed across my tongue, I am sure I heard choirs of angels singing. It was that good! This is a perfect example of a craft distiller going above and beyond and thinking outside the box on his choice of raw materials.

Inulin can be difficult to ferment because yeast does not have a preference for the fructose molecule. However, I am now told that Novozymes makes an enzyme called inulinase that will help break down the chains of inulin. I am further told that yeast maker Lallemand has a specific strain of yeast, Distillimax TQ, that has been cultured to digest fructose and deliver classic Tequila-like taste and aroma. I have further learned that there is a Canadian company called 21 Missions Agave that is a significant importer of agave products into Canada. Wholesome Sweeteners in Sugarland, Texas is an American importer.

Botanicals

A discussion of raw materials also extends to products used to create gin. There are a myriad of botanical raw materials available to a distiller seeking to make gin. A solid reference book on the subject of botanicals is The Drunken Botanist by author Amy Stewart. (23)

Juniper: one botanical that must be present in gin is juniper. However, the legislation does not stipulate how much juniper. Juniper is a berry that is a member of the cypress family of plants. The earliest mention of juniper in literature goes back to 1266 in reference to a remedy for stomach pain. Most juniper grows in places like southern and eastern Europe, however, it does grow in limited quantity in many parts of North America. Take a drive through New Mexico, USA at the right time of year and you will see juniper shrubs bearing small purplish berries. I recently learned that Juniper even grows in the western Canadian provinces - although I am told these berries are very pungent. Shop around for juniper. Try berries from different locations. Maybe even try blending different juniper berries to impart a completely unique taste profile to your gin. The molecules present in juniper that impart its unique flavors include alpha-pinene, myrcene and limonene.

Coriander: the second most important flavoring botanical in gin is the coriander seed. The leaf of the coriander plant is called cilantro and you have likely seen it in your grocery store fresh produce section. Coriander plants grow in many parts of the world and the seeds are easily obtainable. The essential oils in coriander seeds include linalool,

thymol and geranyl acetate. Collectively, these oils impart slight woodsy, floral and citrus notes to gin.

Lemon Peel: lemon peel will be available in dried form. The best lemon peel for gin making will have originated in the Mediterranean region. A small amount of lemon peel will give gin a fresh, citrus note.

Orange Peel: orange peel will likewise be available in dried form. The best orange peel for gin making will come from Spain. As you source orange peel you will find it will be available in bitter and sweet varieties. Experiment with each type and decide which you prefer. I have had gin made with just sweet orange peel and I have had gin with both sweet and bitter peel. The difference is slight, but there is a difference. Another peel worth investigating is from the Italian Solerno Blood Orange.

Grapefruit Peel: grapefruit peel can lend some very attractive dry-type notes to the finish of a gin. If you have ever licked a grapefruit peel and experienced the dry sensation, that is what the peel will lend to a gin. When served in a Gin & Tonic, the result can be marvelous.

Angelica Root: angelica root comes from Germany and Belgium. Angelica has a reputation for imparting a floral note to Gin, but also an earthy note too. In fact, angelica is a close relative of the parsley and dill plants. I personally use angelica root only sparingly in my home-made gins, but research shows that many of the big commercial names in gin do use angelica root. The essential oils in angelica include limonene, pinene and beta-phellandrene.

Orris Root: this is the root bulb of the Iris flower plant. Mention of this root goes back to Greek and Roman times when it was highly prized for use in perfumes. It has a reputation in gin circles as being the ‘fixer’. That is, the active ingredient, irone, reportedly marries and holds together the tastes and aromas from the various botanicals in a gin. I recently found orris root at a local health food store in the roots and herbs section. I now use orris in my homemade gin and I can attest that in fact it does marry together the flavors of the other botanicals. If you are looking for a bit of useless trivia, consider that perfume brand Chanel No. 5 uses Orris Root in its formulation.

Licorice Root: this is the root of the plant glycyrrhiza glabra. Licorice can add some body and sweetness to a gin and can prolong the taste sensation on the tongue.

Pink Peppercorn: the pink peppercorn is the fruit of the Peruvian pepper tree, schinus molle. Pink peppercorns added to a gin can lend a bit of citrus note as well as contribute to some warmth on the finish. Audemus Spirits in France is gaining a reputation for its Pink Peppercorn Gin.

Tonka Bean: The Pink Pepper Gin just mentioned will have your taste buds doing the happy dance because of the magic ingredient in it – tonka beans. The cumaru tree is native to South America and its seeds are called tonka beans. The beans impart a sensuous helping of coconut and vanilla and chefs around the world crave them. Problem is, tonka beans contain coumarin which is a blood thinner and the USFDA has had a ban on them since the 1950s. If you can find some tonka bean, your gin will be the talk of the town. If your travels take you to London, you will find Pink Pepper Gin in bars. Try it. You will be impressed.

Cinnamon: cinnamon is the bark of a tree native to the island of modern-day Sri Lanka. Today much cinnamon comes from India and Brazil. Cinnamon is high in chemical compounds eugenol, cinnamaldehyde and linaool.

Cassia: Cassia is a relative of the cinnamon family and originates in south-east Asia, hence its colloquial name 'Chinese cinnamon'. Like cinnamon, it will add a spicy, floral note to a gin.

Cardamom: if you dabble in Indian cooking or if you frequent Indian restaurants, you have seen cardamom pods and the tiny black seeds in the pods. Cardamom is a member of the ginger family. In small quantity it can add a spicy, citrus type note to a gin. The essential oils in cardamom include linalool and linalyl acetate. There are two varieties of cardamom – green and black. The green cardamom will impart a slight eucalyptus note to gin. The black variety will impart a slight smokiness to a gin. Either should be used in very limited quantity.

Grains of Paradise: these small dark brown berries from West Africa resemble small peppercorns and are a member of the ginger family. They impart a peppery note to a gin if used in small quantity. Grains of Paradise is an ingredient in Bombay Sapphire Gin.

Star Anise: this eight segment, star-shaped seed comes from an evergreen tree (related to the magnolia) that grows in southwest China and parts of Vietnam. In a gin, star anise will impart a very definite licorice taste. Active ingredients in star anise include anethole and glycyrrhizin.

Fennel: fennel is a perennial herb that grows in the Mediterranean region. If you have ever sautéed some apple with chopped up bits of fennel, you will know how wonderful it tastes. Fennel can add some body to a gin and can lengthen the taste sensation on the tongue.

Cubeb: we are all familiar with cubeb's relative – black pepper. The piperene and limonene essential oils will give gin a spicy, citrus note.

Lavender: lavender bushes are commonplace in the south of France. Lavender imparts a wonderful aroma to gin. Now imagine those aromas in a martini glass as you raise that glass to take a sip. Lavender in a gin takes a martini to a whole new level.

Apple: the main acid in apple is malic acid. Apple can lengthen the taste sensation on the tongue and add substance to a gin.

Cucumber: this vegetable is loaded with fatty acids and flavors. I have tried using bits of cucumber in the actual gin distillation , but the fatty acids tend to make the distillate turn cloudy upon proofing. Hendricks Gin from the U.K., and Uncle Val's Gin from the USA, both use cucumber in their recipes. It is my understanding that both these products have cucumber essence added post-distillation. It is interesting to note that both these products come in dark bottles. I presume this is to guard against possible cloudiness in the bottle acting as a consumer visual deterrent.

Parsnip: I have recently learned that prior to the understanding of sugar cane as a sweetener, parsnip – which is native to the Indian sub-continent- was used as a sweetener. Take a pan and sautee some parsnip sometime and you will experience its wonderful sweetness. Now, imagine taking parsnip and soaking it in a finished Gin for a period of several days. The alcohol will pull some of that residual sweetness from the parsnip. But, you don't have to imagine this. You can taste it for real by getting some Piger Henricus Gin from a small distiller in Quebec, Canada called Les Distillateurs Subversifs. I have a bottle of their product in my collection and I guard it closely. It is truly divine.

RoseHip: the hip is the fruit of the rose plant. Rosehips have a wonderful citrus-like aroma and can elevate the aromas of a gin quite elegantly.

Kaffir Lime Leaf: the kaffir lime is native to south-east Asia and is used in cooking. The leaves are available in North America is dried format. On their own, they have minimal aroma. Soak them in alcohol and the aroma pops out. Add some of this macerated concoction to a distillation run for gin and the citrusy notes will amaze you.

Fruits: I have had gin where small quantities of blueberry and even rhubarb have been added. It is hard to detect these individual fruit notes in the gin on a stand-alone basis, but they are nonetheless there combined with the other botanicals and imparting subtle notes of flavor to the gin. I have lately been experimenting with infusing fruits into finished gins. I have had great success in infusing rhubarb into gin and also apple into gin. At this time of writing, some U.K. distillers are reportedly infusing damson plum into gin to great acclaim.

Flowers: I have had gin containing flowers petals from the high desert around Santa Fe, New Mexico. I have had gin containing flower petals from marigold flowers grown in western Canada. The use of flowers is an open book. Experiment and see what happens. I recently tried adding a small bit of dried hibiscus flower to a finished gin. I was quite impressed and this demands further experimentation.

So many botanicals, so many possibilities, so little time. I regard gin as a blank artistic canvas with the distiller as the artist. The days of gin all tasting pretty much the same are over thanks to the craft distilling movement. Explore, investigate and experiment. You will have a lot of fun with gin.

The following are three sources of botanicals.

http://herbies-herbs.com

https://goldenbough.ca/retail/

http://www.starwest-botanicals.com

Lactose

Of the various raw materials available to distillers, lactose (milk sugar) is perhaps most unusual. So far, only a handful of craft distilleries in North America have used lactose.

When a cheesemaker sets about making cheese, an enzyme substance called rennet is added to the milk. The rennet causes the milk to separate into curds and whey. The curds are collected for cheese and the remaining whey liquid is sold to a food processing company. Whey will contain up to about 4% lactose sugar which is comprised of a glucose molecule joined to a galactose molecule. The food processor will extract the lactose and sell it to companies for use as a sweetener. Brewers know how to utilize lactose. It is one of the ingredients that give Guinness beer its silky sweetness. Standard brewing yeast will not digest the lactose. Because the lactose remains in the beer, it contributes body and sweetness to the beer.

Likewise in distilling, the standard saccharomyces cerevisiae yeast cannot thoroughly digest the glucose-galactose combined molecule. But, scientists have figured out that a special yeast called kluyveromyces marxianus will ferment lactose. Distillation of the fermented lactose alcohol seems to be getting the name alpha-Vodka in craft distilling circles. Whether this name will endure, remains to be seen. Blackfly Distilling in Ontario, Canada imports lactose distillate (I am told it is from New Zealand?), proofs it to 40% abv and retails it as Bob’s Super Smooth Spirit. I use Bob’s Super Smooth in my workshops to illustrate the taste profile one can expect from lactose. All who have sampled this product are pleasantly surprised at its floral aroma and silky texture. Leche Spirits of Roswell, New Mexico launched its Milk Money Vodka in 2015, complete with a bottle that resembles an old-fashioned milk bottle. Black Cow Milk Vodka from Black Cow Distillery in Dorset, U.K. is gaining quite a following too. In Canada, Dairy Distillery opened its doors in 2018 just outside of Ottawa, Ontario. Its VodCow product made from lactose obtained from a nearby dairy processor is turning heads and gaining a following. In early 2021 I was informed that After Dark Distillery in Sicamous, B.C. was engaging in efforts to ferment whey from a local dairy using a

strain of kluyveromyces marxianus yeast obtained from Cedar Lane Laboratories in Toronto, Canada. My textbooks also suggest that a saccharomyces pastorianus lager strain of yeast will also ferment the glucose-galactose molecule, (also called melibiose) although I have no experience with this yet.

My concern with lactose as a raw material is an economical one. Whey from a dairy is mostly water and will have only a fermentable sugar content of up to about 4% by volume translates into a Brix reading of 4ºBrix. An economical ferment should ideally start with something that is around 20ºBrix. A 1000 liter ferment of 4ºBrix material might generate 25 liters of alcohol at best. To collect enough material to fill a 1000 liter still for a Vodka rectification run would mandate about 32 successive ferments. That's a lot of effort. The other concern with whey material obtained from a dairy is the propensity for bacterial contamination. The pH of whey will be around the 4.0 to 4.2 level. This is right on the threshold of where lactic acid bacteria could gain a toehold and start to multiply. A distiller would not want bacterial to start eating the fermentable sugars before the yeast has had a chance to do its work.

Ideally, what a distillery would want is whey material that has been passed through a filter apparatus to remove some of the water load. Such material is termed whey isolate or whey permeate. The Brix level would be much higher on a permeate product which would give a more efficient ferment.

In late 2020 I was contacted by a large dairy operator in the Calcutta region of India regarding the use of whey. Their planned strategy was to approach the numerous local makers of cottage cheese in the area and purchase their left-over whey. The plan was to transport they whey back to their dairy factory where they would add it to a fermenter tank. The lab analysis of some of this whey showed 2º Brix of fermentable sugar content. In the heat and humidity of India, and given that the cottage cheese makers were small operators, the fear that I immediately expressed was one of bacterial contamination. The other reservation I expressed was the economics of working with such a low fermentable content.

In the absence of a reliable supply of whey, what a distiller could do is visit a local craft brewer and inquire as to where they buy their bags of lactose sugar used in their stouts and porters. Chances are they are using a product from a supplier called Country Malt who sell 55 pound bags of lactose under the identity GLM-Lact55. Country Malt very likely obtains this product from a protein processor in Wisconsin, USA. A distiller would mix the lactose power with water to create a slurry that measures around 20ºBrix. Kluveromyces yeast would then be added and the fermentation allowed to proceed.

Cream

And while on the subject of dairy related materials, distillers should keep a close eye on the continued success of Bailey's Irish Cream. Thanks to advances in food processing technology, it is now possible for a craft distiller to concoct a cream-based beverage alcohol that could resonate with customers.

Cow's milk comprises 86-88% water, 3-6% milk fat, 3-4% protein and about 5% lactose. To create cream, a dairy will remove some of the water load from milk to raise the milk fat concentration to as high as 36%. The fat globules in cream are a thermodynamically unstable system in that they will want to separate from the cream. A fat globule is surrounded by protein and a layer of phospholipids. Fat globules are hydrophobic. Weaken or break the fat globule membrane and that globule will seek to join up with other fat globules. The reason that the fat globules start to separate from the cream in the first place is due to naturally occurring bacteria in the cream. The bacteria weaken the protein and phospholipid layer surrounding the globules.

Stoke's Law explains the action of a fat globule separating from cream.

Stoke's Law states:

$$V = 2/9*[(pc-pf)/u]*g*R^2 ;$$

where pc is the density of the cream, pf is the density of the milk fat cream, u is the shear viscosity, g is the gravitational constant and R is the radius of the fat globule.

Intuitively, Stoke’s Law tells us that reducing the size of the fat globule slows the rate at which the globule separates from the milk. The size of the fat globule can be reduced by agitating the milk solution with a shear mixer turning at up to 5000 rpm. To further slow the separation of the fat globules, sodium caseinate or calcium caseinate can be added to the mix. The caseinate coats the fat globules to stabilize them.

Despite the complex science, it is possible for a craft distiller to make a cream-based product through a couple different approaches:

Contact a vendor called Creamy Creations located in Paramus, New Jersey. They sell a cream emulsion that already has been slightly fortified with alcohol. Add some of your own craft distilled product to round off the recipe.

Source cream from a local dairy. Buy a high-speed, shear mixer that operates at near 5000 rpm. This will serve to break up the fat globules. In a product emulsified using a blender, the shelf life prior to cream-fat separation will be perhaps 6-8 weeks. (24)(25)

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6

Yeast & Fermentation

Yeast is a member of the fungus family. Fungus is a substance we do not usually think of in a positive light. When it comes to distilling, we should set aside our negative aspersions and think of yeast as the friendly fungus. It is a uni-cellular, eukaryotic organism, about 1/10th the diameter of a human hair. It takes the 400X magnification setting under a microscope to be able to view a yeast cell.

Early mankind understood that there was an organism that could make fruit generate a liquid capable of imparting a pleasant intoxicated feeling. But, it was thought this organism was a direct extension of the divine Gods. In 1680, Dutch naturalist Anton van Leeuwenhoek was able to observe yeast using a rudimentary microscope. Following many refinements of microscopic devices, in 1857 French scientist Louis Pasteur used a microscope to determine that yeast was a living organism. He summarized his findings in his groundbreaking paper "Mémoire sur la fermentation alcoolique". As microscope capability continued to advance, a deeper look inside a yeast cell became possible. Today, scientists have a very detailed understanding of what comprises a yeast cell.

A significant advance in the understanding of yeast came in 1879 thanks to the efforts of Emil Hansen at the Carlsberg Brewing Company in Copenhagen, Denmark. Hansen was able to isolate a single cell of yeast and after exposing it to a sugary solution was able to demonstrate that the cell multiplied itself. He went on to develop protocols for culturing yeast. The yeast strain that he worked with was eventually named saccharomyces carlsbergensis. Today, this strain of yeast is called saccharomyces pastorianus, otherwise known as lager yeast.

Ale yeasts, are called saccharomyces cerevisiae and exhibit a much smaller genomic structure than lager yeasts. Ale yeasts have displayed considerable diversity across time. Ale yeasts have multiple copies of some of their genes in their DNA structure. This gene multiplicity has allowed mankind to isolate and propagate a variant of saccharomyces cerevisiae suitable for bread baking. Variants have been isolated and propagated for making wine, different styles of beer and different styles of beverage alcohol. Different variants of saccharomyces cerevisiae will even perform at different preferred temperatures. As a craft distiller, remain open to exploring different yeast strains from different reputable suppliers.

Physiology

Figure 32 illustrates the interior structure of a yeast cell. Figure 33 illustrates the yeast cell wall make-up. (1) The cell wall is comprised of beta (1,3) and beta (1,6) glucans interspersed with proteins and mannoproteins that allow for the passage of molecules of fermentable sugars and nutrients into the cell structure. Some of the cell wall protein material consists of proteolytic enzymes. In particular, glucanase and mannanase, help with the “softening” of the cell wall to permit daughter cell formation. Invertase breaks down sucrose into its constituent components, glucose and fructose which can then pass the cell wall. Alkaline phosphatase and lipase help hydrolyze fatty acids and lipids so their residues can pass through the cell wall. The outer surface of the cell has tiny attachments called lectins (fibrillar layer) which are made of mannoprotein.

At the end of a fermentation cycle, the yeast cells agglomerate and settle to the bottom of the fermenter tank. It is the lectin fibrils that cause the cells to stick together in a mass to promote faster settling to the tank bottom.

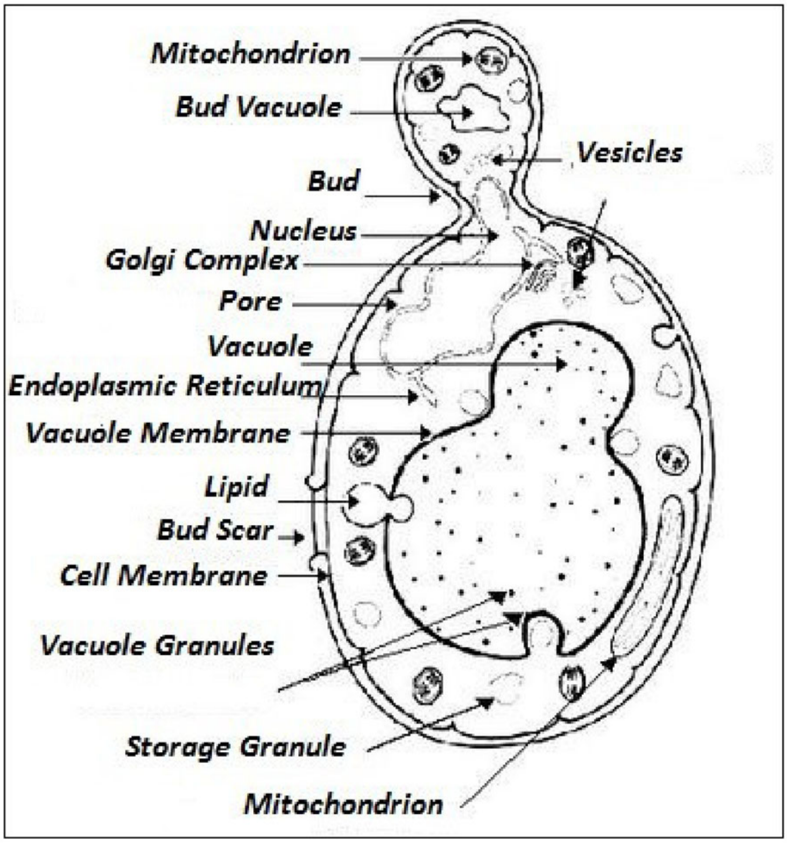

Figure 32 – Yeast cell parts

The plasma membrane is a phospholipid bi-layer. A lipid is created when a molecule of glycerol joins to a molecule of fatty acid. Adding a phosphate appendage to this structure creates the phospholipid construct. The plasma membrane is interspersed with transfer proteins that allow the passage of nutrients into the cell and it is dotted with sterols needed for cellular growth.

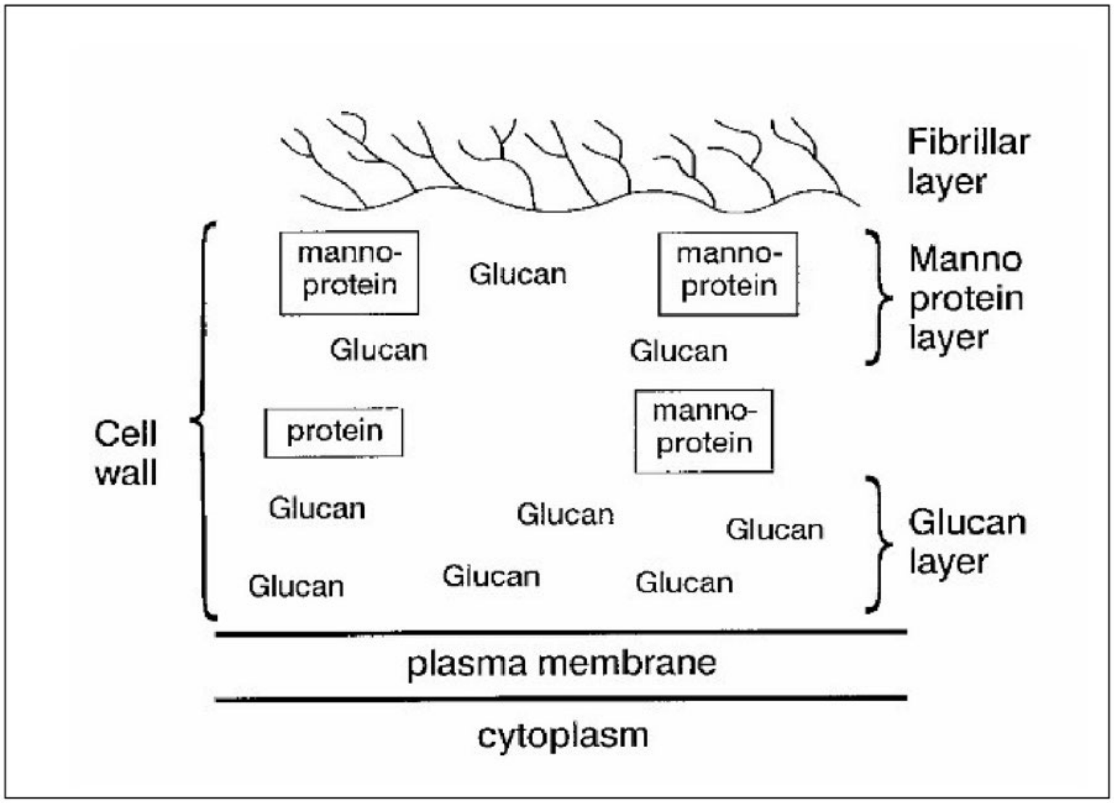

Figure 33 – Yeast cell wall

If the expression sterol sounds vaguely familiar, it should. We hear about sterol if our Doctor warns us our cholesterol is too high. Cholesterol is a molecule of the form C27H46O. It is essential for the vitality of cells in the human body and it is synthesized in the liver by way of a 37-step process. The body utilizes a transportation system to move cholesterol molecules through the bloodstream. The transportation vehicles are low density and high density lipoproteins (LDL and HDL). If the LDL molecules develop a gene defect, they lose their ability to bind to cholesterol molecules and the transportation system breaks down leaving cholesterol molecules stranded in the bloodstream. White blood cells in the bloodstream swing into action to neutralize these unwanted defective invaders by way of oxidation. But, in ridding the bloodstream of this unwanted traffic, the white cell-driven oxidation process creates a foam-like substance which builds as plaque on blood vessel walls which in turn leads to heart disease. When a Doctor prescribes a statin type drug (such as Lipitor) to counteract a patient's cholesterol, the aim is to disable the 37-step process involved in cholesterol formation. Reduced cholesterol molecules means a reduced propensity for defective LDL molecules leave cholesterol bits stranded in the bloodstream which in turn means less chance of harmful, artery clogging plaque. But, the statin drug argument remains highly controversial. Reducing cholesterol formation by way of the 37-step process means possible endangerment of cellular health throughout the body, which is why statins come complete with an array of side-effect aches, pains and ailments.

Yeast cells require a sterol called ergosterol for optimum cellular health. A paper from 1930 (2) revealed that ergosterol had first been recognized in yeast cells in the late 1890s. It is a naturally occurring substance within the cell structure. Different yeast strains will have varying amounts of ergosterol (between 0.2% and 2%). The 1930s study concluded with observations that the rate of drying the yeast after cultivation affected the amount of available sterol. Faster drying was deemed better than slower drying. Aeration during yeast manufacture was deemed critical with intense aeration being desired. Now you can understand why all the homebrewing books out there stress the importance of splashing and aerating your wort at the time of yeast pitching. I am certain that with modern day technology, yeast makers such as Lallemand take great care to ensure their yeast products contain an optimal amount of ergosterol. This further speaks to the importance of using a reputable yeast supplier. Low ergosterol will mean poor cell health and a poor fermentation.

The nucleus of a yeast cell is a storehouse of the DNA material required for reproductive growth. As noted earlier, DNA is best visualized as a ladder structure where the rungs are basal pairs of nucleotides. Yeast has its DNA coding contained on 16 fragments of DNA, each packaged in a protein structure called a histone. The proper name assigned to these fragments is chromosomes. Researchers agree that the genetic code of yeast (Saccharomyces Cerevisiae) involves over 6000 genes with a gene being a DNA segment responsible for encoding one protein type.

Ribosomes are responsible for providing sites where proteins can be synthesized. Ribosomes consist of ribosomal RNA (rRNA) and protein. Some ribosomes are free and some are fixed. The free varietals reside in the yeast cell cytoplasm and are responsible for making proteins and enzymes that will serve the needs of the cell. The fixed varietals reside in the endoplasmic reticulum which is an appendage to the nucleus. It is these fixed varietals that create proteins and lipids used for cell membrane and organelle membrane creation. The endoplasmic reticulum itself comprises two parts – the smooth and rough parts. The rough part is where the protein-making, fixed ribosomes are located. The so-called smooth part is where the protein and lipid-making, free ribosomes are located.

The mitrochondrion is the powerhouse of the yeast cell where Krebs Cycle ATP energy is generated and where the entire cell cycle of growth through death is regulated. A mitochondrion is typically about 1 µm in size, although it can be up to 10 µm. A yeast cell can contain more than one mitochondrion. The enzymes involved with the functioning of the Krebs Cycle and with the electron transport chain reside in the mitochondrion. The mitochondrial membrane comprises sterols and phospholipids. The membrane structure comprises two parts, the inner and the outer. The outer membrane portion has been shown to contain more of the ergosterol. The inner membrane contains more of the phospholipids. In addition, the mitochondrion contains self-replicating DNA which is used by the cell to fabricate new organelle material for daughter cells.

The vacuole is a storehouse of nutrients and also the production center for the enzyme protease. This enzyme breaks down proteins so that the cell can re-use the smaller bits (peptides and amino acids) to make new cellular material. The vacuole is often referred to in the singular. However, a yeast cell can contain a series of smaller vacuoles that are all clustered together. The number and size of the individual vacuoles is a function of yeast stress. As the yeast cell becomes stressed in the latter stages of fermentation, the number of vacuoles increases. The vacuole walls are a phospho-lipid structure with elastic features. They will expand to offer rigidity to the cell in the early part of the ferment when the fermentable sugars are placing high osmotic pressure on the yeast cell. As the ferment proceeds and the osmotic pressure recedes, the vacuole will relax in size. It has further been shown that the vacuole is a store for phosphate deposits, where the phosphate is used to sequester amino acids, although scientists agree that more research is needed to fully illuminate this feature.

All of these working parts are contained in the cytoplasm, which is a semi-fluid watery sac. Contained within the cytoplasm are glycogen and trehalose, which are both branched starch-type materials. The cytoplasm is where the yeast breaks down the fermentable sugars into glucose units that are then utilized by the mitochondria. When yeast is first added to the fermenter tank, it strives to become adjusted to its surroundings. In this initial early going, it keeps itself alive by consuming bits of its own glycogen. In the latter stages of the ferment, the cell will replenish its glycogen from the fermentable sugars present in the fermentation vessel. Trehalose is used as a safeguard material. Yeast is generating alcohol during a fermentation cycle and alcohol is toxic to yeast. The trehalose can create a thickening of the membrane to ensure no toxins leak into the cell.

Storage granules (also called peroxisomes) are comparable to a garbage collection service in that they collect waste materials and export them outside the cell wall.

The Golgi complex is comparable to a traffic cop directing the flow of traffic. Molecular material will be shuttled through the Golgi which will determine whether to direct the traffic into the vacuole for further use or into the storage granules (peroxisomes) and thence to the exterior of the cell.

A yeast cell reproduces itself by a process called budding in which it creates a daughter cell identical in appearance to itself. The pinched neck feature at the top of the cell in Figure 33 is the daughter cell. It will have all the same features at the parent cell. A cell can generate several daughters and each of those daughters in turn several progeny. Normal, healthy yeast cells will experience up to an eight-fold population increase during a ferment. This figure will vary with the amount of fermentable sugars. A lower gravity (fewer fermentable sugars) recipe will see more cell re-production than a higher gravity recipe used by distillers. Higher gravity recipes will thus require close attention to ensuring proper conditions for the yeast along with adequate amounts of nutrient and minerals from the water. Ensure the yeast cells have optimal conditions, and the cells will rapidly multiply and ferment sugars to alcohols.

Fermentation Stages

Figure 34 shows a curve to illustrate the growth of yeast cells. (1) The overall process of fermentation comprises four distinct phases: Lag Phase, Exponential Phase, Stationary Phase and Decline Phase.

Lag Phase: When a distiller adds yeast to the fermenter, at first nothing appears to be happening. Hence the expression Lag Phase. But, there is something happening. Sensor genes in the cell DNA detect osmotic pressure from the fermentable sugars that are present. As the yeast acclimatizes to its surroundings, it relies on its internal reserves of glycogen to energize itself. Then it begins absorbing dissolved oxygen from the mash in the fermenter tank. It further absorbs FAN (free amino nitrogen) nutrients from the mash material in the tank. Recall from earlier information presented that FAN is the amino acid / protein material that gets liberated from the endosperm cells of the grain materials in the mash by the enzymes, either the ones generated by malting or the commercial ones you have added.

In the earlier chapter on Microbiology, it was noted there are 20 amino acids.

Alanine

Arginine

Asparagine

Aspartic acid

Cysteine

Glutamine

Glutamic acid

Glycine

Histidine

Isoleucine

Leucine

Lysine

Methionine

Phenylalanine

Proline

Serine

Threonine

Tryptophan

Tyrosine

Valine

Scientists have shown that a yeast cell will either assimilate Asparagine, Aspartic acid, Glutamine, Serine, Threonine, Methionine and Proline across the cell wall or create these amino acids by chopping off the NH2 attachment from a protein in the fermentation mash and using carbon and hydrogen from the fermentable sugars present. Isoleucine, Valine, Phenylanaline, Glycine, Tyrosine, Lysine, Histidine, Arginine, and Leucine must be present in the fermentation mash as the yeast cell cannot synthesize these acids from basic building blocks. A shortage of thee amino acids in the fermentation mash will have effects on the types of alcohols generated in the ferment.

During the Lag phase and into the subsequent phase, the cell is also acquiring sterols and unsaturated fatty acids that will be used in daughter cell production. Sterols and fatty acids can be taken up either in the presence of dissolved oxygen or without dissolved oxygen.

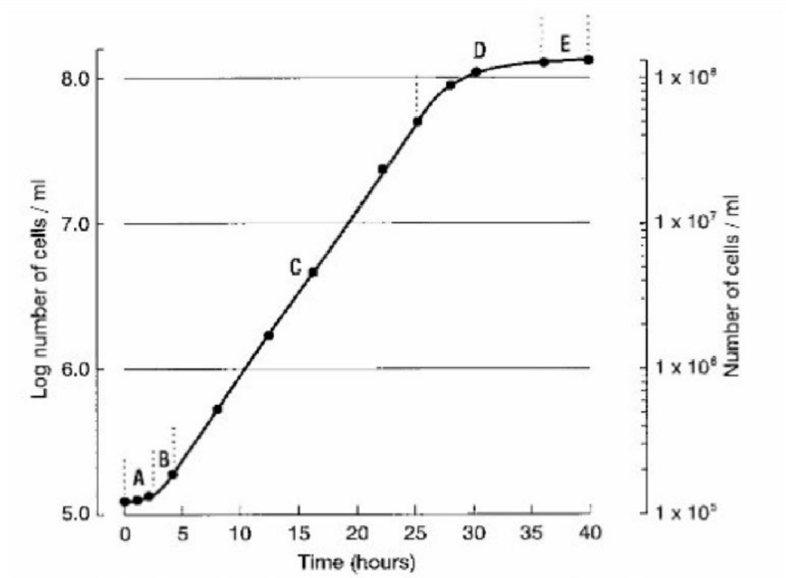

Figure 6. Batch growth curve for brewing yeast culture in shake flasks at 20ºC
(A) log phase,
(B) accelerating,
(C) exponential phase,
(D) decelerating phase, and
(E) stationary phase.

Figure 34 – Yeast cell growth curve

As sterols and unsaturated fatty acids are taken up, the process of synthesizing new cellular wall material then gets underway in earnest. The yeast is also busy at this stage synthesizing proteinaceous material for use as enzymes. The enzymes will be utilized to facilitate the chemical process of moving (absorbing) glucose, maltose, maltotriose, fructose and sucrose molecules through the yeast cell wall. The enzymes make this process proceed smoothly and efficiently.

The Lag Phase typically lasts for about 6 hours with a distilling strain of yeast. With a beer making strain, the Lag Phase could be closer to 20 hours.

Exponential Phase: Once the yeast has acclimatized itself and readied itself for cellular growth, it begins transporting fermentable material across the cell wall. Sucrose is first targeted by the enzymes which split the molecule into its constituent parts, glucose and fructose. The cell then takes across glucose and fructose at about the same rate each. The cell enzymes then break down maltose and maltotriose and move the constituent bits across the cell wall.

The fermentable material is broken into either glucose or fructose. These molecules are directed to through the multi-step EMP glycolysis pathway (refer back to Figure 10) and converted into pyruvate. Concurrent with the onset of pyruvate production, the Krebs cycle will activate (refer back to Figure 12). The ATP energy derived from the Krebs cycle is used to help with the creation of new daughter cells. Those daughters will then make daughters of their own through the cell division process called budding. The increase in yeast cell population is extremely rapid. In fact, exponentially so. This is why this phase of the fermentation process is given the name Exponential Phase.

Eventually, though, the dissolved oxygen content of the fermentable medium depletes. With the Krebs cycle impaired due to a lack of dissolved oxygen, the yeast cell will resort to oxidation of pyruvate to form acetaldehyde and then ethanol. This is fermentation.

The ability of yeast to survive without oxygen is remarkable. Plants and animals in the absence of oxygen will simply die because they are aerobic. They need oxygen to live. But, yeast is a survivor that can live in aerobic or anaerobic conditions. Cell genetics and the general conditions within the fermentation vessel will determine how many daughters a cell of yeast will produce. This pyruvate oxidation process will repeat until either the fermentable sugars run out or the yeast cell comes under duress from the surrounding toxic alcohol it has created.

Stationary Phase: The rate of daughter cell production levels off as the amount of newly created cellular material depletes. This is where the Stationary Phase derives its name. The population of cells effectively remains level or stationary. The Stationary Phase is a time of stress on the yeast cells. However, the yeast cells and daughter cells that exist in the fermentation vessel are survivors. They will quickly adapt to changing conditions and find alternative ways to keep living. This is where a further distinction can be drawn between yeast cells and members of the plant and animal kingdoms. To bolster its cell walls to guard against the toxic ethanol in its environment, a cell will absorb amino acid material from its surroundings. The NH_2 part of the amino acid is cleaved off to help make cell wall material. The remaining skeletal portion of the amino acid is then oxidized into an alcohol molecule with multiple carbon atoms in its structure. This sort of alcohol molecule is termed a higher alcohol. The process by which this all occurs is termed the Erlich Pathway. The longer a fermentation process is allowed to carry on, the more higher alcohols that will be created. The framework for higher alcohols is of the general format C-H-OH, where the number of hydrogens equals (2 x number of carbons +1). For example, C_5H_{11}-OH is a higher alcohol. A quick math check reveals that (2 x 5) +1 = 11 and there are in fact 11 hydrogens in this higher alcohol.

Higher alcohols are a distillers best friend. The flavors and mouthfeel textures in higher-end, more expensive beverage alcohol products come in large measure from the higher alcohols. Consideration of higher alcohols ties to my observations in Scotland where a distiller I talked to at Glenkinchie Distillery knew exactly how long to allow each ferment to continue. As he explained to me, to extend the ferment longer would mean the introduction of too many higher alcohols that take away from the desired flavor profile. That is, the flavor profile desired by his end customer, Johnnie Walker, who is blending the Glenkinchie product with a series of other malts to create a blended Scotch with desirable character.

The subject of higher alcohols and the duration of the stationary phase, demands a deeper investigation prior to launching a craft distillery project. Craft distillers should conduct small batch fermentations using different yeasts and different lengths of ferment cycle time. Take note of which combination of parameters give the distillate flavor profile most likely to appeal to consumers.

Decline Phase: Eventually, the yeast cells will have run out of sugars to consume and will be under serious duress from the alcohols in the surrounding environment. At that point the population of cells will decline due to cell death. This is called the Decline Phase.

Cell Division

Figure 35 illustrates the stages in yeast cell division as daughters are made. (3) When the yeast cell decides to form a daughter, enzymes in the cell wall cause weakening in a small area of the wall. The cell wall then bulges out slightly to form a bud. As this is occurring, the cell begins to make DNA material which will be passed to the daughter. This is the ‘S’ part of Figure 35. At this point, the cell does a quality check. If DNA defects are noted, cell division is arrested. This is the G2 part of Figure 35. If all is normal, the ‘M’ phase unfolds, where M denotes mitosis. In mitosis, the DNA material is passed to the daughter cell. What follows next is the separation of the daughter from the parent. But one final quality check is in order, which is G1. If DNA defects exist in the daughter or if the daughter is improperly sized, she will not be allowed to replicate her own daughters in her own ‘S’ phase.

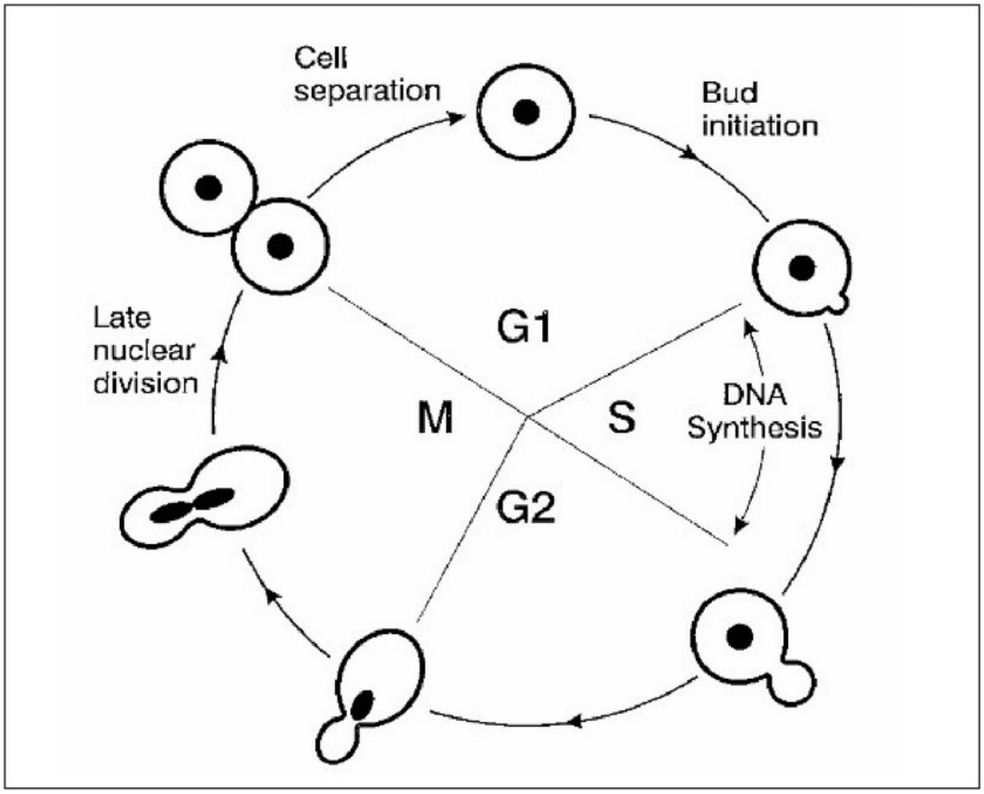

Figure 35 – Yeast cell growth stages

Yeast Strains

A distinction must be drawn between yeast strains used in beer brewing and yeast strains used by distillers. In a brewery scenario, it is very common to harvest yeast at the end of a ferment and re-pitch it into the next ferment. In a distillery, the amount of raw materials used in a batch make for a higher specific gravity than would be the case in a brewery. Yeast gets stressed when asked to perform a ferment on high gravity material. As a result, distillers do not re-pitch their yeast into a subsequent batch. It would be like a person running a marathon and then being asked to immediately run another one without any rest.

The science of creating new yeast strains is beyond the scope of this book. What follows is a brief summary of what I have gleaned from various papers I have read on the subject.

Mating occurs if a yeast cell detects a different type of yeast cell nearby. Each of the cells arrest their growth in the G1 or G2 phase. The two cells will then combine (mate), and a new culture will be created. (3)

Meiosis occurs under conditions of deprived nutrients which causes yeast cells to break into many tiny bits in an effort to survive. Scientists have determined that a stressed cell containing two copies of its chromosomes (diploid cell) will turn into four ascospores, each containing a single copy of the DNA material. Two of these four units are of one mating type and the other two are of another mating type. Scientists can separate these types and encourage each type to then multiply. Repeated efforts at this sporulation can result in unique cultures of yeast being identified.

Cytoduction is a method that involves taking the cytoplasm components of one yeast strain and transferring them to another strain. The resulting creation is then cultured and tested for its ability to ferment.

Spheroplastic fusion is a method in which the cell wall of a yeast cell is removed, leaving the inner cell parts 'naked'. The same is done to another yeast strain. The two spheroplasts are then merged and a new cell wall is encouraged to grow. The resulting new strain will have unique characteristics. For example, if this technique was done with Sacharomyces Cerevisiae and Sacharomyces Rouxii, the resultant strain would be one that could tolerate higher levels of fermentable sugar in the fermentation vessel.

An advanced approach to making yeast cultures is Recombinant DNA. In this method, some DNA material from another eukaryotic cell (such as a plant) is inserted into the yeast cell. Scientists can make the yeast cell express some of the genetic behavior of the foreign DNA material. This approach has been used to make yeasts with improved fermentability (attenuation).

You are unlikely to hear much about these techniques. Can you imagine the social uproar if the average consumer found out that their Budweiser beer was made with genetically manipulated yeast?

What is for certain though is that there are some highly capable yeast vendors that will work with you as you launch your distillery. One of the best, in my opinion, is Lallemand. They have a number of well-developed strains of distilling yeast that each have unique properties. I encourage you to study what they have available.

Thanks to these advances in genetic engineering, scientists now have agreed that the main species of yeast in Nature is one called saccharomyces cerevisiae. But, under the umbrella of this species are nearly 700 different strains. A good analogy to describe the situation is that of man's best friend, canus familiaris, the dog. Underneath the umbrella of the species canus familiaris are many strains. Think poodle, doberman, pit bull, boxer, hound, bulldog and so on. All have four legs, a tail and will bark. But all are different and have different capabilities. And so it is with yeast species saccharomyces cerevisiae. There are strains ideally suited to making English ale, porter and stout. There are strains for red wines, white wines and champagnes. There are strains for rum, whisky and vodka. Note that there is a yeast species called saccharomyces pastorianus which is used for making lager beer. This species is capable of fermenting the lactose sugar found in whey.

Yeast Propagation

To create sufficient quantities of yeast to supply brewers and distillers, a yeast manufacturer will start with a bit of proprietary yeast culture in a sterile vessel. A dilute medium of molasses is made up to a concentration of about 0.5% sugar. This solution is augmented with ammonium salts and trace minerals. Temperature is maintained at 30ºC and vigorous amounts of oxygen are supplied to the vessel. Under these conditions, the yeast will generate numerous daughter cells and the population will grow exponentially. Additional molasses mixture is slowly fed to the growing mass of yeast. Eventually, after about 30 hours, the ability to supply enough oxygen quick enough will be compromised by the voracious appetite of the growing population and the propagation process is halted. The yeast population is then separated from the sugar medium by way of a vacuum filter. The yeast might then be dried and packaged for retail sale. Or, the yeast might be packaged as a liquid slurry and sold to a brewery or distillery for quick use. A dried yeast can be stored in the refrigerator for several years. A slurry product will have to be consumed within days.

Sensitivity

Yeast is a sensitive organism. In order for yeast to properly reproduce, it needs proper pH, proper temperature, inorganic ions, vitamins, nitrogen, oxygen, a carbon source and water. It has to be added to the fermenter vessel in proper quantity and care must be taken to avoid exposing it to toxins.

Proper pH: pH is short form for Hydrogen Potential. Mathematically, pH is the negative base 10 logarithm of the number of moles per liter of hydrogen ions in a solution. pH values are expressed on a scale that goes from 1 to 14. A solution that has pH of 2 will have a high level of hydrogen ions.

For example, $H3PO4$, phosphoric acid, will have a high level of Hydrogen ions and as such in concentrated form might have pH as low as 2. Caustic soda, NaOH, has no Hydrogen ions (in fact it has OH- ions) and mathematically, its pH might be near 14. The water that you and I drink from the tap in our kitchens will have a pH of about 7.

Yeast will perform at its best if exposed to a pH range of of 5.5 to 5.8. Grain is acidic thanks to its phytic, ferulic and propionic acid contents in the seed coat layers, so adding grain to water will reduce the pH. If the pH of the water is 7 or just below, addition of the grain should be sufficient to reduce the pH to between 5.5 and 5.8. I have also found that darker roasted grains that are typically used by brewers in dark beers are quite acidic. Addition of a small amount of dark roasted grain will very effectively lower the pH of a grain mash at a distillery. Another acidic material for adjusting a mash pH is honey. To illustrate, take a cup of warm tap water and test the pH. Next, add a teaspoon of honey and re-test the pH.

Proper Temperature: Temperature is the one variable that will most certainly have a detrimental effect on yeast. Expose yeast to a temperature much above 34ºC and the heat will most certainly kill it. Yeast for distillers will function optimally between 20ºC and 30ºC, with each yeast manufacturer having a different optimal range. For example, yeast maker Lallemand says its yeast functions optimally at 28 to 30ºC. Allowing temperature to drift down to near 20ºC will not kill the Lallemand yeast, but the rate of fermentation will slow markedly. White Labs, on the other hand, says that its yeast functions optimally at between 22 and 25ºC. Another yeast I have recently discovered is from a Canadian company called White Star. According to data on the package, White Star has its yeasts cultivated in Australia and shipped to Canada in bulk where smaller containers are filled for retail sale to brewers and distillers. I have found that White Star yeast performs very well at normal room temperatures of around 19-20ºC.

When adding yeast to a fermentation vessel, it is critical not to shock the yeast. Adding yeast to a mash without proper re-hydration is simply asking for that yeast to be stressed and to deliver off-flavors. Prior to adding the yeast to the fermenter, take the yeast and add it to previously boiled (sterile) water that is at about 33ºC. Stir the yeast particles into the water to make a slurry. Adding yeast to warm water serves to soften and re-hydrate the yeast cell walls so that the yeast cells can more easily absorb the fermentable sugars, FAN and fatty acids across the cell walls. When you add this slurry to the fermenter full of grain mash, which will be at about 28-30ºC, the temperature differential between fermenter tank and yeast particles will only be a few degrees so no shock will occur. In the case of fruit or wine as a raw starting material, follow the manufacturers recommendations which will most likely call for the yeast slurry to be added at room temperature to the material in the fermenter.

As a ferment proceeds, it generates significant amounts of heat. This will be discussed further in a later chapter on equipment needed for distilling. But, for here and now, note that the amount of heat generated will be a function of the size of fermenter and its ability to retain heat. For my recipe development research and experimentation, I conduct ferments in 60 liter plastic fermenter pails purchased from my local home brewing store. Given the small volume of these pails, they conduct heat to their surroundings relatively quickly. Even though one of my small ferments might generate 6ºC of additional heat, I have not had a problem with yeast becoming stressed due to overheating. Compare this to a large 1200 liter tank with large amounts of grain or other raw material inside. The heat generated will be significant at about 1.3ºC per Brix degree of starting gravity. This heat must be removed via cooling jackets on the tank otherwise yeast distress will result.

Inorganic Ions: To keep a yeast cell at its optimum, ideally it should be exposed to mash water containing about 20 ppm magnesium ions, 0.3 ppm zinc ions, 100-120 ppm calcium ions, 0.15 ppm manganese ions, and 0.10 ppm copper ions. Water in many parts of the globe will have ion contents generally close to these levels. Depending on where you live, you may have to make a modest addition of calcium chloride or calcium sulphate mineral salt. For example, in southern Saskatchewan where I now live, local residents claim they like their tap water. To be fair, it does have a nice taste. But, using it for making mashes is another matter. It has close to 700 ppm Total Dissolved Solids, 42 ppm magnesium, 95 ppm sodium and 230 ppm sulphate. On a good day, the pH is around 8.5. For making mashes of grain that will be fermented and used for distilling requires very little in the way of adjustment. Making beer is another matter altogether. Depending on the style of beer I am making, I often end up using a blend of tap water and Reverse Osmosis (R.O.) water along with mineral adjustments using as many as four mineral salts.

Vitamins: Just as human health can benefit from taking a multivitamin, so too does yeast function better when given added nutrient. When starting a fermentation (at the time of yeast pitching), it is advisable to add between 200 and 400 ppm of powdered yeast nutrient to the fermentation vessel. In a 30 liter fermentation, this equates to between 5 and 10 mls. I typically use a product such as Nutristart, made by French company Laffort. I have also used a product called Fermaid K. The additives in the powdered nutrient will give yeast what it needs to excel. Not all powdered nutrients are created alike. Always check the manufacturer's recommended rates of addition first. Many of the yeast makers will sell a proprietary nutrient mix that is designed to work with their yeast.

Nitrogen: as discussed earlier, yeast needs nitrogen and it will seek to get it from the raw materials used. The proteins in the endosperm cells of grain kernels are enzymatically degraded into amino acids and small peptides during the malting process and mashing process. In a grain-based process, there should be satisfactory amounts of nitrogen to satisfy the yeast. The standard unit of measure for Nitrogen is called FAN which stands for Free Amino Nitrogen. This number is a sum total of amino acids, small peptides and ammonia in the material to be fermented. For a high gravity ferment in a distillery, a distiller will want FAN levels of 200 ppm. If grain has been properly malted and mashed or if enzymes have been correctly, FAN levels should be in good standing. If you are using materials other than grains, be prepared to have to add a considerable amount of nutrient that contains amino acids.

Although not essential, thanks to advances in technology, a craft distiller can purchase a desk-top analyzer unit to determine FAN levels in a mash. The principle behind any such unit is the ninhydrin assay method, which was discussed in a prior chapter. A sample of mash liquid is mixed with a series of reagents to induce a color change. Using a spectrophotometer, the amount of light absorbed by the sample at 570 nanometers wavelength will correlate to the FAN level present. Alternatively, companies like White Labs in California offer a service for $69 whereby a distiller can send them a sample jar of mash material and they will calculate FAN for you. For a given raw material recipe, once the FAN is calculated, it will not have to be done repeatedly. Only changes in raw material or changes in process parameters will dictate the need for an additional test. If sending a sample to a laboratory, time is of the essence. Any bacterial population that establishes itself will start to consume the FAN and the laboratory assay number might be misleading.

Oxygen: Yeast needs dissolved oxygen in a mash to allow it to quickly get on with the task of creating new cellular material. There is debate as to how much oxygen is really needed. World renowned yeast authority, Inge Russell, has solved the problem. (4)(5) She succinctly states in her writings that a distiller should have 1 ppm dissolved oxygen per degree of Brix. Recall that 1ºBrix is the same as 1 gram of sucrose in 100 grams of material to be fermented. A typical Brix level for a mash in a distillery is about 20 to 22ºBrix, so a typical distillery mash will need 22 ppm dissolved oxygen. A distiller will entrain dissolved oxygen into a mash by agitating it while adding grain. The act of pumping the completed mash to a fermenter vessel will also cause a pickup in oxygen. There should be no need to add supplemental oxygen to a mash.

Carbon Source: As previously discussed, glucose with its six carbon atoms is the basic building block of starches in grains. Glucose and fructose are present in fruits, grapes and molasses. The carbon atoms in these molecules provide the source of carbon for yeast.

Proper Storage: Your supply of yeast should be stored in the refrigerator. At normal refrigerator temperatures, yeast will only lose

4% of its viability per year. Unrefrigerated yeast will lose about 20% of its viability per year.

Water: good quality water is critical for yeast to function. More about water in the next chapter.

Proper Quantity: There is one more variable that is important and that is the quantity of yeast that is added to the fermentation vessel. Through discussions with White Labs (USA) and with Lallemand Yeast, I have determined that 9-10 grams of yeast per 20 liters of mash volume is the minimal pitching rate. The simple analogy that I like to use is that of a table laid out with all sorts of delicious sugary, sweet food. You have invited guests to this festive occasion. Think of these guests as yeast cells. If there are too many invited guests, there will not be enough food to go around and guests will be most unhappy. If there are too few invited guests, each guest will eat until fully contented, but there will be food left over. What a waste! If, however, a proper number of guests are invited, all will feast until satisfied and there will be little food left over.

The mathematical approach to figuring out how much yeast to add to achieve a good ferment is based on volume, concentration of fermentable sugars and the weight of a gram of yeast cells. Consider this example: a home distiller prepares a 20 liter mash of grain and using his refractometer he notes the mash has a reading of 20ºBrix. Using a base starting figure of 750,000, he calculates 750,000 x 20,000 mls of volume x 20ºBrix = 300 billion cells of yeast needed to achieve a good ferment. If there are on average 30 billion yeast cells per gram in the dried yeast he will be using, then he will need to add 10 grams of the (rehydrated) dried yeast to his fermentation vessel. This simple calculation aligns very well with the numbers quoted to me by White Labs (USA) and Lallemand Yeast. This calculation is typical of what one will find also in books on beer brewing. In fact, if you are wondering about the 750,000 base starting figure, that number is derived from the writings of the late George Fix in his 1998 book An Analysis of Brewing Techniques.(6) I highly suggest getting his book, which you will find via on-line book sellers.

My travels to distilleries in Scotland have revealed that it is best to add more than just the minimal amount of yeast as discussed above. In fact, Inge Russell (4)(6) suggests that adding perhaps up to double the minimal amounts discussed above would be satisfactory. Deviating slightly from the analogy of guests invited to a feast, the more yeast cells added to a ferment, the quicker the ferment goes. In Scotland, it is common for a ferment to last only three days. As explained earlier, when I asked the distiller at Glenkinchie Distillery in Pencaitland why he opts for a 3 day ferment, he explained, the longer you allow a ferment to drag on, the more non-ethanol products (ie. higher alcohols, esters, etc..) the yeast spins off and the more the flavor profile of the distillate changes.

I suggest experimenting with various yeast addition amounts as part of your small-scale recipe development efforts. Keep detailed notes and what will emerge will be an optimal yeast amount that gives an excellent distillate taste profile. It is also advised to get creative and add different types of yeast to a ferment. I have read some literature on the subject and it appears that the Japanese Whisky makers might well be adding two or maybe three yeast types as they make their elegant, fruity Whiskies. For example, consider adding a distillers yeast, a beer brewing yeast and a champagne yeast to an experimental small-scale ferment.

Toxins: There are a few items that are absolutely toxic to yeast. These include fusarium molds, chlorine ions and iron ions. If sourcing grains from a farmer, be sure to visually inspect the grains for evidence of dark staining on the kernels, a sure sign of toxic molds. Be sure to also avoid farm-sourced grain that contains weeds, seeds and chaff. As

described earlier, yeast has been known to consume this foreign matter and generate alcoholic solvents which can ruin a distillation. If using fruits, wine grapes or even molasses, be sure there are no visible signs of toxic molds. The water used as part of the fermentation must be free of iron ions and chlorine, both of which are toxic to yeast. If you plan to locate a small distillery in a city, you should have few issues with iron in the water. If, however, your planned location is in a rural setting and will have you drawing process water from a well, it is wise to get the water tested so that you know exactly what you are dealing with. You may well find that a filtration system is needed to remove iron particles.

If you are interested in some deeper reading on yeast, I suggest you acquire the book by David Quain and Chris Boulton entitled Brewing Yeast and Fermentation or the book by Fergus Priest and Graham Stewart entitled Handbook of Brewing. Either will help you delve deeply into yeast and fermentation. (7)(8)

Fermentation Products

A sharp distinction must be drawn when it comes to describing the output from a fermentation. People are inclined to think that a fermentation generates alcohol. This inclination can be forgiven because we see the expression % alc listed on beer and distilled spirit bottle labels.

What a fermentation generates is a series of molecules with an OH appendage. These molecules will have at minimum one carbon atom in their structure and possibly up to eight carbon atoms. In addition, a fermentation will generate various acid compounds. Collectively, we have learned to describe the output of a ferment as alcohol. In reality, what the ferment generates is best described as the alcohol spectrum.

One molecule generated is acetaldehyde. Its structure comprises a central carbon atom with an oxygen atom, a hydrogen atom and a CH3 molecule attached.

A fermentation might generate trace amounts of acetone. The structure of acetone comprises a central carbon atom to which is joined two CH3 molecules and one oxygen atom.

A ferment might generate methyl pectate from pectin molecules present in fruits and grains.

The largest output from a fermentation will be ethanol, C_2H_5OH.

A three carbon product generated by fermentation is n-propanol which is of the structure C_3H_7OH.

A four carbon product created during fermentation is isobutanol, sometimes referred to as 2 methyl, 1 propanol. The structure is C_4H_9OH.

A five carbon product created during fermentation is isoamyl alcohol with structure $C_5H_{11}OH$. This product might also be referred to as 3 methyl, 1 butanol.

An eight carbon structure created from a ferment is phenylethanol. Its structure of C_8H_9OH is created when a phenolic 6-carbon ring attaches itself to an ethanol molecule.

A fermentation can create up to about eight different esters. In the Microbiology chapter, I discussed the mechanisms for ester formation by a yeast cell. The esters that can arise from a ferment include: ethyl acetate, ethyl butyrate, ethyl caproate, ethyl caproate, ethyl hexanoate, ethyl lactate, ethyl octanoate, and isoamyl acetate.

A ferment can also create a phenolic called 4-vinyl guaiacol by way of the decomposition of ferulic acid in grain husks in the mash. (9)

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7

Water

Water is easily taken for granted. However, it should be regarded as a critical raw material in the overall alcohol production process.

Understanding the chemistry behind adjustments to mash water chemistry at first glance does not appear easy. But as this chapter will illustrate, the science is not as complex as one might think. One reference book I recommend buying is Water, A Comprehensive Guide for Brewers.(1) This book, co-authored by Palmer and Kaminski, will help you more thoroughly explore water chemistry. Although written with the beer brewer in mind, this book can be used by distillers too.

Water Data

The first step in understanding your water is visit a business in your community that retails filtered water to the general public. Water sellers are required to have in their possession the most recent source water quality analysis data for your community. Another way of obtaining water data is to talk to your local City Hall or visit their website to retrieve the water data.

When interpreting water quality data, there are some key terms to focus on: (2)

Parts per Million (ppm): numbers expressed on a water quality report will be in parts per million (ppm). This is fairly intuitive and made easier by using the metric system of measure. If one has some mineral (let's say 50 milligrams) and dissolved it in 1 million milligrams of water, the net result would be a mineral concentration in that water of 50 parts per million. Thankfully the density of water is 1.00, so 1 million milligrams is the same as 1 kilogram which is the weight of 1 liter of water. So, 50 ppm is the same as 50 mg/liter.

MilliEquivalent/Liter (mEq/L): To understand milliequivalents, we must consider the valence (or charge) of various substances. When it comes to water reports, there are two key mineral substances to focus on: calcium and magnesium. The valence charge of calcium and also of magnesium is +2. Calcium has an atomic weight of 40 and magnesium is 24.2. To express these minerals in mEq/L, take the ppm concentration and divide it by (atomic weight/valence). In the case of calcium, the formula is:

Ca (ppm) / (40/2).

With magnesium, the formula is:

Mg(ppm) / (24.2/2).

Hardness: This is a reference to the amount of calcium and magnesium in the water. These are the constituents that contribute to hard scale build up on the showerheads and taps in your house. The formula used to arrive at the Hardness number is:

Hardness = 50*([Ca ppm/20] + [Mg ppm/12.1])

Calcium ion (Ca^{2+}): Calcium ions are very important to both brewers and distillers. Calcium ions assist yeast cells in making invertase and protease enzymes. Calcium ions are also beneficial in helping the alpha and beta amylase enzymes in malted grain to perform optimally as calcium ions help to lower the mash pH down towards the optimal level desired by these enzymes. Recall from an earlier chapter that enzymes function according to the lock and key model. The shape of an enzyme molecule must fit the substrate in order to bind. Calcium, by adjusting pH, is effective in regulating the general shape of the protein enzyme and its electric charge to ensure good binding. Calcium ions also promote the precipitation of some proteins which slightly reduces pH. (3)

Grain is naturally acidic due to the presence of acids in the grain kernels. Calcium ions in the water will react with the naturally occurring phosphates on grain kernels (K_2HPO_4) in a reaction that resembles the following:

7 Ca^{+2} ions + 2 PO_4^{3-} ions = 2 H^+ ions + insoluble calcium phosphate.

The net result will be a drop in pH levels thanks to the creation of hydrogen ions.

Distillers will want calcium contents in the water analysis data to be between 100 to 120 ppm. A distiller's mash will have a lot more fermentable sugar in it than a typical beer maker's wort, so the enzymes need all the extra help they can get. Low amounts of calcium in the starting mash water will require correcting by the addition of calcium. Adding calcium sulphate ($CaSO_4$) to a mash will see the molecule dissociate into its individual Ca and SO_4 ions. Adding calcium chloride ($CaCl_2$) to a mash will likewise see a dissociation which will provide Ca ions.

$CaCl_2$ is present in stable hydrated format as $CaCl_2 \cdot 2H_2O$. The molecular weight of this molecule is 146.8 grams/mol. The gram molecular weight of Ca is 40 and that of Cl is 35.4. Ca comprises 40/146.8 = 27% of the $CaCl_2 \cdot 2H_2O$ molecule. Cl_2 comprises 48%. Adding 1 gram of $CaCl_2$ to 1 liter of mash water will raise the Ca content by 270 ppm. The Cl content will rise by 480 ppm. Adding ¼ gram per liter of $CaCl_2$ will raise Ca levels by 67.5 ppm and Cl by 120 ppm.

$CaSO_4$ is present in stable hydrate format as $CaSO_4 \cdot 2H_2O$. The molecular weight of this molecule is 172.14 grams/mol. The gram molecular weight of

Ca is 40 and that of SO4 is 96.07. Ca comprises 40/172.14 = 23% of the CaSO4·2H2O molecule. SO4 comprises 56%. Adding 1 gram of CaSO4 to 1 liter of mash water will raise the Ca content by 230 ppm. The SO4 content will rise by 560 ppm. Adding ¼ gram per liter of CaSO4will raise Ca levels by 58 ppm and SO4 by 140 ppm.

pH: Have you ever noticed that some substances, such as a cup of green tea, will taste a bit soft? Have you noticed that some substances, such as orange juice, taste a bit sharp? This is all related to pH which is the 'power of hydrogen' in a solution. In a solution containing water, the water molecule (H2O) will partly dissociate into its constituent parts. The OH- molecules will float around freely in solution. The H+ ions will attach themselves to other H2O molecules to form H3O+ molecules. In 1 liter of pure water, scientists have determined that 1 x 10-7 moles of H+ will typically dissociate. A mole is 6 x 10^{23} particles of a substance. So, in 1 liter of water, there will be about 55.5 mols, which equates to 333 x 10^{23} molecules of H2O. The fraction of H+ ions that dissociate is thus very small. To better quantify the fraction that dissociates, scientists compute the negative logarithm of 1 x 10-7, as pH = -log10 [H+]. In this water example, the pH value computes to 7. This is why pure water is regarded as having a neutral pH of 7.

An acidic substance such as orange juice will have about 1 x 10-4 moles of H+ that dissociate. The pH of orange juice will be pH= -log10 [H+] = 4.

A basic substance such as caustic soda will have about 1 x 10-12 moles of H+ that dissociate. The pH of caustic is thus pH= -log10 [H+] = 12.

Magnesium (Mg^{2}+): Magnesium is beneficial in the yeast fermentation cycle as it assists in the various metabolic pathways used by the yeast

cell. The optimal amount of magnesium in water is between 10 and 20 ppm. Magnesium is readily available in stable hydrate format as $MgSO_4 \cdot 7H_2O$, which is better known as Epsom salt. The molecular weight of this molecule is 246.36 grams/mol. The gram molecular weight of Mg is 24.3 and that of SO_4 is 96.07. Mg comprises 24.3/246.36 = 9.8% of the $MgSO_4 \cdot 7H_2O$ molecule. SO_4 comprises 39%. Adding 1 gram of Epsom salt to 1 liter of mash water will raise the Mg content by 98 ppm. The SO_4 content will rise by 390 ppm. Adding ¼ gram per liter of Epsom salt will raise Mg levels by 24 ppm and SO_4 by 98 ppm.

Where I used to live prior to 2020, my local water had a calcium level of 40 ppm. When I did small mashes that comprised 24 liters of water and 8 kgs of grain, I added ¼ gram x 24 liters = 6 grams gypsum (calcium sulphate) to the mash kettle prior to starting the mash. This raised my calcium level from 40 ppm up to 98 ppm (40+58 = 98 ppm), a level well suited to optimal yeast fermentation performance.

Sodium (Na^+): 150 ppm is the most sodium that can be tolerated by yeast. It is unlikely that sodium levels in your water will ever be above 100 ppm. Sodium in small amounts will have a beneficial effect on flavors. In the rare cases where your water has extremely low levels of Sodium, consider adding minute amounts of sodium bicarbonate (Baking Soda). Adding ¼ gram per liter will raise sodium levels by 19 ppm.

Chloride (Cl^-): Chloride ions are not to be confused with atoms of Chlorine (Cl_2). Chlorides can be present in water in conjunction with calcium. Chloride ions in water can help accentuate flavors. Most tap waters will have small, but adequate, amounts of chloride ion present. Chlorine, on the other hand, is definitely toxic to yeast and must be avoided. If your tap water has the distinct aroma of chlorine, be sure to

pass the water through a 5 or 10 micron carbon block filter prior to using. Such filters are available from any water supply store.

Sulfate (SO_4^{2-}): Sulfates in water can contribute to promoting a crisp, clean taste. Beer brewers often desire sulfate in brewing water to promote crisper hop tastes. To a distiller, sulfates are not that critical.

Nitrate (NO_3^-): Nitrates in water might come about if your community sources its water from an agricultural area where nearby farmers apply lots of nitrate fertilizers. Nitrate ions are toxic to both yeast and humans.

Iron (Fe^{2+}, Fe^{3+}): Iron is toxic to yeast, so make sure your water is free of iron. This should not be an issue with tap water from your municipality, but if you are drawing well water in a rural area, have it tested for iron. If iron is present you will need to install an iron filter to capture the iron content.

Total Dissolved Solids (TDS): When you have water that comes from your tap with a noticeable taste profile to it, that means there are tiny dissolved mineral particles in the water. Collectively these tiny particles are termed Total Dissolved Solids. There is no guideline for how much TDS will or will not affect the outcome of a fermentation. I am now living in a rural area of southern Saskatchewan in Canada where I have water with high TDS levels around 630 ppm. But since moving here in March 2020 I have done a number of grain mashes that were all successful in terms of fermentation and distillate taste profile. So, if you are in an area of high TDS, do not worry too much. However, making beer with high TDS water is another matter. This is why I have started

using a blend of Reverse Osmosis (R.O.) water and tap water for making beer.

Alkalinity ($CaCO_3$ or HCO^{3-}): Alkalinity is a very important water constituent as it allows for the use of more acidic ingredients in the fermentation process. On a water report, you will see a line item called Alkalinity as $CaCO_3$. This figure is the amount of acid needed to titrate a water sample to reach pH 4.5. The amount of acid is then expressed as mEq. and multiplied by 50.

Residual Alkalinity: Alkalinity was thoroughly studied back in the 1950s by German brewing scientist Paul Kolbach. He determined that 3.5 mEq. of calcium would neutralize 1 mEq. of H_2O alkalinity. He also determined that 7 mEq. of magnesium would neutralize 1 mEq. of H_2O alkalinity. Any alkalinity remaining after these additions was termed residual alkalinity. Kolbach developed the following formula for residual alkalinity:

$$RA = \text{Alkalinity as } CaCO_3 - [Ca/1.4 + Mg/1.7]$$

To use this formula for your water, insert the ppm amounts of Alkalinity, Ca, and Mg into the equation.

Residual alkalinity can be counterbalanced using acidic substances. As an example, consider the water in Dublin, Ireland which could have alkalinity as high as 260 ppm. The RA of Dublin water will be around 200. Brewers in Dublin have learned over time that the addition of goodly amounts of dark roasted grains to a beer recipe will counter the RA because dark roasted grains are notably more acidic that just standard malted barley. The net result is a wonderful beer that we recognize as Guinness Stout. Try this same stout recipe in a location like Prague in eastern Europe and the beer will not taste good at all. Th reason is the water in Prague has low alkalinity. This is why brewers in Prague focus on making lighter lager style beers.

Tennessee and Kentucky sit atop massive limestone geological formations. Water in these areas has higher alkalinity which affords the distiller the ability to use more acidic ingredients. One distiller that is availing itself of the higher alkalinity is Kentucky craft distiller Corsair Distilling. Corsair has come out with unique creations such as Oatmeal Stout Whisky, where the alkalinity allows for the use of acidic, darker roasted and toasted grains.

The sour mash technique is often used in making bourbon in Tennessee and Kentucky. In the sour mash technique, acidic stillage liquid remaining in the still pot after a run is used to acidify a mash of grain. Similarly, some acidic fermented grain obtained from the fermenter at the end of a fermentation cycle could be used to acidify a new mash.

If you live in an area with high alkalinity, you should add acidic material to your mash water to reduce the pH to about 6.5. I have in the past used hydrochloric acid (HCl). Of late I have shifted to using a winemakers product called Acid Blend which is a granulated mixture of malic, citric and tartaric acids. As noted in the previous chapter, honey could be used as well. With your pH adjusted to just under pH 7, the addition of mash grains will then complete the task of reducing pH towards the desired mash target level of 5.5-5.8.

Intrigued by what Corsair Distilling is doing with dark roasted grains, my mashing experiments have shown that an 8 kg mash recipe containing 500 grams of dark roasted barley or chocolate malt will pull the mash water pH down by almost 1 full point (ie from pH=6.8 to pH=5.8). Intrigued also by the sour mash method, I have noted the pH of stillage left in my still is about pH 3.5. At the end of a distillation run, I take some of the left over stillage and freeze it in small plastic containers. When it comes time to do another mash, I add some of this frozen stillage to my mash water as it heats.

Water Adjustment Examples

Author George Fix in his Principles of Brewing Science (4) offers an excellent treatment of water science.

pH	CO3 ion	HCO_3 ion	H_2CO3
9	32	95	0
8	5	97	3
7	0	81	19
6.5	0	58	42
6	0	31	70
5.5	0	12	88
5	0	4	96

To illustrate Fix's methodology, consider the above table and an example of water at a pH of 8 with an alkalinity of 250 ppm. According to Fix, brewers typically aim for bicarbonate levels to be reduced to less than 25 mg/liter CaCO3 equivalent. From the third column in the Table, water of pH 8 will have 97% of its carbonates present as HCO_3. So, to reduce the water chemistry down to less than 25 mg/liter equivalent, the following formula shows that HCO_3 must be reduced to:

$$[(25) / (250)] / (0.97) = 10.3\%.$$

From the third column in the Table, in order to get to this level, the pH of the mash must be reduced to just under 5.5.

Consider some actual values from a craft distillery in southern British Columbia, Canada. The local water has pH of 8, Ca of 18 ppm, Mg 34 ppm and Alkalinity 238 ppm. The Residual Alkalinity (RA) is:

$$238 - [(18/1.4) + (34/1.7)] = 205.$$

This water is not exactly the most balanced and could very easily interfere with flavor balance on a distilled product. Plus, the calcium is too low for what the yeast needs to thrive. This distillery adds gypsum to raise the calcium level to 100 ppm. At 100 ppm, the new RA becomes:

$$238 - [(100/1.4) + (34/1.7)] = 146.$$

Better, but still not balanced. I suggested what this distillery could do to come closer to balanced water is add a 25 kg bag of Chocolate Malt to every mash. The acidity of the Chocolate Malt grains would be offset by the residual alkalinity and they would likely notice a significant improvement in distillate flavor.

This suggested approach aligns with Fix's Table shown earlier. This distiller would aim for a mash pH of just under 5.5 calculated as:

$$[(25) / (238)] / (0.97) = 10.8\%$$

(from the Table, 10.8% HCO_3 ion is a pH of just under 5.5)

Now, let's use the method outlined in Palmer and Kaminski's (1) book. Appendix B in their book has various logarithmic graphs to assist in solving water alkalinity problems. The authors present graphs to cover situations with 50, 100, 150 and 200 ppm alkalinity.

For the example of the craft distillery in British Columbia, I looked at the graph for the 200 ppm data (200 ppm is fairly close to the actual alkalinity of 238 ppm). Next I located pH 8 on the bottom graph axis. I then identified the curve on the plot for a desired mash water pH of 6. Scanning over to the vertical axis provided me with a alkalinity after acidification value of 60 ppm. That is to say, adding acid to reduce the pH will reduce alkalinity from 200 to 60 ppm, a reduction of 140 ppm.

Next, I computed the expression 140 / 50 = 2.8 mEq./L.

Palmer and Kaminski advise that water be acidified with acid of strength ‘1 N’, where N stands for Normal.

Based on the above shown computation, the distillery in question should add 2.8 mls of 1 Normal acid to each liter of mash water. This will reduce the RA (residual alkalinity) and get the pH to 6. If 900 liters of water are used, this equates to an acid need of 2520 mls, or 2.52 liters.

Palmer and Kaminski point out that to make 1 liter of 1 N hydrochloric acid will take 83.5 mls of hydrochloric acid (HCl). Hydrochloric acid is sold to the purchaser at 37% strength.

Sulfuric acid would require 27.2 mls of acid to make up 1 liter of 1N acid. But, sulfuric is sold to the buyer at 98% strength and using it requires serious personal protective equipment. If 900 liters of water are used in the mash, this still equates to an acid need of 2520 mls, or 2.52 liters. It’s just that you used less sulfuric acid to make up your acid solution.

In this example, if the distiller wanted to use acidulated malt, the acid quantity number would be the same. Acidulated malt, or acid malt, is barley that has been steeped in lactic acid. Acidulated malt is about 3% by weight lactic acid. Malted barley density is about 336 grams per liter. So, it would take about 28 kgs of acid malt to accomplish the pH and alkalinity reduction. Quickly glancing back at the first part of this example, I had suggested a 25 kg bag of chocolate malt could be used. Knowing that chocolate malt will be more acidic than ordinary malt, but likely on par with acidulated malt, based on Palmer and Kaminski’s graph method, I reckon my idea of a bag full of chocolate malt is pretty close.

The graphs in Palmer and Kaminski are based on complex formulas. The underlying scientific concept is that the alkalinity of water changes as a curvilinear function of pH. What follows is a basic description of how to use the Palmer and Kaminski method. I will use the B.C. craft distillery example mentioned earlier.

Step 1: Identify the Alkalinity as CaCO3 from your water report. Divide that number by 50 to obtain the mEq./L of alkalinity.

Step 2: Determine the pH of your water, either from the water report or from checking it with a pH meter. Identify the target pH that you wish to take your mash water to.

Step 3: Identify the mEq. of carbonate present in your water as a function of pH. Also identify the mEq. of carbonate that would be present at a low pH of say 4.3. As an example, the mEq. values in the following data Table correspond to three different starting pH levels.

pH	mEq. at starting pH	mEq at pH of 4.3
7.5	-0.93	-0.01
8.0	-0.98	-0.01
8.5	-1.00	-0.01

Step 4: Determine the difference in mEq. values between start and target. The following table presents these values.

pH	mEq. at starting pH	Diff. between start pH and pH of 4.3
7.5	-0.93	+0.92
8.0	-0.98	+0.97
8.5	-1.00	+0.99

Step 5: Take the calculated value from Step 1 and divide it by the difference value from Step 4. In the example of the B.C. craft distillery, we know Alkalinity is 238 and starting pH is 8. Thus, from Step 1, 238/50 = 4.76. And, 4.76/0.97 = 4.90.

Step 6: Identify a target pH value and its mEq. value. For a target pH of 6, the mEq. value is -0.30. For a target pH of 6.5, the mEq. value is -0.58.

Step 7: Determine the difference between the mEq. at pH 8 and the mEq. at target pH. For a target of pH 6.5, the difference is -0.58 minus

-0.98 = 0.40. For a target pH of 6, the difference is -.30 minus -0.98 = 0.68.

Take the 4.90 value from Step 5 and multiply it by each of these values. For a target of pH 6, the mEq. /L of acid to add is 4.90 x 0.68 = 3.33. For a target of pH 6.5, 4.90 x 0.40 = 1.96. Efforts at picking values off of a graph in Palmer and Kaminski's book yielded an acid need of 2.8 mEq./L to attain a pH of 6. The more rigorous math tells us to add 3.33 mEq./L.

Lastly, I will show you my situation at home where I make 24 liter mashes and acidify my water with Acid Blend purchased from the local home brew store. To make a 1 N solution of Acid Blend will require 68 grams of Acid Blend in 1 liter of water.

My starting pH is 8.5 and my alkalinity is 328 ppm as CaCO3.

Step 1: 328 / 50 = 6.56

Step 2: Target pH is 6.5

Step 3-4: mEq. in my water is -1.00. The difference between this value and a low pH value of 4.3 is 0.99.

Step 5: Compute 6.56 / 0.99 = 6.62.

Step 6: For as target pH of 6.5, the mEq. value is -0.58.

Step 7: The difference in mEq. values between start pH and target pH is -0.58 minus -1.000 = 0.42. Next compute 6.62 x 0.42 = 2.78 mEq/L. For a 24 liter mash, I need 2.78 x 24 = 66.7 mls of 1 N acid made from Acid Blend. This equates to about 4.5 grams of Acid Blend. The pH of my water does vary on a frequent basis, so I do not ever add a pre-determined amount of acid. I tend to add it in small pinches, let it dissolve in the water and check the pH with my pH meter. But, if I think about a typical mash, the calculated amount of 4.5 grams sounds awful close to what I do add.

Bottom line is, water chemistry is a gnarly subject matter, but one that a craft distiller must embrace. I hope I have illuminated the subject for you in a small way.

A large commercial brewing or distilling operation might resort to adding copious amounts of acid or lime to precipitate out some of the alkalinity. Boiling the process water would also help to precipitate out the alkalinity. The chemical reactions of these procedures are as follows:

$$Ca(HCO_3)_2 + heat = CaCO_3 + CO_2 + H_2O \text{ (heating method)}$$

$$Ca(HCO_3)_2 + Ca(OH)_2 = 2CaCO_3 + 2H_2O \text{ (lime treatment)}$$

$Ca(HCO_3)_2 + 2HCl = 2CaCl_3 + 2H_2O + 2CO_2$ (acid treatment)

Geology

The rock strata under your geographic area will strongly influence the water chemistry in your area. For example, the city of Vancouver, Canada draws its drinking water from an area in the mountains north of the city where the rock formations are granitic. Water in Vancouver is practically devoid of mineral content because these granitic rock formations impart few, if any, minerals to the water. I find beers brewed in Vancouver to be severely lacking in body and taste profile. This is no doubt due to the lack of mineral content in the water which in turn has affected the fermentation process. Another area of Canada that has water with practically no mineral content is St. John’s, Newfoundland which sits atop a massive geological deposit of granite. The best water in Canada comes from areas with limestone geology.

Proofing Water

Water is further critical when it comes to proofing spirits. The procedure for proofing will be discussed in a later chapter. It is critical that spirits be proofed with top quality water so as to avoid imparting any off-flavors into the spirit. Remember that alcohol is a solvent. Proofing spirits with tap water is inviting the alcohol to precipitate out minerals from the water. This will create small bits of mineral floating in your bottle of alcohol. Definitely visually unappealing.

To provide this top quality water, source out Reverse Osmosis water, otherwise known as R.O. water. A reverse osmosis machine comprises three parts. Incoming municipal water passes first through a filter bed to remove any heavy particulates. Next the filtered water passes through a water softener to remove calcium ions. Lastly the softened water flow passes through a semi-permeable membrane made of material such as sodium acetate. The pore sizing on this membrane is such that the H2O molecule will slip through but larger molecules will not. The result will be water that has a maximum impurity of only about 15 ppm total mineral content.

The diagram in Figure 36 illustrates a Reverse Osmosis flow. As a small batch distiller, you do not need a full blown Reverse Osmosis apparatus. Many grocery stores these days have dispensing units where you can fill a 20 L jug with R.O. water for $3 or less.

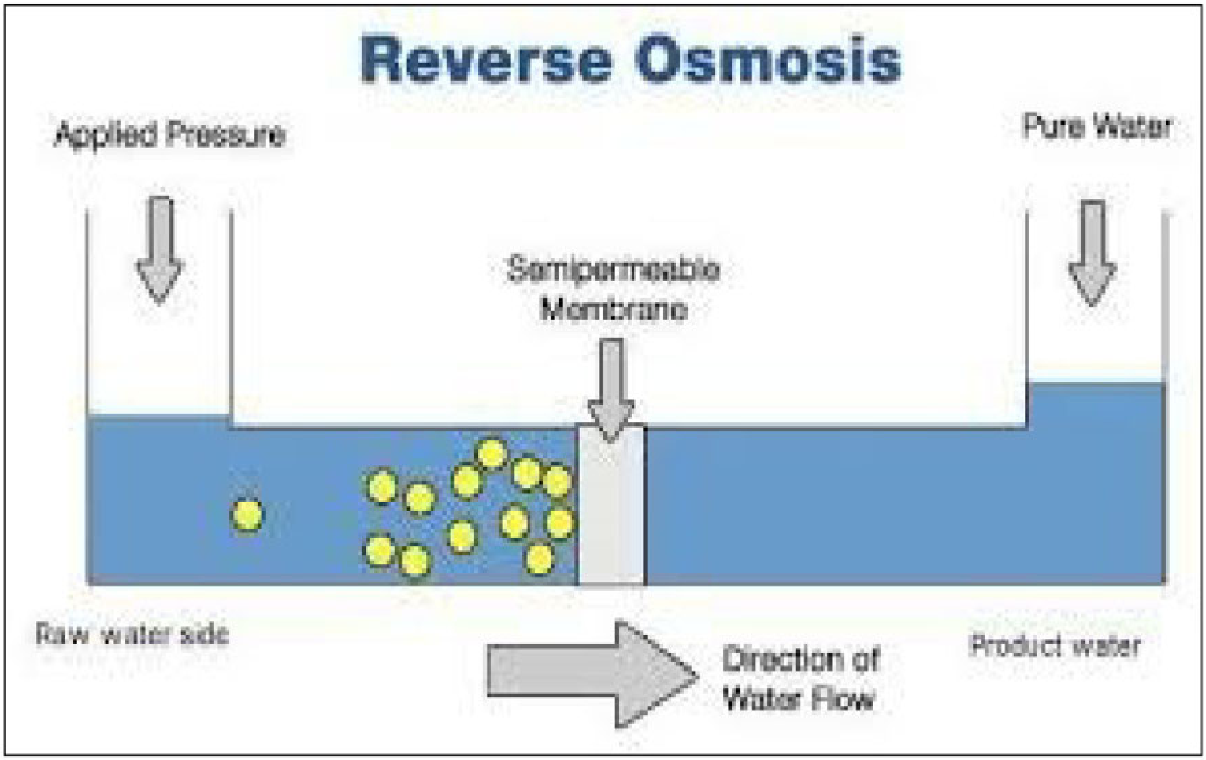

Figure 35 – Reverse Osmosis flow

Down the Drain

If you are planning on setting up a craft distillery, one issue that is gaining momentum is the chemistry of any waste water going down the drain into your town or city sewer. The local Public Works manager will likely tell you that any wastewater going down the drain should have a pH of between 6 and 9.

Immediately this becomes an issue because the pH of any spilled mash swept down the drain will be about 5.5 and the pH of stillage liquid from your still will be about pH 3.5. I have seen in several cases where craft distillers have been ordered to install a holding tank to capture any non-compliant waste. Once in the tank, the pH can be adjusted by adding caustic soda. It is also likely that a distiller will be asked to perform a BOD test on any material destined for the sewer. A BOD test is biological oxygen demand. The test entails adding a small amount of test material to a cylinder. Oxygen is then injected into the cylinder up to a certain pressure. After 5 days the pressure is examined. A decrease in pressure means the test material has absorbed oxygen. A set of calculations will produce a BOD test value. If the value is much over 300 ppm, you will likely have to take further measures to mitigate the waste material. If oxygen-scavenging waste is let into the sewer system, it will deprive sewage settling ponds of oxygen and open the way for anaerobic algae to grow which will hamper the sewage treatment efforts.

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8

Distillation Fundamentals

As early as 2015, I started noticing craft distilling start-ups struggling to find their footing, plagued by inadequate distillation experience and inadequate recipe development. At the time, I was convinced this problem was an anomaly that would rectify itself.

Six years later, I continue to see the same problems. Moreover, I still have people coming through the 5-day workshops with a mindset that craft distilling is the ticket to a life of riches.

Nothing could be farther from the truth. Like any entrepreneur jumping into an industry with little product or business experience, a person approaching a craft distilling start-up with a lack of science under their belt is foolhardy.

My advice is to slow down. Engage in some home activity to make sure you really do enjoy making alcoholic beverages. Make certain that you really want to go down the craft distilling road. A gleaming copper still can be an alluring, romantic sight. But, it takes plenty of hard work to run a craft distillery. Doing some home activity and getting your hands dirty will calm your urges to rush out and buy equipment and sign a lease on a building.

As you do distillation runs, the scientific concepts will quickly start to make intuitive sense to you. If you are an existing craft distiller and are reading this book, I urge you to take the time to explore concepts such as double pot distillation. Take the time to sample commercially-made whisky products from Scotland, Ireland, Kentucky, and Canada. How do these expressions similar? How are they different? Take the time to sample craft distilled gin and vodka products from far and wide. Which expressions do you like? Which ones do you not like? Where does your product fit on the spectrum?

This chapter is an examination of the basic scientific concepts that underpin alcohol distillation.

Surface Tension, Boiling and Vapor Pressure

Surface Tension: In Nature, molecules will strive to exist in the state of lowest energy/greatest stability. For molecules in the liquid state, surface tension plays a role in helping to achieve this stability. For example, after you next wash and wax your car, sprinkle some water on the freshly waxed surface of the car. Notice that the water forms distinct, stable droplets. This is because the surface tension of the water droplets is greater than the forces of attraction between the water and the waxed surface of the car. As another example, add some water to a container of olive oil. Notice that the two liquids do not mix. The surface tension of the water is different than the surface tension of the oil and the oil will prefer to exist as stable droplets on the water surface.

Surface Tension and Boiling: Consider a cup full of water (H2O). The oxygen atom in one molecule of water (water comprises 2 hydrogens and 1 oxygen) is attracted to the hydrogen atoms in a nearby molecule of water. This attraction, called hydrogen bonding, is what provides water with its surface tension. Related to hydrogen bonding is the concept of Van der Waals forces which are electrostatic in nature and which also contribute to surface tension.

At the very surface of the cup of water, the water molecules are attracted to nothing above because above the water surface is just air. This means that at the surface the water molecules have a net force pulling inwards towards the bulk of the water. This inward force contributes to the inability of the water to escaping from the cup. The act of the water molecules escaping from the cup is what we would call boiling. Thus, liquids with a higher surface tension will have a higher boiling point than liquids with a lower surface tension.

As a numerical example, consider that water has a surface tension of 72 dynes/cm and a boiling point of 100ºC. Ethanol has a surface tension of 22.4 dynes/cm and a boiling point of 78.5ºC. Therefore under the influence of heat energy, ethanol will boil before water. This concept is at the very crux of distilling.

Mixtures and Boiling: Consider once again a cup containing water with surface tension of 72 dynes/cm and a boiling point of 100ºC. Now, add some ethanol to this cup of water. The ethanol has a surface tension of 22.4 dynes/cm and a boiling point of 78.5ºC. The water molecules will be attracted to the ethanol molecule by way of hydrogen bonding. The resulting molecular configuration will have a surface tension that is somewhere between 72 and 22.4 dynes/cm and a boiling point somewhere between 100ºC and 78.5ºC. The exact surface tension and boiling point will be a function of the relative concentration of water and ethanol. But, it will not be a linear function. French scientist Francois Raoult showed this to be so in the mid-1800s. Raoult was a physicist and dedicated his career to the study of liquid-liquid systems. One system he spent considerable time with was the water-ethanol system.

Vapor Pressure: A concept that is closely related to surface tension is that of vapor pressure. Consider water in a container. The molecules of water at the microscopic level are vibrating with kinetic energy. This kinetic energy is called vapor pressure. So, why does the water not escape from the container? The answer is that surface tension inhibits the vibrating molecules from developing enough kinetic energy to break free of the container. Vapor pressure is a function of temperature and that function tends towards being an exponential relationship.

There are several ways of expressing vapor pressure including: pounds per square inch, kilopascals, millimeters of mercury, Torr and atmospheres. I prefer the units of millimeters of mercury (mm Hg). For example, water at 30ºC has a vapor pressure of 33.3 mm Hg. Water at a temperature of 50ºC will have a vapor pressure of 92.5 mm Hg. The atmosphere around us exerts a downward pressure on us of 760 mm Hg. In order for a liquid to boil, it must have a vapor pressure that equals or exceeds 760 mm Hg.

If vapor pressure is a function of temperature, this implies that heating a liquid will impart kinetic energy to its molecules. In other words, heating the liquid will raise its vapor pressure. Imparting enough heat energy to make the vapor pressure equal to 760 mm Hg will result in the liquid breaking its surface tension at the surface of a container.

Imparting heat energy to raise the vapor pressure of a liquid to 760 mm Hg is one matter. Adding additional heat energy will cause a phase change from liquid to vapor. The change from liquid to vapor is what is commonly termed making a liquid boil. If a liquid has a fairly high vapor pressure at room temperature to begin with, it will take relatively less added heat energy to eventually raise the vapor pressure to 760 mm Hg and to initiate the phase change. Ethanol has a vapor pressure at 30ºC of 65 mm Hg. Water has a vapor pressure at 30ºC of 33.3 mm Hg. This means then that ethanol will require less added heat energy than water to arrive at 760 mm Hg and boiling. This is why we say that ethanol has a lower boiling temperature (78.5ºC) than water (100ºC).

Francois Raoult

French physicist Francois Raoult was able to take his studies of the water-ethanol system to the point of establishing a definitive law which we now call Raoult's Law. Raoult's Law, states that the vapor pressure of a liquid-liquid system, such as water-ethanol, is equal to the respective amounts of water and ethanol in the mixture:

$$P_{total} = (x_1 * P_1) + (x_2 * P_2) \;;$$

where x_1 and x_2 are the mole fractions of water and ethanol respectively, P_1 is the vapor pressure of water alone and P_2 is the vapor pressure of ethanol alone.

This equation shows that as the amount of ethanol in a water/ethanol solution increases, the total vapor pressure (P_{total}) will likewise increase. Therefore, as the amount of ethanol in the solution increases, the boiling point decreases. Through repeated and careful study, Raoult came to understand this relationship in intimate detail and constructed a visual representation which is illustrated in Figure 37.

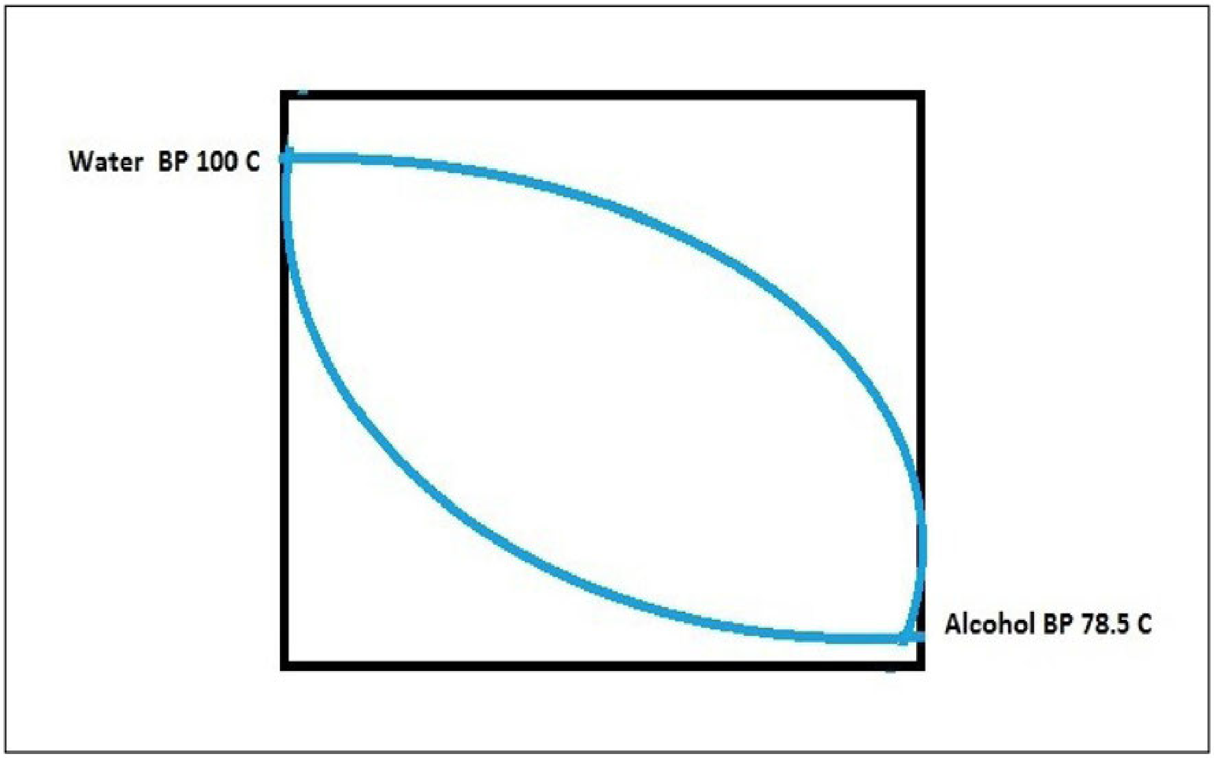

Figure 37 – Raoult's Law plot

In order to more fully appreciate this curve, there is one more individual to consider and his name was Charles Antoine, a French engineer. He was concerned with predicting the vapor pressure of liquids and in 1891 he published a paper in "Annales de Physique et de Chimie" in which he introduced the Antoine equation:

$$\text{Log}(P) = A - B/(T+C)\ ;$$

where A, B, and C are constants that Antoine determined through experimentation. T is the temperature in degrees Celcius. The output of the equation, P, is in units of mm of Hg.

Using Antoine’s A,B, and C values, one can calculate various values of P (vapor pressure) for ethanol at various temperatures. One can calculate the vapor pressure of water at various temperatures. These calculated values can then be funneled back through the Raoult’s Law equation to solve for x1 and x2.

One can then create a plot with T on the vertical axis and x1 and x2 on the horizontal axis. This plot will look like the bottom part of Figure 37. This bottom part of the plot in Figure 37 is called the Bubble Line. Temperatures along the Bubble Line are where the first bubbles of vapor would start to be seen as a liquid-liquid mixture is heated. From the Bubble Line we can conclude that the relation between the boiling point of water and the boiling point of ethanol is not a straight line, but rather a curvilinear function.

The upper portion of the plot in Figure 37 is called the Dew Point Line. Temperatures along the Dew Point Line are where the first drops of condensation would appear as a vapor mixture cools.

Raoult determined that the mathematical relation at work for dew points is:

$$1/P_{total} = x1/P1 + x2/P2 \;;$$

where x1 and x2 are the mole fractions of water and ethanol respectively, P1 is the vapor pressure of water alone and P2 is the vapor pressure of ethanol alone.

Using the Antoine Equation, one can calculate the values to create the Dew Point Line.

Consider the following simple examples of Raoult's Law:

A mixture of 10% mol fraction ethanol and 90% mol fraction water exists at 30ºC. Avogadro's number says that a mol is 6.022×10^{23} particles. The mixture consists of 10 mols ethanol (C2H5OH) and 90 mols water (H20). The gram molecular weight of ethanol is 46 grams per mol. The gram molecular weight of water is 18 grams per mol. Ethanol at 30ºC has a vapor pressure of 65 mm Hg, water is 33.3 mm Hg.

From Raoult's Law, Ptotal = (x1*P1) + (x2*P2).

Ptotal = (10/100)*65 + (90/100)*33.3 = 36.47 mm Hg

Next, consider a mixture of 20% mol fraction ethanol and 80% mol fraction water at 30ºC. This mixture consists of 20 mols ethanol (C2H5OH) and 80 mols water (H20). The gram molecular weight of ethanol is 46 grams per mol. The gram molecular weight of water is 18 grams per mol.

Ptotal = (20/100)*65 + (80/100)*33.3 = 39.64 mm Hg

As these examples show, as alcohol concentration increases in a liquid-liquid mixture, so too does vapor pressure which means that as alcohol concentration increases, the mixture boils sooner (boiling point of the mixture drops).

Congeners and Purification

Any molecule with a H (hydrogen) atom or an O (oxygen) atom as part of its makeup is capable of electrostatically attaching to another molecule with an H or an O atom. As has been previously discussed, the fermentation process generates a family of alcohols, with each alcohol member having a different number of carbon atoms in its structure. In fact, the myriad of products resulting from a ferment includes alcohols such as propanol, butanol, n-methyl-n-propanol, n-methyl-n-butanol, isoamyl alcohol, iso-amyl acetate to name but a few. In a solution mixture, these various alcohols will be drawn to one another by way of weakly attractive Van der Waals forces.

Depending on how and where a hydrogen or oxygen atom attaches itself to another molecule will determine the nature of that molecule. For example, propanol will have an oxygen atom attached in a different location than 2-propanol. Each of these molecules created by hydrogen bonds and Van der Waals attractions will have its own unique vapor pressure and boiling point. In many cases, the boiling points of these molecules will be in close proximity to that of ethanol (78.5ºC).

During distillation, when sufficient heat energy has been imparted to any one of these alcohol family molecules, consider what happens. Does propanol by itself turn to vapor? Does ethanol by itself turn to vapor? In fact, what happens is very complex and it relates back to the ideas of surface tension and hydrogen bonding. With sufficient heat energy imparted, ethanol will achieve its boiling point. But, the surface tension of the ethanol molecules and the surface tension of any other molecules present mean that some of these other molecules could attach to ethanol and be taken through the distillation apparatus as the ethanol boils. The same scenario applies to all the other alcohol family molecules as they attain their various boiling points.

In other words, performing a distillation run will not necessarily give just ethanol. The various passengers that emerge from the still along with the ethanol are termed congeners.

Consider a container of watery liquid from a fermentation comprising various molecular members of the alcohol spectrum. Heat that container slowly up to about 95ºC and vapors will continually rise from the container starting from about 65ºC. Those vapors will comprise ethanol plus various other alcohol family members plus some attached water and/or other molecules. Capture the vapors and cool them down. Now drink the resulting liquid. Yes indeed, it will impart that feeling of pleasure that early mankind recognized as intoxication. Will this liquid be utterly delicious and full of layers of flavor? No, it will not. But it will be passable as an alcoholic beverage. If you have ever watched the television show Moonshiners, you have seen the characters producing distillate that measures 100 proof (50% alcohol). They regard it as really good stuff. In reality, it is not good at all. It is loaded with congeners and needs further distillation.

Circle back to Raoult’s Law which states that as the amount of higher vapor pressure component in a solution increases, the boiling point of the solution decreases slightly. Take the captured alcoholic liquid in this example and heat it again so that vapors rise from the container. Capture the vapors and cool them down. Now taste the liquid. It will be better than the previous iteration and will comprise more ethanol and slightly fewer other molecules because the heat energy has caused the ethanol to break free of its molecular passengers.

Take this liquid and heat it again. Raoult’s Law tells us that because it has a higher concentration of higher vapor pressure molecules, it will have a lower boiling point. Capture the vapor and cool it. It will taste even smoother than the previous iterations. It will contain fewer water molecules, fewer other alcohol family members and a high quantity of ethanol molecules. The heat energy imparted to make it boil was sufficient to further break the surface tension between the various molecules. Because the concentration of ethanol molecules has been increased by this latest boiling effort, the vapor pressure of the overall solution is increased.

Heat and condense it again and the taste will be further improved, for it will now consist of mostly ethanol. This iterative story describes how alcoholic liquid created during fermentation can be purified by successive vaporizing and cooling in a distillation apparatus. As you experiment at home, you will quickly see how easy this is to grasp. You will quickly become very adept at creating good product certainly far better than anything produced on the television show Moonshiners.

Raoult understood this process intimately and was able to graphically describe it using a diagram similar to what appears in Figure 38.

Note that at the right side of the curve there is a small tail of sorts. Using repeated vaporizations and condensations, there is a limit to how pure one can make the an ethanol/water solution. Raoult determined that the maximum vapor pressure in the water-ethanol system occurred at 78.5ºC and an ethanol concentration of 95.6 weight percent. But, we typically do not refer to alcoholic strength in weight percent. A solution of 95.6 weight percent will have 95.6 grams ethanol and 4.4 grams water. The density of ethanol at room temperature is 0.789 kgs per liter. The density of water is 0.997 at room temperature. Volume equals mass divided by density, so the mixture is comprised of 121.16 mls of ethanol and 4.41 mls water. In other words, 96.5 volume percent ethanol.

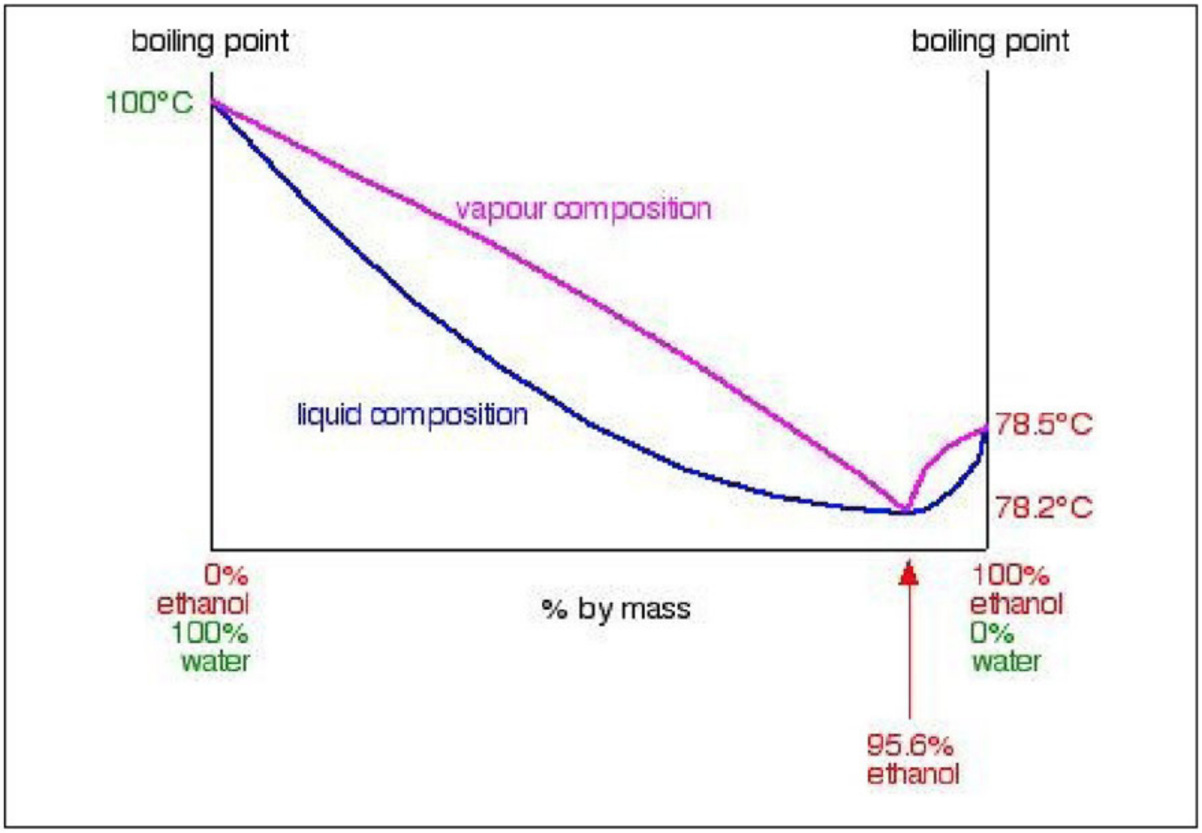

Figure 38 – Azeotropic point

This level of purity is called the azeotropic point and is the purest that a distiller will ever get when producing ethanol. Earlier I mentioned the alcohol factory at Unity, Saskatchewan. On my tour, I inquired as to what percent alcohol their final distillate was. The answer, 96.5%. If a still manufacturer ever tries to tell you that you will generate pure ethanol (or some number greater than 96.5%) from the equipment he wants to sell you, you can refute his claims with the above knowledge of Raoult's Law and the azeotropic point.

Heating

Take a pot of water and place it on your stovetop. Turn the heat on and bring the water to a boil. How quickly did it manage to attain a boil? Repeat this exercise with a much larger pot full of water. How quickly did it attain boiling? There is relationship between energy required and mass which is expressed as:

$$Q=m*Cp*(\Delta T) ;$$

where m is the mass of liquid being heated, Cp is the specific heat capacity of the liquid being heated and ΔT is the temperature range through which you are heating the liquid.

The larger the mass being heated, the more energy that will be needed to attain a temperature rise. The larger your still, the more heat energy you will require. If running a still heated by steam, this will entail a larger steam boiler for larger volume stills. If heating your still by means of an immersed electrical heating element, the larger the still, the more heating elements that will be needed. Keep this in mind as you begin sourcing equipment. The general rule that I use is to take the volume of the still expressed in liters. Multiply that volume x 1000. For example, a 600 liter still will ideally require a 600,000 BTU boiler. As for electrically heated stills, I have seen them and on one occasion used one. Not for me, thanks. I find them too slow to heat up. I advise staying with steam heating.

Latent Heats: Continuing on with our example of a pot being heated, notice what happens when that pot starts to boil. Does all of the water in the pot instantly turn to vapor and rush out of the pot? No, it does not. It takes time and plenty of heat energy to move the mass of water from its liquid state to a gaseous (vapor) state. This is the concept of Latent Heat of Vaporization (LHV). As you experiment at home, watch the thermometer on your still as the alcohol starts to emerge from the still. Notice that the temperature of the still will hover at the 78-79ºC mark for quite some time. This is because the heat energy being added to the still is being consumed by the latent heat of vaporization of the ethanol to make it change to the vapor phase.

Let’s consider some numbers in the context of 1 liter of ethanol in a small pot still equipped with a small condenser. The condenser is the worm-tub design with a coiled copper tube immersed in water. The weight of the 1 liter of ethanol is 0.79 kgs (790 grams). Let’s suppose we wish to heat the ethanol from 20ºC to 78.5ºC (its boiling point). The specific heat capacity of ethanol is 2.46 Joules/gºC. The energy required to heat the ethanol is thus:

$$q=(790)(2.46)(58.5) = 113.69 \text{ kJ.}$$

Now, let’s further suppose we wish to take the ethanol through its boiling point and create a phase change from liquid to vapor. The latent heat of vaporization for ethanol is 841 Joules per gram. Hence it will take:

$$841(0.790) = 664.4 \text{ kJ.}$$

664.4 kJ of energy to fully vaporize the ethanol. This is why during a distillation run, the temperature of the still will take a long time to surpass 78.5ºC. The ethanol is absorbing a lot of heat to transition from liquid to vapor.

Cooling

If one exposes steam vapor to the exterior of a tube through which is flowing cold water, does all the steam contacting the cold tube immediately turn to a liquid? No it does not. There is a considerable amount of energy that must be given up in order to condense the steam vapor. This is the concept of Latent Heat of Condensation (LHC). Vaporization and condensation are the opposite of one another. So, the latent heat of vaporization in our example is 664.4 kJ. This energy must be absorbed by water in a condenser to go from vapor phase to liquid phase.

Consider a condenser pot filled with 4 liters (4000 grams) of cold water at 10ºC. We wish to use this pot to cool the alcohol vapors in our previous example. The hot alcohol vapors hitting the condenser piping immersed in the condenser pot will transform into liquid format and surrender the 664.4 kJ of heat. The water in the condenser will obviously rise in temperature as it absorbs the heat. The specific heat capacity of water is 4.184 J/g ºC. Using the formula $q=m*Cp*(\Delta T)$,

$$664400 \text{ J} = (4000)(4.184)(\Delta T)$$

Solving for ΔT temperature change gives a value of 39.7ºC.

The ethanol which is now a hot liquid then must surrender a further 113.69 kJ to lower its temperature to 20ºC. Using the equation $q=m*Cp*(\Delta T)$:

$$113690\ J = (4000)(4.184)(\Delta T)$$

The temperature change is 6.8ºC. So, in total, the water in the condenser pot will go from its initial 10ºC to 56.5ºC.

Obviously this is not appropriate. Having a condenser pot get that hot is not practical. More cold water must be introduced into the condenser pot to help it stay cool.

Consider adding ice chunks to the condenser pot to keep it cool. The ice will have to remove a total heat content from the ethanol of

664.4 + 113.69 kJ = 778.09 kJ. Assume during the distillation 2200 grams of ice is added to the condenser in small chunks. Assume that the ice chunks are at -15ºC. As soon as an ice chunk melts, some of the water is scooped from the condenser to make room for the addition of another ice piece. As a chunk of ice moves from its initial -15ºC through to 0ºC, it

will be seen to not only change temperature but to change from solid to liquid. The amount of heat absorbed by this ice to go from -15ºC to 0ºC is given by:

$$q=(2200)(2.1)(15) = 69.3\ kJ$$

Next a determination of how much heat has been absorbed by making the ice melt must be made. This value is given by 334 J/g x 2200 g = 734.8 kJ.

The total heat load removed by the ice additions is 734.8 + 69.3 = 804 kJ. The goal was to remove 778 kJ, so mission accomplished. This example illustrates that at the small, home distilling scale cooling a condenser pot is easily done with ice chunks and water.

Next consider a larger still of 1000 liters situated in a craft distillery. Assume a distillation run is being done and 600 liters (474 kgs) of 96.5% ethanol will have to pass through the condenser during the time it takes for the distillation run. Assume the still is fitted with a condenser which is a shell in tube style with twelve copper pipes inside the shell through which water flows. Each copper pipe is 25 mm diameter and 2 meters long. The surface area of copper in total is 1.88 m2 of copper. Tube thickness is 0.003 m. The total heat to be removed from the flow of alcohol is roughly 401,000 kJ plus 68,000 kJ. The flow rate of alcohol coming off the still is 118.5 kgs per hour. The heat to be removed over time is given as:

$$q=(118.5)(2.46)(58.5) = 17{,}053 \text{ Joules}$$

It is assumed that the overall heat transfer coefficient of this cooling system (U) is 650 kJ/hr m² °C. Next, consider the determination of the log mean temperature difference. This value must be calculated because in cooling there is a logarithmic relationship that says the rate of cooling diminishes the closer the cooled liquid gets to the final target temperature.

$$(T1-t2)-(T2-t1) / \ln [(T1-t2)/(T2-t1)] \;;$$

where T1 is the alcohol vapor temperature, t2 is the water out temperature, T2 is alcohol out temperature and t1 is water in temperature.

This equates to: (78.5-60)-(20-10) / ln(18.5/10) = 8.5/0.615 = 13.82.

The cooling area is thus A=17,053 / (13.82)(650) =1.89 m^2.

This calculated result aligns to the surface area of the shell in tube condenser (1.88 m^2).

When looking at different sizes and makes of still, one can be assured that the still designer has undertaken some very rigorous math to arrive at a condenser design. The still designer should be able to offer a close estimate of the amount of water that will be needed to run the condenser. In this particular example, the flow rate will be about 1.75 liters/minute. This raises two issues.

First, make sure that your planned distillery location is not subject to water use restrictions. Determine the per-unit cost of water that will be charged to you on your monthly utility bill. Make sure that the incoming volume of water is sufficient to meet the needs of the condenser. I have seen craft distillers try to operate using well water where the well is only providing 2 gallons per minute at best. Lastly, make sure the temperature of your incoming water is cold. If it is not in the range of 10ºC, you may find you are having difficulty cooling the condenser. In situations like this, a glycol cooled water reservoir may have to be installed to help matters.

Pot Distillation

Consider the image of a copper pot still as illustrated in Figure 39. Consider what happens when this still is filled with liquid from a fermentation vessel. That liquid will contain water plus the various alcohol family members.

Figure 39 – Copper pot still

As heat energy is applied to the underside of the still, at a pot temperature approaching perhaps 58ºC, any constituents with low boiling points will break the surface tension of the liquid and will rise up the still neck. As the vapors hit the cooler upper reaches of the neck, the vapors will lose heat energy into the copper metal of the still and will return to a liquid form, dribbling down the interior surface of the still. But dribble far, they will not. For as soon as the liquid picks up more heat energy, the liquid will return to vapor form. This condensation and vaporization will break some of the attractive bonds between the water molecules and the alcohol family molecules. With some repeated vaporizations and condensations, the copper metal in the still heats up further. More hydrogen bonds and Van der Walls bonds are broken. Eventually, the vapors will be able to rise up to the top of the still and find their way down the goose neck shaped lyne arm and into the condenser. But, the process is not complete. Heat energy is continually being applied to the pot still which is getting warmer. The next molecules to attain enough energy to break the surface tension will be those having a slightly higher boiling point, such as methanol or methyl pectate.

Somewhere near the top of the pot, these vapors will condense and begin to dribble back down the interior surface of the still. As soon as sufficient heat energy is regained, these molecules will turn to vapor again. In accordance with Raoult’s Law, the newly re-vaporized molecules will have fewer other molecules attached and will have a lower boiling point. As the vapors rise again, they lose heat energy which is imparted to the copper pot causing it to heat up marginally further. This loss of heat energy causes condensation and the methanol molecules dribble down the inside of the pot. But, they have been further purified and with a marginally lower boiling point they soon re-vaporize and start rising. This time they make it to the top of the pot and enter the lyne arm and travel to the condenser. Collectively, these lower boiling point molecules are what distillers term the Heads. In the U.K., they are termed Foreshots.

The next molecule to consider is ethanol. As was discussed in the chapter on fermentation, ethanol will comprise the majority of the alcohol molecules present after a fermentation. The pot still continues to be gently heated. The heat energy being imparted to the pot is now being taken up by the ethanol molecules. This is the previously discussed concept of Latent

Heat of Vaporization at work. It takes a fair amount of heat energy to ultimately cause the relatively large mass of ethanol to change from liquid to vapor phase. Once sufficient heat energy has been absorbed by the ethanol, it will strive to break the surface tension and with water molecules (and other alcohols) in tow, will start rising up the pot still. When these molecules run out of sufficient heat energy to remain in vapor phase, they condense and begin to dribble down the interior walls of the still. These molecules quickly regain heat energy and vaporize again. In compliance with Raoult's Law, they are now further purified and have a lower boiling point. As they rise up through the pot still, they rise further before condensing. After several successive iterations, the ethanol molecules enter the lyne arm and journey onwards to the condenser. This is what a distiller in North America calls the Hearts. In the U.K., this material is called the Spirits.

The following figures are data on the boiling points of the pure form of several members of the alcohol spectrum:

Acetone 56ºC, Methanol 65ºC, Ethyl Acetate 77ºC, Ethanol 78.5ºC, n-Propanol 87.7ºC, Iso-Amyl 131ºC, Iso-Butanol 89.7ºC, Phenylethanol 225°C.

As these products conjoin with each other and with ethanol molecules in the distillation pot, their actual boiling points drop dramatically to closer to 80-85°C.

Heat energy continues to be applied to the pot still. Next in succession to break the surface tension and start boiling will be the various higher molecular weight members of the alcohol family all with boiling points slightly above that of ethanol. These family members will eventually make it to the top of the pot still and enter the lyne arm. This is what a North American distiller calls the Tails. In the U.K., this material is called the Feints.

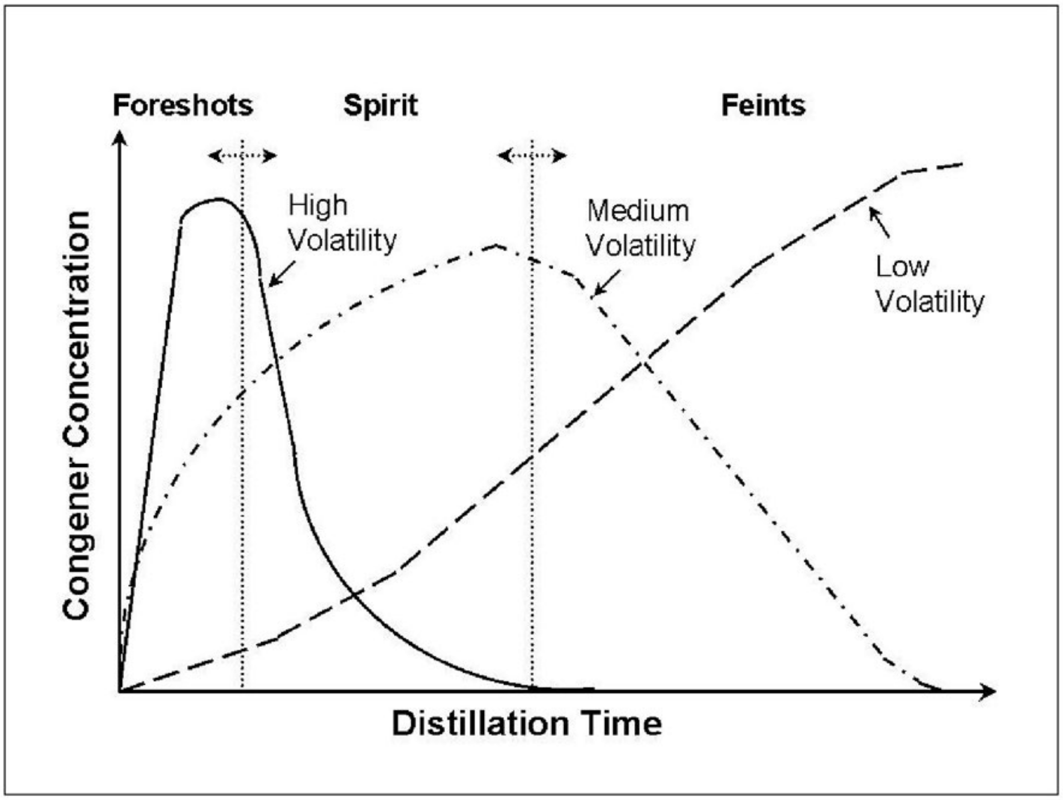

Figure 40 – Distillation curves

Figure 40 shows Heads, Hearts and Tails in graphical format. I encourage you to memorize this diagram. It will serve you well.

Starting at the left side of the graph, you can see that shortly after time t=0 when the distillation run starts, some distillate will make an appearance. This is the Heads, or as this British diagram indicates, the Foreshots. These are the acetone, methanol, methyl pectate type members of the alcohol spectrum. Note however, that the curve for the Heads (Foreshots) reaches a peak and quickly declines. At some point during this interval, the distiller will have to decide when to stop collecting the Heads and start collecting the Hearts (Spirit). Note further that the curve for the Hearts (Spirit) overlaps with the curve for Heads. Herein rests the art of distilling. Only the distiller can decide when to make that cut. The only tools for analysis will be experience, taste and smell. One interesting technique involves wetting one's finger with some distillate and rubbing that finger on the gums. If you feel a pronounced tingling sensation, you are collecting mainly Heads.

As that tingling diminishes with subsequent samples applied to the gums and as the distillate starts to taste better, you are nearing your cut point. Next, notice in Figure 40 that there will come a time to make a cut from Hearts (Spirit) to Tails (Feints). This is because the curves for Hearts and Tails overlap. A hydrometer along with experience, taste and smell will help you make this cut point decision.

When I am double pot distilling Whisky for personal consumption, I make my Heads cut and then I run my pot still until my hydrometer reads 10% alc. In other words, no Tails cut. After several successive runs like this, I have enough distillate to re-charge the pot still. On the second distillation run, I run until my hydrometer reads 50% alc. This cut point has been determined from experience. My resulting distillate will average about 70% abv. I dilute it with water to 60% abv and proceed to add it to an oak cask for ageing. The design of the pot still, its surface area, the fill level that you choose and even the surrounding ambient air temperature will all affect the extent of repeated vaporization and condensation in the still (reflux). Once you arrive at what you deem to be a set of optimum parameters, be consistent from batch to batch.

Distillate coming off of a pot still will not be ultra-smooth. The molecules of ethanol coming off the still will have other, denser alcohol molecules attached. This is because a pot still offers only relative limited opportunity for vaporization and condensation to purify the distillate in accordance with Raoult's Law. If you are a Scotch whisky devotee, try to find photos on-line of the stills that various distilleries are using. Combine this research with some tasting. You will find that stills having longer, taller necks will have a lighter profile than stills with short, squat necks. It's all about the amount of reflux. As will be discussed in a coming chapter, distillate placed into an oak cask will oxidize and mellow over time. As you sample Scotch made at a distillery using a still with a short, squat neck, take note of the texture. If it feels oilier that Scotch made at a facility with aa longer-necked still, what you are experiencing is the effect of heavier, denser alcohol chains that passed through the process by virtue of the still design. It is observations like this that will guide you in your equipment selection.

If I were to start a craft distillery, I would source pot stills and make whisky the double-pot way as the Scots do. True, it would require lengthy ageing, but in the end it would be a superior product to a column distilled whisky. An example of a craft distillery that uses pot stills is Tuthilltown Spirits in upstate New York. If you ever see a bottle of their Manhattan Rye, buy it. It is superb and it exemplifies what pot distillation can do for a whisky. This product is only aged for 4 years. If it were to be aged longer it would be beyond superb.

Coffey's Creation

In the mid-1800s, the head of Excise Collections for the Irish government was a gentleman by the name of Anneas Coffey. He was a clever man by many accounts and he decided that there had to be a more efficient way to distill Whisky than with a pot still. What he ended up devising is illustrated in Figure 41.

The secret to his design (sometimes called the Coffey Still, and sometimes called the Patent Still) is the horizontal plates at regular intervals up the column. This invention paved the way for the modern column stills that you may have seen in craft distilleries and opened the door to continuous stills that are designed to run 24/7.

The big Whisky makers in North America usually run continuous stills. In the world of craft distilling, there is probably little room for continuous stills. In mid-2017 I became aware of a couple craft distiller start-ups in America that had opted to purchase continuous stills. They were shocked when they realized that a continuous still was not really meant for running a few hours each day. Continuous means 24/7 with all the attendant people to make a non-stop distillery operate.

Coffey Stills typically produce distillate at 95% abv strength, although by adjusting the off-take point in the right hand column, distillate can be pulled off the still at less than 95%. In Scotland, there are several modernized versions of Coffey Stills in operation at facilities that make the alcohol that will comprise blended Scotches. In Canada, I am told there is a Coffey Still at the Diageo-owned distillery in Gimli, Manitoba where Crown Royal

Whisky is made. In Japan, the Nikka Whisky Company uses a Coffey Still to make the base alcohol for its superb blended products. In late 2020, I discovered Admiral Rodney's Rum from Saint Lucia. It is a blend of various ages of Coffey-distilled Rum distillates. An absolute marvel to sip and enjoy.

Column Distillation

Take the two-column Coffey design and put the columns atop one another to create a large single column design. This is where the column still concept comes from.

To make columns even more efficient, still makers utilize different design configurations for their plates ranging from small bubble caps to inverted domes to perforated sieve plates. The diagram in Figure 42 illustrates a simplified series of plates in a column still.

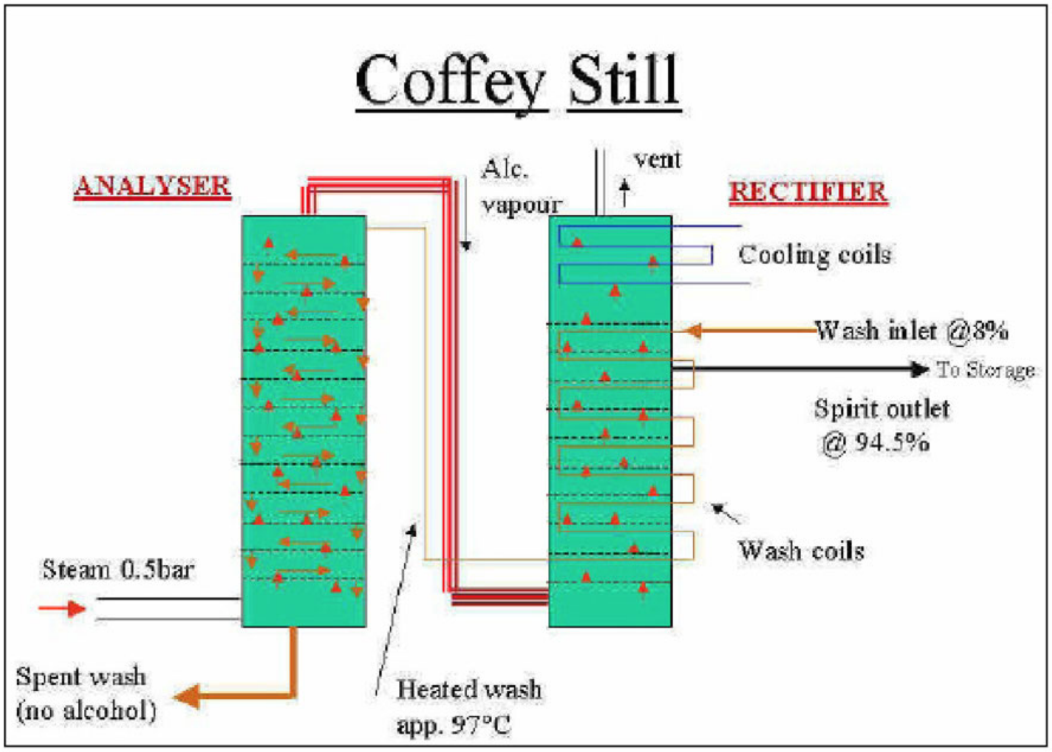

Figure 41 – Coffey Still

Prior to commencing a distillation run, the distiller will run water through the internal cleaning system in the column and allow a small amount of water to be collected at each plate. This is Raoult's Law in action. During the distillation run, alcohol vapors will interact with the water layer at the various plates to form a water-ethanol binary mixture. The vapor generated at each plate will display a higher concentration of alcohol, just as Raoult's Law dictates. When the distillation run starts, heat energy will be applied to the pot containing the liquid from the fermentation tank. As with the previous example of a simple pot still, the first molecules to attain sufficient heat energy to break the surface tension will be the low boiling constituents. These low boiling compounds will rise from the pot and enter the column. Heat energy will be absorbed by the mass of copper in the column and the molecules will condense and dribble back down towards the pot. Through subsequent repeated vaporizations and condensations, these molecules will make the journey to the top of the column and onwards to the condenser. The next molecule to break the surface tension will be methanol. The first alcohol spectrum members to exit the distillation are called Heads, just as in the previous discussion of a pot still. The repeated vaporizations and condensations have imparted heat to the column still, similar to how the pot still was heated in the previous example.

Next up are the ethanol molecules. The concept here is the same as in the previous discussion on what happens to ethanol in the pot still. The major difference, however, between the pot still and the column still is internal surface area. The column still with its plates, bubble caps and associated hardware has more surface area and hence more opportunities for molecules to repeatedly vaporize and condense. As molecules condense, they dribble downwards only to collect in the water layer present on the plates. As the molecules regain heat energy, they rise from the plate and travel upwards, purified in accordance with Raoult’s Law.

With a column still, the right side of Raoult’s curve comes into play. With sufficient plates, column height and internal surface area, clean alcoholic distillates can be generated with ethanol content at or approaching the azeotropic point of 96.5 volume percent ethanol.

One really great reference book I suggest getting is The Compleat Distiller by Nixon and McCaw. (1) It will gently guide you through the material discussed in this chapter. Another reference is the Alcohol Textbook, although it is a more expensive resource. (2)

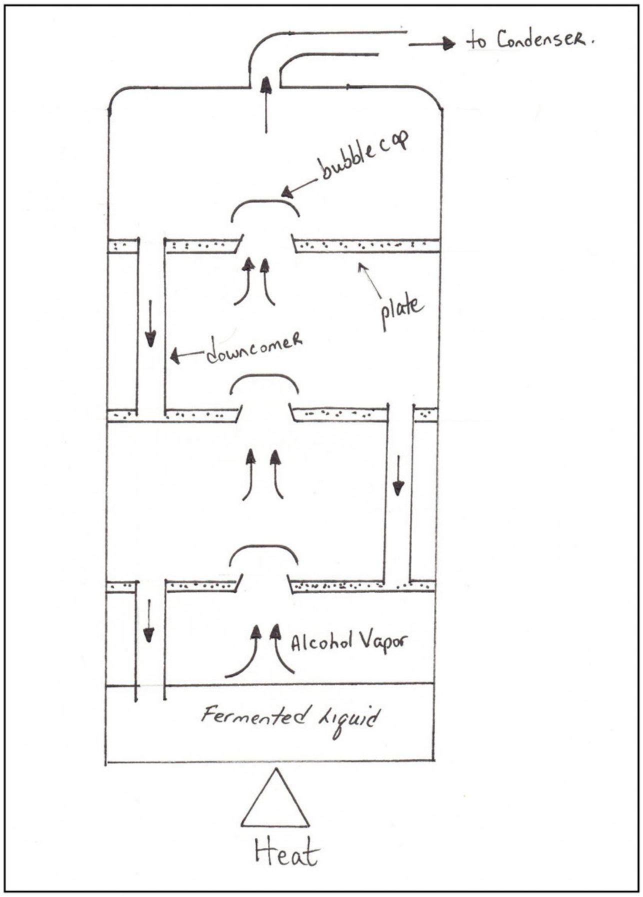

Figure 42 – Schematic of a column still

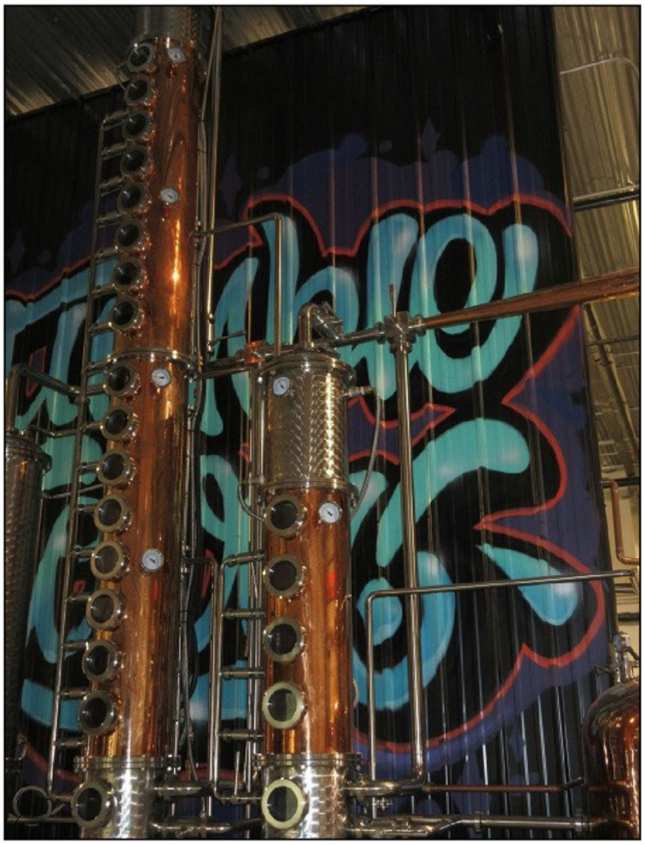

Figure 43 – Stumbletown Distilling

If you are a connoisseur of good quality vodka, you will quickly be able to spot the quality differences between craft distillers who are using a tall column with as many as 16 plates and those who are using a short column with fewer than six plates. An example of truly outstanding vodka in Canada comes from Park Distilling in Banff, Alberta. Park uses a large German-made column still and the last time I checked was using triticale grain as its raw material. A start-up I assisted with in 2019 was at Stumbletown Distilling in Saskatoon, Canada. Their column set-up comprises a short 4 plate column plus a 16 plate column for vodka rectification. Figure 43 illustrates. A vodka rectification run on this still took 14 hours. In fact, this is the distillery that helped me with my M.Sc. thesis project. We made Purple Wheat vodka on the still shown in Figure 43.

When shopping for a still, pay strict attention to what the manufacturer has used for plate configurations. In early 2017, I assisted with the start-up at a distillery that had opted for 12 sieve plates in the column. A sieve plate is a flat piece of copper with multiple small holes drilled in it as shown in Figure 44. I noticed the lack of surface area on the sieve plates had negatively affected the purity of the distillate being produced.

Figure 44 – Sieve plate

The concept of the sieve plate extends to the large columns used at ethanol factories. These factories will typically have a sieve plate column early on in their process, followed by other columns with bubble caps. My advice is to leave the sieve plates to the large ethanol factories.

Figure 45 – Bubble caps

Figure 45 illustrates what bubble caps look like. Studying this image will help you intuitively grasp why the bubble caps have more surface area than sieve plates.

As you start to assemble your plans for your craft distillery take the time to travel around to as many different craft distilleries as possible. Look at what equipment is being used. Take pictures and ask questions. And above all, taste, taste, taste.

As a final caveat, understand that there are any number of snake oil salesmen out there who have figured out how to bring in cheaply made, sub-standard pieces of equipment from China. Not every fabrication plant in China turns out top notch product. If someone starts peddling a still to you that has been made in China, ask them to whom they have sold other similar units. If they cannot give you proper references that you can pay a visit to, lace up your boots and run away as fast as your legs will carry you. Other questions to ask include whether or not the factory in China operates to an ISO 9001 quality control program. If you seem to be getting the run-around on this query, best to walk away. Another question to ask is whether you can see a copy of the engineered drawings that have been stamped by a North American engineer. Fire Inspectors in many parts of North America are starting to get wise to imported equipment from China and are asking for drawings. If the salesman peddling his Chinese wares cannot produce proper drawings, best if you walk away. It would be devastating financially if you bought something from China only to find out your local Fire Inspector refuses to sanction it.

References

1 Nixon, M., McCaw, M. (2010) The Compleat Distiller. Seattle, USA: The Amphora Society.

2 Madson, P.W. (2009) Ethanol distillation: the fundamentals. In: The Alcohol Textbook, fifth edition, chapter 20. eds Ingledew, W.M., Kelsall, D.R., Austin, G.D., Kluhspies, C. Nottingham, UK: Nottingham University Press.

9

Distillation Equipment

With an examination of raw materials, water, yeast, fermentation and distillation now complete, the question arises – what does one need for equipment to start making alcoholic spirits? What follows is an introduction to equipment needed for a craft distiller make product for licensed, legal, sale to the public.

Material Grinding

Raw materials have to be crushed or ground prior to starting a mash.

Craft distillers will need a roller mill or a hammer mill if using grains as raw material. Typically roller mills for craft distillers will have 2 rollers as Figure 46 shows. The surfaces of the rollers will be roughened. One roller will turn at a slightly different speed than the other. The net result is the grain kernels are both compressed and sheared apart as they pass through the rolls. Roller mills are best used in conjunction with malted grains which are more friable than un-malted grains.

For harder, un-malted grains, a hammer mill is advised. Hammer mills consist of a rotating shaft with small, hard, metal hammers on the shaft. The incoming stream of grain hits the high speed, rotating hammers causing the kernels to shatter. By varying the speed of the rotating shaft, the degree of kernel shatter can be controlled. I sometimes engage a local farmer in my area to grind grain for me on his hammer mill and we have found that 1250 rpm is an optimum speed of rotation. Figure 47 provides a schematic of a hammer mill.

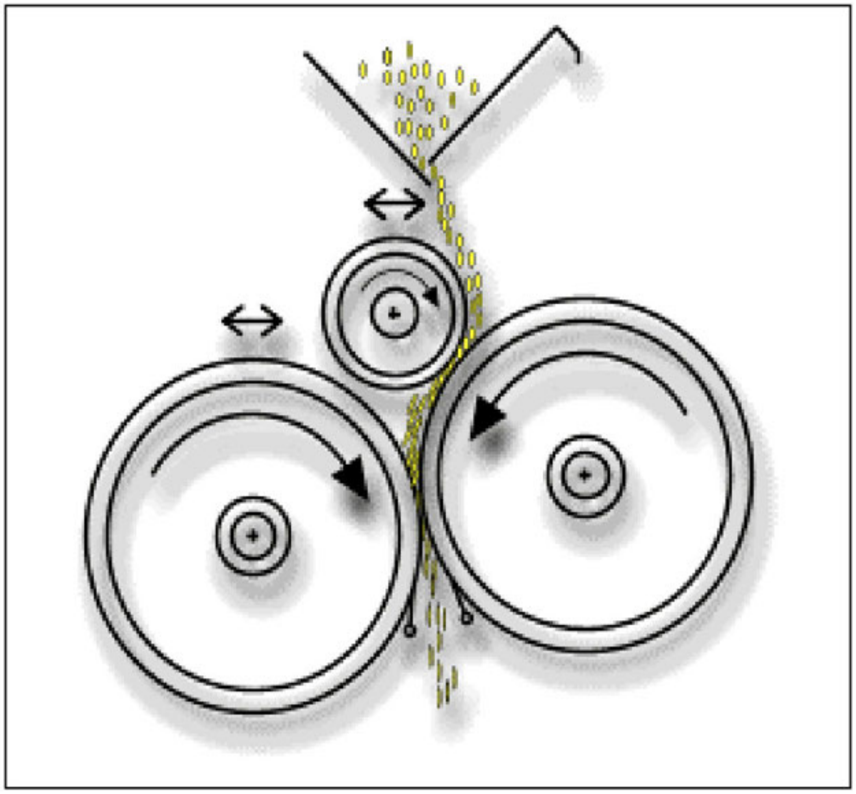

Figure 46 – Roller Mill

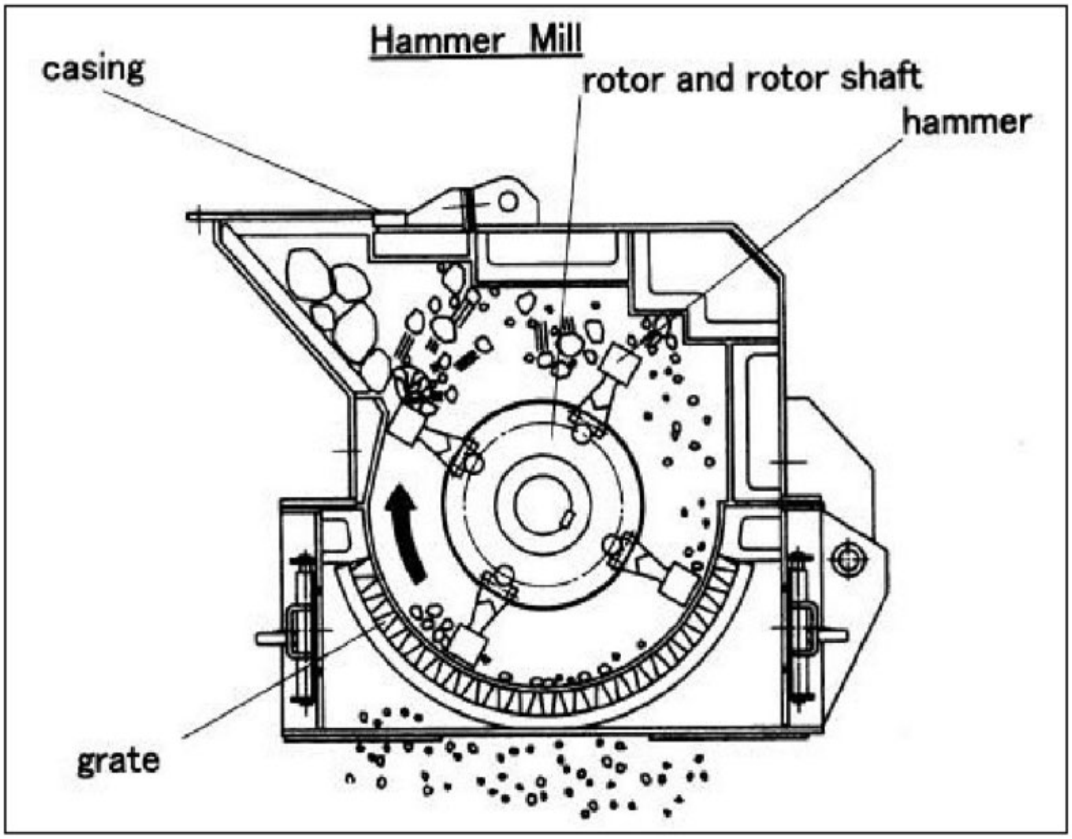

Figure 47 – Hammer mill

For fruit as a raw material, most makers of high capacity, positive displacement mash pumps also sell a hopper attachment for the mash pump. After shoveling fruit into the hopper, the fruit will be crushed and ground as it passes through the auger of the mash pump. There are also machines that consist of a rotating chamber with sharp protrusions on the inner surface. As the fruit tumbles inside the chamber, the fruit flesh is scraped from the pits. I have noticed that Europe is a very good place to source ancillary equipment for fruit handling and processing.

Recall from an earlier section of the book that fruit pits contain an organic substance called amygdalin. During fermentation, amygdalin can break down into glucose, benzaldehyde and small amounts of hydrogen cyanide. These are the precursors for the formation of ethyl carbamate which is regarded by health authorities as a possible carcinogen. Therefore, it is critical to not ferment fruit on the stones, especially broken stones.

When sourcing a grinding mill for grain, it might be wise to give thought as to how to deal with dust created during grinding. There actually may not be that much dust created, but somehow the subject of grinding grain is becoming a red flag for Building Inspectors approving the ventilation systems at craft distillery projects. Do not be alarmed if the inspectors dictate having the grinding mill in its own separate room complete with dedicated explosion proof ventilation fans, explosion proof light fixtures, and an explosion proof motor on the grinding mill.

Mash Vessel

When working with grains, they have to be cooked (mashed) as outlined in the chapter on Raw Materials. Craft distillers will be faced with a wide selection of stainless mash vessels, all with different features. I have previously stated my opposition to mash-lauter beer brewing type equipment for a distillery start-up. I feel so strongly about this topic, what follows is a reiteration of what has previously been said: There are no shortage of vendors who will try to sell a craft start-up a mash-lauter tun. I am assuming that you have been to a craft brewery and have seen a mash-lauter tun. I am assuming that you have either seen pictures of Scotch distilleries or have been to Scotland where you have seen mash-lauter tuns up close. In this sense, it is an easy sell for a salesman to peddle a lauter-tun beer type system to a craft distillery start-up. Be assured, the equipment in a Scottish whisky distillery has been designed for efficiency and is not standard-issue beer brewing equipment.

Visit a craft brewery in your area and inquire if you can go behind the scenes for a look at the mash-lauter tun in action. It consists of a vessel, usually steam jacket heated. Near the bottom of the vessel is a perforated bottom (false bottom) with tiny slits in it. As a brewer sets out to do a mash, grain is loaded into the tank. The grain will rest on top of the false bottom. Next hot water will be added to the tank to cover the bed of grain. Steam flowing through the vessel jacket will be used to fine tune the temperature of the mash. After the mashing procedure is over, a brewer will pass hot water across the bed of grain. The applied water will come from a separate tank (usually called the hot liquor tank) containing hot water for flushing the grain bed. The water will percolate slowly down through the bed of grain and in so doing, flush off the sweet fermentable sugars that have been broken down from starch molecules. Repeated flushing will be necessary to remove the sugars and even then the recovery will perhaps be 85% of the total available sugars in the grain. A mash-lauter tun will come equipped with a set of rotating rakes to stir up the grain bed to speed up the flushing process. There is a certain art to using a mash-lauter tun. Apply the hot water too aggressively and the bed of grain will compact, thus hindering proper run-off. Make the sparge water too hot and bitter tannins can be extracted from the grain bed. And, finally at the end of the process, the brewer will have to remove the spent grains from the vessel. This in itself is a less than pleasant task. Quite frankly, I have had enough start-up experiences using Chinese made mash-lauter tuns at craft distilleries to do me for a long while. I cannot recommend the purchase of a beer system for a craft distillery project. I do have a reverence for single malt Scotch which uses mash-lauter tuns. But to reiterate, these vessels are tailor made for the industry. They are not cheap beer brewing systems made in China.

As I stressed earlier in this book, I would take a page from the lager beer industry in Europe. I would purchase a stainless steel vessel that is either steam injected or steam jacketed. The vessel would be equipped with an electric motor driven agitator. The vessel would also be equipped with glycol cooling tubes wrapped around the circumference. Grain and water would be added to the vessel. The steam heat would be used to achieve desired mash temperatures. The converted mash would be cooled via the glycol cooling tubing and the cooled mash pumped to a fermenter vessel using a positive displacement auger pump. In your travels, if you happen upon a craft distillery that purchased a turn-key package of equipment from a German equipment maker you will likely see this style of vessel in use. A hasty choice of mashing equipment can quickly turn your distillery project from a dream to a nightmare. Please make an informed equipment decision.

While on the subject of mashing vessels, it is worthwhile mentioning pectin. For fruits, and to a lesser extent with grains, one must be cognizant of a carbohydrate called pectin. During fermentation, an naturally occurring enzyme in grain called methyl pectinase can react with the pectin to form a methyl pectate, which is a low boiling point, undesirable compound in the heads (foreshots) portion of distilled beverage alcohol.

When using fruit as a raw material, one technique for limiting the amount of methyl pectate is to heat the mash of fruit to near 40ºC and hold that temperature for 30 minutes to hydrolyze (break down) the pectin. The yeast can be added when the temperature of the fruit mash has subsided to less than or equal to 30ºC depending on the strain of yeast being utilized. I have personally used this approach and can attest that the amount of heads material generated during the distillation run is no more than would be generated from a typical distillation of a mash made from fermented grain.

Boiler Sizing

Most jurisdictions will have specific boiler regulations and threshold limits. A boiler for a craft distillery will be classed as a low pressure steam boiler. Various jurisdictions might impose a threshold limit based on either the heating capacity of the boiler or its internal heating surface area. If faced with a limit, stay under that threshold and a local commercial plumber can install the boiler. Exceed that threshold and the distinct possibility of having to engage an expensive, ticketed, journeyman steam fitter to conduct the install and do any regular maintenance could arise. The added expense will not be cheap.

As for boiler sizing - every still maker will know the amount of heat energy required to most efficiently run their design of still. The general rule I go by is to multiply the still pot size x 1000. For example, something in the range of 600,000 BTU boiler capacity should be ample to heat a 600 liter still and a mash tank at the same time. Heat energy requirements can be expressed as British Thermal Units (BTU/hour) or as Horsepower (H.P.) or as Pounds of Steam per Hour.

One Boiler Horsepower is equal to 33,475 BTU/Hr.

Boiler Horsepower x 34.5 = Pounds of Steam per Hour.

1 kJ of heat energy = 0.95 BTU of energy

A Full Size Example

Consider the case of a craft distiller installing a 600 liter still and a 1200 liter mash vessel. The goal is to be able to heat a mash and run the still simultaneously. What size of boiler is needed?

For the mash, the distiller will add 300 kgs of grain and 900 liters of water. The starting temperature of the water/grain mixture is 15°C and the final target temperature is 85°C.

The specific heat capacity of water is 4.2 kJ/kg°C. The specific heat capacity of the grain is assumed to be 4.0 kJ/kg°C. The specific heat capacity of ethanol is 2.46 kJ/kg°C. Moving the ethanol through its boiling point and into vapor phase requires 841 kJ per kg of energy.

The fermented wash loaded into the still is assumed to comprise 90% water and 10% ethanol. For a total charged volume of 600 liters, this is 540 liters water and 60 liters ethanol. The starting temperature is 15°C and at the end of the run the temperature in the pot will be 95°C.

The input energy needed to heat the water part of the mash equates to:

$$q=(900)(4.2)(70) = 264{,}600 \text{ kJ.}$$

The input energy needed to heat the grain part of the mash equates to:

$$q=(300)(4.0)(70) = 84,000 \text{ kJ.}$$

The sum total is 348,600 kJ. The mash vessel will absorb some heat energy and it will also radiate some heat energy because it is not perfectly insulated. Assuming that the vessel is 92% efficient, the heat input needed will be 348,600/0.92 = 379,000 kJ. Multiplying by 0.95 will express this number as 360,000 BTU.

For the distillation, the input energy needed to heat the water part of the wash in the still equates to:

$$q=(540)(4.2)(85) = 192,780 \text{ kJ.}$$

The input energy needed to heat the ethanol part of the wash to the boiling point of ethanol (79°C) equates to:

$$q=(60)(2.46)(64) = 9500 \text{ kJ.}$$

The input energy to heat the ethanol from liquid into vapor is:

q=841(60 liters)(0.79 kgs/liter) = 39,900 kJ.

The sum total of the distillation energy is 242,180 kJ. The still will be radiating heat to the surroundings as will the column attached to the still. Assuming 92% efficiency brings the required energy to 242,180/0.92 = 263,200 kJ. In BTU units, this is 250,000 BTU.

Adding together the heat energy for the mash and for the distillation yields a number of 610,000 BTU.

Earlier, I had suggested a good rule for estimating boiler size was to multiply the still size by 1000. In this example, the boiler size estimate would be 600,000 BTU. Putting some numbers to the situation yields a calculated value of 610,000 BTU.

In advising craft startup projects, I have come to realize that plumbing and heating tradespeople do not always understand the math of mashing and distilling. Salespeople seeking to earn a commission from selling a boiler likewise do not always understand the math. While this synopsis may sound harsh, it has to be stated. As a craft distiller, do your own math calculations and avoid buying an improperly sized boiler.

Do not be surprised if Fire Inspectors ask to situate the boiler in its own separate room that has been fitted with ventilation. It is also critical to bear in mind that as steam travels through the heating jacket on a still or on a mash tank, the steam will start to condense to liquid as its thermal energy is absorbed away. The condensate liquid will then pass into a device called a steam trap. A steam trap is a valve device that allows condensate to exit the flow without taking steam with it. The condensate then ideally should be returned to the boiler via a pump. Alternatively, I have seen craft setups where the operator allows the condensate to trickle down the drain. The boiler is then fed fresh makeup water as required.

Be mindful of the distance back to the boiler as well as any elevation changes. These variables will determine the size of condensate return pump that will have to be installed. I have seen more than one craft distillery situate its boiler too far away from the still only to find out that the efficiency of the operation becomes compromised. All I can advise is to design the floor layout with the boiler as close as practical to the still and mash vessel.

Fermentation Vessel

Craft distillers have many options when sourcing fermenting vessels. There are vendors of stainless steel fermenter tanks in Canada, the USA, Germany, Croatia and just about everywhere in between. One previously mentioned Canadian firm that is gaining a reputation for providing vessels (mash and fermenter vessels both) to the craft distilling industry is Ripley Stainless from Summerland, British Columbia. To view some of Ripley's craftsmanship, make a trip to Tumbleweed Spirits in Osoyoos, British Columbia. Two other Canadian firms with a solid reputation for top quality vessels are DME, based in Prince Edward Island, and Specific Mechanical based in Victoria, B.C. Both DME and Specific Mechanical built their reputations as suppliers to the craft brewing industry. In America, three names that immediately come to mind are Bridgetown, and Ager Tank both in Oregon and Glacier LLC in Washington State. An on-line search will yield a plethora of names. Just be sure that if you are seeking something made in America that you do not get led astray and buy something made in China. The old adage still applies: you get what you pay for.

Further to the old adage of getting what you pay for, be aware that not all stainless steels are created equal. Stainless steel is carbon steel with increased amounts of nickel and chromium added. These latter elements create a tough oxide layer on the rolled sheet of steel. But, what if a foreign supplier opted to use nickel with some sulfide impurities in it? Or, what if the amounts of nickel and chromium were reduced to save money? The result will be an inferior oxide layer. One that if scratched or dented will begin to show signs of rust. Sourcing stainless steel tanks requires considerable due diligence on your part, especially if the vessels are made in China.

Cooling

The cooling capacity of mash tanks and fermenter vessels is another matter to consider. As discussed in the chapter on Yeast, different yeast suppliers will offer products that are designed to perform at different temperatures. In the case of Lallemand yeast, their distilling strains are engineered to function optimally at 30ºC. This means that after completing the mash, one should cool it to 30ºC, pump it to a fermentation tank, add the yeast, and then have a cooling system on the fermentation tank to ensure the heat generated by fermentation does not cause the mash temperature to rise above 30ºC.

A properly designed cooling system will be needed to get the mash from perhaps as high as 90ºC (in the case of a recipe containing corn) down to 30ºC. A cooling system will comprise a refrigerated glycol setup with the glycol tubes wrapped around the clad outer circumference of the mash vessel. A good glycol system will cool a mash one degree Celcius per minute. Not necessarily a cheap item to purchase, but it is certainly a necessary one. In my travels I have seen craft distillers attempting to cool mash tanks by circulating cool tap water around the tank circumference. This works providing the water is very, very cold. If the distillery is located in an area where the tap water is warmish, one can expect trouble using this technique to keep fermenter temperature in check. Plus one must consider the monthly cost of the wasted water going down the drain. I have even seen at least one craft distiller leave the mash overnight to cool on its own. Allowing a mash to cool slowly, or even overnight is begging for an infection from bacteria such as lactobacillus. Allowing a mash to cool slowly will allow the bacteria to gain a toe-hold and get a head start on the yeast in the competition to eat fermentable sugars. Budget for that glycol chiller. Do yourself a favor. Make your life easy.

When contemplating chillers, remember that not all chillers are created equal. When searching for a proper chiller, you might quickly find yourself talking to a salesman who sells chiller units for the beer industry. I recently finished assisting a craft distiller to identify vendors for his needed equipment. I now have learned that there are many chiller manufacturers in North America, but the equipment they are selling is definitely aimed at the craft beer industry. A craft brewer will cold condition freshly fermented ale style beer at around +7ºC for a couple weeks before bottling.

Consider a couple examples. The math underpinning cooling is complex, so these examples are greatly simplified to illustrate my point.

First, suppose a beer brewer wants to cool 1000 liters of fermented 5% abv beer from 18ºC down to 5ºC. The amount of heat energy to be taken out of the beer can be quickly estimated if one assumes the beer is going to behave essentially as water.

Recall from earlier, the formula $q=(m)(cp)(\Delta T)$. The heat capacity of water is 4.184 kJ/kg°K, the temperature change is 13ºC and the mass is 1000 kgs if we treat the 5% beer as water, leaving us with a q value of 54,300 kJ.

For this calculation I will use a variation of this formula:

$$h=(cp)(density)(q)(\Delta T)$$

Assume the chiller is pumping cooled glycol/water mix through the cooling jackets on the beer vessel. The heat capacity of glycol is assumed to be 3.90 kJ/kg°C, although this figure will vary based on the percentage of glycol in the mixture and the temperature of the mixture. Assume the beer vessel must be cooled to target temperature in 2 hours. For the needed 13ºC degree temperature drop:

$$h=(3.90)(1.11)(q)(13) = 56.27(q)$$

If q is the flow rate of coolant to do the work of extracting heat, then let's set q at 8 liters per minute. The equation then gives a result of 450 kJ/min, or 27,000 kJ/hour. The heat load will be removed from the beer vessel in 54,300/27,000 = 2.01 hours, which is close to what a brewer would be happy with.

Another simplified way of approaching this example is with the formula:

$$\Delta q/t = (k)(A)(\Delta T)/L;$$

where k is the thermal conductivity coefficient, and A is the cross section area of the tank which I will set at 1 m2. I will use the coefficient of water (0.6) because the 5% abv beer is essentially water. Further assume that the 1000 liter volume is in a tank of height 1 meter. The temperature drop desired is still the 13ºC. Solving for Δq/t gives 7.8 W/s or 468 W/min. To remove the 54,300 kJ of energy will take 116 minutes or 1.93 hrs. This is 2 hours in round figures. These two variants of solving the same problem basically agree with one another.

Next, consider a more extreme example of what one would encounter in a distillery setting. Take the q=(m)(cp)(Δ T) approach and apply it to a tank of hot mash at 80ºC. The mash will be comprised of 250 kgs of grain and 750 liters of water. The heat capacity of grain is 1.6 kJ/kgºC. That of water is 4.184 kJ/kgºC. The mash thus has a heat capacity of 3.538 kJ/kgºC. The desired temperature drop is 50ºC. That is, from 80ºC, the goal is to cool down to 30ºC at which time the distiller will pitch the yeast. Therefore the heat load to be removed is:

$$q = (1000)(3.538)(50) = 176{,}900 \text{ kJ.}$$

Take the equation h=(cp)(density)(q)(ДT) and have the chiller running at a flow of 8 liters per minute:

$$h=(3.90)(1.11)(8)(50) = 1731 \text{ kJ/min or } 103{,}896 \text{ kJ/hour}$$

The heat load will be removed from the mash in 176,900/103,896 = 1.7 hours, assuming a high degree of heat transfer efficiency across surfaces. This is unacceptably slow for a hot mash and is just asking for problems with bacterial infection in the mash.

Next, consider this situation using the formula:

$$\Delta q/t = (k)(A)(\Delta T)/L$$

Assume k, the thermal conductivity coefficient, as being k=0.5. ΔT is the required 50ºC of temperature drop. Exact data on thermal conductivity of grain mashes is sparse in literature, but raw grain has a conductivity slightly less than water. Solving for Δq/t yields 25 W/s or 1500 W/min. The heat load will be removed from the mash in 176,900/1500 = 117.93 minutes or 1.96 hours. Again, unacceptably slow.

These examples aptly illustrate why I get so frustrated when I hear of craft distillers talking to beer chiller salespeople without having considered these basic calculations. As for the gentleman I recently assisted, I was shocked to learn that the beer chiller salespeople he was talking to had a poor grasp of these mathematical formulas. Uncertain verbiage like “that chiller unit should be OK for cooling a mash” is to be avoided. Be diligent please. A lot of money is being spent on a craft distilling start-up. Don’t let a commission hungry salesperson deliver a pitch for an inferior piece of equipment. Sorry to be so blunt, but it has to be said.

A properly configured glycol chilling system will comprise a refrigeration unit connected to a reservoir tank containing a glycol/water mixture. The reservoir will in turn be connected to the piping that wraps around the cooling jacketing on each of the process tanks. The chilled fluid will be moved through the system by a pump suited to low temperatures. Prior to doing a mash, one will turn on the refrigeration system which will circulate the reservoir tank contents until a target temperature of 2ºC has been hit. At this temperature, the water/glycol solution will quickly and easily cool the hot contents of a mash tank. Any competent commercial refrigeration company will be able to help with design and set up. In my past experiences, I have noted that a 5 ton refrigeration unit and a 1500 liter reservoir tank will be more than sufficient. A 5 ton unit is equivalent to a 17.5 kW unit. If 1 kJ/sec is equal to 1 kW, then 17.5 kW is 17.5 kJ /sec or 1050 kJ/min or 63,000 kJ/hour. Using the previous formula of:

$$h = (3.90)(1.11)(q)(50);$$

one can quickly see that a flow rate (q) of 18 liter/min of the glycol mixture will remove the heat load from the hot mash in 176,900/233,766 = 0.75 hours (or 45 minutes).

My past observations of a 5 ton system in action repeatedly showed that a 1ºC drop per minute was attainable. A 50ºC drop should take 50 minutes. In this example, the number crunches out to 45 minutes.

A start-up entrepreneur will likely run into tank vendors who will promote wine fermentation tanks as adequate for distilleries. Remember that a wine maker will start a ferment at room temperature after crushing the grapes. For that winemaker, a tank with minimal cooling capacity will suffice as it is a long way from room temperature to the yeast danger zone of 32ºC. A distiller, however, who is starting a ferment at near 30ºC will need vessels equipped with glycol cooling on the entire circumference of the tank to take away the generated heat load. I have seen many configurations of fermentation tanks being used in craft distilleries I have visited. It is probably wise to travel to various craft distilleries and talk to the owners. Do your due diligence before making a purchasing decision. Do not get lured into buying tanks with inadequate cooling capacity.

Pumps and Hoses

Craft distillers will need a mash pump and associated hoses. There are many manufacturers of mash pumps. Most will be European based, although with some searching you will also find North American manufacturers. If sourcing from outside North America and if your local Electrical Inspector is a concern, make sure the pump motors are certified for both 50Hz and 60Hz. A good way of finding mash pump vendors is to speak to any company that currently supplies equipment to the beer or wine industry. You will run into two general formats of pump: impeller style and positive displacement (auger) style. I have about seen enough impeller style pumps at craft distilleries to convince me that they have no place at a distillery. Moreover, I have been told that impeller style pumps will wear out under the wear and tear of heavy, dense grain mash. A positive displacement auger pump means what the name implies. One turn of the auger will move material through the pump very smoothly and efficiently. Positive displacement auger style pumps will have reversible capability, which an impeller pump will not. With the flip of a switch, the auger pump can be made to turn backwards. When pumping mash into a tank or into the still, it is nice to be able to reverse the flow to clean out a hose at the end of the pumping task. A positive displacement pump will cost more than an impeller pump. Figure out the cost to one's sanity and blood pressure of having a cheap impeller pump that causes fits of rage. I have never yet met a craft distiller who was unhappy with a positive displacement pump.

There are many vendors of hoses on the marketplace. Be sure that any purchased hose is food grade quality and if planning to pump hot mash or hot liquids, be sure the hose in question is temperature rated.

The other pump that a distiller will need will be an alcohol pump to move hi-proof alcohol into blending tanks and to move alcohol from the blending tank to the bottle filling apparatus. If getting an electrically driven pump, it must be explosion proof to satisfy the Fire Inspector. The cost of an explosion proof electrically driven pump will not be cheap. To lessen the price, give some thought to an air driven diaphragm pump. These pumps typically are in the $500 range and require a small air compressor to run on. With no electrical components, it is automatically explosion proof which will put any Fire Inspector at ease.

Stills

Craft distillers face an ever-increasing number of options when it comes to stills. The major factor at play will be one’s capital budget. There are German still makers that have been in business for 100+ years such as Kothe, Holstein, Carl, and Mueller. These brand names will command above average prices. Demand for these popular names is robust, so it might take several months for delivery once placing an your order and making a deposit payment. Growth in the craft industry over the past 6 years has prompted non-German companies to move into the market. Hillbilly Stills created a sister-company called HBS Coppers that makes copper pots up to 175 US gallons (660 liters) in size. Distillation columns of 8, 10 or 12 inches are available with plate configurations of between 4 and 12. I advise having a discussion with HBS, especially if you are seeking something genuinely made in America.

Due diligence remains paramount when considering a still maker with a limited reputation. To illustrate, consider the case of Corson Distilling, a small American firm from Idaho that entered the distillation playing field in 2012. Sadly, the Corson story in 2018 took a bizarre twist. Corson became the subject of a class action lawsuit where plaintiffs argued that Corson accepted down-payments and failed to deliver. Other plaintiffs argued shoddy workmanship. Corson is no more. And the distillers who bought their products have nobody to lean on for support or replacement parts.

An Italian still-maker called Barison is active in the North American market now through its representative Prospero Ltd. I have seen these Italian stills and tasted the product created on them. I am suitably impressed. And this leads to another caveat. Vendors will seek to sell a craft start-up a complete turn-key package that includes a still, tanks, pumps, grinding mill, etc. Parse the data carefully and it will become clear that one can put together the same package cheaper if sourcing all the components individually. The argument then becomes, is it better to go for the expensive ease of turnkey or the cheaper, but more time consuming method of sourcing all parts separately?

There are North American firms having stills made in China for distribution to craft distillers starting up in Canada and America. Just remember, there is a difference between something made in America and something assembled in America. A Chinese still assembled in America, does not mean it was made in America. I have heard widely mixed reviews on these Chinese products. I remain largely un-impressed by these Chinese offerings, save for a couple exceptions. There are at least ten firms that I can list that are sourcing stills from China. For legal repercussion reasons, I shall refrain from listing them. Suffice it to say, if ads keep popping up on your computer for distillation equipment, chances are the ad is promoting Chinese-made equipment. Based on the information provided to me by some craft distillers using these Chinese built products, my advice is to travel around and visit craft distilleries that are using these stills. Speak directly with the distiller in person, taste their products and decide wisely. Be certain to inquire as to whether these stills were made to ISO 9001 quality standards with engineered drawings. Demand to see the engineered drawings. Demand proof that the Chinese fabrication facility is actually ISO 9001 approved. Demand evidence that weld seams meet an established North American welding specification. Fire Inspectors are getting more demanding as time goes on. These inspectors reserve the right to demand drawings and more.

In late 2016, I assisted with a start-up at a distillery in Alberta, Canada. Their complete setup had been sourced from China via a company located in America. The mash vessel was what one would see in a beer brewery. The fermenter tanks looked to have been sourced from the chemical industry. I was only modestly impressed with this setup during the four distillation runs I assisted with. This underscores the ease with which anyone can approach the Chinese and have them cobble together an equipment package for the North American craft distiller. Do your due diligence, please.

Also, be very cautious if approached by a vendor selling stainless steel column stills. The fermentation process will generate sulfur compounds in trace amounts. If left unchecked, these compounds will travel through the distillation process to create a slight burning sensation on your palate as you sample the distillate. The only way to remove sulfur compounds is by way of copper. A distillation column made of copper will react with the sulfurs in the vapor stream to produce a copper-sulfate which adheres to the inner wall of the column and does not end up in the final distillate.

To reiterate, take serious note that Fire Inspectors are becoming very aware of the craft distilling movement. So much so that in many jurisdictions, inspectors are asking to see proof that the still meets with codes such as ISO 9001 or ANSI or CSA. Make sure the still that you buy meets these standards. What the inspectors are really looking for is proof of structural integrity. Did the manufacturer have a quality control program? Were its welding personnel certified? Are there engineered drawings available? If you cannot lay hands on this supporting documentation, it might be best to look elsewhere. If you don’t, that cheaper Chinese still you bought might end up being nothing more than a decorative talking piece when a Fire Inspector will not approve of it.

When starting the process of looking at various stills, one should have a clear notion of what products will be made because with stills, size and configuration do matter. Let’s suppose one wanted to make a whisky, rum, or brandy. These products will have plenty of flavor associated with them so a pot type still that has a reduced amount of surface area will do just fine.

For example, consider the still in Figure 48 made by Spanish company Hoga who have sold a number of stills to craft distilleries in North America. I have not heard anything negative about Hoga Stills.

Figure 48 – Hoga still from Spain

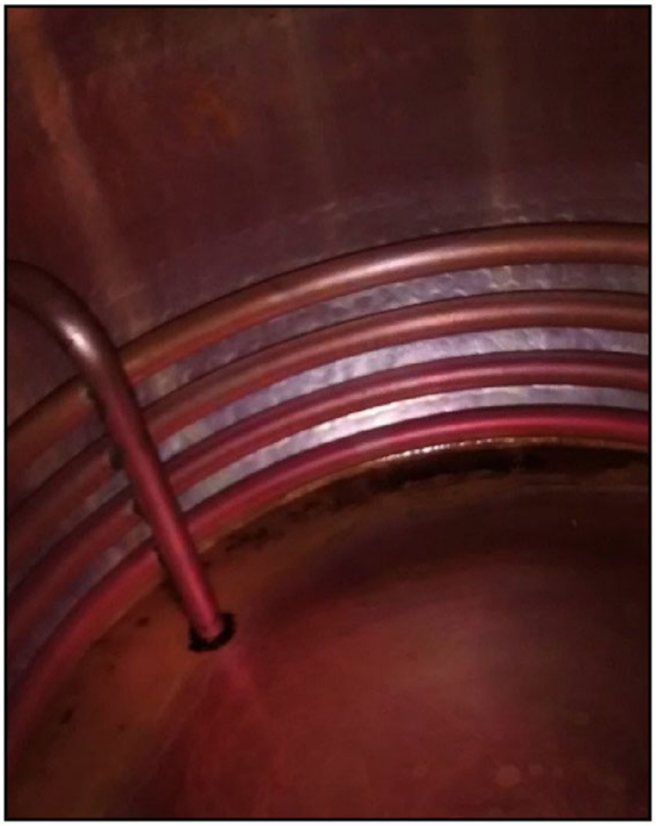

Figure 49 – Steam coils in a Hoga still

Their stills are heated via a steam coil immersed in the still. They come equipped with an agitator and the price point for a complete still assembly is very economical. Figure 49 illustrates the steam coils. This photo was taken at a craft distillery called Wildlife Distilling in Canmore, Alberta, Canada.

On one of my recent visits to Scotland I heard tell of a craft distillery that had recently started up to make craft whisky. Their choice of still was Hoga. If a person in Scotland living in the shadow of the famous big-name distillers is prepared to make whisky on a Hoga Still, that to me speaks volumes.

Another still maker to look at is Hagyo Stills from Hungary. A typical Hagyo design is illustrated in Figure 50.

Figure 50 – Hagyo still

The Hungarians have been making flavorful distillates for a very long time and I continually hear good things about Hungarian craftsmanship.

And the list could go on and on. The point is, if the goal is to make a flavorful spirit, then there is no need for a massive tall column. A smaller design with reduced surface area will work fine.

But, if the goal is to make vodka, then making a clean distillate will require plenty of surface area to clean up the distillate and remove the congeners. Tall columns with plates and bubble caps will see the purchase price of the still rise rapidly. One immediate question is, how many plates are needed? Another related question is, how tall should the column be? My experience says that a craft distiller seeking to make vodka should first do a distillation run through a 4 plate column. This is often termed a stripping run or a whisky run. After a series of such runs, there will be enough distillate collected such that the still pot can be re-charged. The ensuing distillation run will direct the vapor flow up through the tall column. As a minimum, 14 plates should be employed in the tall column and the column diameter should be at least 10 inches. If the ceiling height in the building will allow for more column height, consider getting 16 or more plates in the column design. There is no use leasing a space with a 15 foot ceiling only to later decide to install a still with a column height of 16 feet. A landlord will not be too thrilled at a request to cut a hole in the roof.

If ceiling height is an impediment, this is where a split column design might come in handy. Consider the image in Figure 51 of a Still Dragon unit with dual columns. This still is located at After Dark Distilling in Sicamous, B.C. Still Dragon informs me that this design is also be available with copper columns. In my discussions with Still Dragon it has been made clear that their stills are designed in the USA and then manufactured in China under strict supervision. The factory where the stills are made is ISO 9001 quality control certified.

Still Dragon definitely is the real deal. I would not hesitate to buy their products. The fact that so many craft distillery start-ups have selected Still Dragon speaks volumes to me.

Referring for a moment back to Figure 43, Stumbletown Distilling sourced its equipment from Chinese vendor DYE. This is another vendor to take seriously. It has an ISO 9001 quality system and a solid reputation for good equipment. I was seriously impressed with this DYE equipment when doing my thesis project research.

When looking at various stills, be careful not to fall for clever sales pitches. Every still maker likes to think their product will make vodka. Every still maker has the same objective – to sell you a still. Be careful out there. Don’t get led astray.

On the subject of clever sales pitches, I continue to hear a lot of hype about i-Stills and g-Stills which are made in Europe. Their respective marketing pitches center around instrumentation and ease of use. These vendors know that there are many people trying to get into the distilling game who lack the necessary knowledge. So, why not sell a still that comes loaded with instrumentation? Make it sound like distilling is as simple as pressing the start button on a household appliance. This I tantamount to distilling for dummies.

Utterly sad on one hand, but deviously clever on the other hand. I have it on good authority from two craft distillers that bought these instrument-laden inventions that after six months, the software suddenly stops working. It will only start working again once the still owner agrees to pay a monthly fee in perpetuity. This is verging on the type of behavior I would expect from Microsoft who now annually relieves my wallet of a software licensing fee. Clever indeed.

Figure 51 – Still Dragon with dual columns

A final note on the subject of stills pertains to gin. The botanicals added to make gin contain essential oils. These oils have a nasty habit of adhering to still internal surfaces, gaskets and piping joints. If making gin, it might be advisable to purchase a small, dedicated still that is used for gin alone. This decision will save one the tedium of having to scrub the still clean before using it for a distillation run of something other than gin.

Filtration

Craft distillers making vodka will want to filter the product with activated charcoal before selling it to the consumer. The question invariably arises as to what activated charcoal really is. Briefly stated, take peat, coal, coconut husk or wood, heat to 1000ºC and then blast with hi-pressure steam at 130ºC. The result will be a burnt mass called charcoal.

There is more technical content to charcoal than I ever imagined. When the charcoal is being blasted with steam, cracks and pores develop in the charred particles. These pores range in size from small to medium to large, or in scientific parlance from micro to meso to macro. When charcoal is exposed to a liquid containing higher alcohol molecules that might impair taste and flavor, these molecules will get caught in the micro, meso and macro pores. This is the basis for what is termed charcoal filtration. Literature (1) says that the particulate size of charcoal that works best for filtration is 20 to 40 mesh (0.4 mm to 0.85 mm). When buying charcoal from a vendor, it is best to purchase pre-washed product. But, activation is the bigger issue. I used to think that all charcoal was activated. That was until I spoke to the good people at Brewhaus in Texas. They explained to me that charcoal needs to be added to a pot of water and boiled. The water must then be dumped off and fresh water added. This boiling process must be repeated up to four times prior to using. Boiling the charcoal cleans out the pores in the particles and readies the pores for the task of capturing off-flavor molecules in a distillate. Brewhaus explained that it is advisable to use 4 grams of charcoal per liter of distillate you want to filter. Personally, I think this is excessive. I would use more like 0.5 grams per liter. A craft distiller would add the requisite amount of charcoal to a blending tank filled with distillate. Ideally the distillate should be watered down to between 55 and 60% alcohol. The addition of water will cause the off-flavor molecules to coalesce and be more easily captured by the charcoal pores. After repeated stirring and settling over a 24 hour period, the distillate could be pumped through a plate and frame filter like the one in Figure 52.

With the plate and frame device, the alcohol will be passed through what amounts to a sandwiched layer of filter pads usually of 0.25 micron pore size. I have never yet seen a plate and frame device that works seamlessly. Unexpected leaks seem to be the order of the day.

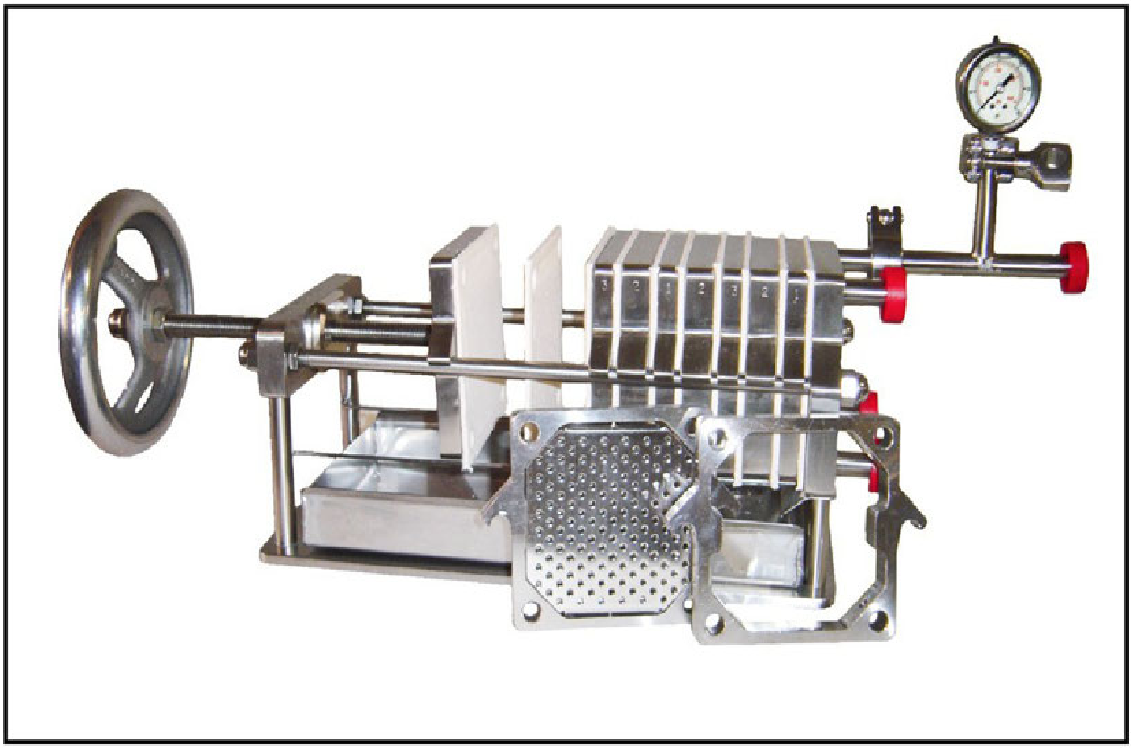

Figure 52 – Plate and Frame filter

There are also cartridge type systems as illustrated in Figure 53. (2)

Figure 53 – Cartridge filter housing

The cartridges can be purchased carbon impregnated. I have even heard of craft distillers using carbon and silver impregnated cartridges. The one drawback to these impregnated cartridges is the price per unit at near $250 each. The overall filter assembly can also be quite pricey. Talk to various vendors for more details. Figure 55 illustrates the flow pattern for the liquid passing through cartridges inside the filter housing. One variant of the cartridge concept that is becoming popular is the PES filter, where PES stands for Poly Ether Sulfone, the material the cartridge filter media is made from. I have seen PES filters in action and am quite impressed.

Blending Tanks

A craft distiller will need one or more blending tanks where alcoholic distillate can be diluted (proofed) with water to reduce the strength to the desired level for sale to the customer. There is no shortage of vendors in the marketplace who can provide small, stainless steel blending tanks of size 300 to over 600 liters. If possible, try to source a blending tank with an agitator to ensure even mixing.

Figure 54 – Cartridge filter module

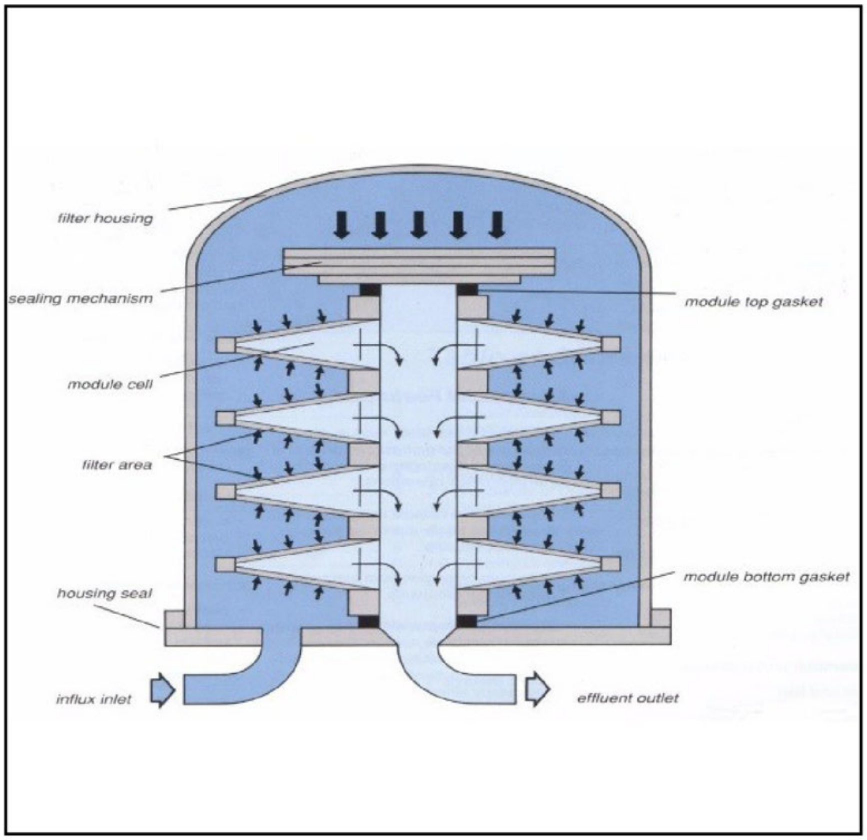

Figure 55 – Cartridge filter flow

Bottle Filling

There are a number of makers of bottle filling devices in the marketplace. The most common design will be the level filler type. Spacing washers are used to configure the fill nozzles so that each bottle gets filled to the same level. The liquid will flow into each bottle by gravity. An economical design for small craft distillers will be one that holds four bottles at a time. Bottles will be placed on the filler and removed by hand once filled. Another design is the volumetric filler. This type of filler operates based on time. The operator calibrates the machine to deliver a desired volume to a bottle. To fill a bottle, the operator positions the bottle at the fill spout and hits a button that starts the timer. The flow will halt after the calibrated time has elapsed leaving the desired volume in the bottle.

Closures

There are two options available for bottle closures – corks and screw caps. Cork is the thick bark that grows on the Portuguese oak tree. Natural corks are becoming something of a contentious issue thanks to global climate change which has resulted in fungal organic compounds often being present in natural cork. If the alcoholic liquid in a bottle comes in contact with a natural cork closure there is a risk that any fungal organic compounds may leach from the cork. The result can be off-color and off-taste developing in the alcoholic beverage. This is why the closure industry has now developed synthetic and semi-synthetic cork materials. It is strongly advised that these types of cork closures be sourced to avoid scenarios of customers complaining about your product quality. If a cork closure is not what a craft distiller wants in terms of brand image, there are any number of screw cap products available in the marketplace. A capping machine will be necessary to install these types of closures. Shop around and consider different vendors. The cost of a capping machine could be significant.

Bottles

There was a time when North America boasted bottle manufacturing facilities. Under duress from globalization, many of these facilities have now closed, unable to compete with the cheaper products coming from China and Mexico.

To learn how bottles are made, there are several videos (3) on YouTube that will illustrate the process. The ingredients used in making glass are silica sand, lime, soda ash, and recycled glass. These ingredients are fed into a furnace where they are melted. At the bottom of the furnace is a slide gate. As the gate opens, a viscous stream of molten glass oozes forth. Shears cut the viscous stream of molten glass into smaller blobs which are directed into preliminary molds that form the blob into the basic shape of a bottle. These partially formed bottles are then picked up by tongs and dropped into a second series of molds. Hot air is blown into the mold to finish the bottle formation. In all there might be six of each type of mold in action. Once the process starts, it runs 24/7. The formed bottles which are still hot are allowed to cool slowly and then inspected for cracks. Finished bottles are palletized and sent on to the end user.

Take a look at the bottles of spirits for sale at a typical liquor store. Pick up some bottles. Feel them. In your mind, how do you judge a heavier bottle versus a lighter bottle? Studies have suggested that a consumer will regard the spirit in a heavier bottle as having greater quality. Look at the shapes of bottles. Are there some shapes that are easier to grasp than others? The bottle you ultimately choose for your craft distilled product will be what gives a potential customer his or her first impression of your product. Choose carefully.

If sourcing bottles from places like China, bear in mind that you might encounter some quality issues. It is reasonable to expect some variations in the tolerance of the bottle opening. If using cork as a closure, expect some corks to fit tight and others to fit not so tight. When I used to conduct workshops in Kelowna, BC, I would often show up early to assist with a bottling run. It soon became clear that 10% breakage was the norm for their Chinese, custom-made bottles. No compensation ever materialized from the supplier to pay for breakage.

Be somewhat wary of custom-molded bottles. For the cost of several thousand dollars, one can engage a Chinese glass maker to prepare a custom designed bottle. Be very certain that there are no hidden restrictions on minimum order sizes of custom bottles. Remember, a glass factory ideally likes to operate 24/7. If the process has to shut down so as to remove the molds being used and replace them with your molds, someone has to pay for this production interruption and it will be you, the customer. I have heard of craft distillers getting hit with large, expensive minimum order quantities, to the tune of 20,000 bottles. I have even heard of Chinese manufacturers asking craft distillers to order a shipping container full of bottles at one time. I was recently contacted on Linked In by a Chinese vendor who had a minimum order quantity of 6000 bottles. That quantity is still too large in my opinion. As a start-up craft distiller, it is not advisable to have money tied up in bottle inventory. Be certain also that the supplier in China will be able to deliver according to your needs. In 2018 I heard of a craft distiller who had placed an order for custom made bottles and then proceeded to launch a marketing campaign for the release of its whisky. As the release date neared, the Chinese supplier called to advise that they were not happy with how the custom molds had turned out and that it would be several more months before the bottles would arrive.

In my experiences, I have seen remarkably good quality bottles coming from Europe. Bottle opening tolerances were uniform and breakage was a non-issue. Give serious consideration to European manufacturers such as Saver Glass, Bruni Glass or Vitri Speciale. In North America, another vendor to talk with is Universal Packaging. They have an extensive collection of stock bottle designs and I have seen their bottles in use by a number of craft distillers.

Labels

Take a stroll through your local liquor store. Look at the various bottles of product for sale. Notice that many spirit makers are using labels that are adhesively applied. A good number of other producers are using bottles that have information screened onto the bottle. Which method makes the strongest impression on you? Are there certain colors that you feel more attracted to? Studies have shown that green is suggestive of nature, balance and harmony. Red is suggestive of heat, power and action. Yellow is suggestive of happiness and cheerfulness. Yellow is also an attention-getter, which is why many taxi cabs are yellow. One excellent use of yellow can be seen with a Canadian product called Ungava Gin. The makers of this gin took the unprecedented step of coloring their gin yellow which makes it practically jump off the shelf when placed beside other gin brands that are colorless. The color gold suggests richness and extravagance. The same can be said for purple. This is why Crown Royal Whisky in Canada has successfully used these colors since 1939. The color blue suggests intelligence, power, respect and authority. Studies have shown that this color is equally respected by men and women. White denotes sophistication, luxury and even mystery. Black is suggestive of calm, and peace. Black is also a safe neutral color to use. The graphic designer you work with for label design should be well versed on the psychology of color.

Trade Shows

In the first quarter of every calendar year there will be a number of trade shows that will feature vendors of everything from boilers to bottles. The two big ones are the American Distilling Institute Show and the American Craft Spirits Association Show. If you are contemplating getting into craft distilling, a visit to one of these shows is a must.

Used Equipment

Finally, don’t be afraid to start looking for used equipment. I continue to see ample amounts of equipment for sale in America these days. In some cases, it is a distiller who is upgrading to larger equipment, but in many cases it is start-up projects that failed to ignite. At the crux of the issue seems to be the 3-tier liquor distribution system. Distributors cannot possibly handle everyone’s product. Craft distillers rushing into the business in search of wealth and fame are quickly finding out that a scientific understanding is a prerequisite to making good products. The distributors are very good at separating good quality product from mediocre product. A distributor who decides it is unable to move product for a craft distiller has just given that craft distiller a death sentence. If you see used equipment for sale, you will want to quickly go and look at it. Don’t buy it sight unseen. An excellent source for used equipment is the Discussion Boards on the American Distilling Institute (4) website, https://adiforums.com/forum/26-for-sale-peer-to-peer. Another vendor to contact is U.K.-based Ryebeck Ltd. (5)

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10

Cleaning

The 4-Ts of Cleaning

Reducing bacteria count in process vessels, pumps and hoses is a foremost concern for distillers. There are 4 components to a cleaning program, called the 4-Ts: Time, Titration, Temperature and Turbulence. (1)

Time: How often do you clean a vessel and ancillary equipment? When you do run a cleaning cycle, how long is the cycle?

Titration: What chemicals or solutions do you use?

Temperature: Is your cleaning solution applied at colder temperatures or warmer temperatures ?

Turbulence: How aggressively do you clean? Are you using high pressure spray jets?

The first step in any cleaning cycle is to give the vessel or equipment item to be cleaned a high pressure water rinse. This will remove larger, visible accumulations of unwanted material clinging to surfaces. The next step is to apply a treatment of a substance capable of dissolving proteinaceous material that may have accumulated on the vessel or equipment.

Caustic: Caustic soda (sodium hydroxide) at a 2% solution strength is widely used in the brewing and distilling industry for its powerful efficiencies in dissolving caked-on material from tank surfaces, pumps and hoses. It has good rinse-ability which means a flush with warm, clean water will be sufficient in removing caustic residue. Safety is critical when using caustic soda. Be sure to wear a safety visor and also rubber gloves when measuring out caustic for use in a cleaning cycle. A splash of caustic in the face or on the hands can have nasty, burning consequences. There will be vendors in your community that sell industrial cleaning supplies. Speak to them about sourcing a pail of caustic soda either in liquid slurry format or dried granulated format. Or, visit a local craft brewery and find out where they source their cleaning supplies.

TSP, PBW & Oxyclean: Detergents are also good for cleaning equipment. One detergent that I have used for many years is tri-sodium-phosphate which sells in hardware stores under the brand name TSP. It has good rinse-ability and is excellent at dissolving caked-on material from surfaces. Recently when at a home brew shop looking for a relatively expensive product called Powdered Brewery Wash (PBW), I was told to instead visit my local WalMart store and get a container of Oxyclean (the plain stuff with no added fragrances or fabric softeners). Funny thing, Oxyclean sure looks identical to PBW, and it works just as well at a fraction of the price.

Following cleaning with water and caustic (or other suitable detergent), the next step is to apply a final application of a bacterial killing solution to sanitize the vessel and equipment.

Sodium hypochlorite: This chemical, otherwise known as Javex, is very effective at killing bacteria. When mixed with water, sodium hypochlorite forms hypochlorous acid. The problem with Javex is that

it can lead to pitting on stainless steel surfaces. Craft distillers should avoid using the stuff altogether. If doing small scale, home recipe trials using plastic fermentation pails, Javex can be used as a sanitizer. Javex is rinseable, but be sure to give your equipment a few extra water flushes when using this product.

Quaternary Ammonium: Also known as ‘quats’, a quantity of 2 mls in 1 liter of water will create a powerful bacterial sanitizer. If you have ever used sanitary wet hand wipes that come in individualized pouches, you have experience with ‘quats’.

Peracetic Acid: To sanitize equipment, brewers are likely using peracetic acid. This product will break down to radical oxygen and dilute acetic acid, so no final rise is required after application. Visit a local craft brewery and ask the brewer about the cleaning chemicals being used.

Iodofor: Iodine is familiar for its ability to stain. Iodofor is Iodine that has been blended with a high molecular weight substance to help avoid the staining aspect. The concentration of Iodine in an Iodofor solution is 12.5 ppm and it is very effective at killing bacteria.

Citric Acid: This can be a distillers best friend for removing sulfide scale buildup inside a still. Citric acid can be purchased in bulk, crystalline form. A solution of 450 grams to 1 liter of water should be an adequate mixture ratio to give a still a good cleaning.

In most major cities, one will likely find a salesperson representing a firm called EcoLab. I have experience with EcoLab sales reps and they know what they are doing when it comes to craft brewing and distilling. Working with them will steer a craft distiller in the right direction.

Cleaning in Place Systems: Craft distillers, when sourcing equipment, should budget to have a cleaning-in-place (CIP) system installed on tanks, still pots, and columns. A CIP system consists of a multi-nozzle spray ball positioned inside a tank or a still. Cleaning solution is supplied at high pressure to the spray ball using the positive displacement auger pump, or some other high pressure pump. The cleaning solution sprays from the spray ball at high pressure and impacts all internal surfaces of the vessel being cleaned. After the cleaning solution has been sprayed, the process is repeated using water to rinse. I have come across craft distillers who regret not opting for a C.I.P. system. Be sure to stand firm if a manufacturer of tanks or stills tries to explain that a C.I.P. system is really not needed. It is needed. Insist on it. Take tie as well to examine the variety of spray nozzle designs available. I have seen some nozzles that are very effective and some that are only slightly effective. In your travels to either breweries or distilleries, I suggest asking some pointed questions about the type of spray nozzle being used in the CIP system.

Effectiveness Test: How does one know if a particular cleaning process has been effective? Are there any bacteria remaining? There is a quick test one can do and it is called the ATP Bioluminescence Test. If the letters ATP look familiar, they should. Earlier, ATP was discussed in the context of the Krebs Cycle. Every living cell has ATP energy associated with it, and bacteria cells are no exception.

A glowing firefly buzzing around late at night leads to an understanding of the ATP test. A portable ATP test kit will include a test tube with what resembles a Q-Tip swab in it. The swab is rubbed on the cleaned surface of the vessel in a cross-hatch type pattern over a small area. The swab is inserted back into the tube holder. The bulbous end of the tube is then snapped off. This will release some chemicals into the tube. After shaking for a few seconds, the tube is inserted into a black box device and in about 15 seconds, a digital number will pop up on the display.

Here is what has occurred: The bulbous end that was snapped off contained an enzyme called luciferase and a chemical 6-hydroxybenzothiazol, also called luciferin. If there was any ATP energy residue on the swab, it caused the formation of light (just as a firefly generates light due to the presence of these two substances in its body). Inside the black box, there is a detector that is set to measure light of the wavelength 532 nanometers. The digital reading is in RLU's, relative light units. The desired situation is a low reading (less than 100 units). If after a CIP cycle, there are still high RLU readings, then the cleaning cycle will need to be lengthened, or changes made to spray nozzles to get a more effective pattern. ATP test kits are readily available from a number of vendors. Do a search on-line and contact some vendors. (2)

In my visits to Scotland, I have become accustomed to seeing fermenter vessels made from pine and larch wood staves. I have yet to make a visit to bourbon distilleries in Kentucky, but I am told to expect to see some wooden fermenter vessels. When I inquired of Scottish distillers as to the type of cleaning cycle used on a wooden vessel, I was told the cycle was a short one with a very dilute cleaning solution. The aim was to clean, but not to kill off all the bacteria in the tiny cracks of the wooden staves. As described in an earlier chapter, bacteria can decarboxylate a fatty acid molecule with the net result being ester formation which lends flavor to the distillate. As a craft distiller, give due thought to the extent of cleaning that will be undertaken. Some bacteria left in the system can actually help develop estery flavor. In 2018, I took matters one step further with my home-based, recipe creation efforts. In a series of ferments, I thoroughly cleaned as usual but then deliberately added Lactobacillus Plantarum bacteria mid-way through the fermentation cycle to encourage ester formation. This apparently is the technique employed by Japanese Whisky makers. The bacteria were obtained from Lallemand who sells them under the product name Sour Pitch. In late 2020 I bottled this creation and I am beyond impressed. I am now a huge proponent of the power of bacteria when used in a controlled manner in grain mashes.

References

1 Power, J., Larson, J., (2003). Managing the four T's of cleaning and sanitizing: time, temperature, titration and turbulence. In: The Alcohol Textbook,4th edition. Eds. Jacques, K.A., Lyons, T.P., Kelsall, D.R. Nottingham, UK: Nottingham University Press.

2 Hach website (2018) ATP Test Kits. [online] Available at: https://www.hach.com/kits/atp-test-kits/family?productCategoryId=35547105124. [Accessed December 2018].

11

Instruments, Proofing & Tax

Four Essential Instruments

Craft distillers will need the following four instruments: a thermometer, a hydrometer, a refractometer and a pH meter.

The thermometer can trace its rudimentary beginnings back to 1593 and the time of Galileo. In the early 1600s, Italian inventor Santorio took Galileo’s basic design and added a numerical scale. In 1645, Italian nobleman Ferdinand II developed the first ever liquid-in-glass thermometer. In 1714, German scientist Daniel Fahrenheit improved Ferdinand’s design further by using mercury as the liquid inside the glass.

For small scale recipe development, one can purchase a digital thermometer from a local home brewing store. But, for a licensed craft distillery operation more expensive equipment is needed.

Craft distillers in the US (1) will have to purchase a standard mercury-in-glass style of thermometer. The use of thermometers for proofing alcohol in the US is governed by 27 CFR part 30, section 22. Depending on the style of thermometer (there are only four allowed styles), the accuracy will have to be at between 1 degree Fahrenheit and ¼ of a degree Fahrenheit. From time to time, TTB officers may request an opportunity to verify the accuracy of thermometers used by craft distillery proprietors.

In Canada, (2) craft distillers can use either a mercury-in-glass thermometer or a digital model. Digital models, while nice to use, can be expensive to buy. A suitable digital unit must be capable of reading temperatures between -25ºC and +45ºC with incremental steps of not more than 0.1ºC. Digital thermometers will have to be examined annually for accuracy. In Canada, The Science and Engineering Directorate (SED) of the Canada Border Services Agency has authority over all instruments used in alcohol proofing. This agency will be the one who does your scheduled calibrations. In Canada, mercury-in-glass thermometers must read between -25ºC and 45ºC with 0.5ºC increments. Glass thermometers, once approved, must be re-examined every five years.

The hydrometer can trace its origins back to scientists Nicholson and Baume in the mid-1800s. For small scale recipe research, one can purchase a cheap hydrometer from an on-line vendor. I have had good success with Nova-Tech USA (www.NovaTech-USA.com) based in Texas, and routinely use their alcoholmeters in workshops. I place my order on-line and within days my parcel arrives via UPS. The two models I use are #6603-11 and #6603-12. One is for alcohol strengths in the 40-60% range. The other is for alcohol strengths above 60%. Another vendor to consider is Bosa Grape in the greater Vancouver area who also sells all manner of supplies and tools for home distillers and craft distillers alike.

Craft distillers are tightly regulated when it comes to alcoholmeters (hydrometers). From time to time TTB officers will verify the accuracy of hydrometers used by craft distillery proprietors. In the US, alcohol strength is expressed in units called proof. Hydrometers are divided into 11 classes, with each class representing a different alcohol proof range. For example, a class L hydrometer shall read between 90 and 110 proof with an accuracy of +/- 0.2 proof. The use of hydrometers in proofing alcohol is governed by 27 CFR part 30, section 22. Hydrometers are calibrated for accuracy at 60ºF. Proofing tables must be used if the temperature of the alcohol being proofed differs from 60ºF. Thermco Products in New Jersey is one accredited supplier of hydrometers to the distilling industry. Cole Parmer and Vee Gee Scientific are others to consider. (3)(4)(5)

In Canada, alcohol proofing is based on density units of kg/m^3. Hydrometers in Canada must individually have a range of no more than 20 units (ie 20% to 40%, 40% to 60% alc and so on), so craft distillers will have to purchase a series of about six hydrometers to cover the range of alcoholic strengths they are dealing with in their distillery. Each hydrometer will cost at least $275. The accuracy of a hydrometer must be +/- 0.2 kg/m^3. The procedure for acquiring hydrometers involves making the purchase, having the vendor send the hydrometer to the Excise Canada Regional Testing Laboratory, having the unit certified and then having Testing Laboratory send the unit to you. Once approved, hydrometers must be re-examined every five years. In Canada, Bosa Grape is a good supplier. Digital units are allowed in Canada, but the last time I inquired, I was told cheaper digital units sold under the brand name SNAP were not certifiable by the Regional Testing Laboratory.

In the early 1800s, scientists Karl Balling, Adolf Brix and Fritz Plato all developed measuring scales to record the sugar concentration of solutions. Today, the most commonly referred to scale in the distilling industry is the Brix scale where 1 degree Brix is the equivalent of 1 gram sucrose in 100 grams of solution. Beer brewers most often use the closely related Plato scale.

An optical refractometer comprises a lens, an eyepiece and a scale (Plato or Brix). The user places several drops of fermentable liquid to be tested on the lens and then looks through the eyepiece. The scale visible through the eyepiece is calibrated so that with pure water on the lens a reading of 0 will result. Scales on refractometers usually go from 0 to 35º Brix. Drops of sugary solution on the lens will cause light to refract (bend) as it passes the lens. This will cause a shaded line to appear on the scale which the viewer can then read. For both home distillers and craft distillers, refractometers are easy to find. I purchased one a couple years ago for about $120 from an on-line store that retailed scientific instruments. In Canada, take a look at the website for Ontario Beer Kegs (www.OntarioBeerKegs.com). There, one will find hydrometers and much more (and at cheaper prices than I paid). In the US, industrial supply companies like National Industrial Supply will likely sell refractometers. (6)(7)

The first rudimentary pH meter was developed in 1906 by Fritz Haber. In 1936, American scientist Arnold Beckman refined the device. pH is a mathematical construct based on the negative base 10 logarithm of hydrogen ion concentration. The pH scale goes from 1 to 14 with pH 1 being a strong acid and pH 14 being a strong base. Water is around pH 7. pH meters are especially useful for dealing with un-malted grains and artificial enzymes where the pH of the mash should be at the enzyme manufacturers recommended level. pH meters are easily obtainable from on-line retailers of scientific instruments and from home brew supply stores.

Closely related to spirits proofing is the issue of a weigh scale. In Canada, the US and the U.K., craft distillers will be required to purchase a digital platform scale suitable for weighing larger totes or pails of bulk alcohol. Knowing the mass of alcoholic liquid in a bulk tote will then allow the distiller to quickly calculate the volume of absolute alcohol (or the proof gallons) contained in the tote. This data will be required for monthly government reporting purposes. Weigh scales, once approved, will have to be re-certified about every two years. I have come across a vendor in the US called Arlyn Scales who are marketing an explosion proof scale. Platform scales will in fact plug into an electrical outlet to power the digital display. I personally have not yet met a craft distiller who had encountered issue with a Fire Inspector wanting an explosion proof scale. But, seeing a vendor such as Arlyn Scales offering an explosion proof model has me wondering if Fire Inspectors are changing their attitudes and demanding explosion proof scales.

American Proofing System

In the US, 27 CFR part 30 section 62 provides the TTB Gauging Manual. (8) Figure 56 illustrates a portion of this Table.

Consider the following short example using the excerpt from the Table in Figure 56:

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TABLE No. 1

TRUE PERCENT PROOF

Hydrometer reading	Temperature °F.									
	61°	62°	63°	64°	65°	66°	67°	68°	69°	70°
51	50. 6	50. 2	49. 8	49. 4	49. 0	48. 6	48. 2	47. 8	47. 4	47. 0
52	51. 6	51. 2	50. 8	50. 4	50. 0	49. 6	49. 2	48. 8	48. 4	48. 0
53	52. 6	52. 2	51. 8	51. 4	51. 0	50. 5	50. 1	49. 7	49. 3	48. 9
54	53. 6	53. 2	52. 8	52. 3	51. 9	51. 5	51. 1	50. 7	50. 3	49. 8
55	54. 6	54. 2	53. 7	53. 3	52. 9	52. 5	52. 0	51. 6	51. 2	50. 8

Figure 56 – excerpt from TTB Gauging Table

If the hydrometer in a sample of alcohol distillate reads 54 proof and the temperature of the solution being proofed is 64ºF, the true proof strength of the solution being proofed would be 52.3 proof. To convert proof to percentage alcohol, simply divide by 2.

In the US, alcohol is recorded in quantities of proof gallons on TTB monthly reports. The proof gallon is an old British unit of measure in which one gallon of alcohol at a strength of 50 % is deemed to be one proof gallon. To convert normal volumetric gallons to proof gallons, simply multiply volume by percent alcohol and divide by 50. As an example, suppose a craft distiller makes 80 gallons of 90 proof (45% abv) Whisky. This equates to:

$$(80 \text{ x } 45) / 50 = 72 \text{ proof gallons}$$

Canadian Proofing System

In Canada the unit of measure for alcohol reporting is liters of absolute alcohol (LAA). To convert regular volumetric liters to LAA, simply multiply volume by percentage alcohol. As a simple example, a 750 ml bottle of vodka at a strength of 42 % will have:

$$0.750 \times 0.42 = 0.315 \text{ LAA (or 315 mls of absolute alcohol)}$$

In Canada, the Canadian Alcoholometric Tables provide the data necessary to proof alcoholic spirits. (9) Figure 57 illustrates a portion of the table.

Consider the following two examples each using the portion of the Canadian Excise Tables shown in Figure 57.

22.5	934.0	1.0698	47.1	0.9980
22.5	934.2	1.0696	46.9	0.9980
22.5	934.4	1.0694	46.8	0.9980
22.5	934.6	1.0692	46.7	0.9980
22.5	934.8	1.0689	46.6	0.9980
22.5	935.0	1.0687	46.5	0.9980
22.5	935.2	1.0685	46.4	0.9980
22.5	935.4	1.0682	46.3	0.9980
22.5	935.6	1.0680	46.2	0.9980
22.5	935.8	1.0678	46.1	0.9980
22.5	936.0	1.0676	46.0	0.9981
22.5	936.2	1.0673	45.9	0.9981
22.5	936.4	1.0671	45.8	0.9981
22.5	936.6	1.0669	45.7	0.9981
22.5	936.8	1.0667	45.5	0.9981
22.5	937.0	1.0664	45.4	0.9981
22.5	937.2	1.0662	45.3	0.9981
22.5	937.4	1.0660	45.2	0.9981
22.5	937.6	1.0658	45.1	0.9981
22.5	937.8	1.0655	45.0	0.9981
22.5	938.0	1.0653	44.9	0.9981
22.5	938.2	1.0651	44.8	0.9981
22.5	938.4	1.0649	44.7	0.9981
22.5	938.6	1.0647	44.6	0.9981

Figure 57 – excerpt from Canadian Excise Table

First, suppose the temperature of the alcohol solution being proofed was 22.5ºC and the hydrometer was reading a density of 936 (which is 936 kg/m^3). Locate 22.5ºC in the left hand column and scroll down until you find the density reading of 936.0 in the second column. Move across the table to column 4 and you can see the alcoholic strength of the solution being proofed is 46 % alcohol.

As another example, suppose a craft distiller has a bulk tote containing 200 kgs of alcoholic distillate. The Excise Inspector happens to stop by for an audit and demands to know how much absolute alcohol is contained in the tote. The distiller would measure the temperature of the alcohol in the tote and then draw off a sample to measure the density. Suppose the temperature was 22.5ºC and the density according to the hydrometer was 937.8.

The distiller would multiply the mass (200 kgs) by the figure from column 3 (1.0655) to determine volume in the bulk tote.

$$200 \times 1.0655 = 213.10 \text{ liters.}$$

Next, multiply 213.10 by the figure in column 4 which is 45.0% to determine the amount of absolute alcohol in the bulk tote:

$$213.10 \times 045 = 95.895 \text{ liters.}$$

The amount of absolute alcohol in the bulk tote is therefore 95.895 liters of absolute alcohol calibrated to 20ºC.

While these instruments and tables may at first glance appear daunting, they are actually quite easy to use. With a little practice, a distiller will soon become very competent.

As a final note, the cheaper hydrometers bought for Canadian home distilling will have the units of measure expressed as kgs per liter. On a certified hydrometer used by a craft distiller, the units are kgs/m³. Sticking with the most recent example, a reading of 937.8 kgs/m³ on a certified hydrometer would be 0.9378 kgs per liter on a cheap home-use hydrometer.

Such is the elegance of the metric system and the shifting of the decimal point.

Proofing with Other than Water

The above examples of proofing all pertain to using water as the proofing medium. What if one were proofing with, say, lemonade to make a lemon-flavored Moonshine? The hydrometer instruments are not designed to work in non-water solutions. So, some algebra is required.

Using the above American example of 80 gallons of 45% alcohol which equates to 72 proof gallons, suppose that the distiller wanted to take that alcohol and add lemonade to make a final product at 30% abv strength. Even after lemonade addition, the number of proof gallons of alcohol in the mixture will still be 72. The fact that lemonade has been added does not diminish the amount of alcohol present. The mathematical expression C1V1 = C2V2 is used to solve this problem, where C1 is the initial alcohol concentration and V1 the initial volume. C2 is the final desired concentration and V2 the final total volume.

$$C1V1 = C2V2$$

$$(45)(80) = (30)(V2)$$

Algebraically solving for V2 gives 120. Therefore, adding 40 gallons of lemonade to the 80 gallons of alcohol will give a total volume of 120 gallons and the desired final strength. To be absolutely certain of accuracy, the distiller will submit a sample of the flavored alcohol to a certified laboratory for verification. On the bottle labels, the distiller must state the alcohol percentage and be within +/- 0.15 of the stated 30% strength, hence the need for laboratory verification.

Using the metric system, the math is similar. Using the previous Canadian example, suppose a distiller has 213.1 liters of alcohol. That quantity contains 95.895 liters of absolute alcohol. Suppose the distiller wanted to add flavoring syrup to proof down to 30% abv strength. The fact that syrup is being added does not diminish the quantity of alcohol in the mixture.

$$C1V1 = C2V2$$

$$(45)(213.1) = (30)(V2)$$

Solving for V2 gives 319.65.

Starting with an initial volume of 213.1 liters and adding 106.55 liters of syrup gives the final volume of 319.65 liters at 30% abv strength. To verify, a sample will have to be sent to a laboratory for verification because in Canada, the alcoholic strength stated on a label must be within +/- 0.2 of the actual value. In this case, the lab test result better come back at between 29.8% and 30.2% alcohol, otherwise any labels that have been printed will not be accurate and will have to be re-made.

U.K. Proofing

The U.K. uses the % alcohol by volume methodology. The Tables used will be similar to the Canadian methodology.

Owing to the fact that the Imperial gallon is larger than the US gallon, a proof gallon in the U.K. is 1 gallon of alcohol at a strength of 57%. In days of old when a sailor was given some Rum, he would mix it with gunpowder and light it. If the Rum burned, it was deemed to be at proof (57%) or higher. If it did not burn, it was deemed to be under proof.

Taxation and Surety

Taxation is calculated on each liter of absolute alcohol made or each proof gallon made. In Canada, a distiller will be assessed a tax of $12.61 per liter of absolute alcohol made. In Canada, the federal politicians have made provision for the excise rate to automatically rise by 2% each April. In the US, the rate used to be $13.50 per proof gallon. In late 2020, the US Congress renewed the Craft Modernization Act and further opted to make permanent the alcohol excise tax rate of $2.70 per proof gallon on the first 100,000 gallons made. In the U.K. the excise rate is near 27 Pounds Sterling per liter of absolute alcohol. In Australia, the figure is near A$82 per liter of absolute alcohol. Taxation does not stop with federal governments. State governments and provincial governments can add tax as well.

Craft distillers will be required to post what is called a Surety Bond with the appropriate authorities as part of a craft distilling license. The Surety Bond functions like an insurance policy. If the alcohol a distiller has sitting in bulk (ie. in oak casks) were to be lost or stolen, the Surety Bond would cover all taxes owing at the above stated rates. The tax man wants his money no matter what. As a distiller accumulates more and more alcohol in bulk, the surety Bond must be adjusted upwards accordingly.

References

1 search online for “27 CFR section 30” to find the relevant legislation

2 http://www.cra-arc.gc.ca/E/pub/em/edm1-1-5/edm1-1-5-e.html#_Toc347404444 (or search online for “Excise Canada Alcohol Proofing”)

3 www.thermocoproducts.com

4 www.coleparmer.com

5 www.veegee.com

6 www.novatech-usa.com

7 www.AcklandsGrainger.com

8 search online for “27 CFR section 30” to find the relevant legislation

9 search online for “Canadian Alcoholometric Tables” to find the ZIP file containing the table data.

12

Oak Ageing of Spirits

What is Wood?

In the earlier chapter on Microbiology, I described the basic construct of cellulose and hemicellulose. Recall that:

The OH group at the right side of a glucose molecule is facing upwards. If the OH group were facing downwards and if between 7000 and 15,000 such units were joined together using 1-4 linkages, the result would be a material substance called cellobiose. Join together thousands of cellobiose units and the resulting material will be cellulose which is a primary constituent of wood.

If the respective H-OH structures at carbon atoms 2 and 3 were flipped around, the result would be a six carbon sugar called mannose. If Nature removed one of the carbon atoms from the glucose structure to leave a five-carbon product. The formula of this five-carbon structure is HOCH2(CH(OH))3CHO. This is termed a xylose.

If Mother Nature assembled a chain of xylose, mannose and glucose molecules together so that there were a total of between 500 and 3000 molecules, it would be termed a hemicellulose, which is another primary constituent of wood.

Bind cellulose and hemi-cellulose chains together with lignins, tannins and volatiles and the result would be a substance called wood. Lignin is a complex three-dimensinal structure based on units that derive from coniferyl and sinapyl alcohol molecules. Tannins are polyphenols of low to intermediate molecular weight and do not contribute to the strength of wood. The basic structure of a polyphenol is a six-carbon ring joined to a three-carbon molecule joined to a six-carbon ring molecule. The two variants of tannin in wood are hydrolysable (capable of being broken down) and condensed. A hydrolysable tannin can be broken down into gallic and ellagic acid. Condensed tannins take the form of catechin and epicatechin molecules and are less astringent than hydrolysable tannins. The volatiles in wood are a wide ranging group of organic acids that includes phenolic aldehydes, volatile phenols and lactones. Examples of phenolic aldehydes are vanillin, syringaldehyde, coniferaldehyde and sinapaldehyde. The main volatile phenolic of interest in oak is eugenol with a clove-like aroma. An ester comprises a short chain fatty acid joined to a carbon atom, which is joined to an oxygen atom and a alkyl OCH2 group. If the fatty acid were to loop around and tie to the OCH2 appendage, the result would be a cyclical, ring-like structure called a lactone. Lactones help provide woods with their unique woodsy aromas. Lactones derive from the breakdown of a compound called 2-methyl-3-(3,4-dihydroxy-5-methoxibenzo)-octanoic acid. Breakdown yields two variants of lactone, namely cis and trans. The cis-variant is readily detectable by the human nose. (1)(2)(3)

What differentiates one species of wood from another are the types and amounts of molecular structures present and also the size of the medullary rays present. Medullary rays run lengthwise along the long axis of a tree. In cross section, the medullary rays appear to emanate radially from the core of the tree. In softwoods such as pine and spruce, these rays are narrow. In hardwoods such as oak, maple, cherry, and elm, the medullary rays are wide and impart considerable strength to the wood. A long time ago mankind figured out that hardwoods in addition to being strong, had the innate ability to contain liquids. This is why oak wood is such a popular wood for barrel making. The other scientific factor that enables certain woods to hold liquids is clogged cells. Wood contains xylem cells that allow the tree to transport moisture and nutrients internally from the tree root system. Over time, these cells get clogged with an organic substance called tylose. As the xylem cells become clogged over time, the wood is able to contain liquid and so becomes a prime candidate for use in barrel making. Oak is an example of a hardwood that experiences clogged xylem cells. (2)

Oak

Oak trees grow in two primary regions of the world – North America and Europe. In North America, the most predominant species of oak tree is Quercus Alba, otherwise called North American oak. Other species that occur in North America include Quercus Prinus, Quercus Stellata and Quercus Durandii. In Europe, the two predominant species of oak are Quecus Robur and Quercus Sessillis. The main difference between North American oak and European oak is the organic acids contained in the wood. European oak has a more complex array of acids and will impart a more complex flavor to an alcoholic liquid aged in it. In fact, European oak will impart notes of butterscotch and vanilla to a spirit whereas a North American oak will tend more towards the coconut, spicy, clove taste profile. (4)

Barrel Making

The barrel making process starts with oak logs about 30 centimeters in diameter being harvested and taken to a processing mill. The oak logs are cut into quarters and each quarter is then sawn into boards called staves. The staves are then dried. It is interesting to note that staves destined for use in barrels that will hold wine are aged outdoors, exposed to the elements for up to two years. During this time, Mother Nature will break down the hemi-celluloses, lignins and organic acids through weathering. Staves destined for barrels that will hold alcoholic spirits are dried in a kiln oven for several weeks at about 50ºC to break down the hemi-celluloses, lignins and acids. The breakdown of lignin causes an increase in eugenol, syringic and vanillic aldehydes in the wood structure. However, it must be noted that kiln drying of wood results in lesser amounts of eugenol and vanillins that outdoor-drying of wood. This sets up the argument that the best wood for barrel making would be outdoor-dried. But, the spirits industry places heavy demands on barrel makers. Slow drying of staves outdoors is not a time effective option. After drying (whether outside or in a kiln), the staves are then shaped and their edges beveled. The staves are assembled into a cylindrical format and held in place with metal rings, called hoops. Figure 58 illustrates how the staves are cut from a log. This photo was taken in the visitor center at Speyside Cooperage near Craigellachie, Scotland during my 2018 visit.

Figure 59 – Staves from an oak log

Toasting

The semi-completed barrel is then exposed to either radiant heat or steam heat. Recall from the chapter on Raw Materials that when a long molecular starch molecule is heated, it starts to break down into smaller units of glucose (sugars). In barrel making, the radiant or steam heat applied to the semi-completed barrel breaks the hemicelluloses into smaller sugar units. The more heat applied, the more sugar units that are created. This process is called toasting. Toasting can run the gamut from light to medium plus. A typical light toast will take 5 minutes and the wood surface will reach 180ºC. A medium toast will last for about 35 minutes. A more aggressive toast will see wood surface temperatures of up to 230ºC.

Oak Volatiles and Flavors

Toasting further causes the lignins to break down into volatile aldehydes and ketones, both of which have a positive aroma profile. As the degree of stave toasting rises, the amount of volatile aldehydes and ketones available to help build flavor will decline. Conversely, the amount of lactones available will increase.

If steam heat is used to toast (as opposed to dry radiant heat), more lactones will become available for dissolution into the contents of the barrel. However, this is not universally true. Beverage scientists have determined that the lactone availability will vary across oak growing regions and in fact sometimes from tree to tree.

A higher degree of toast will also release more eugenol (spice), guaiacol and 4-methyl guaiacol, all of which emanate from the heat-induced degradation of lignins in the wood. These guaiacol compounds will lend a degree of smokiness to an aged spirit.

As the degree of toasting ramps up, the amount of gallic and ellagic acids lessen. Toasting also breaks down the lignin to release vanillin molecules. (5)

Furfural and 5-methylfurfural are generated by the breakdown of carbohydrates, in particular cellulose and hemicellulose, during the toasting process. These compounds have a sweet, caramel or butterscotch aroma.

If you are thinking that the chemistry of wood is complex and that wood should not just be taken for granted, you are very correct. Craft distillers should spend a significant amount of time getting to understand the types of oak available and the degrees of toast available.

Charring

The inside of the toasted wood barrels is next lit on fire for up to 90 seconds to burn the hemicellulose wood sugars. This process, called charring, creates is a carbon layer that acts as a filter to help remove immature character from the distillate that will eventually reside in the barrel. The heat from charring also causes the lignins, tannins and other organic acids in the wood to further release eugenols and guaicols. Charring also adds to the release of lactones. One particular product that is released due to the thermal degradation of hemicellulose is furfural (an aldehyde structure). Furfural undergoes a quick series of complex reactions to produce Maillard type products which add to the color of the distillate in the barrel. Watch the You Tube video (6) of Jeff Arnett (former Master Distiller at Jack Daniels) where he describes how the charring creates color in the Whisky.

Following charring, the barrel hoops are further pressed into place. The barrels are then fitted with tops and bottoms, leak tested and shipped to a waiting distillery. In addition to the Jack Daniels video, there are a number of other excellent YouTube videos that will provide you with the full visual experience of barrel making. (7)(8)

Ageing Parameters

There is an ongoing debate over humidity and temperature storage conditions for oak-barreled alcoholic spirits. If oak barrels containing alcoholic distillate are left in an area of high humidity, water will be impeded from evaporating from the barrel due to what is termed a vapor gradient. Alcohol will, however, evaporate and there will be a reduction in alcoholic strength. On the other hand, if oak barrels are left in an area of low humidity, more water than alcohol will evaporate from the barrels. In a modest humidity surrounding, a more balanced evaporation of water and alcohol will result. No matter what the environment, there will be evaporation and this is termed angels share. If the temperature of the storage area is too hot, the delicate flavors of the alcoholic distillate could be impaired resulting in a poorer quality spirit for the craft distiller to sell to his customer. The scientific papers I have read suggest that a humidity level of about 65% and a temperature of 20ºC (room temperature) is best. Jeff Arnett, has a different opinion on temperature. He maintains one of the secrets to Jack Daniels Tennessee Whisky is the variation in seasonal temperature which causes the distillate in the oak barrels to expand into and out of the fibers in the wood staves. As he demonstrates in the video, alcohol distillate in a barrel can soak into the wood fibers by up to about ½ inch.

Researchers, in a study designed to thwart the angels share, compared barrels aged at storage facilities in two geographic regions of Scotland. One of these storage facilities was insulated and the other was not insulated. Barrels were stored at various levels in the facilities. The study concluded that temperature is the key variable controlling angel’s share. In places like Scotland where the average temperature is cooler, the angel’s share is about 2% a year. In a place like Tennessee where Jack Daniels has some 77 warehouses, the average temperatures are a bit warmer. The angel’s share in

Tennessee is probably closer to 4% a year. The implication for a craft distiller is to keep the temperature of the barrel storage area at a cooler level. The angels will never be eliminated.

Opinion differs as far what the alcoholic strength of the distillate being placed in the oak barrels should be. Scientists have generally concluded that 55% alcoholic strength in the barrel will give maximum extraction of solids from the wood. But, many distillers I have talked to in Canada use a strength in the 60 to 65% range. There is nothing wrong with this strength either. In fact, the American legal definitions for spirits have gone a long way to resolving some of this opinion difference. Recall from the chapter on Spirit Definitions that bourbon and other American whisky classes must be aged in oak at not more than 62.5 % alcohol. Some of the big commercial whisky makers in Canada reportedly load distillate into oak barrels at 75% strength or more. I suspect this is in an effort to optimize the number of barrels needed for ageing. Scientific literature says that higher alcoholic strengths result in little flavor alteration during ageing. But, as has been made clear, the big Canadian players are adulterating the final aged product with up to 9.09% of other 'stuff' so as to impart flavor. Small wonder that many large Canadian whisky makers are looked down upon in global whisky circles.

In-Barrel Reactions

A 1981 paper by author George Reazin is a valuable source to help illuminate the ageing complexities. (9) Reazin was a scientist at the Seagram's research facility in Kentucky. He undertook a 12 year study of 110 Proof (55% abv) distillate in new charred oak barrels. What he demonstrated was:

In a barrel there is an oxidation reaction that creates flavorful ethyl acetate as follows:

$$\text{ethanol} \rightarrow \text{acetaldehyde} + \text{acetic acid}$$

$$\text{ethanol} + \text{acetic acid} \rightarrow \text{ethyl acetate} + H_2O$$

There is a multi-step reaction in a barrel in which lignins break down into flavorful end products:

$$\text{lignin} + \text{ethanol} \rightarrow \text{wood lignin} + \text{ethanol lignin}$$

$$\text{wood lignin} + \text{ethanol} \rightarrow \text{coniferyl alcohol} + \text{sinapic alcohol}$$

ethanol lignin + ethanol → coniferyl alcohol + sinapic alcohol

sinapic alcohol + oxygen → synapaldehyde

coniferyl alcohol + oxygen → coniferaldehyde

synapaldehyde + oxygen → syringaldehyde

coniferaldehyde + oxygen → vanillin

Barrel ageing results in an uptake of sugar molecules from the wood. Reazin observed a hyperbolic uptake of arabinose, glucose, and xylose from the hemicellulose component of wood.

Reazin noted an uptake over time of beta-methyl-gamma-octalactone (oak lactone) from the barrel structure. He noted that 1 ppm of oak lactone in 40% abv distillate gave a pleasant taste of oak wood with a trace of coconut. Reazin described what he thought might be a mechanism between ethyl lignin, tannins and gallic acid in creating lactones.

Furfural is a compound formed from hemicellulose during barrel toasting. It has a sweet, almondy, nutty caramel taste and flavor. An addition of 10 ppm furfural and 1 ppm lactone to 40% abv distillate enhanced wood, caramel and vanilla notes. More furfural diminishes the wood notes and enhances the caramel and vanilla notes.

Reazin's work also demonstrated that ageing distillate in used barrels did not give the same flavor uptake as ageing in a new charred barrel. Moreover, he observed that re-charring a barrel causes lignin to alter to a more reactive state. A re-charred barrel imparted more flavor compounds into distillate than did a once-used, initially charred barrel. This is a critical observation for craft distillers who have acquired used barrels. Get them refurbished! There is but one chance at impressing a customer with excellent tasting product.

Lastly, Reazin examined the effects of distillate strength and temperature. Not surprisingly, he noted that as the strength of the distillate rose form 55% abv towards 77% abv, the flavor pick-up in the distillate dropped off sharply. He also studied the behavior of distillate in barrels stored at different heights in the storage house (rick house) where the temperature difference between ground level and top level was 9ºF (about 5ºC). He noted a 3 to 5% pickup in flavor compounds per every 1ºF (0.5º C) of temperature gain. A critical observation for craft distillers is that the uppermost level in the rick house had an annual average temperature of 73.4ºF (23 ºC).

Size Matters

Although not explored in Reazin’s study, the size of the oak barrel is a significant factor in ageing. This is due to the surface to volume ratio. When approximating surface to volume ratio, measure the widest diameter of the barrel and also the height of the barrel. Ignore the fact that the barrel staves have some curvature to them. Use the formula

pi x diameter x height to calculate the surface area of the barrel. To this figure add pi x radius squared to determine the surface area of the top and bottom parts of the barrel. Knowing the volumetric size of the barrel allows you to arrive at the square centimeters per liter surface to volume figure.

Play around with some hypothetical figures and mathematically it will become apparent that surface to volume ratio will decline as the volume of the barrel increases. A small barrel size of 20 liters will have a surface to volume ratio of near 195 square centimeters per liter. A barrel size of 200 liters will have a ratio of 90 which is just about half that of the small barrel. This means that a smaller 20 liter barrel, in theory at least, will age an alcoholic spirit in half the time of a 200 liter barrel. This notion is important for home distillers who will be sourcing small barrels of size 10 liters to 20 liters. Just remember not to place alcoholic distillate in small barrels and forget about them for three years. Disappointment is assured. Be sure to frequently check the spirit in a small barrel to ensure it is not taking on a woody taste. Craft distillers aiming to have a product ready in a shorter time, might consider using small 56 liter (15 gallon) barrels. Bear in mind, however, that whisky in different jurisdictions will have different criteria for ageing times and age statements.

Sourcing Barrels

There are several avenues of approach for craft distillers to obtain barrels. For small batch recipe experimentation, consider 1000 Oak Barrels from Manassas, Virginia who make good quality small barrels. A Canadian vendor to consider is Canadian Oak Barrels in Ontario, Canada. But, I am told that this company does not make its own barrels. It reportedly outsources the cooperage efforts to Gibbs Brothers Cooperage in Arkansas. I have personally sourced small barrels from Gibbs Brothers and was very impressed with their workmanship.

For Canadian craft distillers who are not subject to restrictions regarding the use of brand new barrels, a good approach is to talk to American small batch craft distillers who are making whisky, which by law must be aged in charred new oak barrels. Once these barrels have been used once, they often get sold.

Full sized (200 liter) used barrels can be sourced from the big distillers. For example, Jack Daniels makes its used barrels available to craft distillers in rationed quantities of about 20 at any given time. However, bear in mind that these barrels may have already been used for up to five years. A craft distiller runs the risk (as Reazin’s 1981 study showed) that the organic acids and wood sugars in these barrels may be partly (mostly?) diminished.

In Jeff Arnett’s videos, he states the argument that many Jack Daniels barrels will find their way to the Scotch Whisky makers in Scotland. This argument is true, but what is not revealed is the other half of the story. As I learned in Scotland in 2018, while visiting Speyside Cooperage, the ex-bourbon casks from America mainly arrive broken down into bundles of staves. These staves are re-assembled into barrels and perhaps even re-charred. So, if re-charring is being practiced by experienced whisky makers in Scotland, why would a craft distiller all of a sudden think that magic things will occur by getting a crotchety, old, used barrel from Jack Daniels?

For Canadian craft distillers who end up getting cheaper used barrels, there is a way to get them refurbished. A gentleman who took one of the 5-day workshops several years ago has started a small business near Edmonton, Alberta that refurbishes barrels. His company is called First Choice Cooperage and you can easily find it on Facebook (@AlbertaOakBarrels). It is my understanding that the charge for refurbishing a barrel will be several hundred dollars. But, when compared to the cost of a new barrel, refurbishing starts to make sense.

If a new barrel is your aim, talk to a manufacturer like The Barrel Mill in Minnesota, USA who will toast and char full sized barrels to various specifications depending on what the end user wants. Consider also Gibbs Brothers, located in Arkansas and McGinnis Wood Products in Missouri. Independent Stave Company in Kentucky is another to look at. (6)(8)(9)

I have also learned that the corporate owner of Speyside Cooperage (a French company called Tonnellerie Francois Freres) now has a cooperage in Jackson, Ohio. Give thought to contacting them to see what they can provide (www.speysidebci.com).

With so much complex chemistry at work, I trust it is now apparent why I speak out so forcefully against craft distillers who seek shortcuts by using oak chips and sticks in a bottle to turn distillate brown. This dastardly technique comes from the wine industry, where ageing is often done in stainless steel holding tanks laden with oak chips. When the craft distilling movement got underway, these chip and stick vendors wasted little time in giving their sales pitch to start-up distillers. While it is true that a stick will impart oaky notes and brown color to a distillate, what is missing from the equation is the oxidative reactions that normally would occur in an oak cask. To satisfy yourself that this is the case, take some whisky that has been exposed to oak chips. Dilute it to 20% abv strength and sample it. Next take some whisky that has been barrel aged, dilute the dram to 20% and sample. You will notice a greater depth of flavor in the barrel aged product.

If you have not heard already, you soon will hear that there are clever operators touting accelerated ageing techniques. These include playing loud rock music in the barrel ageing room, exposing distillate and oak sticks held in a vessel to bright light, and even strapping barrels to the rolling deck of a ship sailing across the ocean. Any of these techniques simply serve to enhance the wood to liquid interaction. True, this might hasten the extraction of flavor compounds from the wood. But, the key to barrel ageing is the oxidative and condensation type reactions that occur in the barrel. My advice is to not bother wasting time with any carnival barker crowing about ways to make alcohol mature faster.

My visits to Scotland have reminded me that Whisky is 500+ years old. It deserves more respect than just a handful of oak sticks tossed in a holding tank for three weeks. It deserves more respect than a slick talking, faux-chemist peddling an accelerated ageing short cut. One cannot cheat Father time and oxidation chemistry. Think about the battle to draw a customer over from his/her go-to, big name brand. Craft distillers have one chance to impress the customer. There is no substitute for proper, lengthy, barrel ageing.

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13

Marketing And Branding

In the many workshops I have conducted and in the many conversations I have had with people interested in craft distilling, I have noted a common theme. People somehow think that if they can make liquid dribble off a still, there will automatically be a lineup of customers waiting outside their distillery door to buy the alcohol. Most assuredly, this will not be the case.

This conclusion was solidified for me during my travels in Scotland. I visited many distilleries where the annual output was between 10 and 16 million liters. When I inquired as to how many people worked at these various distilleries, the low numbers shocked me. To run a distillery 24/7 and make millions of liters annually requires only a dozen employees. I can recall meeting a fellow student from South Africa while I was on campus. He worked for an ethanol factory that was producing ethanol at the rate of 100,000 liters a day, every day, using sugar cane juice as a raw material.

To be very blunt, there is no need for any entrepreneur to be making more mundane alcohol. The world is drowning in the stuff.

However, what is missing are more unique expressions of alcohol. An entrepreneur seeking to start a craft distillery should focus on making products that the big commercial distillers either cannot make, or will not make.

As part of successfully taking craft alcohol expressions to the marketplace, effective marketing and branding will be critical. As I like to remind people in my usual blunt fashion, anyone can make the stuff. But, if one cannot market it and sell it, there will be no viable business. If you cannot market and sell your product, you will have just entered into a very expensive hobby.

Marketing

Marketing is a social science. Some say it is a pseudo-science. In the late 1990s while studying for my MBA at Heriot Watt University, I was overwhelmed by the Marketing course I took. I still have flashbacks to the final exam where one of the essay questions demanded the outline of a marketing strategy to save the entire European automotive industry. However, what that course did was open my eyes to the power of marketing strategy. Since taking it, I have read copious amounts of material on brand strategy and have become quite enamored with the science of marketing.

Twenty years ago, marketing was focused on the ‘wants’ of a consumer. The Maslow Hierarchy Model (1) posits that a consumer ‘needs’ food, clothing and shelter. Once these goods have been acquired, a consumer will then go on to ‘want’ items of a more material nature that serve to display social status and esteem. The Maslow Model uses the term ‘self-actualization’ to describe this fulfillment through items of ‘want’.

When it comes to alcohol, people do not need it. Rather they ‘want’ it, and for five main reasons: to help them celebrate, to help them reward themselves, to help them commiserate, to help them physiologically relax and to help them experience hedonistic pleasure.

Hedonistic pleasure refers to people (like myself) who approach alcohol with a critical attitude. Hedonists enjoy the aromas that a finely made spirit throws off. They enjoy the estery flavors, the body, the texture, the mouthfeel. Give a hedonist like myself a product that fails to fulfill my quest for drinking enjoyment and I will criticize it to no end.

But hedonists are in the minority. People who seek out alcohol for the other four reasons will likely mix their alcohol with sodas or fashion it into a cocktail. With mixing, the character of that spirit is largely covered up. Any glaring defects are watered down to the point of being passable, even noticeable. If a person is prone to mixing their alcohol, why then would that person seek out craft-made alcohol that carries a higher price point? To the mixer, does it really matter that the alcohol might have been made locally in small batches?

In my workshops, I stress the list of reasons why people like to drink alcohol. I emphasize the importance of understanding the drinking reasons in one's local market. I emphasize the dangers of trying to sell a high-priced bottle of craft alcohol in a market where people favor lower priced brand name products. But in every workshop, there is a portion of attendees that meet my arguments with what can best be described as blank stares.

I have thought about this response reaction and I think I have arrived at an explanation. Since the 2000 tech bubble crashed, the North American, western European and Asian consumer has enjoyed two decades of economic growth, interrupted by the 2008 sub-prime mortgage debacle and by the 2020 corona virus pandemic. Both of these events were met with massive stimulus measures to prop up the economy. What central bankers have further learned over the past two decades is the economy can be propped up if people have access to more credit. This has been made manifest over the past decades due to artificially low interest rates. The mantra still being preached as of early 2021 by the US Federal Reserve is 'lower for longer'. Cheap money is now becoming a permanent fixture. Ease of obtaining things to satisfy our consumer wants is also becoming entrenched in society thanks to the digital wallets on our smartphones and credit card machines that demand only a tap of our card.

With easy money available, consumers are now questing after more want-satisfying stuff. I am convinced that a significant portion of people who have attended my workshops have done so as part of their quest for ego satisfaction. These people paid over $3000 for a workshop and also incurred travel, hotel and meal costs. They had never brewed a batch of beer, a batch of wine or baked a loaf of bread with Fleischmann's yeast. They told me they hated their bosses, and they hated their jobs. But, they intimated they were determined to borrow money and make liquid drip off a still. Thinking that making alcohol drip off of a still will be compensation for one's unhappiness is flawed logic. True, your ego might feel good when your friends occasionally stop by your distillery to marvel at your equipment. But, at the end of the day, you are running a business. You are making a product that you hope to sell to make money to pay your loans and to pay the rent.

Our consumer choices of want-satisfying stuff is playing a role in how we think that others see us. Consider this argument in the context of a coffee. Do people on their way to work flock to a local greasy-spoon diner or to the corner gas station for a coffee to go? No, they end up at a Starbucks-type drive-through location where a barista makes them a coffee from medium-roasted Nicaraguan coffee beans. They add to their coffee not just sugar and milk, but likely sustainably grown, organic, fair-trade, cane sugar and organic cream.

Think also about the rapid surge of craft breweries in North America. Consumers no longer want to buy just a beer. They want a Saison, a Grisette, a barrel rested Imperial Stout, an IPA with a certain level of IBU bitterness from a certain hop and so on. They want to boast of their beer experiences on social media platforms. This behavior has fueled insane numbers of craft brewers to the point where there are over 9000 in North America alone. Are they all making gobs of money? No, they are not. But they are all busy trying to cater to the consumer who is questing after want-satisfying stuff. And I have little doubt that many of these craft breweries were started for the same ego satisfaction reasons that drew people to my workshops.

A critical issue to consider is that beverages like beer, wine and even coffee can be consumed as-is. People don’t mix their beer and they don’t mix their wine into a cocktail. At most they might add a splash of cream to a coffee.

Distilled alcohol, on the other hand, is a strong substance to imbibe. Hence, consumers are prone to wanting to mix it (dilute it) to make it more approachable. The big commercial distillers have long recognized this issue. They know consumers will mix their booze. Why spend extra money for locally craft distilled alcohol when it is just going to get mixed?

For decades now the focus amongst the big commercial players has been on providing the consumer with mixable alcohol of moderate quality while finding ways to manufacture it cheaper so as to maximize profits.

The big commercial distillers focus has also been on reminding the consumer that the purchase of a particular brand name of alcohol is a good choice. The big distillers advertise, not to sell more product, but to remind the consumer of their recent wise buying choice. The advertisement that Grey Goose Vodka runs in Conde Naste Travel Magazine is a reminder and a validation that the consumer’s choice of Grey Goose has been the right one. No other vodka will suffice. The fact that this advert appears in a luxury travel magazine only makes the message penetrate further into the human psyche. There is an art and a science to advertising and the big players have it figured out perfectly.

The big distillers have devoted this energy to getting inside the consumer's head because they do not want a repeat of what happened over 30 years ago to the beer industry. Back then, the big commercial brewers did not pay enough attention to the upstart craft beer market. Soon, craft brewers were offering beer expressions that were approachable and had unique flavor. The next thing the big players knew, the horse was out of the barn and running wild. The craft beer market has since usurped about 15% of the North American beer market. To get a reign on the horse, the big brewers over the past several years have been buying up some of the larger, more successful craft brewers that have wide product distribution. But, the damage done by the craft beer movement will never be un-wound. The big distillers have taken due note and they are not going to let their alcohol horse get out of the barn again.

If you are Canadian, the next time you are perusing the aisles at your local liquor store, take a closer look at some of the offerings from the big players. You will see some savvy, new expressions from the Canadian Club and Wiser's brands. Dr. Don Livermore at Hiram Walker Distillery is on a mission. He has upped his game. He is intent on pushing the upstart craft movement back into its corner. In Regina, Saskatchewan where I used to live, the old football stadium (Taylor Field) has now been torn down. In its place stands a multi-million dollar new facility. For the final playing season in the old facility, Wiser's placed a small graphic depiction of the old Taylor Field on its Whisky bottles sold in Saskatchewan. Here was a final chance for a customer to maintain the emotional connection to the much cherished, old stadium. Deftly played! A second example from Wiser's was their 2019 whisky series touting names of famous NHL hockey players, geared to tug at the emotional heart strings of hockey fans.

At this point, I am going to concede some ground. I am now seeing a couple wonderfully-aged expressions that Dr. Livermore has released under the Wiser's brand. In particular, the 15-year-old Whisky expression that retails for $46 is a must-try. Earlier in this book, I slagged Canadian style whisky for it's column distillation which renders a good part of the flavor profile away. I also slagged the Canadian industry for the 9.09% rule and the blending that goes on. But, whatever Dr. Livermore and his team have done to the 15-year-old has made it a delight to sip and savor. Craft distillers will be hard pressed to rival this libation and match the $46 price point. The same applies to Beam Suntory and its slightly more expensive 20 year old Canadian Club expression.

As I survey the distilling landscape and see craft distillers who have passed distillate through a short 4-plate column one time wondering why their product is not selling, my heart aches. The general lack of understanding of the science underpinning mashing, fermenting and distilling is a severe impediment to the future of craft distilling. Factor in a poor grasp of marketing strategy and the impediments looms even larger.

How We See Ourselves

Although I did my M.Sc. degree by distance learning, I did spend time on campus in Edinburgh on three occasions. On one occasion in early 2018, I attended several lectures for the Beverage Alcohol Marketing Strategy course I was taking.

On one visit, I asked my professor a probing question: “If I were to start a craft distillery, how would I go about reaching out to people whom I thought would be my ideal customer?” Her response was simple and to the point. In her thick Glaswegian accent, she told me, “Don’t reach out. People will find you and your distillery.” She directed me to search You Tube for the Harley Davidson video entitled Harley Davidson - Live By It, which she assured me would clarify her answer to my question. (2) In the Harley video, the final statement says “The machine you drive tells the world where you stand”. Take this statement and change the words. “The distillery you buy product from tells the world where you stand”. Change the words a bit more. “The whisky you drink tells the world where you stand”. “The vodka you drink tells the world where you stand”.

Watching that video in the context of beverage alcohol was a seminal moment for me. My professor went on to explain to me that if I did launch a distillery, subconsciously, or unknowingly, I would end up having my personality written all over the project. From the distillery name, to the shape of the bottles to the interior décor, to the color of the paint on the walls, my personality would be on full display. A customer identifying with my personality would be drawn to the distillery. Just like a customer identifying with the imagery in the Harley video would be drawn to buying a Harley motorcycle. If my product tasted good and if I could demonstrate that I understood the science of brewing and distilling, I then had a good chance at retaining that customer.

Brand Identity Prism

My marketing professor then went on to introduce the class to a model developed by French academic J.N. Kapferer. (3) In the late 1990s, Kapferer unveiled his Brand Identity Prism. His prism is depicted as a six-sided figure as shown in Figure 59.

While the big commercial distillers devote significant effort to getting inside the consumer's head, they do not have a monopoly on the technique. By using the model developed by Kapferer, a craft distiller can engage in some serious marketing strategy to win the attention of consumers. But as consumers start to gravitate towards a craft distiller, there has to be a reward waiting for the consumer. The product has to be unique and it has to be credibly good. All of the science discussed so far in this book must be on full display.

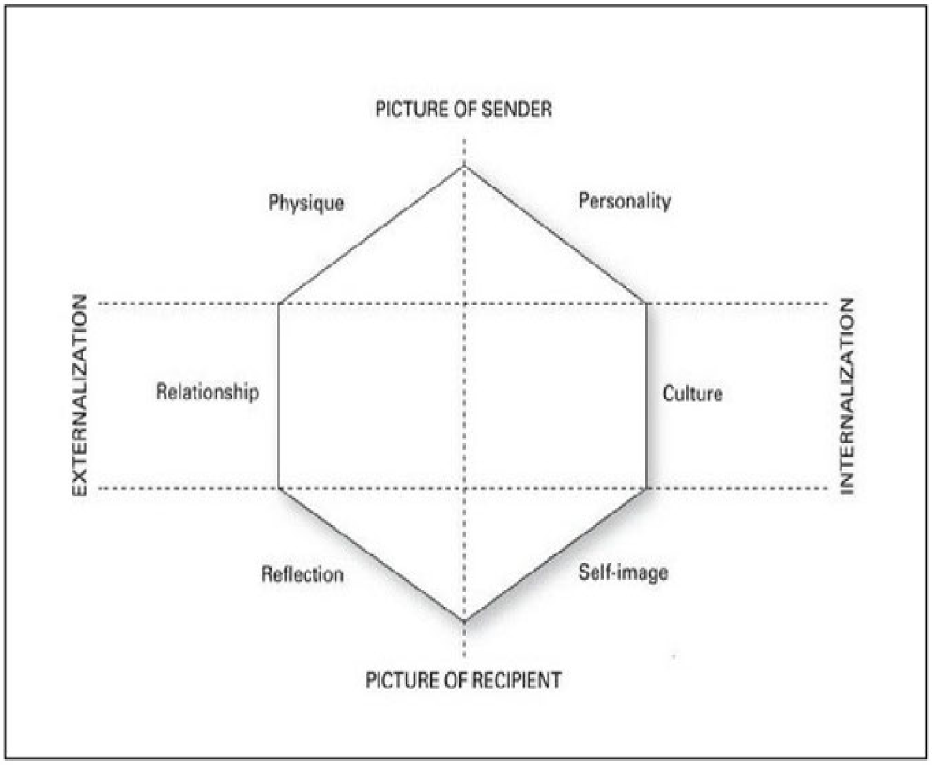

Figure 59 – Brand Identity Prism

The Brand Identity Prism is divided into a top and bottom half. The top half describes the maker of the consumer product. The bottom half describes the consumer who buys the product.

Starting at the upper left of the Prism, the distillery must give thought to the Physique of the craft distillery and its products. Where is the distillery located? What does it look like outside and inside? Each distilled product, will need to have a physique. What does the bottle look like? Is it tall, short, lumpy or elegant? Is it clear or frosted? What about the artwork on the label? What about the taste characteristics of the product. Is it smooth, rough, or elegant? Does it need mix to make it palatable?

Moving to the upper right of the Prism, a craft distiller must give thought to the Personality of the craft distillery and its products. Academic researcher Jennifer Aaker, in a 1997 paper, (4) listed what she deems to the five main personality types: Sincere, Excitable, Competent, Sophisticated and Rugged. Each of us has one of these descriptors governing us. There could also be some minor overlap to a secondary descriptor. If the distillery was a human, what kind of person would it be? Sincere? Rugged? Sophisticated? Competent? Excitable? A nice person? A bad-ass? What about Odd? This is where the entrepreneur's individual personality will be on full display. The name of the distillery, the interior décor, and the artwork on the walls will all be a reflection of personality.

A stellar example of this comes from a craft distillery in Vancouver, Canada called Odd Society Spirits. The very name implies a welcoming place (a society) for people who do not necessarily fit the norm (odd). In other words, a place for people who are oddly different in that they do not follow the masses of other consumers who drink cheap vodka mixed with clamato juice. Combine the name Odd Society with some seriously quirky artwork in the tasting room and on the bottle labels and the personality of the distillery owner comes into focus. Indeed, as my professor told me, whether a person consciously realizes it or not, their personality will shine through in the layout and vibe of their distillery.

Another classic example of oddity is the Gin brand Hendricks. Watch any of their videos to see oddity on full display. (5)

Navigating around the Prism, one must also think about the Culture of the distillery. What sort of people have been hired to help the tasting room on weekends? Their attitude and demeanor towards customers helps to support the culture of the distillery. What are the values that define the culture of the distillery? Customers will pick up on the culture of the distillery. Customers will be attuned to how employees at the tasting bar treat them.

Moving to the far left of the Prism, a distillery and its products must have a Relationship with the customer. The big commercial players do not have tasting rooms where people can congregate on a Friday afternoon. The big players will strive to develop a relationship with the consumer through widespread and repeated billboard and magazine advertising. Are you and your tasting room helpers friendly towards customers? Do you offer to make them feel special by taking them behind the scenes for a quick tour? Relationship can also extend to issues that people care about. People are inclined to rally around a cause or a purpose. Is your craft distillery business involved in a socially responsibility cause? For example, does your distillery support efforts to preserve or protect a local species of animal or waterfowl? Has that social responsibility been made clear to the person walking into your tasting room? Have you made it clear to the customer that your business wishes to have a relationship with them so that together you can work towards a social responsibility issue?

On the lower part of the Prism, the distilled beverage products should help the customer develop a Reflection. When a customer thinks about a distilled beverage product, what do they reflect on? By placing ads in glitzy magazines, the Grey Goose brand wants the customer to reflect on a life of luxury and elegance. When a person drinks a beverage alcohol product, do they reflect on how that product has changed their approach to drinking? Has that product instilled a new love of sipping and savoring? In the Harley Davidson video, riders on the open road have their hair let down and their tattoos on full display. What Harley wants is its bike owners to reflect on is how a Harley bike helps people to more thoroughly love the open road and the freedom associated with it. Consider an example from 2017 when Crown Royal Whisky ran a massive Canada-wide advertising campaign for Canada’s 150th anniversary as a country. The tagline in the ads read: Whisky, made the Canadian way. What Crown Royal was aiming for was to have people buy Crown Royal Whisky and then reflect on what it meant to be Canadian all in the context of Canada’s 150th birthday.

The final part of the Prism is Self-Image. How does a customer wish to be seen by others in public? We all have a sense of who we are and how we would like to be seen. For example, I will not drink low quality, cheap whisky. I will seek out whisky that is well aged because I can and because I am worth it. Will your lineup of distilled products allow a customer to be seen the way they want to be seen? This is why Harley bikes are mainly black. Customers who regard themselves as somewhat tough and cool and freedom loving are not going to buy a beige-colored bike. Some people like to be seen in public as being well dressed, classy, and fashionable. The Grey Goose ads in fancy travel magazines are designed to remind people that drinking Grey Goose at a cocktail lounge will help them be seen in a favorable way in society. This is why Grey Goose does not advertise in magazines related to hunting and 4x4 off-roading.

Consider a couple more examples of the Brand Identity Prism, taken from other industries:

Levi’s jeans rely on the little red label that touts the brand/model of jean. This part of the jean pant is the physique Levi’s wants to be noted for. The personality that Levi’s is aiming to promote is one of casual, real, grounded, spirited, free. The culture that Levi’s is espousing is the American way of life. The relationship Levi’s is aiming at through massive advertising is to have customers equate Levi’s with quality, affordability and distinctiveness. Levi’s wants the customer to look at those jeans hanging in the closet and reflect on how they are suitable and trendy for most occasions. Levi’s wants people to see themselves as being cool, trendy and adventuresome when wearing the jeans.

Dove soap has a physique that is white and uniquely shaped. Dove soap likes to market itself as soft, innocent and friendly in terms of personality. Anyone with similar personality traits will be attracted to Dove. The relationship Dove is aiming at through massive advertising is one of care and support.

The culture that Dove is promoting is one of integrity and accountability. Dove wants users of their soap to reflect on beauty, confidence and modernity. Dove wants its soap users to see themselves beautiful, optimistic and confident.

To become more cognizant of the Kapferer model, I suggest going through repeated practical exercises. Sketch out blank images of Kapferer's Prism on sheets of paper. Then, think about commercial beverage alcohol products that you have bought recently. These could be beers, wines or spirits. Visit the websites for the producers of these products. Study their corporate goals and their history. Try to locate some advertisements for these products in magazines. Next, add some content to the six parts of the Brand Identity Prism. Once you have done this exercise with several beverage alcohol products, you will be able to create your own prism for your craft distillery.

Creating Value

Also deeply entwined in marketing strategy is the strategy of creating value. People will buy a product if they can tick off the six aspects of the Brand Identity Prism and if they perceive value in what they are buying.

Value Through Advertising: The big commercial distillers create value through offering the consumer affordable prices thanks to the enormity of their operations and economies of scale. The big commercial distillers also create value through repetitive advertising. As an example, consider the global behemoth Bacardi that makes 400 million bottles a year. If it allocates a mere 10 cents per bottle to advertising expenses, that is one huge budget for the advertising department. When the consumer repeatedly sees Grey Goose ads (a Bacardi brand) in bus shelters in major cities, that consumer's emotional connection to the brand is reinforced. Value is created. Don't believe me? Find a person who regularly drinks Grey Goose Vodka. Challenge them on that choice of vodka and watch how defensive they get.

Value Through Expertise: What expertise do you bring to your craft distilling start-up? Have you studied at a brewing or distilling school or at a University? Have you previously worked in the industry? Consumers will pay attention to the credentials you offer. They will judge these credentials in the context of how well-made your products are. Before launching a craft distillery project, engage in recipe development at home. Consider taking a course in Microbiology. To illustrate, consider the large number of craft brewery start-ups that have been launched by entrepreneurs highly skilled at home-beer making. Their expertise is demonstrated by the awards they have won.

In many cases, these entrepreneurs included on their start-up team someone who had attended a 2-year brewing college program. I am not seeing this parallel in craft distilling. I am seeing far too many people trying to rush into the business with no experience or education, using money borrowed at today's artificially low interest rates. This is reflected in the generous amount of largely un-impressive craft distilled product that pervades the market.

Value Through Emotional Connection: Consumers are quickly able to pick up on and connect to integrity. What is your level of integrity as a distiller? Do you openly tell people how you make your product? Are you taking people behind the scenes to show them how you mash your grain? Are you offering explanations to teach people how spirits are made? Or, are you bringing in Neutral Grain Spirits (NGS) alcohol from a large factory, re-purposing it into vodka by just proofing it down to 40% and hoping the consumer will never notice the difference?

Value Through History: Have you ever wondered why people flock to antique car shows? Why do people get excited over antique furniture? I wish I knew why history is such a powerful draw. I saw history on full display in 2016 in Paducah, Kentucky when I stopped at the Moonshine Company. The aged gentleman who greeted me introduced himself as Cousin Billy. He said he had been a moonshiner for 56 years, but for 42 of those years he had worked by day as a police officer. With that eyebrow-raising introduction, my curiosity was tweaked. He then led me around the facility and showed me his historical collection of old stills and old photographs from the heyday of moonshining in Kentucky. He regaled me with stories from his moonshining days. What history do you have in your area? Can you incorporate it into your brand image? Can you share it with your customers?

Value Through Heuristics: Heuristics is defined as a practical method to solving a problem. The desire to solve a problem explains why consumers tend to adopt a theme when it comes to adding items to their shopping carts. That theme might be low fat, it might be lite, it might be gluten free. Buying items that align with a particular theme will help a consumer solve a dietary problem. One heuristic theme that can be offered to people at a craft distillery is ease of use. Most customers want a product that it easy to use. When I think about After Dark Distilling in Sicamous, British Columbia, I can see how their flavored moonshine products fit the ease-of-use theme. Their product is typically bottled at 24%. At that strength, you can add an ice cube and sip. Or, you can add a splash of soda. Easy to use, indeed. The easy-to-use theme is now manifesting itself through carbonated RTD (ready to drink) products. Two Rivers Distillery in Calgary, Alberta is developing a following for its Hibiscus Gin, carbonated and canned at 5% abv. Easy to use, easy to drink. What can you offer the consumer that supports the heuristic of easy to use?

Value Through Supporting Events and Organizations: Look around your community for organizations or events that you can reach out to. Are there annual music or cultural festivals? Are there annual sporting events? Are there service clubs? One example of this strategy is a whisky purveyor in Scotland that decided to target the various Masonic Lodges in its geographic area. They crafted a blended Whisky called Old Masters Whisky which they successfully sell to Masonic groups. The previously mentioned Moonshine Company in Paducah, Kentucky supports the annual Quilt Festival. Women from across the nation converge on Paducah, Kentucky each April for a three-day quilting festival. The Moonshine Company is at the ready every year with its specially-labelled peach moonshine called Quilter’s Special.

Value Through Environmental Stewardship

Is there an endangered species that you wish to draw attention to? Consider North of 7 Distillery in Ottawa, Canada and their Leatherback Rum. It is made from molasses that comes from the Caribbean. But, something else comes from the Caribbean every year, and that is the endangered Leatherback Turtle. It migrates to the cooler waters off the east coast of Canada in summer and returns to the warm Caribbean waters in winter. Some of the proceeds from every bottle sold go to support the Leatherback Turtle. People will notice if you get behind a social cause. They will be loyal to your product if its social cause stirs their emotions.

Value by Serving Ethnic Markets: Take a look around at your area. What is the ethnic demographic? What do these people drink? Burwood Distillery in Calgary, Alberta was started in part by a gentleman who took one of my 5-day Workshops. He is an immigrant from Serbia who landed in Canada as a young lad. There are many such people in Calgary who left Serbia and Croatia for a better life in places like Calgary, Canada. But no one in Calgary was catering to their needs and wants for the more traditional spirit beverages like plum-based slivovica and honey-based spirits. Burwood Distillery has now solved that problem with the release of some fantastic eastern-European spirits expressions. The gentleman in question had no experience with either brewing or distilling. So, he did the right thing. He partnered with someone who happens to have a day-job as a professor at the nearby Brewing College in Olds, Alberta.

Value by Serving Religious Markets: Orthodox Jewish people, like many of us, enjoy a drink or two. The issue is, whatever they drink

must be Kosher. The Orthodox Jewish community is under-served. However, by contacting the Chicago Rabinical Council, a craft distiller can arrange for a Rabbi to inspect the distillery. All ingredients used in the making of the alcohol must have come from Kosher suppliers. Another issue of concern is whether or not a distillery has processed any wine products through its equipment. If it has, it will not pass the Kosher approval test. But, if a craft distillery can get declared Kosher compliant, a whole new group of customers awaits.

Value Through Serving Age Brackets: There is one age demographic that businesses dare not take their eyes off and that is the Millennial generation (Gen Y). Another demographic to watch closely is the one coming behind Gen Y called Gen Z. Gen Y people are now in their mid-20s to late-30s. Studies are showing that they treat alcohol differently. They are the ones behind the resurgence in Tequila. They are the ones who will seek an emotional experience at your distillery. They will be watching to see if businesses post on Twitter and Facebook regularly. They will be watching for any videos craft operators post on-line. They are driving a resurgence in vintage cocktails, mainly whisky related ones. They are looking for gin with unique botanicals. They have little interest in heavy, oily Scotch, preferring easier to navigate whisky such as Irish Whiskey. Gen Z has yet to reveal its attitude towards alcohol. Some speculate that Gen Z may even turn its back on alcohol.

Value Through Solving a Problem: Craft distillers might consider conveying a problem-solving message. For example, bourbon has become a much celebrated product in some social circles. Appreciating bourbon has evolved into something of an art form with people taking their cues from the latest bourbon tasting notes in Whisky Advocate magazine. The problem is, what about the consumer who does not care to read bourbon tasting notes or travel the Bourbon Trail? Craft distiller, Corsair Distilling, located in the middle of Kentucky bourbon country, reached out to that consumer segment with a problem-solving

solution. Corsair uses a straightforward marketing message to clearly convey its brand. That message is – Small Batch, Handcrafted Booze for Bad Asses. This message is catching on in a big way and Corsair is enjoying very good success.

As one contemplates a possible craft distillery startup, think about the possible shortcomings in the world of commercially-made spirits. For example, the big commercial distillers do not consistently focus on trends in individual cities, towns or agricultural areas. They aim to release products that can be sold across wide market swaths. As an example of an opportunity missed, in western Canada, craft-made, dill pickle vodka is all the rage. Has a big commercial distiller unveiled its dill pickle vodka? Not a chance. While dill pickle vodka might be popular in western Canada, it may not be popular across all parts of North America. As a result, a big distiller will not pursue the dill pickle expression. Another shortcoming rests in the fact that the big distillers are often using chemical coloring and flavoring in their products instead of all-natural flavors. By focusing on unique, local, and natural a craft distiller can deftly insert its products into the mind of the consumer.

Value Through Avoiding Risk: Consumers do not like to lose. The next time you are at a liquor store, notice the small 50 ml bottles that are usually on a shelf near the cashier check out. In 2017, I had a discussion with a liquor store owner who maintained people that buy the small 50 ml samples of craft distilled products will often come back to her store to get the full size bottles. Instead of buying a $46 full size bottle and potentially not liking it, they opted to take a gamble on a small 50 ml bottle for $5. Better to risk $5 than to lose $46.

Value Through Your USP: People need to know what a craft distillery is all about and they need that information in a concise statement. This is called the Unique Selling Proposition (USP). A good example of a

USP comes from the world of Tequila. The marketplace is full of Tequila and most of it is made in large institutional, mass-production distilleries. In 2015, Arrogante Tequila was seeking to break into the American marketplace and it did so with its USP: "Preserving and honoring traditional craftsmanship is the cornerstone of our philosophy." Arrogante said that it made its Tequila using only traditional stone ovens along with ancestral knowledge to transcend the blue agave cactus into flavorful liquor. It worked. Consumers shifted to Arrogante in large numbers because of this unique perspective. People want to be part of a brand that is unique. There is also something about time-honored tradition that appeals to the consumer.

I have come across many other examples of great USPs in my research. Sacred Spirits in England sets itself apart from other craft gin makers by promoting its use of vacuum distillation of 12 individual botanicals. The resulting individual distillates are then blended according to a tried and true recipe. Kings County Distillery in Brooklyn, New York makes mention of using traditional copper stills fabricated in Scotland, wooden fermenter vessels made by local craftsmen and the use of corn and barley grown locally. But, they really hit a home run when they mentioned that they are a model of traditional and sustainable whisky production. In this day and age of global climate change, words such as traditional and sustainable set off emotional alarm bells in consumers heads. Consumers want to align with organizations that are working towards sustainability.

Value in a Name: Hard to believe, but picking a name for a craft distillery will be challenging. A geographical name such as Yaletown Distilling suggests a location in the Yaletown area of Vancouver, Canada. All fine and good for people from Vancouver. But what about a consumer from a different city or country? Will this name resonate with them?

A theme-based name can be effective, but it can also be subject to pitfalls. For example, Rig Hand Distilling in Edmonton, Canada picked its name to align with oil, which provides substantial economic activity in the area. However, the price of crude oil collapsed shortly after this distillery launched. Oil prices continue to be volatile and the oil industry has shed significant jobs. Now, the Rig Hand custom bottles in the shape of an oil derrick are apt to remind people of job losses and economic hard times. In my mind, the name Rig Hand further conjures up images of a person in greasy, oil-soaked coveralls working on a drilling rig. In terms of the Brand Identity Prism, if the target audience is people who will identify with this image and physique, then all is well. But, what about the wider audience? The name of your distillery can present limitations.

A name that ties to a local geographic area can yield benefits. In a very well executed strategy, Legend Distilling in Naramata, British Columbia picked a different local legend for each of its spirits. Its Doctor’s Orders Gin takes the customer back to the Prohibition era when a person needed a doctor’s note to acquire a bottle of alcoholic beverage. Its Shadow in the Lake Vodka refers to the mystical creature Ogopogo that locals say lives in the nearby lake. In another take on this strategy, Hansen Distilling in Edmonton, Alberta drew attention from consumers by naming each of its products after a significant event in the history of the Hansen family who emigrated from the USA during the 1930s Depression era.

What business name will you choose? What individual product names will you pick? Think it all through carefully.

Psychological Models

Think about your day to day experiences as a customer. How many TV stations do you get at your house? How many radio stations are broadcasting to your community? How many magazines do you see on a weekly basis either at your home or at your office? How many signs and billboards do you see as you drive down the streets of your community? How many flyers are stuffed into your morning paper? The reality is, the consumer is overloaded with information.

Not all of this information is retained in our minds. The website www.tech21.com (6) makes the argument that in a 12-hour day, we are exposed to 105,000 words. After accounting for sounds and pictures, the average person is exposed to 34 Gb of data daily. We are not able to retain all of this information flow. As the consumer makes buying decisions, it is vitally important that information for a given product be presented in such a way that it is retained by the consumer’s brain.

Getting data to stick with the consumer is not a random chance event. There is considerable science behind it. There are several psychological models being used by big brand name players, including large commercial distilling companies like Jim Beam, Diageo, and Pernod Ricard. The good news is, a craft distiller can use these same models to assist with getting message to stick with the consumer.

One particularly powerful model that I rely on when assisting entrepreneurs with craft distilling marketing plans is called Neuro Linguistic

Programming, or NLP for short. This model was developed in the early 1970s in California by academics John Grinder and Richard Bandler.

The NLP Model says there are ‘Proactive’ people and ‘Reactive’ people. Approximately 60% of us can be either reactive or proactive, depending on the situation, depending on the type of day we are having and depending on our psychological makeup. The remainder of us are equally split between being reactive all of the time and being proactive all of the time. A proactive person likes to jump in and get the task underway. A reactive person will tend to watch what others are doing before making a decision.

By incorporating both proactive and reactive words into marketing slogans and image taglines, a craft distiller can interact with both of these psychological groups. Proactive phrases include: go for it, just do it, jump in, why wait?, get it done, take charge, it’s time. Reactive phrases include: think about it, now that you have tasted it, you might wish to, what would happen if, consider this.

As I started applying NLP in 2017, I had a discussion with a friend of my wife’s whom I knew to be a reactive person. When the topic of discussion turned to vodka, she informed me that for two decades now she has only ever drank Stolichnaya Vodka. Pulling an NLP phrase from my arsenal, I remarked “so what would happen if you tasted a craft distilled vodka that was as good as Stolichnaya? “ She agreed to sample some Triticale Vodka from Park Distilling in Banff, Alberta that I had in my collection. She was impressed and vowed to start tasting vodka brands other than just the one she has consumed for the past two decades.

In 2017, the Canadian Armed Forces ran a magazine advertisement for careers. The tag line read – Think About It. This ad was suggesting to the reader that the Armed Forces are not looking for the impetuous 18-year-old with an itchy trigger finger who wants to shoot bad guys. They want people with a sense of reason who can make logical, thought-out decisions. In another magazine, I found an ad for Lamb's Rum with a proactive tagline that read, Plunder the Night. An ad I found for Smirnoff Coconut Vodka had the proactive tagline, Crack it Open. Clearly these spirit brand names are after proactive people who will make a buying decision based on action-type words.

The NLP Model posits that there are 'Internal' people and 'External' people. About 40% of people are internal all of the time and 40% of us are external all of the time. The remainder of us can shift between internal and external depending on the situation at hand and our psychological makeup. Internal people like to gather data and then make a decision. External people will depend on the opinions of others when making a decision. Internal phrases include: you be the judge, take one for test drive today, try it for yourself and see, see what you think, you might consider. External phrases include: others will notice, studies show, experts say, approved by.

A 2017 magazine ad for Jaguar cars pictured a Jaguar car parked beside a Mercedes car. The word Rich was positioned above the Mercedes and the word Chic was positioned over the Jaguar. The implication is that if you drive a Mercedes, others will develop the opinion that you are rich. If you drive a Jaguar, others will think of you as being chic. This ad was aimed square at the external person.

Actor George Clooney is now well known for his association with the Nespresso coffee maker. Attach Clooney's image to this coffee maker and external people will pay $200 in a retail store to get one. George Clooney is a very successful actor and businessman. External people will buy Clooney's coffee maker because in their mind this purchase makes them more noticeable. They will not have to justify their purchase because

Clooney has ‘approved’ it. Several years ago, Clooney and two partners launched Casamigos Tequila. People flocked to the brand because it was Clooney. Such is the power of psychology in advertising. Diageo understands this external mentality and that is why they paid $700 million to acquire Clooney’s Casamigos Tequila brand. An NLP wording strategy should also be supported by a powerful Unique Selling Proposition (USP). The USP for the Casamigos brand was: Our idea was to make the best-tasting, smoothest tequila whose taste didn’t have to be covered up with salt or lime. So we did. Diageo repeated itself in early 2020 with the purchase of the Aviation Gin brand, owned by actor Ryan Reynolds. As part of the purchase agreement, Reynolds has been retained to appear in short advertisement videos promoting the brand. To an external consumer, the purchase of a bottle of Aviation Gin places them in the same sphere as Reynolds.

In Canada, famed hockey player Wayne Gretzky (number 99) has lent his name to a small distillery in the Niagara region of Canada. Many people will buy product from this distillery because being seen with a product bearing the name of a famous person carries gravitas. This is a classic example of not only NLP, but also the Brand Identity Prism at work. This strategy has not been lost on Ed Belfour who launched Belfour Spirits in Little Elm, Texas in 2019. If you are a sports fan, you will recognize that Mr. Belfour was a superstar goalie for the Chicago Black Hawks and the Dallas Stars. In fact, in 2016 he and his son traveled to Kelowna, BC to take one of my 5 day workshops. A more down to earth, and pleasant pair of gentlemen you will be hard pressed to find anywhere. I am more than certain their distillery venture will be a huge success.

In 2016, ads for a product called Smirnoff Double Black Vodka sported a two-word tagline that read, Step Up. This bit of external NLP wording was aimed at the person wanting to step up and be noticed by others.

Jack Daniels Tennessee Honey Whisky has an ad that states, We've Had This Idea on Ice for a While. See what You Think. This wording is aimed at the internal person who is analytical. The words are designed to get people to carefully taste and analyze the whisky. (There is one more subtle hint embedded too. The word 'ice' is suggesting their Honey Whisky is best served on the rocks).

The NLP Model says 5% of people are 'Sameness' people. When sampling a new product, they look for similarities to their favorite product. If they fail to identify similarities, they are unlikely to embrace the new product. My 87 year old mother-in-law has been a drinker of Wiser's Whisky for 65 years. I have tried to entice her to try my home distilled whisky. It apparently lacks similarity to Wiser's, so she will not embrace it. She is part of the 5% of people who are 'Sameness' oriented. As a craft distiller, be aware that this segment exists and no matter how hard you try, these people will never make the shift to your craft distilled products.

About 20% of us are 'Difference' people. This segment is always on the lookout for new and innovative products. In another 2017 ad for careers in the Canadian Armed Forces the tagline read, Careers With a Difference. The Armed Forces has no interest in people who want to remain in one location forever. They want people who are willing to be transferred to different military bases. By using psychological language in the ad, they are pre-filtering the applicants without having to read piles of application forms or perform interviews on inappropriate candidates.

I regularly experiment with different infusions in alcohol. I have had good success with tea-infused gin, which was quite popular in England in the early 1900s. Tea-infused gin is without doubt a different type of product. I often wonder if the tagline, Afternoon Tea Redefined might draw the attention of people who enjoy different products.

About 65% of people will try a new product as long as they perceive that it is not too far different from what they are drinking at the present time. There have been a few monumental brand name failures of companies that failed to recognize this. In the late 1980s, Saturn unveiled a line of cars with the marketing tagline, A Different Kind of Car. Consumers shunned the cars. They did not want a different kind of car. They wanted a car with four wheels that could safely and efficiently get them to where they wanted to go. The Saturn brand name is no longer around. Remember when Coke unveiled its New Coke? Devoted Coke drinkers were scared witless with suggestions of a great new taste, better than ever. It took Coke years to claw back lost market share from its rivals.

A classic example of a spirit brand not shocking customers is Crown Royal. Several years ago, the brand introduced two extensions: Maple Flavored Whisky and Apple Flavored Whisky. Brand managers were careful to keep the bottle shape the same as the regular Crown Royal bottle. The iconic gold cap was retained. The crown and purple pillow were retained on the label. The box shape was the same and the iconic cloth bag with drawstrings was still included, just in a different color. Brand owner, Diageo, fully understood the dangers in shocking the customer out of his or her comfort zone with a new product.

A 2017 ad for Wiser’s Whisky had the tagline, Distilled, Aged and Blended the Same Way Since 1857. The message was that there is no need to worry. This Whisky has not changed.

The NLP model says that about 40% of us are ‘Options’ based and 40% of us are ‘Procedures’ based. The remainder of us gravitate between categories depending on the type of day we are having or the circumstances we face. Options-type words include: possibilities, sky’s the limit, something new, an alternative to. Procedures-type words include: chill and serve, just add ice.

One company that squarely focuses on the Options person is the hamburger chain Fuddruckers. This chain is famous for cooking you a burger and then giving you free run of a wide variety of condiments to complete the construction of your burger to your personal liking.

A company that focuses on the Procedures person is Ikea. Buy a box of parts and with the help of an instruction manual and a screwdriver you can, in a step by step procedure, build yourself a new dining room table.

In a 2017 ad for Smirnoff Double Black Vodka, there were images of various fruits and mixes. The tagline read, A Few More Suggestions on How to Best Bring Out the Taste of Smirnoff Black. The words ‘A Few More Suggestions’ imply that there are many more options available to the end user of this vodka beyond those that appear in this ad. This is called a ‘presupposition’. Clearly Smirnoff is aimed at the segment that like option when experimenting with different ways of drinking their vodka.

As you create a website for your craft distillery, be sure to include a section containing cocktail and food recipes. Include some cocktail and food pairing suggestions but also some detailed step by step cocktail and food recipes. Target both the ‘Options’ person and the ‘Procedures’ person.

The NLP model says that people have different ways of processing words and images in advertising. Approximately 29% of people use a visual system. When they see an ad, they imagine themselves with the product in that ad. The shape of the bottle, the color of the label and the ‘look’ of the beverage in the bottle will all be important. This is sometimes called using ones ‘mind’s eye’. This lends credence to the notion that consumers buy with their eyes first.

A similar percentage of people use a kinesthetic process to evaluate data. A change in emotion, a momentary change in body temperature, a brief warm fuzzy feeling or a quick tingle up the spine are examples of the kinesthetic process that will direct the consumer’s buying decision. For example, when I handle a craft spirit in a mason jar, I am momentarily transported back in time to my grandmothers kitchen and images of her canning using mason jars.

About 11% of people use an auditory system. When viewing an ad, an auditory person will listen to that little voice in the back of their head that directs them whether or not to purchase. If a product is advertised in a video complete with a musical jingle, the auditory person will likely replay the advertising jingle in the back of their head as they consume the spirit beverage.

But, Nature likes variety and that is why studies have shown that about 37% of people will use a combination of two of these systems to evaluate and process advertising data.

For example, an ad tagline for a craft distilled gin that reads, Take Charge of Your Martini will be effective when aimed at the ‘Proactive’ person. Modify this tagline to read, Look How You Can Take Charge of Your Martini. Now it will appeal to ‘Proactive’ people who use a visual system to analyze data.

As another example, take this same tagline and modify it to read Take Charge of Your Martini. Experience Some Today. The word ‘experience’ will cause the ‘Proactive’ person using a kinesthetic system to be drawn to this gin product.

A classic example of kinesthetic words comes from Captain Morgan Rum with its tagline, Got a Little Captain in You? We all like to fancy ourselves at some level to be the swashbuckling pirate. It sends shivers up our spines. The implication is, purchase this rum and you can be your own pirate. Here is that Brand Identity Prism at work again. I find it fascinating how these psychological marketing concepts can tie together.

The NLP model says that about 40% of us are ‘Towards’ people and 40% of us are ‘Away’ people. We move towards what we want and away from what we don’t want. The remaining 20% of us can fall into either camp depending on the situation and our individual makeup. Away-from words include: won’t have to, solve, prevent, block, fix, avoid, eliminate. Towards-words include: attain, obtain, have, get, achieve, enable, accomplish, and advantage.

A powerful example of this language comes from heartburn pill brand Prilosec OTC. Their ads state Block the Acid. Don’t Get Heartburn in the First Place. If you are a heartburn sufferer, are you going to run towards this product? Indeed you are. Wrap this ad with the ever-hilarious comedian Larry the Cable Guy and his Get ‘er done, Get ‘er accomplished comedy line and you have a winning ad campaign.

A powerful example of an ad campaign that draws people towards comes from Bulleit Rye and Bulleit Bourbon. This brand was started by Tom Bulleit who engaged a contract distiller called MGP Products to create a Whisky and a Bourbon for him. He wrapped these products in a story about how he risked everything he had, quit his job and went on a mission to revive the old recipes used by his great-grandfather Augustus Bulleit. At some level, we are attracted to the entrepreneur who risked it all or to the poker player who went all-in and won the tournament. If we cannot be that person, then at least we can buy their product. The Bulleit brand became so successful with this clever marketing that drinks giant Diageo bought the entire brand name.

There is a small craft distiller in Saskatoon, Canada called LB distillers that uses images of scantily clad women on their labels. I have talked to many women about this imagery and have yet to find very many women who are thrilled by it. This is a classic example of how images can send people running away.

The NLP model is far deeper than what I have described in this chapter. For additional reading, I suggest a book by international NLP expert, Shelly Rose Charvet. She travels the world consulting to the big brand names and she assists them in using NLP words to drive consumer sales. Her book, Words That Change Minds, is an excellent read. (7) Another author to consider is Lou Larsen. His books, Extreme Language Patterns and The World’s Most Powerful Written Persuasion Techniques are both good resources to deepen your NLP understanding. (8)(9)

Spirits Contests

Every industry has its awards system. Every year consumers hear about the best pick-up truck, the best SUV, the best airline, the best radio stations, the best movie, the best TV shows, the best, the best, the best.

Every year, the craft beer movement has an array of awards events. Craft beer is divided into style categories and each category has a well-defined description that governs color, aroma, and hop flavor. Judges at beer competitions are trained according to the BJCP guidelines (Beer Judge Certification Program). A medal won for craft beer is a medal well deserved.

Craft spirits have not evolved into recognizable categories yet. Craft distilling has, however, seen the launch of numerous awards competitions. Craft distillers craving additional recognition are motivated to enter these award competitions. The thought of attaining a medal that might boost sales is a powerful drawing card.

What I am seeing at these craft distilling competitions is a multitude of medals awarded for each spirit type. I disagree with this approach. Sports events have shaped the way consumers view competitions. At the Olympics, there are three medal winners in each event. In World Junior Hockey Championships there are three medals awarded at the end of the tournament. If someone told you that they had entered a sports event contest and had won a silver medal, you would automatically assume they came second in the event. That is how we consumers have been programmed to think.

Consider an otherwise unaware customer walking into a craft distillery tasting room and seeing a bottle of gin with a silver medallion attached to it. The automatic assumption is that the gin came second. The carefully concealed reality is that multiple medals were awarded for the gin category in that competition.

I am also starting to sense that judge's comments at spirits competitions are possibly being curated. In September, 2020 I was approached by a contest organizer in Canada who asked me to judge some entries for a competition event he regularly runs. He sent me some spirits samples by mail along with the judging paperwork, explaining that due to Covid restrictions it was not possible to have an in-person event. I tasted the samples along with a good friend of mine who has an advanced palate for tasting spirits. His opinion of many the samples was even more negative than mine. I recorded my scores on the paperwork along with suggestions of what could be done to improve the products. I quickly received a sharp rebuke from the contest organizer because my comments, although helpful in a technical way, were comments he did not wish to give back to the distillers. In other words, here was a contest organizer who wanted nothing more than to earn revenue from the contest entry fees. He did not want to offend the entrants in any way because he wants them back next year for more revenue.

In the 4th edition of this book, my comments concerning competitions drew sharp criticism from the American Distilling Institute (ADI). So in this 5th edition, I am going to ease up a bit and offer some helpful hints for competition reform:

Clear definitions must be laid down for the spirit types. These can be created using the various Canadian, US, and EU government definitions for spirit types. Definitions should also include information on the desired amounts of aroma, taste and mouthfeel.

Given that an alcoholic spirit is at least 40% abv strength, a standard procedure for judging must be stipulated. During a 2018 visit to the Scotch Whisky Research Institute, I learned that their product judging is done in a temperature and climate controlled room, with judges physically isolated from one another. Even the sampling glasses are colored so judges cannot make biased conclusions based on spirit color. Judges must not eat or drink anything for two hours prior to a judging session. Judges must not be smokers. Judges having a cold or the sniffles must recuse themselves. Moreover, spirits should be judged at 30% abv strength so as to avoid sensory fatigue from ethanol numbing the palate.

Thirdly, judges must have documented prior experience with tasting and evaluating spirits. Judges can be selected from among mixologists, craft industry consultants, or retired veterans from the world of commercial distilling.

Fourthly, I suggest dispensing with the multiple gold, silver, bronze medal fiasco. Take an example from the wine industry. Contest entrants should be provided with a certificate and a composite numerical score. When a consumer walks into a tasting room and sees a gin on display that scored 90 points or a whisky that scored 92 points the consumer can draw his or her own conclusions. There will no medals to suggest first, second or third.

If reform is not brought to these competitions, I fear things will only get worse. I will leave you with an example of how an award event led to a complete sham. I trust this example will convince you to agree with me on my call for reform.

At a spirits event in late 2018, medals were awarded to the winners of various spirit categories. But, then the event took a bizarre twist and organizers decided to divide the entries up according to country of origin. A certain craft distiller won nothing in the vodka category judging. But, in the country of origin event his vodka was the only Canadian entry, ergo he won a gold medal. Drive by his distillery today and on a big billboard facing the street you will see “Home of the Best Vodka in Canada”. This is the type of unethical behavior that needs to be addressed.

The time for competition reform is past due. I seriously hope a powerful entity like ADI takes steps to initiate reforms. If ADI creates proper protocol, other contests will either have to follow suit or perish.

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14

Regulatory Requirements

Every country will have its own unique, jurisdictional policy requirements for establishing a craft distillery. When planning a craft distillery, it is prudent to first meet face to face with regulators at the state, province, municipality and planning council levels to determine the pertinent policy requirements.

In this chapter, I describe the policy requirements for an array of locations. Although government regulators are slowly relaxing once rigid policies towards spirit beverages, the regulators have not gone away. The decision to launch a craft distillery will mean embarking on an adventure where the presence of government is ubiquitous. To understand how government has become so entwined with alcohol, consider the following:

Legal Precedents-Canada

In Canada, in 1882, a landmark high court decision in Russell v the Queen decided the federal government had authority over liquor manufacture. This case created the template for Federal Excise tax on alcohol. In 1946, in Canada Temperance Foundation v the Queen, the high court decided that a given province had the right, concurrently with the federal government, to impose taxes and to govern alcohol distribution. This paved the way for provincial liquor distribution monopolies such as Ontario Liquor Control Board, Newfoundland Liquor Corporation. Alberta Liquor and Gaming, and so on. In 2018, the Supreme Court ruled in the case of Comeau v The Queen. The appellant, Gerard Comeau was stopped for a routine traffic check while driving his car from Quebec to his home province of New Brunswick. He was charged for transporting cases of beer inter-provincially. His legal team argued that a citizen of Canada should be able to purchase beverage alcohol in one province and then transport it to another province. The case went all the way to the Supreme Court, which disagreed with Comeau’s argument. The Court’s final ruling offered no challenges or verbiage to undermine the authority of the provincial liquor distribution monopoly model.

Legal Precedents-America

In America, control over alcohol tightened (and alcohol taxes were imposed) thanks to a 1933 report entitled “Toward Liquor Control,” commissioned and personally paid for by John D. Rockefeller, a lifelong teetotaler and prohibitionist. In crafting the report, Rockefeller sent two associates (Mssrs Fosdick and Scott) on a fact-finding tour through all 48 states, as well as across Canada, and the U.K. The report argued for liquor control by state monopolies, and further laid out a regulatory framework that created the template for the Three Tier System. This system mandates arms-length separation of ownership across the three tiers, the producer, the wholesaler and the retailer.

The 21st Amendment of the Constitution of the United States authorizes state control over alcohol importation, delivery and use. But the Commerce Clause of the US Constitution allows for trade to flow freely through and amongst states without policy control. This conflicting set of definitions has been rectified through the legal phrase, ‘Dormant Commerce Clause’, which means the Commerce Clause allowing free movement of goods is not enforced. This lack of enforcement of the free flow of goods entails problems for craft distillers. Over the years, some states have prohibited out-of-state wineries from shipping products to people in the state as per the dormant Commerce Clause. This has sparked a flurry of cases and appeals.

On May 16, 2005 the Supreme Court, in the case Granholm v Heald, ruled that state laws discriminating against out-of-state wineries were in violation of the Constitution of the United States.

Extend this interpretation into the craft spirits industry, and it becomes clear why certain states prohibit consumers from buying copious amounts of craft spirit from the tasting room of a local craft distillery. The fear seems to be one of taking too much away from the sales of out-of-state, big commercial distillers. It is a fine line to walk in the shadow of Granholm v Heald.

In addition to this charged legal atmosphere, craft distillers should also be aware that in the three tier system the large commercial distillers have a substantial amount of leverage over the wholesale distributors. If a craft distiller wants a wholesale distributor to actively push its craft distilled products, those products will have to be more than just merely good. They will have to be top-shelf good. To achieve that, a craft distiller will have to have a firm grip on the science of alcohol making. A craft distiller unable to retain a wholesale distributor will surely have difficulty succeeding.

Licenses - Canada

In Canada, a craft distiller is required to obtain two licenses from the Government of Canada, Excise Department. The first is a Spirits License, which will allow a distiller to produce alcoholic spirits. The second is a Warehouse License which will allow the distiller to possess alcohol on which duties to Excise Canada have not yet paid. The federal duties in Canada are $12.61 per liter of absolute alcohol. As an example, a 750 ml bottle of 40% alcoholic strength contains 0.750 x 0.40 = 300 mls of absolute alcohol. The duties owing to the Canadian Government are calculated as:

0.300 x $12.61= $3.78.

For more details, consult the Excise Canada website at http://www.cra-arc.gc.ca/E/pub/em/edm2-1-1/edm2-1-1-e.html. The excise rate will increase automatically by 2% each April, unless some future government decides to alter that policy.

In Canada, it is required by law that a craft distiller obtain a surety bond to cover unpaid duties on spirits held in bulk. Surety Bonds can be obtained through an insurance company. For example, if a craft distiller had 4000 liters of bulk Whisky ageing in oak barrels and if each oak barrel was at a strength of 60% alcohol, there would be 2400 liters of absolute alcohol contained in the barrels. The duty owing on that alcohol is $12.61 x 2400 = $30,264. Therefore, a surety bond for at least that amount would have to be in place. In the event of theft or other catastrophic loss, Excise Canada would receive the funds from the surety bond to cover the duties owing.

Think of a Surety Bond as an insurance policy with Excise Canada as the beneficiary. The premiums payable on a bond of this size might be $100 per month. The minimum surety bond that must be in place at any given time is $5000.

Licenses - America

In America, a craft distiller is required to obtain a Distilled Spirits Plant license (DSP license) from the Alcohol and Tobacco Tax and Trade Bureau (the TTB). The application process is conducted on-line. For more details, consult the government website http://www.ttb.gov/applications/#Manufacturers. The DSP license will be applied for using TTB Form 5110.41. A distilled spirits bond will also have to be obtained so that the federal government can collect its duty owing in the event that bulk product is damaged or lost. TTB form 5110.56 will be used for this application. In addition, a craft start-up will need to apply for a Basic Permit on TTB form 5110.24 and an Operating Permit on form 5110.25. The Operating Permit will allow the storage of spirits on the distillery premises that have not yet been duty paid. The overall application process will be onerous. Expect to have to provide data on corporate structure, personal financial situation, methods of building security, production method details, environmental disposal details and water usage details. The duty owing to the United States Government is $13.50 per proof gallon, where a proof gallon is one gallon of alcohol at a strength of 100 proof (50 %). On a standard 750 ml bottle with 40% alcohol, the amount owing is $2.14. In 2017 the Craft Beverage Modernization and Tax Reform provision in the Tax Cuts and Jobs Act reduced this tax to $2.70 per proof gallon on the first 100,000 proof gallons. This provision was made permanent in late 2020.

Licenses - U.K.

In the UK, a craft distiller is required to obtain a Distillers License from HM Revenue & Customs National Registration Unit, located in Glasgow. Expect significant changes to this process with Brexit. At this time of writing in January 2021, the Brexit details are being implemented. A distillery start-up will be required to apply for approval of the plant equipment and processes that are intended to be used in the alcohol manufacturing process. This will include descriptive details of items like vessels to be used and a detailed description of the process to be used. For more details, consult https://www.gov.uk/distillers-license-plant-approval. Expect also to run into a rigorous set of expectations from the local planning council. Before starting the overall application process, it is best to meet with the local planners first to see of a small batch distillery is even welcome in the area. In the UK, the duty owing on a liter of absolute alcohol is a hefty 28.74 Pounds sterling. A 1 liter bottle of 40% abv alcohol will command 0.40 x 28.74 = 11.49 Pounds sterling.

Canadian Provinces

Newfoundland: There is at present one craft distillery in Newfoundland with one additional one under development in the Cape Bonavista area. I have talked to the provincial regulators and they are willing to consider meeting with anyone who wishes to seek application. Prior to meeting with the province, you will be required to obtain approvals from your town or city where you wish to establish your distillery. The province will seek a 165% tax mark-up on the landed cost of the spirits produced. A distiller's landed cost will include all costs associated with making the product plus the desired profit margin. For example, suppose a craft distiller identifies his landed cost of 750 ml bottle at $25 per bottle. After taxation mark-ups, this bottle will appear in liquor stores at $62.50. The Newfoundland government will make more profit from this bottle than the craft distiller. This explains why the craft distilling movement has not yet arrived full force in Newfoundland.

Prince Edward Island: There are only a few craft distilleries in P.E.I. Craft distillers in PEI face a steep provincial tax markup of near 165% and an annual minimum production requirement of 3500 liters of finished product. There is a possibility this production minima might be waived in the future. But, even if it is waived, the 165% tax levy will mean craft distilling will not flourish in PEI.

Nova Scotia: In Nova Scotia, the government website advises that a craft distillery application must include items such as: floor plans, the site plan of the proposed distillery, location of any retail store, the legal structure of company and a listing of management and Board of Directors personnel. The applicantion must also detail products to be

produced, alcoholic strength, method of distribution, size and type of containers, production volumes, quality control (including the type of testing equipment to be used, plans to test the alcohol strength of the produced product, what lab will be used to test the product for alcohol content and chemical analysis, the water source, water test results if using a well, cleaning and sterilization process and cleaning schedule). Details will be required as to the number of people to be employed, capital costs and written approval from the city/town zoning department. An applicant must also ensure that the local jurisdiction is not a dry county, as some still exist in Nova Scotia. Lastly, the applicant must include a copy of the Excise Canada Licenses. A craft distillery in Nova Scotia is capped at 75,000 liters of finished product per year. If plans are for a tasting room on-site, necessary pre-approvals from the Fire Marshall will be needed. The good news to this rigorous procedure it is that the Nova Scotia provincial markups on craft alcohol are only 85%. Further reductions of 10% might be available if the distiller uses Nova Scotia agricultural products to make the alcohol. As of late 2018, this province of 950,000 people had about 14 craft distilleries. A common economic argument is that lower taxes stimulate economic activity. Nova Scotia seems to be a good case study in favor of this argument.

New Brunswick: In New Brunswick, a craft distiller will have to produce less than 75,000 liters of finished product per year. The province applies a 160% tax mark-up, although this tax rate might be reduced significantly for craft distillers who opt to sell product only from their tasting room and not through the provincial liquor stores.

Quebec: Quebec is a complex jurisdiction to deal with if contemplating starting a craft distillery. Only since May 2017 has it been possible to have a tasting room at a craft distillery. This is an example of how reluctant the Quebec government has been is to embrace craft spirits. But, the situation is changing. In late 2018, I noted a steady stream of Quebec-based people coming to the 5-Day workshops. Many were from

economically disadvantaged parts of the province. The government was practically paying them to start their planned distilleries to generate economic activity in these areas. Some claimed they were about to receive $250,000 of government money. The landed cost at which a distiller will supply his spirits to the government liquor stores (Societe des Alcools Quebec (SAQ)) will be marked up by about 150%. But, the positive aspect of this steep mark-up is that SAQ will ensure placement of the craft product into nearly 400 stores province-wide. If considering starting a craft distillery in Quebec, I advise taking time to speak with Paul Cirka at Montreal-based Cirka Distillers about his many challenges in dealing with the Quebec alcohol distribution model. One big challenge came after SAQ chemically analyzed Cirka's vodka and concluded that it exhibited too much flavor and therefore was not in compliance with the federal definitions for vodka (CRC 870). It took considerable effort on Mr. Cirka's part (and thankfully winning a medal at an international spirits competition) to educate SAQ that his product was a true craft made vodka made from grain and therefore would have some elements of flavor. Apparently SAQ was only accustomed to seeing neutral grain spirits product which is devoid of any subtle flavors.

Ontario: Like its Quebec neighbor, Ontario has craft alcohol regulations that are difficult to deal with. Thanks to policy challenges mounted in 2015 by the craft distilling community, a craft distillery can now have a tasting room. But all product sold, whether through a tasting room or not is de- facto deemed to be property of the Ontario government who demands a 141% markup tax to the landed cost. For further clarity on dealing with the Liquor Control Board of Ontario, consult the website www.doingbusinesswithLCBO.com. LCBO policies are subject to frequent change. Sales of product made directly from a tasting room could be eligible for small measure of tax relief. LCBO has been experimenting with strategies to promote the presence of craft alcohol in LCBO stores. I suggest speaking with other craft distillers as to their experiences with these LCBO programs. There was also a time when LCBO would demand extensive data from a craft distiller as to

product detail, brand imagery, marketing tactics and sales strategies. Failure to maintain sales levels at the LCBO stores carrying the product could mean de-listing. I suggest investigating whether these policies are still in effect. Unexpected government policy action against craft distillers is a threat that must be considered at all times. For example, in late 2016 Bill 70 suddenly called for a 61% tariff on bottles of spirit sold from a retail tasting room. Thankfully this tax policy never did get formally implemented. This nasty bit of legislation underscores how fickle Ontario politicians can be when it comes to the small entrepreneur. If contemplating a craft start-up in Ontario, think about it long and hard. There are other more attractive jurisdictions to move to.

Manitoba: Manitoba legislation makes it possible to start a craft distillery with maximum output of 50,000 liters per year. Manitoba imposes a provincial markup on spirits of 153%. In 2018, this tax markup was dropped to 85% for craft distillers making less than 10,000 liters annually. Output between 10,000 and 25,000 liters will invite a 100% tax markup on the landed cost.

Saskatchewan: In 2016, Saskatchewan underwent a serious make-over in its liquor policy. Of the 75 liquor stores in the province, 40 were privatized, with half of the privatizations being awarded to out-of-province grocery giant Sobey's. Policy allows for craft distilled products to be sold at a markup of 113% through Saskatchewan Liquor and Gaming (SLGA) retail stores. But, a craft distiller seeking to sell through his or her tasting room could sidestep this markup and pay only $0.70 per liter plus a 10% alcohol tax. Up until late 2018, Saskatchewan allowed for the full use of Neutral Grain Spirits (NGS). Now, NGS has to pass through the still one time. With NGS available for $1.50 per liter, the incentive for craft distillers to mash their own grain was taken away. The 'craft' was removed from craft distilling. I see liquor vendor's shelves littered with low priced flavored product like Pink Lemonade and Hard Ice Tea. These products are nothing

more than bulk ethanol blended with flavor syrup. But in a surprise policy move in early 2021, Saskatchewan shocked the craft industry with the designation of Type 1 and Type 2 distillers. A Type 1 distiller is true craft and grinds its own grain. A Type 2 distiller is one that brings in NGS. There is no crossover between the classifications. A distiller grinding grain and using NGS will be classed as Type 2. A Type 1 distiller will pay a $0.35/liter tax markup on products sold from the tasting room. A Type 2 distiller will pay $0.70/liter. Now that this distinction has been created, I suspect that tax markups levied against Type 2 distillers have but only one way to move, and that is up. If contemplating a craft distillery in Saskatchewan, bear in also mind that the province only has a population of 1 million people, scattered over a wide geographic area. Strip away those that do not drink, those that are children, those that prefer beer, and the numbers start to look thin. If you are thinking about starting a craft distillery in Saskatchewan, think very long and hard.

Alberta: There are nearly 30 craft distillers in Alberta at the moment, and the numbers are growing. Alberta requires the usual licenses and applications that other provinces have. But Alberta is unique in that there will be a flat rate markup fee of $13.76 per liter of finished product. On a 750 ml bottle of 40% strength alcohol, this amounts to $10.32. This is reduced for product sold at farmers markets. Craft distillers can directly deliver to pubs, bars and restaurants. Or, they can place product with the Liquor Connect central distribution warehouse and rely on licensed establishments placing orders. It might be a prudent idea to find a good distribution agent and craft a good product with an enticing brand image that the agent could aggressively market. The one issue to watch as of late 2020 is a policy shift that will allow the use of bulk ethanol. Hopefully Alberta does not get flooded with cheap, flavored gimmick products as Saskatchewan did.

British Columbia: In 2009, this province took the lead on craft distilling policy with its BC Craft Distilling Legislation. There is no

provincial markup applied to craft distilled spirits provided that the alcohol is made from 100 % BC grown agricultural product. For many of the craft distillers I have met in BC, this is a welcome bit of legislation. This also explains why as of 2021 there were about 80 small distillers in BC, with more applications in the queue. But, the BC craft legislation is also restrictive. Sugar cane does not grow in BC, so a craft distiller seeking to make rum is out of luck. There is also only one malting plant in BC – Gambrinus (Rahr) Malting in Armstrong, BC. Sourcing your malted barley from out of province will place a distiller in violation of the Craft Distilling Agreement. Falling outside the craft legislation will mean a sliding scale taxation markup of up to 168% on each bottle made. The exact tax rate will depend on the wholesale landed cost of a bottle of finished product.

American States

State Control and the 3-Tier System: Following the repeal of alcohol prohibition in 1933, several states decided to retain significant control over the sale of alcohol. Other states decided to adopt a more relaxed model that allowed private enterprise to distribute alcohol with oversight by the state. The 17 states that have a monopoly over liquor distribution are: Alabama, Idaho, Iowa, Maine, Michigan, Mississippi, Montana, New Hampshire, North Carolina, Ohio, Oregon, Pennsylvania, Utah, Vermont, Virginia, West Virginia and Wyoming. The state-owned liquor board effectively is the wholesaler who sources the alcohol from distilleries and retails it through state-owned stores. In the remaining States with a 3-Tier System, the distiller makes the product and then relinquishes it to a wholesaler who in turn places the product with retailers. The distiller can hire a sales representative to make sales calls, but at no time can that sales person physically deliver the alcohol. If one reads the craft distilling statistics coming out of the US, one will be led to believe there are about 1900 licensed craft distillers in operation. This number at face value is true. But, the harsh reality is the wholesalers are the ones in control. If a craft distiller has a unique product that the wholesaler can sell to his clients, then sales will result. But, if the wholesaler cannot move enough of a particular product because it lacks quality or is not unique enough, then the craft distiller will be in trouble. In the worst case, the wholesaler will drop the product which means the very survival of the distillery then rests on selling bottles from the tasting room only. If contemplating starting a craft distillery, take the time to meet with the wholesalers in your state. Ask what products they are in need of. This will then aid you in deciding what to produce.

The following is an overview of state requirements. Please bear in mind that by the time you acquire this book, these laws may have changed.

Alabama: There are several craft distillers now operating in Alabama, so getting approvals does not appear to be an issue so long as you are in one of the 42 (out of 67 total counties) 'wet' counties. Alabama is a control State. The issue at present seems to be the 30% markup on product distributed through the State Liquor Board. This marked up value is then taxed at 56% and 4% sales tax is added on too. A distiller providing a bottle of spirit into the system at $10 will see his bottle sold in a State retail store at $21.09 after taxes. Lobbying efforts are underway to modify the requirements of Code of Alabama Title 28-3-200. License application information can be found at: http://alabcboard.gov/license-type-200-manufacturer. Tastings are allowed at a distillery and a person can buy only one bottle per day. Bottle sales are allowed at farmers markets.

Alaska: In mid-2014, the Alaska legislature passed House Bill 309 which effectively brought craft distilleries on par with craft breweries and wineries in terms of being able to offer tasting to patrons and being able to conduct direct sales to bars and restaurants. Alaska is a 3-Tier state. State taxation rates in Alaska are $12.80 per gallon ($2.54 on a standard 750 ml bottle). There are about nine craft distilleries operating in Alaska.

Arizona: the Arizona Department of Liquor Licenses and Control will govern your application for a state craft distilling license allowing you to make up to 20,000 gallons of product per year. The state will allow a distillery to open one remote tasting and retail premise. If your annual output is less than 1,189 gallons you may sell and ship your product directly to Arizona retailers and residents. Craft distillers with output above 1,189 gallons must ship directly to licensed wholesalers in the

State. Arizona Revised Statutes (ARS) section 4, part 205 is the governing legislation. The state tax on alcohol is a modest $3 per gallon.

Arkansas: Craft distilling in Arkansas is very much in its infancy. The Arkansas Department of Finance and Administration, Title 1, subtitle c(14) allows for a craft distiller to sell to wholesalers, to export out of state, and to sell for off-premises consumption. It is probably just a matter of time before small distillers start springing up across the state. State liquor taxes are about $2.50 per gallon.

California: Assembly Bill No. 1295 went into effect January 1, 2016 and with it, craft distilling in the state was given a huge boost. The Alcoholic Beverage Control Act now allows craft distillers to sell up to 2.25 liters per day per person at a tasting room. A person visiting a tasting room can enjoy up to six one-quarter ounce tastings per day. A distillery can also provide mixed cocktails at its tasting room. Liquor taxes in California are $3.30 per gallon. Craft distillers will be limited to 100,000 gallons per year of output, excluding brandy. As of mid-2020, there were about 156 craft distillers in California. A craft distiller will need a Type 74 license and a Type 6 License to own a still.

Colorado: there were about 100 craft distilleries operating in Colorado as of mid-2020. If you are of good moral character, solid background and have not been funded by unlawful money, you can apply to the Colorado Liquor Authorities for a distilling license under Colorado Revised Statutes, Article 47, Title 12, section 402. You must make separate application to your local municipality for creating a retail tasting room. Liquor tax in Colorado is $2.28 per gallon (about 45 cents a bottle). The 3-Tier model applies in Colorado.

Connecticut: In early 2014, House Bill 5429 allowed for the creation of a craft distilling permit process. A craft distiller can make up to 25,000 gallons per year. Samples can be given to the retail public in an amount not exceeding two ounces per person per day. Senate Bill 386 passed in 2015 allows for manufacturers to sell sealed bottles of their alcoholic liquor on the premises, up to 1.5 liters per consumer per day (2 bottles). The place of manufacture must be approved by the Department of Consumer Protection before a distilling permit will be issued. As of mid-2020 there were about 14 craft distillers in the state. State alcohol tax is $5.40 per gallon.

Delaware: Delaware Code Title 4, Chapter 5, sections 512, 546 and 709 govern craft distillers. Craft distillers are exempt from having to shut down on Sundays. Craft distillers can sell up to 12 bottles to a given customer on a given day for consumption off premises. The license fee is geared to production output. Distribution to licensee establishments must be through a wholesaler. There are about 7 distilleries in the state. Liquor tax is $3.75 per gallon.

Florida: Florida Statute Title 34, Chapter 565 governs craft distillation. Florida is a 3-Tier state and distribution to licensee establishments will be through a wholesaler. Craft distillers have to make less than 75,000 gallons per year. An annual license fee of $4000 must be paid. State alcohol taxes are $6.50 per gallon. A craft distiller can have a tasting room provided it is located contiguous to the location where the spirits are produced. A rigorous assessment of the tasting room will be conducted by authorities. A craft distillery may only sell spirits in face-to-face sales transactions with consumers who are making a purchase of no more than 6 bottles of each product. This is a significant step forward over what the legislation used to read. The legislation to improve this situation was HB 141.

No craft distiller shall ship products direct to consumers. As of mid-2020 there were about 56 craft distillers in the state

Georgia: In early 2015, Georgia passed State Bill 63. But despite this, the State seems hopelessly bogged down in any efforts to make life easier for distillers. As of mid-2020 there were about 23 craft distillers in the state. Prior to this bill, a craft distiller could not sell a bottle to a patron at his tasting room. This Bill now allows the craft distiller to charge a fee for a distillery tour. As part of the fee, the patron gets to take home a 750 ml bottle of spirits.

Hawaii: Hawaii Revised Statures, Chapter 16 section 281 govern craft distilling in the state. A craft distiller with a valid Class 1 Manufacturing License can sell his product to licensed wholesalers. A craft distiller may further sell his product to retail customers at his distillery provided the alcohol is made from Hawaiian grown agricultural produce. However, no alcohol will be consumed at that location without additional approvals from the State. There are about 14 craft distilleries in Hawaii.

Idaho: In mid-2014, Idaho took a big step forward with State Bill 1335. This Bill allows Idaho distilleries to provide samples of their products at their manufacturing facilities provided the samples offered are free, offered on the premises of the manufacturer's distillery site, limited to one-quarter ounce and only given to people in three sample quantities over a 24-hour period. Prior to this legislative change, visitors to Idaho distilleries could view the distilling process, but they could not taste or consume any of the spirits. Craft distillers in Idaho will fall under the purview of the Idaho State Liquor Division and Idaho Statutes Title 23. The legislation appears rather tame with no glaring roadblocks. Of course, this is the State level. Individual counties in the state might take a different view towards craft distilling. As of mid-2020 there were

about 14 craft distillers in Idaho. State taxes are $10.92 per gallon. The State government controls liquor distribution and sale.

Illinois: In the 4th edition of this book I reported that Illinois Compiled Statutes, Chapter 235, section 5 called for craft distillers to have a Class 9 License which allowed for sales to distributors. The fee for the license was $2500. A craft distilling license allowed the manufacturer to distill up to 35,000 gallons of spirits per year. A craft distiller licensee could also sell spirits to distributors in the state and up to 2,500 gallons of spirits to non-licensees (ie the general public) in a face-to-face manner. State liquor tax is $8.55 per gallon. In mid-2020, Illinois took a big step forward with House Bill 2675 which allows a small craft distiller to deliver (without a 3-Tier distributor) up to 5000 gallons a year to pubs, bars and restaurants. As of mid-2020 there were about 43 craft distillers in Illinois.

Indiana: Laws in Indiana are complex. Indiana Code Title 7.1, Article 3, section 7 allows for a person to be granted a permit for the commercial manufacture of alcohol. House Bill 1283 passed in 2013 allows for a craft distilling license under which a craft distiller with an Artisan Permit can make up to 10,000 gallons of product per year. However, the applicant for the Artisan permit must already have held a Distillers permit for 18 months preceding the application for the Artisan permit. For a person seeking to become a craft distiller, they would apply for and get a Distillers permit. Then for 18 months they would have to sell their product via a wholesaler only. After the 18 months passes, they would apply for the Artisan permit which would allow them to sell to the public from a tasting room. If blending is part of the plan, a distiller could create blended spirits using alcohol sources from outside suppliers, but the blend must contain 60% of on-site made craft alcohol. State tax on liquor in Indiana is $2.68 per gallon. As of mid-2020 there were about 37 craft distillers in the state, but the overall situation remains complicated.

Iowa: In Iowa, Code 123.43(A) allows for the manufacture of distilled spirits to sell to the Iowa Alcoholic Beverages Division, with the option of sampling and selling bottles at the manufacturing location. As of mid-2020, there were about 21 craft distillers in Iowa.

Kansas: This was the first state in the Union to outlaw alcohol during Prohibition times. 2012 House Bill 2689, which became effective July 1, 2012 paved the way for craft distilling in the state. The overall application process for a craft distillers license is governed by the Kansas Department of Revenue. In many ways, the application process looks like something out of the Prohibition era. From making detailed disclosure as to who owns the furniture at the distillery to how much you have in your various bank accounts, Kansas appears to be a tough nut to crack. The fee for a Manufacturer License is $25,000. As of mid-2020, there are still only about 8 craft distillers in Kansas. The reasons are painfully clear.

Kentucky: Kentucky Revised Statutes 243.120 governs craft distilling. A craft distiller in Kentucky can make up to 50,000 gallons of product a year and can sell from his or her souvenir shop/tasting bar under a Class B license. Samples, not to exceed one ounce in size, can be given to customers. No customer can buy more than three gallons per day. Hours of operation of a distillery shall be 9:00 am to 9:00 pm, Monday through Saturday. State tax on liquor is $6.76 per gallon. As of mid-2020 there were about 47 craft distillers in Kentucky. Sales are capped at 6 bottles per person per day.

Lousiana: Louisiana Laws Title 26 governs alcohol. The State Alcohol and Tobacco Control department takes care of all the practicalities of alcohol manufacture. Steps involved in getting approvals include:

Obtain the appropriate surety bond from the Louisiana Department of Revenue. Please contact the Department of Revenue (225)219-7656.

Register Product Labels online, view information at http://www.atc.la.gov/productlabeling

Complete Louisiana Application www.atc.la.gov

Permit fees ($1000) plus extra fees tied to sales levels.

Schedule A and Fingerprints.

Attach a copy of a bonafide lease or proof of ownership of the premises to be licensed.

Attach a copy of all corporate documentation and proof of registration and good standing with the Louisiana Secretary of State.

Attach proof of lease or ownership of delivery equipment.

Attach proof of contract or agreement with at least one alcoholic beverage distributor.

Attach a diagram of the premises to be licensed.

Attach an in-depth description of the business model that clearly describes the production process and equipment utilized.

Obtain a local alcoholic beverage manufacturer permit (parish or city).

Obtain all required occupational and health licenses (state and local).

Ensure that bottle sizes and packaging comply with state requirements.

As of mid-2020, there were 17 craft distillers in the State.

Maine: Maine Revised Statutes, Title 28A, part 1355 governs small batch distilling. A craft distiller must not make more than 50,000 gallons of product a year. A craft distiller can apply to have up to two off-site retail locations where product will be sold. Craft distillers must distribute their alcohol through the state government system. Craft distillers making less than 25,000 gallons can make application to sell product to the public direct from the craft distillery. State tax on liquor

in Maine is $5.80 per gallon. As of mid-2020 the number of craft distilleries in Maine is about 19.

Maryland: Maryland Code g2b-2-202 allows for an applicant to receive a Class 1 Manufacturing License which allows for the distribution of up to 27,500 gallons per year of brandy, rum, whiskey or alcohol and neutral spirits under a Class 8 License. A craft distiller can offer tours of his location, provide samples (not more than three) in one-half ounce sizes and sell up to three standard 750 ml bottles to a patron. The annual license fee in Maryland is $2000. State alcohol tax in Maryland is $4.41 per gallon. There are about 25 craft distilleries in the state. If considering Maryland as a location, I advise doing some deeper due diligence. It further appears as though Worcester County may have different requirements from the rest of the State.

Massachusetts: In this State, Title 20, Chapter 138 governs alcohol production by way of the Alcohol Beverages Control Commission. Each city has a Licencing Board that oversees alcohol permits. There is a designation in this state for a Farmer-Distiller license which authorizes producing, manufacturing or distilling of distilled spirits by a person who grows fruits, flowers, herbs, vegetables, cereal grains or hops for the purpose of producing alcoholic beverages. A farmer-distiller may sell at wholesale to licensed farmer-distilleries, manufacturers, wholesalers, and licensed retailers in Massachusetts, at wholesale to other buyers specified in state law, and at retail by the bottle for consumption off the premises. A ‘Manufacturer of All Alcoholic Beverages License’ is a license authorizing the manufacturing, rectifying or blending of all kinds of alcoholic beverages and sale of those beverages manufactured, rectified or blended to other licensed manufacturers, wholesalers and retailers in the state. Liquor tax in the State is $4.05 per gallon. At the beginning of 2016 there were about ten craft distillers in the state. As of mid-2020, there were about 29 craft distillers in the state. For more details please see http://www.mass.gov/abcc.htm.

Michigan: the Michigan Liquor Control Commission oversees craft distilling in the state. A Small Distiller license is a:

License issued by the Liquor Control Commission to manufacture spirits, not to exceed 60,000 gallons annually of all brands combined.

License that also includes the manufacture of Brandy. A craft distiller may offer free samples to consumers on the manufacturing premises. The craft distiller may sell spirits to consumers for consumption on the manufacturing premises.

The craft distiller may sell spirits to consumers for off-premises consumption (take-out) for not less than the uniform price set by the Commission. The craft distiller may not sell spirits directly to Michigan retail licensees. The craft distiller may sell spirits to the Michigan Liquor Control Commission who resells spirit products through the spirit distribution system. As of mid-2020 there were 62 craft distilleries in the state.

Minnesota: This is another state that is slowly easing away from the Prohibition-era mentality. In mid-2015, legislative changes finally made it possible to sell bottles of product direct to the customer. The maximum production allowable for craft distillers is 40,000 gallons. A fee of $2000 and a surety bond of $3000 must be paid when applying for a craft distilling license. A separate license will be required if serving cocktails at your distillery.

See http://mn.gov/elicense/licenses/licensedetail.jsp?URI=tcm:29-5337

7&CT_URI=tcm:29-117-32 for details. State tax on alcohol is 2.5%. As of mid-2020, there were about 33 craft distilleries in the state.

Mississippi: Title 67, Chapter 1, section 51 allows for the granting of an alcohol manufacturing license. There were two craft distillers in the state as at the start of 2016 and this number has now risen to 4 as of mid-2020. Alcohol tax is $7.41 per gallon. The Office of Alcohol Beverage Control (ABC) oversees alcohol permits. The annual permit fee is $9025. There are 34 counties (out of 82) in the state that are dry. Do your homework carefully – it appears that this state is not overly open to distilling.

Missouri: there are about 39 craft distillers in the state as of mid-2020. Missouri Revised Statutes Chapter 311, section 180 is the prevailing legislation. A tax bond (about $1000) will be required at the time of your license application. State liquor tax is $2 per gallon. Missouri is the only state that allows for home distillation. Revised Statutes 311.055 states: No person at least twenty-one years of age shall be required to obtain a license to manufacture intoxicating liquor, as defined in section 311.020, for personal or family use. The aggregate amount of intoxicating liquor manufactured per household shall not exceed two hundred gallons per calendar year if there are two or more persons over the age of twenty-one years in such household, or one hundred gallons per calendar year if there is only one person over the age of twenty-one years in such household. Now that's what I call progress!

Montana: The Montana Department of Revenue Liquor Control Division oversees the application process. (See

http://revenue.mt.gov/Portals/9/liquor/alcohol_beveragelicenses/licensing_forms/MDLA.pdf) for the application process. The maximum annual output in the state is 25,000 gallons. Fully 90% of what a distiller offers for tasting at his or her premises must have been made on site. State liquor tax is applied on a sliding scale. Montana is a control State where government acts as both distributor and retailer. As of mid-2020 there were 24 craft distilleries operating.

Nebraska: the State Liquor Control Commission oversees alcohol manufacture. State alcohol tax is $3.75 a gallon. At the start of 2016 there were six craft distillers in the state. This number has risen to 11 as of mid-2020. Annual output is capped at 10,000 gallons. Sections 53-101 to 53-1,122 of the Nebraska Statutes govern alcohol. There are seven tiers of craft distiller licenses available depending on production output. All tiers carry an annual fee of $1000. A craft distillery can sell six cases of product (12 bottles per) per year to a customer.

Nevada: In 2013, Nevada took its first steps away from Prohibition era thinking with the passage of Assembly Bill 153. This bill made allowance for a craft distiller to sell 10,000 gallons to in-state wholesalers per year and 20,000 cases combined total to in-state and out-of-state wholesalers per year with a case being defined as 12 x 750 mls. State Assembly Bill 186 has provided for further relaxations including an increase to the two bottles per person per month limit to two cases per person per month. This bill has expanded the two ounces total that can be sampled at a tasting room to two ounces sampled at farmer's markets, festivals, sporting events and other special events. There are currently 18 craft distillers in the state. State alcohol tax is $3.60 per gallon.

New Hampshire: Title 13, Chapter 178 of the NH Statutes govern alcohol in conjunction with the NH Liquor Commission. Craft distillers

can sell at their facility up to 3000 cases (nine liters per case) per year. A person can buy only 1 case maximum per sale. There were seven craft distillers in the state at the end of 2015 and this figure now stands at 15. There is no state liquor tax.

New Jersey: The department of Law and Public Safety – Alcohol Beverage Control Division governs alcohol production. The craft distilling license fee is about $1000. A similar sized bond must also be submitted. Annual output is capped at 20,000 gallons. State liquor tax is $5.50 per gallon. The lengthy application form can be found at: http://www.nj.gov/oag/abc/downloads/Craft-Distillery-License-Package.pdf. There are around 28 operators in the state.

New Mexico: The NM Alcohol and Gaming Division oversees craft distiller applications. NM Statutes Chapter 60, Article 6A provides craft distilling details. A minimum of 1000 gallons per year must be made by a craft distiller. State liquor tax is $6.00 per gallon. As of late 2020, there were about 13 craft distillers operating in the State. The Manufacturer License fee is $3000 and a minimum of 1000 proof gallons per year must be made under that license. Fully 60% of revenues must derive from the sale of alcohol. New Mexico is a 3-Tier State and producers must distribute via a wholesaler.

New York: The State of New York had about 140 craft distillers at the end of 2020. The New York alcoholic beverage control law has revolutionized craft distilling in the state. A class A-1 license will allow for the making of up to 35,000 gallons per year which can be sold to a liquor wholesaler. A class C license will allow a craft distiller to make only fruit brandy. A class D license will allow for the making of alcohol from agricultural products. This is the category that has fueled the explosive growth of craft distilling in the state. State liquor tax is $6.44 a gallon.

North Carolina: The State Alcohol Beverage Control Commission governs permits for alcohol manufacture under NC Statures Chapter 18B. I cannot find any notation as to the maximum allowable annual production. At the start of 2016, there were nearly 25 craft distillers in operation. At mid-2020, this number stands at near 63. State liquor tax is $12.36 a gallon. Distillers must sell product to a wholesaler in this blended 3-Tier / control State. Retail liquor sales are limited to State-run stores. Wholesalers will distribute to pubs, bars and licensed establishments Liquor prices are subject to an 80% government markup at retail locations when one considers the ABC Board mark-up and the state Excise Fee combined.

North Dakota: Title 5, Chapter 1, Section 19 of the North Dakota Century Code governs craft distilling. A craft distiller may sell to retail patrons at the distillery location. All other sales must be through wholesalers. The one quirk with North Dakota is that at least 51% of the ingredients, excluding water, used by a craft distiller to create distilled alcohol for sale on-premise must be North Dakota grown agricultural products. State liquor tax is $4.66 a gallon.

Ohio: State liquor tax in Ohio is $9.32 per gallon. At the end of 2015, there were just over 20 craft distillers in the state. As at late 2020, this number is near 60. The Ohio Department of Commerce Division of Liquor Control will handle the application process for a fee. A craft distiller will want an A-3-a permit that allows for the annual making of up to 10,000 gallons. A distillery cannot serve more than four, quarter-ounce tastings per day to a person and that person cannot buy more than 1.5 liters of product from you per day.

Oklahoma: Title 37, section 518 (the Oklahoma Alcoholic Beverage Control Act) provides for the issuance of a manufacturing license with an annual fee of $3150. State alcohol tax is $5.56 per gallon. This appears to be a very difficult state. Obtain legal advice before getting in too deep. At mid-2020, there were only 9 distilleries in the state.

Oregon: Lots of action here with 70 craft distillers in business at the end of 2020. State tax, however, is a big $22.73 per gallon. http://www.oregon.gov/OLCC/pages/craft_distilleries.aspx provides you with the details of getting started in this otherwise friendly state. Retail alcohol sales are done through state-controlled stores.

Pennsylvania: At mid-2020, there were just over 80 craft distillers operating in this state. Liquor tax is $7.21 per gallon. The State Liquor Control Board has an application for application for a license termed "a limited license" for manufacture, storage or transportation of alcohol. The annual limit under a limited license is 100,000 gallons.

Rhode Island: at the end of 2018, there were only a couple distillers in the state. As of late 2020, the number had not changed. Liquor tax is a modest $3.75 per liter. The annual license fee is $3000 for a distillery making greater than 50,000 gallons per annum and $500 for distillers making less than 50,000 gallons. Additional fees apply based on production output levels. A $5000 bond must accompany your application. The following link will take you to the application form http://www.dbr.ri.gov/documents/divisions/commlicensing/liquor/LQ-Instructions-Application-Ind-Ptnrship.pdf. Title 3, Chapter 6 of the Rhode Island statutes govern alcohol production. The Department of Business Regulation controls alcohol sales and distribution.

South Carolina: at the start of 2017, there were 23 craft distillers operating in the State. This figure stood at about 34 as at late 2018 and has remained the same since. State liquor tax is $5.42 per gallon. State law defines a micro-distiller as one who makes less than 125,000 cases of product per year. Tasting can be given to patrons, but only up to 1.5 ounces per day. Hours of operation are restricted to between 9am and 7 pm. Bottles sold at the distillery must be priced similar to retail prices at other locations in the county. The bi-annual fee for a distillery is $5000. Sub-article 11, Article 3, Chapter 6, Title 6 of State Code governs craft distilling. A craft distiller can sell up to three bottles per person per day at a price equal or higher than what a retail store would charge.

South Dakota: Chapter 35, section 13 of the State Code governs craft distillers. 50,000 gallons is the allowed for annual production. State liquor tax is $4.68 a gallon. Like neighboring North Dakota, this state requires that at least 30 % of the raw materials, other than water, used by an artisan distiller to produce distilled spirits shall consist of agricultural products grown in South Dakota. At the start of 2017, there were a half-dozen craft distillers in the state. As of late 2018, the number was 8 and it still stands there as of late 2020.

Tennessee: The Tennessee Alcohol Beverage Commission administers distillation. See the information at the following website: https://www.tn.gov/abc/topic/distillery-license. At the start of 2017, there were about 25 craft distillers operating in the state. This number had expanded slightly to 34 as at late 2018. At late 2020, the number stood at 53. Licensing appears generally favorable.

Texas: At the beginning of 2017, there were about 40 craft distillers in Texas. This number had expanded to 108 at late 2018 and has not moved since. State liquor tax is a modest $2.40 per gallon. The Texas

Alcohol Beverage Commission (TABC) will grant a Distillers and Rectifiers Permit. A craft distiller will also need a Manufacturers Warehouse License. The guidelines for all of this can be found at https://www.tabc.state.tx.us/publications/licensing/GuideWholesalers.pdf. There will also be a label approval process to navigate through. There are limits on bottle sales from the tasting room to the tune of two bottles per person per month.

Utah: Alcohol is not condoned by a large portion of residents. Also, state liquor tax is $12.19 per gallon. This may explain why there are only about 15 distillery license holders in the State. The application fee is $3800 and the annual renewal fee is $2900. A surety bond of $10,000 is also required. Title 32B, Chapter 11 of State Statutes govern alcohol production. For more information, visit http://abc.utah.gov/license/licenses_manufacturing.html. Retail liquor sales in Utah are State controlled.

Vermont: As of late 2020 there were about 24 craft distillers in Vermont. State alcohol tax is $5.86 per gallon. For more information, the website http://liquorcontrol.vermont.gov/licensing/instructions provides further details. Distillers can offer tastings and sales at farmer's markets and also at their distilleries under a 4th Class License.

Virginia: As of early-2017 there were about 30 craft distillers in Virginia. This number had grown slightly to 32 at late 2018. At late 2020, the number was at 49. State alcohol tax is a big $19.19 per gallon. Fees for licenses are on a sliding scale based on production volume: ≤ 5000 gallons annually: $450, 5001–36000 gallons annually: $2,500, ≥ 36,001 gallons annually: $3,725. The Virginia Department of Alcohol and Beverage Control in Richmond will handle the entire licensing process. You can sell bottles from your tasting room if you have at least

one of your products in a state-controlled store and have been approved to operate as a 'distillery store'. The state, in other words, likes to control hard alcohol. In fact, the ABC stores apply a hefty 69% tax markup on top of the wholesale price they buy it at. Bottom line is, Virginia holds a tight grip on alcohol. However, in mid-2020, HB 1436 created a new agency to do research into raw materials that could be grown in the state for alcohol manufacture.

Washington: As of late-2017, there were over 65 distilleries in the state. At late 2018 this number had hit 100. At late 2020, the number stands at 122. State alcohol tax is a huge $35.22 a gallon. The Washington State Liquor and Cannabis Board is the governing body overseeing craft distilling. Regulations say: For distillers who are producing 150,000 proof gallons or less of spirits per calendar year, at least half of the raw materials used in the production must be grown in Washington. This provides exemption from some of the tax mark-up. A distiller may sell spirits of its own production directly to a consumer for off-premises consumption, provided that the sale occurs when the customer is physically present on the licensed premises. A sample of .05 ounces is permitted with a maximum of two ounces per person per day. A distiller may also sell spirits of its own production to licensed Washington State Spirits Distributors and Spirits Retailers. A distiller may maintain an approved warehouse off the distillery premises for the distribution of spirits of its own production.

West Virginia: As of late-2017 there were nine distillers in the State. Three years later, and the number is 17. One license category is that of 'mini-distiller'. Annual output is capped at 10,000 gallons and 25% of the raw materials used must be grown or produced on-site. A craft distillery cannot sell more than 3000 gallons in the initial two years of being licensed. The other category of license is that of a 'distiller'. Similar requirements apply as to output within the first two years. West Virginia further uses something called the Bailment Process where the distillery must submit 10% of gross sales to the government

each month who in turn will share these proceeds pro-rata with other spirits retailers in your area. Outdated and backwards to be sure. Think carefully before venturing into West Virginia.

Wisconsin: As of late-2018 there were about 28 distillers in Wisconsin. That number holds steady. Chapter 125 of the State Statutes offers details on permits. A craft distiller will need a manufacturer permit which will authorize the manufacture, tasting and retail sale of product. Wisconsin is a 3-Tier state, but a craft distiller can sell bottles on-site with few limits on quantity per customer.

Wyoming: As of late-2018, there were about 8 craft distillers in Wyoming. That number has changed little. There are no state alcohol taxes in Wyoming. The Wyoming department of Revenue, Liquor Division is the body granting licenses. Title 12, Chapter 2 legislation in Wyoming appears restrictive, going so far as to limit a patron to no more than two tasting samples a day. Think carefully before deciding to set up in Wyoming. It is my understanding that a craft distiller wishing to stock his tasting room shelves with product to be used for samples must first ship those bottles to the State warehouse where they receive a 28% tax markup. Craft distillers are fighting to have this requirement waived.

Reporting Paperwork

All jurisdictions will require a craft distillery to file monthly reports of activity. A month-end report will require stating how many liters of absolute alcohol or how many proof gallons were manufactured in the month. The reporting paperwork will also demand to know what was done to the bulk alcohol produced. Was some of it placed back into the flow of production and re-distilled to make vodka? Was some of it placed into oak barrels for ageing? If any alcohol was bottled, the paperwork will demand to know if it was sold. If it was sold, then excise taxes are due and payable. If it was not sold, it will have to be shown as bottled and sitting in a non-duty paid part of the distillery (the excise warehouse). Was some alcohol perhaps exported to another country? Was some alcohol shipped to another license holder like a winery for use in fortifying wine? The details required will be considerable.

The paperwork in America will be similar in format. But, it will go further and ask for the quantities of various raw materials used and the amounts of alcohol that were generated from these various batches of raw materials. This is a stark difference to Canada where no data on raw materials is required to be stated.

Labels

In Canada there is little government interference with labels. A craft distiller can design his or her own labels without seeking approvals. Government agencies do however reserve the right to conduct spot checks to determine label conformity to laws. For example, the minimum font size shall be 1.6 mm based on the lower cased letter ‘o’. The bottle volume and % alcohol must be clearly stated. The name and address of the distiller must also be stated. So long as the spirit falls under one of the standard definitions, no other requirements apply.

However, a distiller making a spirit from sugar beets, for example, would not be able to call the product rum. A distiller making a moonshine would have to make label disclosure that the spirit was made from grains, as there is no standard definition in Canada for moonshine. In my experience, government agencies in Canada are helpful when it comes to questions on labelling. The one issue that is proving contentious is the definition of whisky. Regulators are sticking to the 3-year ageing requirement. A craft distiller not ageing in oak for 3 years will be required to describe his product as a ‘grain spirit’ on the label.

In America, there is considerable government oversight on labels. The following URL delineates TTB label policy. http://www.ttb.gov/pdf/brochures/p51902.pdf. In America, a distiller will be granted a Certificate of Label Approval (COLA) for the label that will appear on his or her bottle. In many cases, individual states will also want the distiller to submit copies of approved labels. Federal Statute 25 CFR Chapter 5 contains all the details concerning Labelling of Spirits.

Critical Items

In the opening segment of a typical 5-day workshop, I present participants with a long list of things to do for a start-up craft distillery. I ask that people pick out the six most critical items. Invariably, people fail to pick out the item that says “make sure you are wanted”. Not every town or city wants a craft distillery. Even if the town or city wants such a business, not all of the local officials will be on your side. When contemplating a distillery project, I advise meeting with Fire Inspectors, Building Inspectors and Public Works Managers. Take their pulse. Gauge their attitude. If they have toured a craft brewery or craft distillery, they will understand what it is you are proposing. If they have no such experience or if they are against alcohol (remember – the stuff technically is a drug and not all people drink), you may quickly get the sense you are unwelcome. If that is the case, it is best to move on. Find a new possible location. The regulations and codes are difficult enough to navigate as it is. Place the responsibility for interpreting these codes in the hands of a less-than-motivated inspector who has complete interpretive control and you will wish you had never started down the road of creating a distillery. The codes and their interpretations run deep and vary widely from one locale to the next and from one country to the next. What follows is some insight that I have gained over the years.

Codes - Canada

A craft distiller in Canada wishing to start up will have to get Fire Inspection approvals. The Fire Inspector will lean heavily on the National Fire Code and its designations of F1 (high hazard) and F2 (medium hazard) for distilleries. Individual provinces may also have a Fire Code, but it will be based on the National Fire Code. There was a time when a reasoned technical argument gave a distillery applicant a chance at getting an F2 designation. Not so much now anymore. Fire Inspectors are now attuned to the subject of craft distilleries. Assume that you will be faced with an F1 high hazard fire rating. Don’t pretend to be shocked when this news is given to you. Don’t try to argue the decision. Listen carefully to what the Inspector wants you to implement for fire suppression equipment. If what he wants is outside your budget, you would be foolish to sink yourself deep (deeper) into debt to accommodate what is required. I have seen craft distillers dig their heels into the mud and overextend themselves financially to protect their egos. True, they end up satisfying the Inspector’s needs for fire suppression, but they end up facing higher than comfortable debt repayment schedules as a result. To earn enough money to pay the debt, they raise the prices of their products. Soon enough they are no longer competitively priced and the financial pressures start to mount further. While on this critical subject of Fire codes, if you are intent on leasing a property, be sure to structure the lease so that if you run into difficulties with the Inspector, you can withdraw from the lease and walk away. I have seen far too many start-up projects where people have signed a lease with no back-out clause, and gone ahead with the purchase of equipment before trying to deal with the Inspector.

Given the discretionary powers of the Inspector, it is advisable to hire a code consultant to represent your interests. Make sure that the consultant you engage has prior experience with craft distilling. One group that I have heard excellent things about is GHL Consulting in Vancouver. Another firm that comes highly touted is Jensen Hughes – Specialty Engineers. Have the consultant do the talking for you. If you get wrapped up in a dispute with the Fire Inspector you may never see your distillery dream come true. The strategy that I see getting played out is one of the inspector not wanting to be the only person to sign off on a distillery project. Inspectors will challenge you to the point where you go off in search of a professional code consultant who bears a P. Eng. Designation. By having a professional involved, the Inspector will then end up sharing the liability with someone else.

To meet the F1 requirement, a craft distillery will need to either install fire sprinklers or a dry chemical fire suppression system. If the building to be rented or acquired comes equipped with fire sprinklers, then the F1 requirements will already be met. If you have to install fire sprinklers, to ensure adequate water pressure, you may be asked to run a water line direct from the street water line to your sprinkler system. Your town or city will not pay for this upgrade. If there is adequate water pressure at the ingress to your building, the cost of just running the piping and sprinklers throughout the building can start to approach $100,000 for a larger type building. An alternative solution is a foam or chemical based fire suppression system in your distillation area. But, such a system will also start to approach the six-figure level.

Other issues that can enter into the fire inspection equation at the discretion of the Inspector include having: a suitable fire wall between the distilling area and the tasting room area, having the boiler in a separate room complete with various safety shut-down devices, having explosion proof lighting, having incendiary proof electrical junction boxes, having suitable burn time ratings on walls between your distillery and a neighboring business and maybe even having your grain grinding area isolated to a separate room complete with ventilation.

If you want to present a reasoned argument to the Inspector, ask your consultant to consider the following:

In order for an explosion to occur in a distillery, an ignition source, air, and ethanol are all needed. If the ethanol concentration in the air is less than 3.3%, no explosion will occur. If the ethanol concentration in the air is above than 19%, no explosion will occur, but the ethanol will burn. This might allay the fears of an Inspector worried about explosion.

You can present the following example:

A distillery layout (10m X 30m X 10m) has a building volume 3000 m^3. An ethanol spill from a still will vaporize. To determine how many m^3 of vapor results from 1 liter of spillage, the following formula is used:

*1L of Liquid A = 0.83 * (specific gravity of Liquid A / Vapor density of Vapor A) = m^3 of Vapor A ; where the vapor density of ethanol relative to air is 1.59.*

A spill of 1 liter of ethanol will give 0.412 m^3 of vapor. The lower explosive limit of ethanol is 3.3% or 99 m3 in the context of the 3000 m^3 building. This equates to 240 liters that would have to be spilled to bring the entire building to the 3.3% lower explosive limit. The argument can be extended to say that before 240 liters was ever spilled, quick clean-up remedial action would be taken to eliminate any danger.

If burning is the concern of the Inspector, you can present a thermal combustion argument:

The heat of combustion of ethanol is 29.7 MJ/kg. In Canada a building with contents such that a fire would generate less than 1200 MJ/m² might win some favor with the Inspector. Let's take the case of a building of 3000 sq. feet (279 m²). Let's assume that at any given time there are 20 barrels of 60% distillate ageing (200 liter barrels) and let's assume there are 600 bottles of alcohol (40% abv) on site at any time.

The mass of ethanol in casks is calculated as:

$$(200 \times 20 \times 0.60)*0.79 \text{ kgs/liter} = 1896 \text{ kgs.}$$

The mass of ethanol in bottles is calculated as:

$$(600 \times 0.750 \times .4)*0.79 \text{ kgs/liter} = 180 \text{ kgs.}$$

The thermal energy released in the event of fire would be:

$$29.7 \text{ MJ} \times (1896+180) = 61{,}657 \text{ MJ.}$$

In terms of a per square meter value, 61,657/279 = 221 MJ/m².

This falls well inside the allowable limit of 1200 MJ/m^2.

This bit of math might win you kudos with the Inspector. Then again, the Inspector might use his interpretation discretion and ignore your calculations. He might recite the Code verbiage that says: an F1 high hazard rating applies to an occupancy containing sufficient quantities of highly combustible and flammable or explosive materials that constitute a special fire hazard because of their inherent characteristics.

Building Code approvals will also be required. Expect to have the Inspector demand proper ventilation and air flow in your distillery based on square footage and occupancy load.

City or municipal approvals will also be required. Expect to hear from officials on matters as trivial as number of parking stalls at your distillery.

Expect to have detailed discussions with the public works department on the nature of effluent materials you will flush down the drain. Expect to have to provide data on expected BOD and COD levels. These acronyms are a reference to the oxygen-scavenging ability of organic matter. To determine these levels, you will have to engage a testing lab to assess the organic content of spent grain and waste stillage liquids from a typical still. Organic matter from a distillery that is flushed into sewage settling ponds can scavenge oxygen and help create anaerobic algae which will clog transfer pumps and hinder the efficiency of sewage treatment facilities maintained by a Public Works Department.

Electrical inspections will also be required. These somewhat will overlap with the fire inspections. A major issue of focus will be electrical motors on agitators that are not CSA approved or that do not bear the UL certification sticker. Some inspectors might ask for explosion proof lighting and explosion proof junction boxes.

Each Canadian province will have workplace health and safety requirements. It is advisable to check to see what requirements pertain to a small distillery.

Lastly, one must be cognizant that a distillery is an inviting place for bugs and rodents. Because the grain stored on-site will be processed into a consumer beverage, the use of chemical spray or poison bait will be frowned upon. A Health & Safety inspector might demand to see a written pest control policy.

Codes - America

A similar scenario as in Canada will play out in America where the NFPA Code will come into focus. The math underpinning the calculations is similar. Consider hiring an architect or engineer to assist you in getting Fire Inspector approvals. The primary concern of the Inspector will be explosion and fire. It is likely that alcohol will be regarded as a Class 1 B liquid. If a distillery exceeds a certain square footage threshold (possibly 12,000 square feet), expect the expensive topic of sprinkler systems to arise.

NFPA 61 governs combustible dust. Expect to have discussions regarding locating grain grinding activity to a separate, ventilated room.

Building Codes and Electrical Codes will come under close scrutiny as well. Building inspectors may zero in on the subject of ventilation for your space. Electrical inspectors will focus on explosion proof lighting, junctions and panels.

The International Mechanical Code, section 1004 covers boilers. Expect to have to locate your boiler in its own separate room and expect to have to outfit the boiler will various safety shut-off controls.

Expect to encounter OSHA regulations. If you are planning to hire any employees, expect to have to come into compliance regarding safety requirements, safety meetings and protective equipment. One technical consultancy that is highly recommended is Bergeron Technical Services based out of New Hampshire. Their specialty seems to be alcohol production facilities.

Expect to hear about the Clean Air Act that governs discharges into the atmosphere. When I was in the mineral exploration business, I used to run into this Act as it pertained to exhaust emissions from motors used to power drilling rigs. In the context of distilling, emissions can take the form of dust from a grinding mill.

Expect also to hear about the Clean Water Act. How much water are you using to cool the condenser on your still? How much water to do a mash? What are you putting into sewage systems? Various states may also have additional requirements over and above the Federal requirements.

Codes – U.K.

The U.K. is a complex web of legislation. A code consultant is essential. At the heart of it all is the Health and Safety Executive (HSE). In Scotland, look for subsidiary bodies such as The Environment Agency and the Scottish Environment Protection Agency. The legislative Act that governs all is called the Health and Safety at Work Act (1974). The following are some of the regulations that a craft distiller could possibly will run into: Reporting of Injuries, Diseases and Dangerous Occurrences (RIDDOR -1995), Provision and Use of Work Equipment (PUWER-1988), The Management of Health and Safety at Work Regs (MHSWR-1999), Control of Substances Hazardous to Health (COSHH-1994), The Supply of Machinery Safety Regulations (2008), Dangerous Substances and Explosive Atmospheres Regulations (DSEAR-2002), Pressure Systems Safety Regulations (2000), Lifting Operations and :Lifting Equipment (LOLER-1998), Food and Environment Protection Agency Act (1985).

When authorities ask for a DSEAR evaluation to be completed for a proposed distillery location, focus on the location of hazardous substances in the planned facility, a risk assessment of those items, measures to eliminate them and training that will be provided to employees. Further to this, you may be required to undertake a HAZOP (Hazardous Operation) study of your planned facility. You may also have to complete an ALARP (As Low As Reasonably Possible) risk analysis study for your location. Another risk analysis study that you may have to complete is a LOPA (Layers Of Protection Analysis) study. You will also likely run headlong into your local planning board. Expect to have to spend time educating your planners as to the nature of a small batch distillery. As already noted, if contemplating a craft distillery in the UK it is wise to seek the opinion of an engineer or architect well versed in legislative codes and planning studies.

Zoning

In all jurisdictions, not all parts of towns and cities are zoned for alcohol manufacture. When contemplating a distillery, it is essential to first meet with members of the local Zoning Committee. Explain to them what you are wishing to establish. If they are unsure as to exactly what parts of your town are alcohol zoned, solicit the help of an architect who better understands the zoning peculiarities of the town or city in question.

If a re-zoning is required, expect the process to take far longer and to be far more frustrating than you ever imagined. I am aware of a craft distiller in British Columbia that encountered lengthy nine month delays when a member of the public simply questioned whether or not their planned craft distillery would generate any air-borne black mold fungus similar to what is common at the big bourbon distilleries in Kentucky. Thankfully, I was able to make a reasoned presentation to town council to put to rest this peculiar notion, but it all took precious time. Not far from where I live in southern Saskatchewan is the small town of Moose Jaw, Saskatchewan. The town is ripe with history from the Al Capone whisky-running days. But, two members of town council are recovering alcoholics who are opposed to distilleries in their town. Zoning changes and distillery approvals have been denied to several interested parties over the past several years.

Navigating the choppy waters of the various legislated codes will not be easy. It will take longer than expected and will cost more than budgeted. Get ready for it. Eyes wide open.

15

Business Planning & Sense

During the approvals process for an alcohol manufacturing license, you will be asked to submit a Business Plan to the regulatory authorities. If you are seeking bank financing or private investor financing, then you will certainly need a Business Plan to make your case for investment dollars. If you are partnering with others to create a craft distillery, a Business Plan can help you to clarify who brings what talents to the table and who is responsible for what tasks. Even if you are going it alone without external financing, a Business Plan will help keep you grounded and focused.

Search on-line and you will find books and articles on Business Planning as well as templates to follow. Your banker may even have a standard Business Planning template to share with you. What follows is some ideas to assist you as you construct your Business Plan.

Executive Summary: The front part of your plan should contain a tightly written executive summary that sums up the entire plan in a few paragraphs. This is your enticing elevator pitch that you would deliver to a someone who wanted to know more about your planned distillery venture.

Confidentiality: Include a detachable sheet in your plan containing standard confidentiality agreement wording. You do not want a curious investor to take a copy of your plan and use it to build his own craft distillery. If this sounds unlikely, it is not. In 2015, I was made aware of one case in British Columbia in which a party seeking to rent a building to start a craft distillery was asked to provide the building owner with a

copy of their entire Business Plan. Lease negotiations subsequently fell apart and the interested party never did rent the building. But that landlord ended in possession of a very well prepared plan.

Company Description: In a paragraph, describe your craft distillery and who you are.

Company Profile: In a paragraph, outline the name, address of your distillery and a description of the key players in your venture.

Partnerships: Do you have a partner in your planned craft business? Is there a clearly written partnership agreement? Do you have provisions in the event one of you dies? Do you have provisions in the event the partnership falters? A craft start-up is a stressful event that can bring out the worst in people. I saw three partnerships fall apart in 2020 alone. I am sure I will see more in the years to come. A partnership agreement must have a procedure for parting ways. There will have to be a clearly stated method for determining the value of the distillery. This valuation metric might focus on net earnings, or it might focus on providing the departing partner with his original capital plus a reasonable return on that money. These are details your banker will want to know. Avoid structuring a partnership in a 50/50 manner. In the event of a partnership breakdown, decision making could reach an impasse and legal proceedings could arise.

Mission Statement: Describe exactly what your craft distillery is setting out to do. This statement will go a long way towards convincing the reader of your plan to invest in your distillery. This statement will also keep you grounded and focused. What problems are you seeking to solve? How will your distillery make the world of distilled spirits better? To cite some examples from the retail sector, consider that Home Depot

is not about selling hammers and saws. Their mission is to help you make the home of your dreams. WalMart is not just about selling cheap goods. Its mission is to help you save money and live better.

Vision Statement: What will the distillery's future look like as it starts to achieve its mission and goals? What are your plans for growth? What is your exit strategy?

Strengths and Weaknesses of your Distillery: What are the particular strengths of your planned distillery business? What are the weaknesses? Be honest with yourself as you list and describe these. Every business has weaknesses that will need to be mitigated. One weakness of any craft distillery is the lack of buying power. A small craft distiller will not be buying grain by the railcar load, nor will it be buying cargo shiploads of bottles. One strength of a craft distillery is its ability to pivot. In a matter of days, a distiller can create a new recipe variation and have it ready to sell.

Products: In detail, describe the products you plan to make at your distillery.

Strengths and Weaknesses of your Products: What are the strengths and weaknesses of your planned products? Will you be making products from grains people are unaware of? Are you using locally grown raw materials that might be subject to price swings and periodic unavailability? What is the planned physique and personality of your craft alcohol?

Industry Analysis: Describe in detail what has been happening in the distilled spirits market for the past number of years. Describe how craft distilling is impacting the distilled spirits market. What trends do you see emerging? How will your products fit in with these trends? This is a difficult section to complete. Visit your local library and have the librarian help you with a literature search of recent magazines and periodicals. Talk to people in the liquor distribution business. Gather data from places like the American Distilling Institute. Visit distilling conferences and events. I recently discovered an app called ISSUU which gives access to a wide array of electronic magazines. Search amongst the ISSUU collection using key words such as distilling, whisky, gin, craft spirits, artisan spirits. You will be amazed at the industry magazines that you find.

Who is Your Target Market? To assist you in identifying your ideal buyers, check with your local city administrators for demographic data for your city. There are also data mining firms that can sell you demographic and customer habit data for specified geographic regions. Speak with your Chamber of Commerce about your planned distillery. Speak to local bartenders and mixologists about what you are planning. Arrange some focus groups to get a feel for how people view distilled spirits. Visit liquor stores in your wider geographic area and inquire as to what their top-selling brands are. Keep gathering data until you have a firm understanding of your target market.

In a previous chapter, I noted the unique wants of the ethnic and Kosher markets. The ethnic market especially can be key to building a solid customer base. In western Canada, we are seeing a big influx of people from India. Many enjoy spirit drinks, but their taste demands are different. Apparently Teacher’s Blended Scotch is a big seller in India. In 2017 an east-Indian gentleman at one of my workshops informed me that he owned 17 liquor stores in Calgary, Alberta. He told me that if a craft distiller can create a whisky product that meets the Indian desired taste profile, a huge new market could open up for that craft distiller. We are also seeing a huge influx of people from the Philippines. I am learning that one of their preferred spirits is Lambanog, which is distilled from fermented coconut nectar. I am aware of a Canadian entrepreneur with ties to the Philippines who is looking at the concept of doing a first distillation run on fermented nectar and then shipping bulk quantities of that distillate to a craft distillery in Canada for rectification into a higher proof expression that retains the coconut taste profile. I have tasted various Lambanog samples he obtained in the Philippines and I could easily have some as my daily dram.

Pricing: how will you price your products? What are the government liquor taxes or markups? How are the big brand name products priced? I spend considerable time in liquor stores looking at prices. I am seeing a disturbing trend in that craft spirits seem to be priced for the connoisseur. Not everyone is a connoisseur. Not everyone is willing to pay $60 for a bottle of vodka. What about the average person who just wants a good tasting spirit? Herein is a possible weakness of your business. Are your operating expenses such that you are unable to price your product for the average person's budget? If your expenses will push you out of the average person's price range, it might be best to re-think your strategy.

Competition Analysis: How many craft distillers are in your area, province or state? Gather significant details on all of them. Obtain their products and do some blind-sampling with family and friends. Report these sampling observations in your plan. Make sure you intimately understand what competing products are on the marketplace. Talk to liquor wholesalers. Ask them what craft products they would really like in their portfolio. I had such an experience recently in Calgary, Alberta. A liquor store owner told me that she was having trouble finding enough unique expressions of Grappa. She also advised she was having trouble getting enough spirits of the Amaro class (think Campari). Two gaping holes in the market just waiting to be filled by a craft distiller.

Strengths, Weaknesses, Opportunities, Threats (SWOT) Analysis: Undertake a complete SWOT analysis at this point incorporating everything you have discussed in your Business Plan so far. To the busy reader, this summary page is the one page that will be focused on. It will clearly outline the strengths, weaknesses, opportunities and threats that pertain to your planned distillery.

Marketing Plan: How will you market and sell your product? How will you draw a crowd to your tasting room? Will you engage salespersons? How will they be paid? Will you be targeting pubs, bars, restaurants? How will you use social media platforms to promote your products?

In the American state-owned and 3-Tier system, it might be an advantage to retain salespeople to identify new leads. Some time ago, I had a conversation with a distiller in Wisconsin called Driftless Glen. He explained that his plans involved retaining a large wholesaler to move product. But when the wholesaler expressed a reluctance to identify new customers and markets, the distillery had to hire salespeople to comb the marketplace in surrounding states to identify new leads and new locations for the wholesaler to place product into. Wholesalers like to add a hefty markup to the price, but they do not necessarily want to work to justify it.

Operational Details: Who will be responsible for what at your distillery? Who will your suppliers be? Where will your operation be located? What are the details of your lease agreement for your location? Who will your bank be? What will be your hours of operation? What invoicing and accounting procedures will you adopt? What will your audit procedures be? What about your month end reporting procedures? What insurance policy coverage will you need? Cover it all. Describe your equipment. Describe the production methodology. Not every reader of the Business Plan will know what a mash tank is. Not

every reader will know what a blending tank is. Describe, describe, describe.

Regulations: Describe in detail what province, state and county government regulations you must abide by. Describe also the building, electrical and fire codes you must adhere to.

Funds and Uses: Detail how much money you will need to start up. What pieces of equipment must you buy and by when. Provide a spreadsheet detailing projected inflow and outflow of cash for three years into the future. Structure your spreadsheet around variable costs and fixed costs. Variable costs will include the cost of grain, yeast, enzymes, bottles, caps, labels to make a batch of alcohol. Fixed costs will be your monthly costs of rent, utilities, insurance, advertising, wages, telephone, internet, fax, security system and so on. Next figure out what price you must adhere to such that after provincial or state tax mark-ups are applied the bottle of spirit is still decently affordable to consumers. Assume a modest number of bottles only in your sales figures. Remember, a start-up craft distillery is a new product, an unknown entity. Coming up with three years of sales projections is hard. Be sure to assume modest volumes and modest growth rates. Do not make the fatal error of assuming huge initial sales.

I am aware of a situation in which a banker kept rejecting a craft distillery loan application until such time as the applicant had significantly upped the projected sales numbers. Apparently this banker had to impress someone at head office. The applicant kept inflating his sales projections more and more out of proportion until the banker approved the loan. This distillery’s actual sales numbers are nowhere close to what was forecast and now every month is a struggle to make ends meet and to pay the bank loan.

I am aware of a situation in which wild sales assumptions were made. Bank loans were taken out, both persons involved in the project quit their day jobs, and over-expenditures were incurred on equipment. When reality hit home, they both ended up taking day jobs again. Craft distilling was not the bliss they thought it would be. Their distillery was listed for sale in early 2021.

Do not get frustrated if it takes you time to get your Business Plan finalized. There are a lot of moving parts in the plan. Do not make hasty, unrealistic sales forecasts. If the project does not make economic sense, do not force it into being. Re-evaluate your choice of equipment and look at more affordable locations.

Crowd Funding: If you are contemplating using a crowd funding platform to raise money, you will need a solid plan to present to participants. Crowd funding is viewed through a different lens in different countries. In America, the Obama administration passed a 2016 bill called the Jobs Act. Title 3 in this Act provides for crowd funding from accredited and non-accredited individuals. A non-accredited person has a net investible liquid net worth of less than $1 million. The sensibility of crowd funding is that no one person is putting in enough money to damage themselves financially if the venture fails. You are not giving up equity in your business. Instead you will be offering perks like a T-shirt, a bottle of gin sent to each small investor every year on their birthday, a chance to work for a day in the distillery, a chance for an investor to have a recipe named after themselves. The perks awarded will be a function of how much money a person puts into the crowdfunding effort. Typical crowdfunding platforms include WeFunder, IndieGoGo, Kickstarter, Dreamfunded, Fundable and Barnraiser. When deciding on a platform, be sure to verify that the platform endorses alcohol-related ventures. If you are unsure how it all works, it is wise to consult an attorney experienced in these matters. Different states have different cap levels on monetary amounts.

In Canada, investing is governed by the various provincial securities agencies. Best to chat with them to see what, if any, requirements or stipulations they have. When I inquired in 2020, the Saskatchewan Securities Commission said a business engaging in crowd funding was required to submit a list of participants to the Commission.

In the U.K., there will be regulatory requirements governing crowdfunding as well. In the 5-day workshops, the shining example that I use from the U.K. is craft brewer, BrewDog. Through crowdfunding, they have tapped into some ripe sentiment amongst the younger generation and have raised staggering amounts of money for expansions.

You will need a video to go along with your crowd funding pitch and business plan. A well-made video will help you capture the emotion of the potential investor. Look around on-line and you will find some BrewDog videos from past crowdfunding campaigns. Look at how the video choreography uses motion and action to draw the viewer in. Take note of their irreverent attitudes. For a lower budget approach, look around on IndieGoGo for an old video for Kettle River Brewing in Kelowna, British Columbia. This is a video done at low cost/no cost. The video work was done by local talent and the voice over was apparently done for free by their bookkeeper. They managed to raise a portion of what they were seeking.

However, not all crowdfunding efforts are a success. Search around on Kickstarter for an old video link to Murica Moonshine. This video was crafted by professional actors and it was well scripted. But, at no point in time did it address the notion that craft distilling is now legal. In fact, one is almost left with the sense they are doing something illegal with the funds they hope to raise. Also, at no point do they ever say who the key players are and where they will be setting up the distillery. The very simple has been totally overlooked. The fund raising was a flop. I came across another failed effort in 2017 in which the entire sales pitch was made by the former Master

Distiller from Four Roses Bourbon in Kentucky. He waxed prophetically about his 45 years of experience and how he wanted to build a $2 million dollar bourbon distillery. The entire effort failed to raise the desired funds. People apparently had no interest in a sales pitch that failed to illustrate how the project would differ from a big corporate distillery. Had he described how he wanted to build a small craft distillery and maybe mentor a new generation of distillers and make a product suited for the millennial generation, he might have succeeded. As of October 2020, he was still trying to raise money. This gentleman has a wealth of knowledge. He just needs to jazz up his sales pitch and tug on people's emotional heart strings.

Private Placements: It is possible to ask individual investors for more substantial amounts of money. In this era of low interest rates, money sitting in a bank account earns nothing. People are looking for alternative investments. To assist you with this, you will need an attorney well skilled in the legalities of raising venture capital money. In America you will be dealing with SEC Rules 504, 505 and 506. In Canada, your legal counsel will be filing paperwork with the various securities commissions. One entity in Canada that has had success in finding larger investments for craft start-ups is Toronto-based firm FrontFundr.

Business Sense: Finally, you have to put your emotions aside and determine if your envisioned craft distilling project even makes sense. As you do some rudimentary calculations, assume modest sales levels and start with ample working capital to sustain the business for at least one year.

What follows are a few basic examples that illustrate the economics of craft alcohol. Each example is based on the premise that 300 kgs (660 pounds) of grain will make about 300 bottles (750 ml size) of distilled alcohol at 40% alc/vol.

In these examples, the math assumes that un-malted grain is used which is cheaper than malted grain. It is further assumed that sales are 300 bottles per month. An assumption of $10 per square foot is made for rent of a building. Modestly priced assumptions are then included for utilities, insurance and advertising. No provision is made for wages to anyone. In each example, I have stated a wholesale price which is the landed cost price. Applicable taxes are then added to this landed cost figure. In these examples, I am using a retail shelf price of $45.60 per bottle. In my travels, this price level is typical for craft spirits that I see in liquor stores.

Example 1 is from Canada, where the province of Ontario imposes a 140% mark-up on spirits. Example 1 with its high taxation explains why the most populated province in all of Canada has fewer than 30 craft distilleries in total. In this example, sales of 3600 bottles in year 1 will result in a business operating loss of just over $29,000.

Example 2 portrays the same situation as Example 1, except in this example the distillery owns its building and has taken on zero debt. This example makes a critical point: In order to make a craft distilling project succeed in a high tax environment, the bank debt has to be kept to a minimum and ideally the distillery should own the building. Based on modest sales in Year 1 of 3600 bottles, the business will generate an operating profit.

Example 3 takes the same set of assumptions and sales levels as in Example 1 but in the context of a jurisdiction that imposes an 85% tax markup to the wholesale, landed cost. Notice the difference in operating loss. The key point is that a lower tax mark-up jurisdiction is more favorable than a high tax jurisdiction.

Bottles Sold in 1 Year	3600
Your wholesale price per bottle	$19
After **140%** Provincial Mark-ups – shelf price that consumer pays	$45.60
Annual Gross Revenue	$68,400
Cost of Bottle/Label/Cap/Box based on $4 per unit cost	$14,400
Cost of Grain/Yeast/Enzymes based on $0.75 per unit cost	$2700
Excise Canada Duty @$3.63 per bottle	$13,068
Annual Rent (assume 4000 sq. feet @$10 per sq. foot)	$40,000
Wages – You work for free.	$0
Annual cost of Phone/Fax/Internet/Security System	$2400
Utilities (natural gas heat, power bills for running air conditioning in Summer…)	$3000
Annual Insurance premiums on your equipment	$2000
Annual Maintenance, Cleaning supplies and Miscellaneous	$1200
Annual Advertising costs	$1200
Annual Principal + Interest Loan Payments to Banker (assume $100,000, 7 yrs, 6%)	$18,000
Annual Total Expenses	$97,968
Per Bottle Costs based on 3600 bottles	$27.21
NET GAIN (LOSS)	($29,568)

Example 1

Bottles Sold in 1 Year	3600
Your wholesale price per bottle	$19
After **140%** Provincial Mark-ups – shelf price that consumer pays	$45.60
Annual Gross Revenue	$68,400

Cost of Bottle/Label/Cap/Box based on $4 per unit cost	$14,400
Cost of Grain/Yeast/Enzymes based on $0.75 per unit cost	$2700
Excise Canada Duty @$3.63 per bottle	$13,068
Annual Rent	$0
Wages – You work for free.	$0
Annual cost of Phone/Fax/Internet/Security System	$2400
Utilities (natural gas heat, power bills for running air conditioning in Summer…)	$3000
Annual Insurance premiums on your equipment	$2000
Annual Maintenance, Cleaning supplies and Miscellaneous	$1200
Annual Advertising costs	$1200
Debt Re-payments	$0
Annual Total Expenses	$39,968
Per Bottle Costs based on 3600 bottles	$11.10
NET GAIN (LOSS)	$28,432

Example 2

Bottles Sold in 1 Year	3600
Your wholesale price per bottle	$19
After **140%** Provincial Mark-ups – shelf price that consumer pays	$45.60
Annual Gross Revenue	$68,400

Cost of Bottle/Label/Cap/Box based on $4 per unit cost	$14,400
Cost of Grain/Yeast/Enzymes based on $0.75 per unit cost	$2700
Excise Canada Duty @$3.63 per bottle	$13,068
Annual Rent (assume 4000 sq. feet @$10 per sq. foot	$40,000
Wages – You work for free.	$0
Annual cost of Phone/Fax/Internet/Security System	$2400
Utilities (natural gas heat, power bills for running air conditioning in Summer…)	$3000
Annual Insurance premiums on your equipment	$2000
Annual Maintenance, Cleaning supplies and Miscellaneous	$1200
Annual Advertising costs	$1200
Annual Principal + Interest Loan Payments to Banker (assume $100,000, 7 yrs, 6%)	$18,000
Annual Total Expenses	$97,968
Per Bottle Costs based on 3600 bottles	$27.21
NET GAIN (LOSS)	($9,264)

Example 3

Example 4 takes the same sales assumptions as in Example 3. The tax mark-up is set at 85%. Example 4 shows that the distillery owns its own building and carries no debt. Lower tax mark-up jurisdictions are favorable, especially when a business is not burdened with rent payments and debt payments.

Work up a variety of situations for your jurisdiction and see how the numbers crunch out. Be realistic in terms of what you think you will pay for rent, advertising, and other overhead items. If you over-inflate your sales numbers to make things look rosy, you are only fooling yourself.

In these various examples, consider what would happen to your numbers if you decide that some of the distillate made each month was going to be set aside and aged for five years in oak casks. That means no sales income on that distillate for those five years.

Example 5 is from a US state operating on the 3-Tier model where the craft distiller has to engage a wholesaler to place product into retail locations. Note the hefty markup applied by the wholesaler.

Example 6 portrays the same situation, except this time the distillery owns its building and has taken on zero debt. Once again, the key point is a distillery ideally should keep its bank debt to a minimum and own its building.

Bottles Sold in 1 Year	3600
Your wholesale price per bottle	$24.64
After **85%** Provincial Mark-ups – shelf price that consumer pays	$45.60
Annual Gross Revenue	$88,704

Cost of Bottle/Label/Cap/Box based on $4 per unit cost	$14,400
Cost of Grain/Yeast/Enzymes based on $0.75 per unit cost	$2700
Excise Canada Duty @$3.63 per bottle	$13,068
Annual Rent	$0
Wages – You work for free.	$0
Annual cost of Phone/Fax/Internet/Security System	$2400
Utilities (natural gas heat, power bills for running air conditioning in Summer…)	$3000
Annual Insurance premiums on your equipment	$2000
Annual Maintenance, Cleaning supplies and Miscellaneous	$1200
Annual Advertising costs	$1200
Debt Re-payment	$0
Annual Total Expenses	$39,968
Per Bottle Costs based on 3600 bottles	$11.10
NET GAIN (LOSS)	$48,736

Example 4

Bottles Sold	3600
Price You Get per Bottle (assume 750 mls or 0.2 US Gallons @40%) when you pass it to the Wholesaler.	$19
State Tax $12 per gallon = $2.40 per bottle	$2.40
Federal Tax @$13.50 per Proof Gallon = $2.15 per bottle	$2.15
After tax shelf price after wholesaler 30% margin and retailer 20% margin	$36.75
Annual Gross Revenue	$68,400

Cost of Bottle/Label/Cap/Box based on $4 per unit	$14,400
Cost of Grain/Yeast/Enzymes based on $0.75 per unit	$2700
Annual Rent (assume 4000 sq. feet @$10 per sq. foot)	$40,000
Wages – You work for free.	$0
Annual cost of Phone/Fax/Internet/Security System	$2400
Utilities (natural gas heat, power bills for running air conditioning in Summer…)	$3000
Annual Insurance premiums on your equipment	$2000
Annual Maintenance, Cleaning supplies and Miscellaneous	$1200
Annual Advertising costs	$1200
Annual Principal + Interest Loan Payments to Banker (assume $100,000, 7 yrs, 6%)	$18,000
Annual Total Expenses	$97,968
Per Bottle Costs based on 3600 bottles	$27.21
NET GAIN (LOSS)	($29,568)

Example 5

Bottles Sold	3600
Price You Get per Bottle (assume 750 mls or 0.2 US Gallons @40%) when you pass it to the Wholesaler.	$19
State Tax $12 per gallon = $2.40 per bottle	$2.40
Federal Tax @$13.50 per Proof Gallon = $2.15 per bottle	$2.15
After tax shelf price after wholesaler 30% margin and retailer 20% margin	$36.75
Annual Gross Revenue	$68,400

Cost of Bottle/Label/Cap/Box based on $4 per unit	$14,400
Cost of Grain/Yeast/Enzymes based on $0.75 per unit	$2700
Annual Rent (assume 4000 sq. feet @$10 per sq. foot)	$0
Wages – You work for free.	$0
Annual cost of Phone/Fax/Internet/Security System	$2400
Utilities (natural gas heat, power bills for running air conditioning in Summer…)	$3000
Annual Insurance premiums on your equipment	$2000
Annual Maintenance, Cleaning supplies and Miscellaneous	$1200
Annual Advertising costs	$1200
Annual Principal + Interest Loan Payments to Banker (assume $100,000, 7 yrs, 6%)	$0
Annual Total Expenses	$39,968
Per Bottle Costs based on 3600 bottles	$11.10
NET GAIN (LOSS)	$28,432

Example 6

16

How Are Commercial

Products Made?

To help you keep small batch craft distilled alcohol in perspective, it is interesting to look at how the large commercial operators generally make their products.

Canadian Rye Whisky: A 1999 paper written by J.A. Morrison (1) that appeared in the Alcohol Textbook casts valuable light on the production of Canadian Whisky. He does not identify his employer, but I rather suspect he was with Alberta Distillers.

He explains that the water chemistry is adjusted so that there is at least 75 ppm calcium content. Stillage liquid from a prior distillation run is then added to adjust the pH of the mash water. Next, milled rye grain is added (along with the water) to a mash vessel and steam injection used to raise the mash temperature to 65ºC. Two enzymes are added and a hold period initiated to allow the enzymes to break down the endosperm cell walls and release the starches. Temperature is next raised to 85ºC to complete the gelatinization of the grain. After a hold period at this temperature to complete the task of converting starch to fermentable sugar, the mash is pumped through coolers and directed to the fermenter vessel. The pH of the mash in the fermenter is then further adjusted. The water to grain ratio is 5:1. The fermenters have internal cooling coils and a typical ferment will last 3 days.

To provide material for fermenter pH adjustment, a small mash of rye grain is prepared and inoculated with Lactbacillus delbruecki bacteria. The bacterial culture is allowed to flourish causing the pH of the small batch of mash to drop to 3.6. This acidified rye slurry is then heated to kill off the bacteria. The mash slurry is cooled and subsequently pitched into the fermenter, although the paper does not state what the pH target is.

After 3 days, the fermented mash with about 8% alcohol in it is passed to a surge tank called a beer well. The mash is fed from the beer well to the top of a stripping column containing 45 trays (plates). Steam flows from the bottom of the column towards the top and as the mash descends from the top of the column towards bottom and meets the upward flow of steam heat energy, the alcohol content is vaporized off. The vapors rise to the column top where they exit at about 57% alcohol strength. The stillage coming out the bottom of the column will have virtually no alcohol left. The stillage is dried in a rotary kiln and sold as animal feed to the cattle industry.

The distillate emerging from the top of the column is collected and mixed with water to achieve about 28% abv. This mixture is directed through a hydro extractive column. This column operates on the principle that higher alcohols, esters and aldehydes are less miscible in water than ethanol is. As the water mixes with the higher alcohols, esters, aldehydes, it alters their vapor pressure and they exit the top of the extractive column as a vapor. Because ethanol is miscible in water, the temperature of the stream entering this extractive column is never high enough for the ethanol to turn to vapor. What emerges from the bottom of this column is a stream containing ethanol and a few of the remaining higher alcohols and esters that did not completely volatize off. The strength of this stream is about 12% abv.

This stream is then fed into the re-boiler at the bottom of a 60 plate rectifying column. What comes off the top of the rectifying column will be 94.5% alcohol. At this strength, there will be only a small trace amounts of various higher alcohols to impart subtle flavors to the finished product. This distillate is de-facto a vodka. The collected 94.5% alcohol is diluted down to a suitable strength for oak barrel ageing.

At a typical large distillery, this process could also be unfolding in parallel on a separate still(s) using different grain varietals. Canadian Whisky is generally a blend of distillates from different grains. For example, it is my understanding that Crown Royal Whisky is a blend of distillates from five grain types. It is further possible, that in a typical large distillery, there will be a distillation apparatus configured to deliver distillate at a lower alcohol content that comprises some higher molecular weight alcohols. It is my understanding that Canadian Club Whisky is a blend of 68% abv distillate and 95% abv distillate, with the 95% distillate comprising the majority.

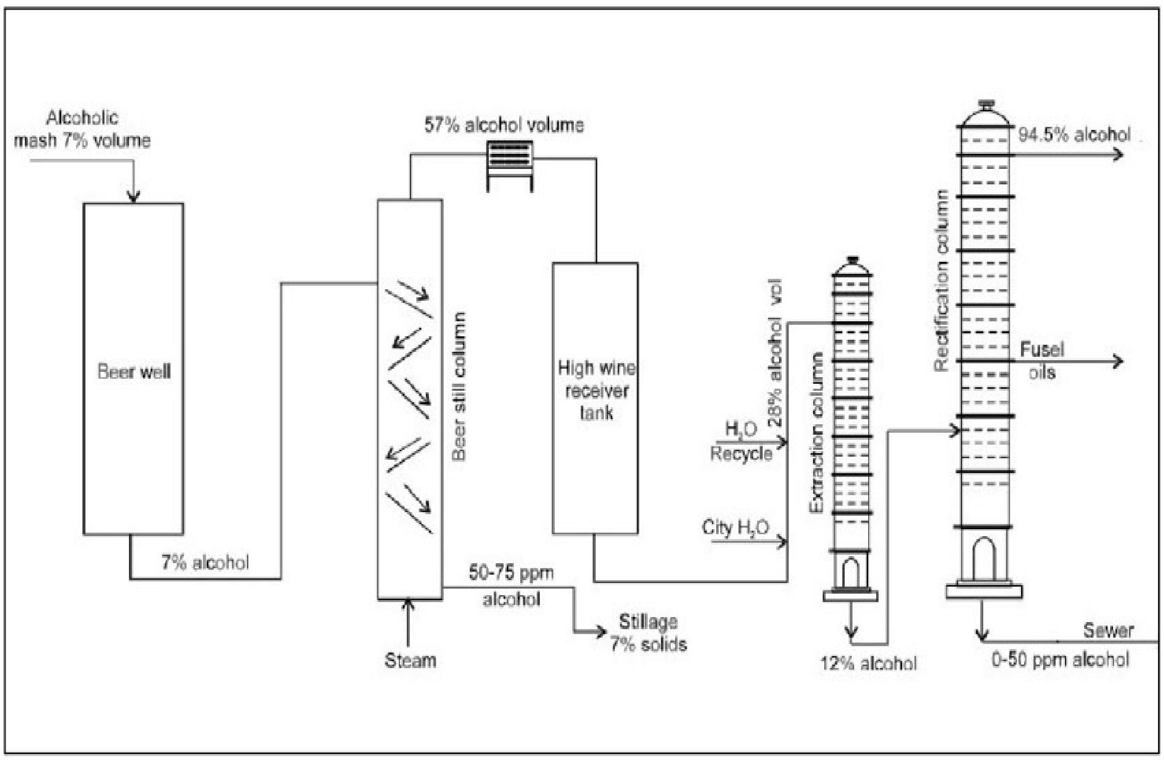

Figure 60 – Schematic for Canadian Whisky

The diagram in Figure 60 illustrates the Canadian Whisky distillation process.

Bourbon and American Whisky: The process mentioned above is similar to that used in making bourbon, except for bourbon, the distillate is passed through a very large pot still so that the alcohol taken off will be less than or equal to 80% abv. This lower alcohol strength and the presence of higher molecular weight alcohols explains why a typical bourbon has more mouth feel, body and texture than a typical Canadian Whisky. That does not necessarily make Canadian Whisky a bad thing. Canadian Whisky is just different and some would argue it should be appreciated for what it is instead of having it compared it to other whisky styles.

Bourbons will usually have about 70% corn in the mash bill with the balance made of wheat, rye and barley. The big name bourbon brands will be a blend of various ages of distillate.

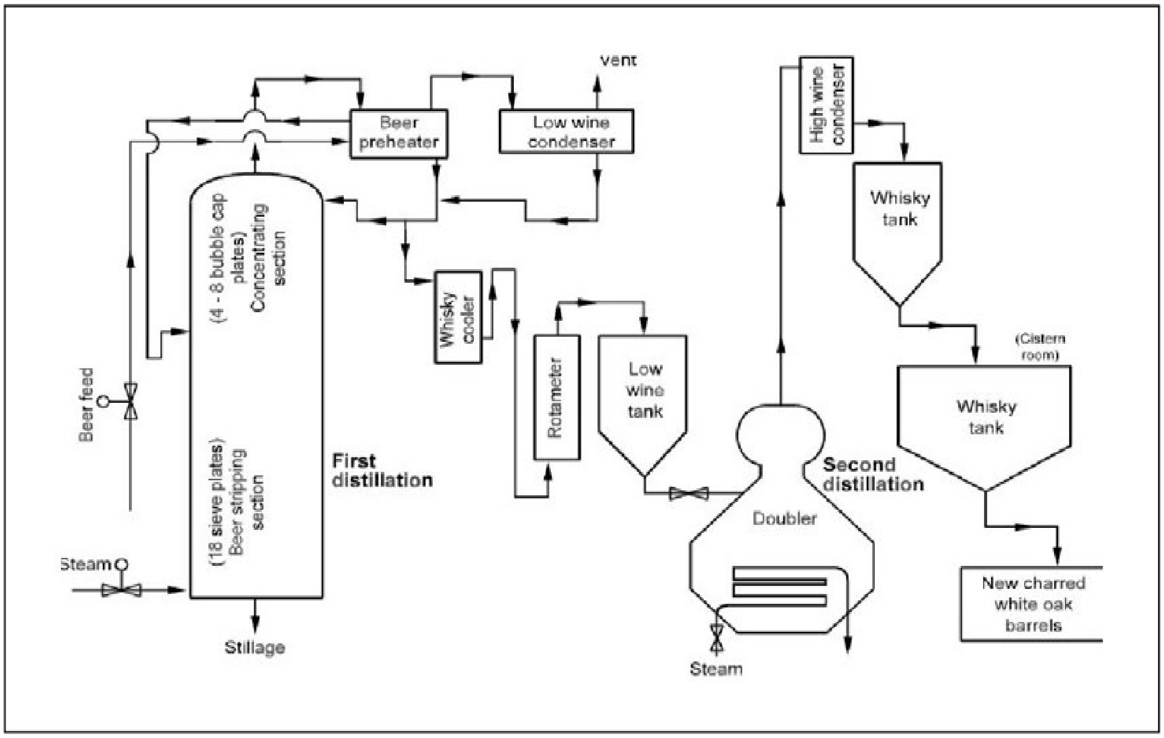

Figure 61 – Schematic for Bourbon Whisky

The schematic in Figure 61 illustrates the general bourbon process.

Vodka: If the general process illustrated in Figure 60 had at least two other columns after the extractive column, a higher strength distillate could be obtained. This higher strength material could then be used for vodka. As I mentioned in an earlier chapter, the ethanol factory at Unity, Saskatchewan has a total of 8 columns in its process.

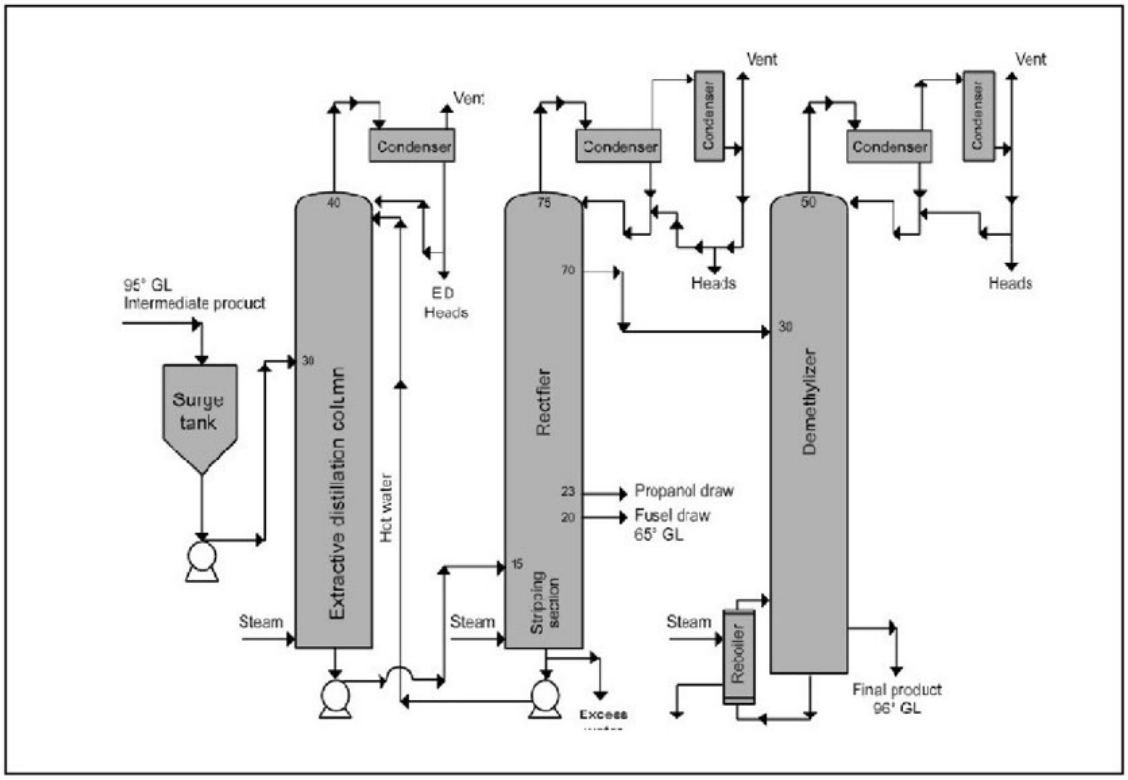

Figure 62 – Schematic for Vodka distillate

Rum: Rum is made from molasses or cane juice. Earlier, I summarized the molasses making procedure with reference to sugar cane juice being mixed with lime (calcium hydroxide) and heated under vacuum. Centrifuging then separates the sugar crystals from the residual sludge (molasses).

There are three strains of yeast that can be used to ferment molasses: saccharomyces cerevisiae, schizosaccharomyces pombe and saccharomyces bayanus. Molasses is mixed with water to a starting gravity of 16 to 20ºBrix. Yeast is added and fermentation will proceed rapidly, taking about 24 hours to substantially complete. Recall, that yeast needs amino acids and small peptides as nutrient. A rum maker will add ammonium sulphate as a nutrient source and also sulfuric acid (or stillage from a prior distillation run) to lower the pH to a desirable level for the yeast.

Some rum makers use pot stills to make their product. These pot stills might be arranged in a retort system. In a retort process, alcohol vapors from one pot enter a second pot. These vapors heat the liquid in the second pot and vapors soon begin to rise from the second pot. The vapors will then travel to a third pot setup and then on to a condenser. The schematic in Figure 63 illustrates a retort system.

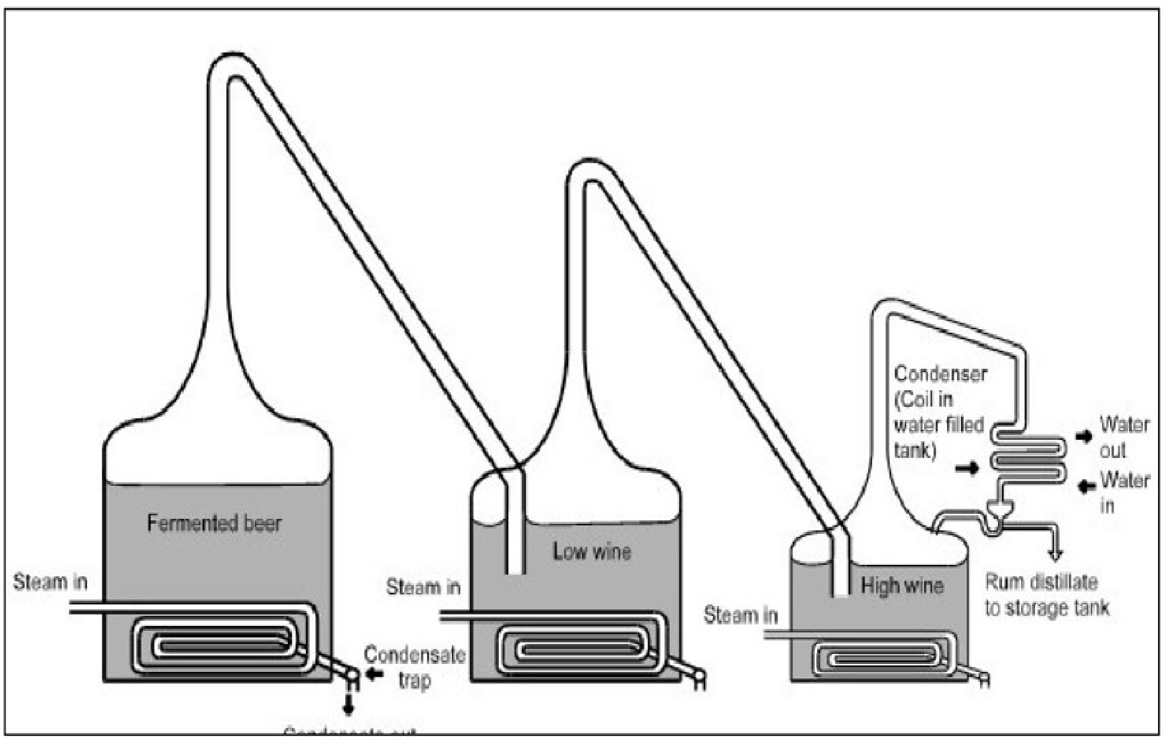

Figure 63 – Schematic for Rum retort setup

Rum made using pot distillation will contain esters and heavier molecular weight alcohols which will make it more flavorful.

Some rum makers use column stills to produce distillate that is approaching 95% abv. The overall lack of complexity is compensated for when the customer mixes the rum with cola or uses the rum in a cocktail.

Ageing of rum remains an opaque subject and one that I would like to learn more about. I have had 12 year old rum from Jamaica. I have 12 year old rum from Panama. Both made in a similar fashion, yet both widely different in texture and mouthfeel. The profile of a barrel aged distillate can be influenced by heat and humidity. In a high humidity environment, such as the Caribbean, there is a tendency for alcohol to evaporate from the cask before water does. This can upset the flavor profile of the distillate being aged. The Caribbean islands are volcanic and somewhere on a typical island there likely will exist areas of higher altitude. By situating an ageing warehouse at a higher elevation, advantage can be taken of the slightly cooler temperatures, breezy airflows, and lower humidity. During ageing, some rum makers reportedly go one step further and add plums or raisins to the barrels to provide extra layers of flavor. The chemistry of rum is a complex list of chemical esters, phenols and higher alcohols. Taste some Ron Zacapa from Guatemala, or some 15 year old Matusalem Gran Reserva from the Dominican and the complex layers of flavor will immediately be evident. I have given up trying to understand how rum is aged. I have resigned myself to just enjoying it. I remain convinced that the Caribbean ecosystem with its unique flora, fauna and climate is largely responsible for the taste profile of rum. I have tasted rum made by craft distillers in Canada and there is no comparison to what is made in the Caribbean.

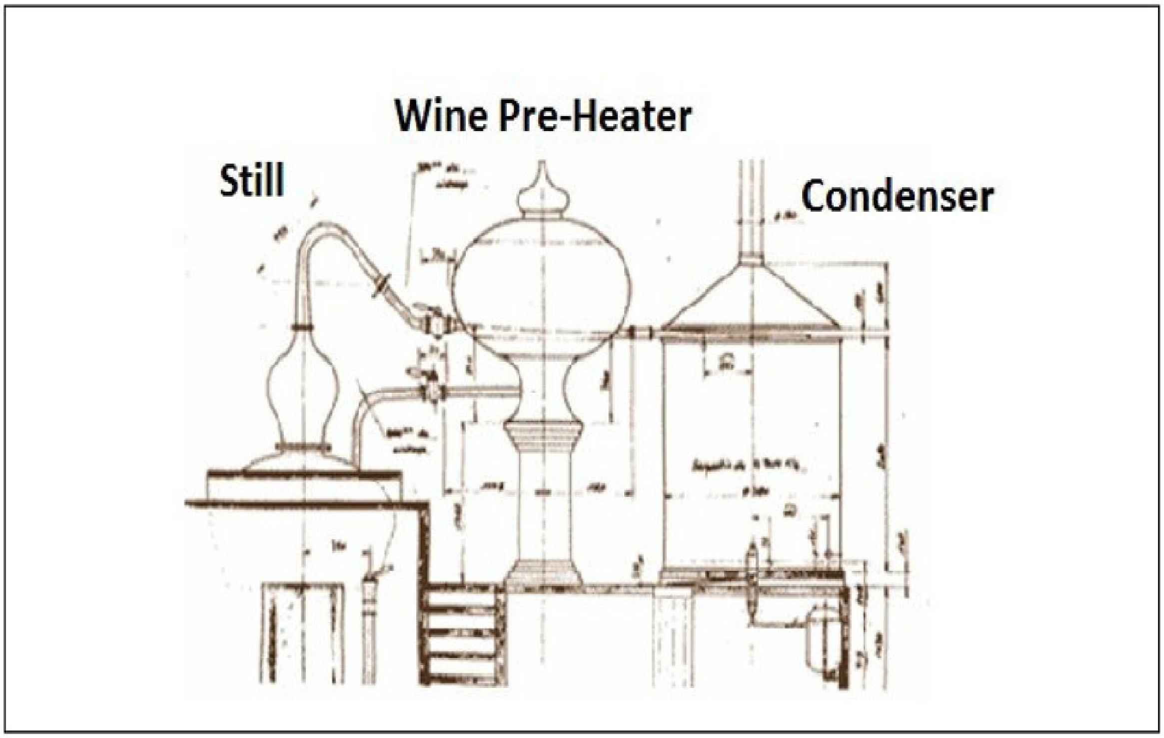

Figure 64 – Schematic for Rum retort setup

Cognac / Brandy: Cognac and brandy are often made on an al-Ambic style of still. Figure 64 illustrates a Charentais style of al-Ambic still. The unique shape of this design influences the amount of reflux and the flavor in the final distillate.

Wine grapes are harvested in late Fall of a given year in the Cognac localities of France. The grapes are crushed and the juice fermented. Starting in February of the immediately following year, the distillers get to work double distilling the fermented wine. In the first run, the still is charged with fermented wine and the wine pre-heater tank is also filled. As the distillation proceeds, the distiller will take warmed wine from the pre-heater and feed the still as required.

In a sense, the first run (la premier chauffe) in the process is almost a continuous type affair. The distillate coming off the still is divided into heads, hearts and tails. The heads are discarded. The hearts (called Brouillis) will average about 30% abv. The tails will be kept for the second pot distillation run. In the second run (la bonne chauffe), the Brouillis and tails are charged to the still. Any minor trace amount of residual heads coming off this run are discarded. The hearts are divided into two fractions. The first fraction (averaging about 70% alc) is called Cognac and the second fraction at a lower strength is called le Secondes. By law, all the distilling has to be done by March 31. As of April 1, the ageing process begins.

Scotch Malt Whisky: Scotch Single Malt Whisky is a double pot distillation process. In the first part of the process, the wash still is charged with fermented barley wash. The distiller will run the still until the alcohol content of the liquid flowing from the still is practically zero. The collected distillate from several of these runs is then charged to a spirits still which is run until the alcohol coming off is about 50% alc. The average strength of the spirits still distillate will be around 68% alc. This will vary widely between distilleries based on still design and shape. The art to distilling with two pots focuses on how full they are charged, the heating rate, and the ambient temperature in the still house.

In 2018, I had a tour of the Abercrombie Copper Works in Scotland to see first-hand the care to which Diageo goes to in order to maintain its copper stills. Figure 65 shows the neck portion of a still that was in for refurbishment.

Figure 65 – Abercrombie Copper Works

Figure 66 illustrates the parts of a typical pot still.

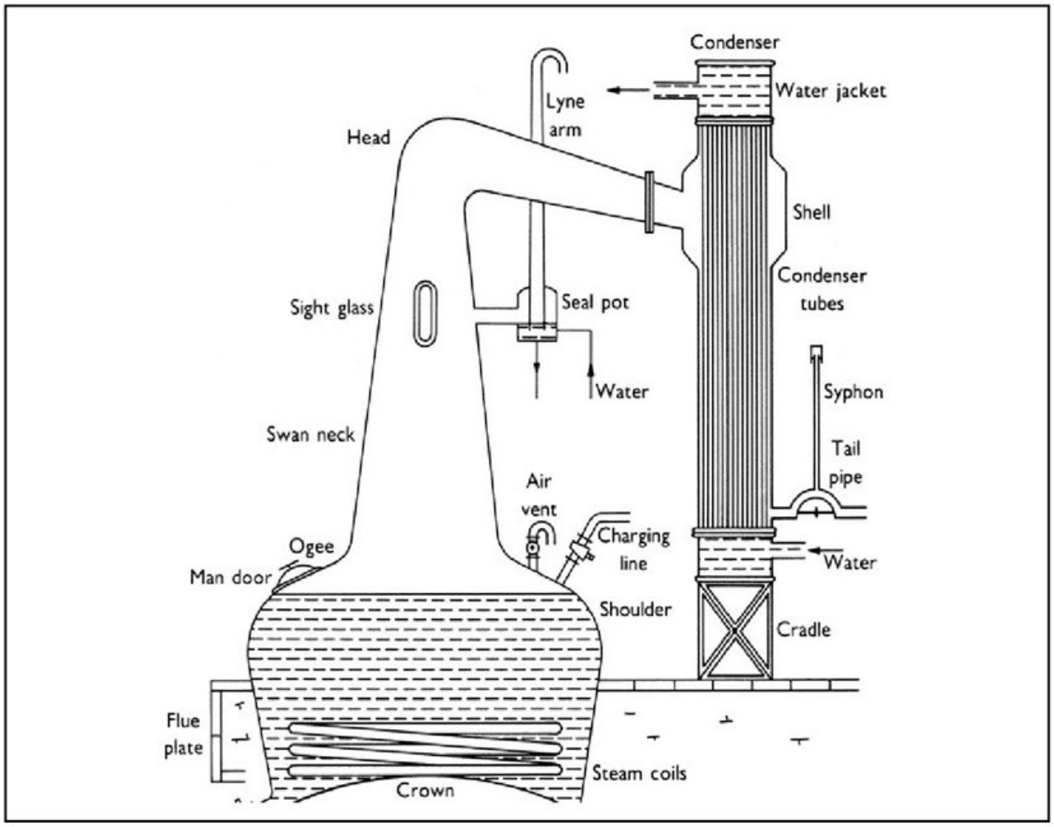

Figure 66 – Schematic for a Pot still

Scotch Grain Whisky: Scotch Grain Whisky is distilled on continuous stills. I have never been to one of the large grain distilleries in Scotland as they are not open to the public. However, it is my understanding that a modern variant of the Coffey still is used. Earlier in this book, I provided a schematic of a Coffey still. The picture in Figure 67 illustrates what a more modern Coffey still looks like.

Figure 67 – Modern Coffey Still (North British Distillery)

Irish Whisky: You likely know from experience that Irish Whisky is smoother than a typical Scotch. This is the result of the triple pot distillation method. Figure 68 provides a flow diagram for Irish Whisky distillation. The product stream from the wash still is divided into two parts: the higher strength low wines and the weaker strength low wines. The distinguishing point between high wines and low wines is around 50% abv. Once enough low wines have been collected, a distillation run is carried out in the low wines still. The stronger part of the product stream (strong feints) is sent to the spirit still while the weaker distillate is set aside for re-distillation. Eventually the spirit still will have enough material (strong low wines + strong feints) for a distillation run. The product stream coming off this run will be 82-85% abv. This distillate is watered down to somewhere around 60% abv and loaded into oak casks for ageing. To clarify one more facet of the Irish process, distillate destined for making a blended Irish Whisky might only get distilled

twice. The label on a bottle of Irish Whisky will clearly state whether triple distillation has been used or not.

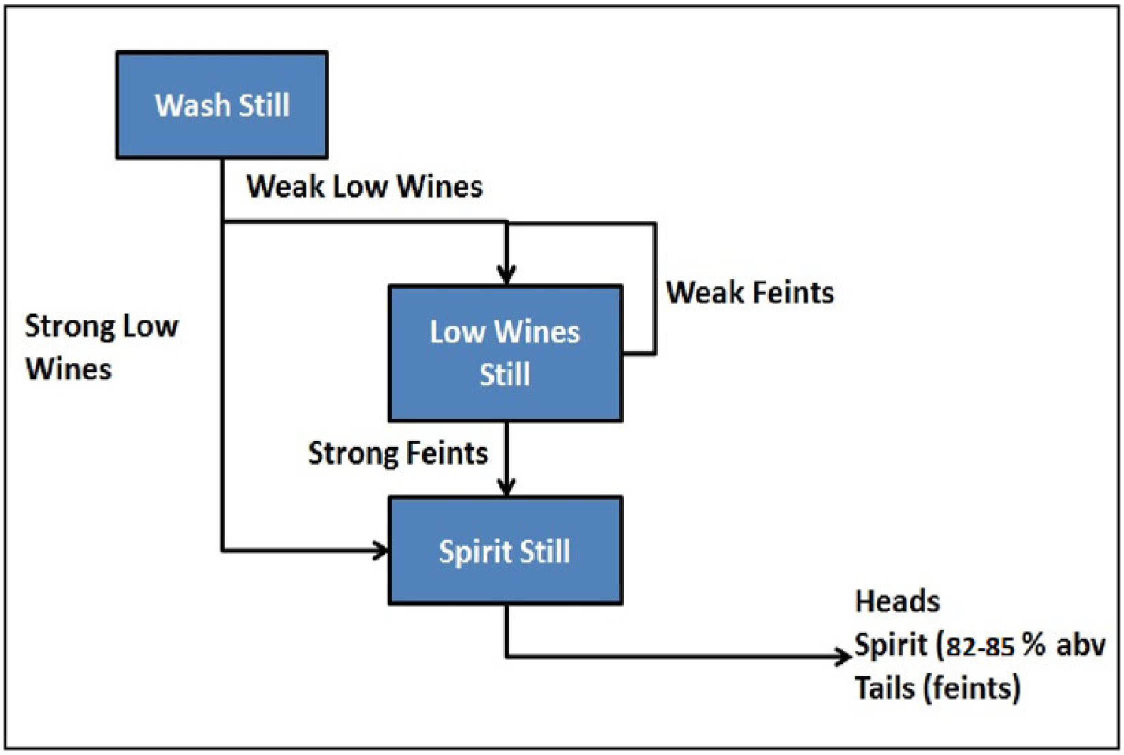

Figure 68 – Flow diagram for Irish Whiskey

As I complete these edits, I am enjoying the occasional dram of Bushmills 16 year Old single malt Irish Whisky. Normally with a single malt Scotch I will add a couple mls of water (1/2 teaspoon) to my good sized dram to open it up. With the Bushmills triple distilled product, a few drops of water is all that is needed to open up the full array of flavors. I am a relative newcomer to Irish Whisky, but my first impressions are indeed favorable.

Tequila: Traditionally Tequila has been a double pot distilled product where the procedure is similar to that described for Scotch Malt

Whisky. However, there is more and more Tequila being made on column stills as demand soars. Earlier in the book I discussed the agave raw material and its makeup. I also discussed the ageing nomenclature and the use of sugar as a raw material for the unaged products.

Gin: The big commercial distillers, like Bombay Sapphire at its Laverstoke Mill complex for example, generally use the vapor infusion technique which is a batch distillation approach. A large copper pot still (with column) will be filled with hi-proof grain alcohol and water. The vapors will rise up through the column and then pass into a copper attachment outfitted with mesh baskets. The baskets contain the various botanicals used in the gin recipe. The vapors pass through the botanicals, stripping out the flavorful essential oils, and then carry onwards to the condenser. At the end of the batch run, the still is emptied, the baskets of spent botanicals emptied and another batch readied. This routine apparently goes 24/7 with military-like precision, according to one of my professors who once worked at a gin distillery.

References

1 Morrison, JA, (1999) Production of Canadian Rye whisky :the whisky of the prairies. In: The Alcohol Textbook, Nottingham University Press, pp:169-194.

17

Small Scale Research

A few years ago, I wrote a book called The Recipe – Reviving the Lost Art of Home Distillation. I have decided that this fifth (and final) edition of Field to Flask might just as well include some of the information from The Recipe, especially since The Recipe is banned for sale in many worldwide locations owning to its provocative title.

I cannot stress enough the importance of taking time to engage in small scale distilling at home before making the leap into the highly competitive craft distilling arena In this book, I have discussed raw materials, fermentation, cleaning, water chemistry and distillation. All this information is applicable to everything you do on a small scale at home.

Equipment Needed

Grinding Mill: If using malted grain, a hand-cranked roller mill will suffice. Retail home brewing supply stores will sell roller mills for around $150. Inside the mill are two rollers with roughened surfaces. One roller is geared to turn slightly faster than the other as you turn the crank handle. The net result will be a ripping and shearing of the malted grain kernels. The spacing between the rollers can be adjusted to provide for varying degrees of grinding fineness. If a roller mill is not available in your area, give some thought to OntarioBeerKegs.com if you are in Canada. In the USA, take a look at MoreBeer.com. Figure 69 illustrates my hand-cranked roller mill.

Figure 69 – Roller mill

Figure 70 – Plate grinder

For un-malted grains, a standard hand-cranked roller mill will not suffice. Un-malted grains are much harder than malted grains and a roller mill does not have the strength to properly grind the hard kernels. I have experience with two different methods for milling un-malted grains: a plate grinder and a VitaMix blender.

A picture of my hand-cranked, Corona Mill plate grinder is shown in Figure 70. This unit, comprises two plates. One plate is stationary and the other plate turns with the crank handle. The action of plate turning against plate with grain kernels sandwiched in between tears the grain kernels apart. The only drawback to this unit is the physical energy required, with around 1,350 turns of the crank needed to grind 8 kgs of grain.

Figure 71 – VitaMix blender

A VitaMix is a high speed, state of the art blender that quickly grinds hard grain kernels. Figure 71 illustrates my VitaMix unit. I paid a significant sum for my VitaMix at a fancy home-cooking store. It was only later that I learned I could have gotten it much cheaper at Costco Wholesale. I am very impressed with the VitaMix and its ability to quickly grind up grain for grain mashes and fruit for fruit mashes. Just remember to remove the pit or stone from fruit before grinding in the VitaMix.

Mash Kettle: You can spend a little or a lot on a mash kettle. Most of the mash kettles available on the market have been made in China. Nothing wrong with Chinese kettles necessarily, just remember that the quality of construction will fall short of any similar kettle made in North

America. If you want a top quality mash kettle made in North America, Blichmann Engineering makes a variety of kettles from 304 stainless steel.

Figure 72 – Mash kettle and burner

I tend to think of Blichmann Engineering as the Rolls Royce of equipment makers. My budget falls a bit shy of the Rolls Royce category so I have opted for cheaper mash kettles made in China. In Canada, a good vendor for equipment for brewing and distilling is OntarioBeerKegs.com. In the USA, take a look at MoreBeer.com. Go to your local book store and buy any magazine dedicated to home beer brewing and you will see adds for mash kettle equipment makers. I suggest getting a mash kettle that is in the order of 60 Liters (15 gallons). Figure 72 shows one of my mash kettles.

Heat Source: For a source of heat for a mash kettle, big box stores like Home Depot, Lowe's or WalMart will have propane fired burners for a reasonable price. In Figure 72, my mash kettle can be seen resting on a burner from WalMart that I bought for $50.

Once you load your ground grain and water into your mash kettle, you will need some way of stirring and agitating it. True, one could purchase a long-handled spoon from a home brewing supply store, but there is a more expeditious method. I went to Home Depot and purchased a paint mixing stick for $9.99. This stick fits into my standard electric drill as shown in Figure 73.

Figure 73 – Agitator and drill

This setup quickly and easily ensures that a grain-water mash mixture is thoroughly stirred.

Cooling: Once you have completed a mash, it must be cooled to a suitable temperature so that yeast can be added. I use an immersion chiller made from copper tubing. Cold water flows in one end and as the water circulates through the copper tubing, it picks up heat from the mash. Circulating water through the immersed chiller for about 45 minutes will drop the temperature of a hot mash down to 30ºC, at which point yeast can be added. Figure 74 illustrates a typical copper coil immersion chiller. These coiled units can be purchased at any home brew store or on-line supplier, but expect to pay. A cheaper alternative involves purchasing a coil of 3/8 inch copper tubing and making your own immersion chiller.

Figure 74 – Immersion chiller

There are four basic instruments that are also needed for small scale work: a thermometer, a refractometer, a pH meter and a digital weigh scale all as illustrated in Figure 75.

The thermometer can trace its rudimentary beginnings back to 1593 and the time of Galileo. In the early 1600s, Italian inventor Santorio took Galileo's basic design and added a numerical scale. In 1645, Italian nobleman Ferdinand II developed the first ever liquid-in-glass thermometer. In 1714, German scientist Daniel Fahrenheit improved Ferdinand's design by using mercury as the liquid inside the glass. The thermometer unit shown at far left in Figure 75 cost me $42 at a brewing supply store. It is rugged and reliable.

In the early 1800s, scientists Karl Balling, Adolf Brix and Fritz Plato all were developing measuring scales to record the sugar concentration of solutions. Today, the most commonly referred to scale is the Brix scale where 1 degree Brix is the equivalent of 1 gram sucrose in 100 grams of solution.

Figure 75 – Instruments

The optical refractometer comprises a lens and an eyepiece. The user will place several drops of liquid to be tested on the lens and then look through the eyepiece. The scale is calibrated so that with pure water on the lens a reading of 0 will result. Scales on refractometers usually go from 0 to 35º Brix. Drops of sugary solution on the lens will cause light to refract (bend) as it passes the lens. This will cause a shaded line to appear on the scale which the viewer can then read. Refractometers are easy to find. In Canada, OnterioBeerKegs.com sells them for less than $50. In the USA, take a look at an industrial supply store like National Industrial Supply. An elegant way to capture a sample of liquid from your mash kettle is to use a tea strainer. Reach into the mash kettle, take a sample of mash into the strainer and allow drops of liquid to drip onto the refractometer lens. Tea strainers can bought for $3 at any shop that sells coffee beans and tea leaves.

The first rudimentary pH meter was developed in 1906 by Fritz Haber. In 1936, American scientist Arnold Beckman refined the device. pH is a mathematical construct based on the negative base 10 logarithm of hydrogen ion concentration. The pH scale goes from 1 to 14 with pH 1 being a strong acid and pH 14 being a strong base. Water is around pH 7. pH meters are especially useful for dealing with un-malted grains and artificial enzymes where the pH of the mash should be at the enzyme manufacturers recommended level. pH meters are easily obtainable from home brewing supply stores. pH meters require periodic calibration. This is normally done by turning a small set screw while holding the tip of the meter in some calibrating/buffer solution. I make it a point to check the calibration of my pH meter every 5 or 6 times I use it.

A good digital weigh scale will see plenty of use in your undertakings. I have found that WalMart has a decent selection of digital scales.

Fermenter: Once a mash is complete and cooled to 30ºC, it should be dumped into a suitable vessel for fermentation. I opt for simplicity when it comes to fermentation vessels. I purchased several 60 Liter plastic buckets from my local home brewing supply store. These buckets are made from food-grade plastic. Figure 76 illustrates a typical fermenter pail. About 10 minutes before adding yeast to your cooled mash, it is necessary to re-hydrate the yeast cells. The general rule that I advise is to add the yeast to sterilized warm water that is around 33ºC. Stir and dissolve the yeast into the water, let rest for 10 minutes and then add this slurry to the fermenter pail that contains the cooled mash.

Figure 76 – Fermenter pail

With the yeast added to the fermenter vessel, all that remains is to cover the vessel. Plastic fermenter pails will often come with a lid that has a pre-drilled hole for a fermentation lock. Secure the lid onto the vessel, insert the fermentation lock and fill it with water. For one reason or another, my plastic fermenter pails either do not have lids or the lids have been lost over the past three decades. With my fermenter vessel filled, I put a garbage bag over the pail and tuck the edges of the bag under the pail. Avoid the standard black household garbage bags as they often have been sprayed with an odor-neutralizing chemical. Purchase blue plastic re-cycling bags which are odor-chemical free. Figure 77 illustrates two of my ferments covered by plastic bags.

Figure 77 – Covered fermenter pails

Stills: For my small-scale research at home, I use al-Ambic stills purchased from www.copper-alembic.com in Portugal. Figure 78 illustrates one of my stills. I have never had any issues getting stills delivered from Portugal. I place my orders on-line and within two weeks the still arrives via Fed-Ex or UPS. The paperwork enclosed in the box with a still will reference the use of the still for decorative uses or for production of essential oils. Certainly helpful in the event a curious customs officer decides to inspect the contents of the box.

This vendor sells stills in sizes ranging from 1.5 liter to over 60 liters. In Figure 78 the still is resting on a hot plate. Hot plates work well for still sizes up to 20 liters. For sizes greater than 20 liters, a propane fired burner is recommended, similar to the one in Figure 72.

The copper stills from Portugal are all hand-hammered. As a result, fit between the lid and the pot will not be perfectly tight. The vendor advises making up a rye flour-water paste to seal the joint between the lid and the pot. As the still heats up, the rye paste bakes on and makes for a very secure seal.

There are two general styles of still available from the above-mentioned vendor. The regular variety is configured so that the swan neck tube fits into the tubing leading into the condenser. A bit of tape is required to secure the connection. The premium variety of still, at a slightly higher price point, will have a threaded connection to secure the swan neck to the condenser tubing. I highly recommend the premium version.

To keep the condenser cool, I fill the condenser pot with water and as the distillation run proceeds I add chunks of ice. The condenser is outfitted with an outlet port. I attach a piece of 3/8 diameter plastic hose to the outlet and let the excess water from the condenser drain off into a catchment container.

Care must be taken not add too many solids to these al-Ambic stills for fear the solids scorch during distillation and impart burnt flavors to the distillate. I take the precaution of straining my mash through a mesh bag or a cooking strainer (colander) prior to doing a distillation run.

Figure 78 – al-Ambic pot still

With any of these al-Ambic stills the secret is to heat them low and slow. You are not in a rush. You are not trying to meet a production deadline. You are trying to make a quality product that you will enjoy sipping. The other tip I can offer is not to overfill them. As they heat, the alcoholic liquid inside has a tendency to foam up. If any of the foam makes its way into the neck of the still, the alcoholic vapors will interact with this material. What drips out of your condenser may be an unsightly brown colored liquid. When I do a distillation run I never fill the still much beyond the level of the handles. This leaves plenty of room for foaming and bubbling to occur.

If you are interested in making vodka or whisky that is distilled to a higher alcoholic strength than you would get from an al-Ambic still, consider a column type of still design. There are a handful of vendors who offer these stills in the USA.

I have a personal preference for Hillbilly Stills from Barlow, Kentucky because my travels have taken me to visit their manufacturing facility in Kentucky. While there, I had a chance to witness up close and personal their team of craftsman working on the components that comprise a typical Hillbilly Still. Matt Haney and his Dad, Mike, are two of the finest southern gentlemen I have ever met. If you do purchase a Hillbilly still, a trip to Barlow, Kentucky is an absolute must. There are other vendors out there who are making Hillbilly knock-off, look-alikes. If you are contemplating one of these imitations, do your due diligence before placing your order.

A Hillbilly Still consists of a stainless steel pot that utilizes a 5500 watt heating element. This is the same element that is in a typical residential electric hot water heater. The heating element draws its power from a 220 Volt outlet wired to a 30 Amp breaker. This is the same type of outlet that a clothes dryer connects to. The stainless steel pot of a Hillbilly Still is available in 13 US gallon and 26 US gallon sizes. The copper column atop the stainless steel pot comes in two configurations, 4 plate and 6 plate. The 4 plate is ideal for making whisky distillate. The 6 plate is suited for making higher strength distillate. To make a distillate suitable for use in crafting a gin, I have had to add two extra sections into the column. The added surface area allows me to make 95% abv distillate. Figure 79 illustrates a typical Hillbilly Still.

The cooling water for the top section of the still (dephlegmator) and for the condenser comes from your garden hose. A section of garden hose will suffice to drain off the water flow to the dephlegmator. Another section of hose will be required to take away the water that flows through the condenser.

With any electrically heated still, one has to be cognizant of material burning onto the heating element. I take great care to filter my fermented mashes through mesh bags or colander sieves to remove solids. The one exception to this practice is rye grain. I find that the VitaMix grinder pulverizes the brittle rye kernels to the point that it is not always possible to filter or sieve out the fine solids. When making rye distillate, I mill my rye grains using the old-style, hand-cranked plate grinder which gives me a coarser grind. It is then easier to sieve out the solids in the mash before filling the still. For some reason, it is only rye grain that causes issues with burning onto the heating element. Don't worry about not being able to fill the 26 gallon (105 liter) pot full on a Hillbilly Still. I often will do distillation runs where I have only filled the pot half full. The mantra of 'low and slow' applies to electrically heated stills too. I normally set the amperage controller to draw 15 amps.

More recently, I have discovered a product that can help a person make 95% abv distillate. The Turbo 500 is made by the same New Zealand company that makes Grainfather brewing systems. I used a Grainfather brewing system to complete my M.Sc. thesis work. I use my Grainfather system to make beer at home. I have never used the

Turbo 500, but if it performs anything like the Grainfather brew system, then I am sold. The Turbo 500, shown in Figure 80, retails for $800 Canadian dollars.

Figure 79 – Hillbilly Still for home use

Figure 80 – Turbo 500 for home use

18

Small Scale Recipes

This chapter presents some basic recipes that will be of help to you as you delve deeper into craft distilling. These recipes are ones that I have personally used. Use them exactly as presented herein, or modify them as you see fit. In these various recipes:

You will have to decide if you need additional calcium (Gypsum) to adjust your water.

You will also have to decide if you need to adjust your mash pH. Dark roasted grains, the sour mash method or the addition of acid will all work.

You will have to decide on the amount of yeast. I indicate 11-12 grams in these recipes, but, you may want to experiment with 15-18 grams.

Mashing – Malted Grain

The following mashing procedure for malted grain assumes that there is no sparging involved and that fermentation is on the grain.

Weigh out the grains using a digital weigh scale.

Grind the malted grains using a hand-cranked roller mill.

Clean and rinse out your mash kettle using a cleaning agent of your choosing.

Add the water to the mash vessel. Water to grain ratio should be 3:1. Check the pH of the water. Take a sample of your water and check the pH. Adjust pH down about 6.8.

If the calcium level of your tap water is less than 100 ppm, add gypsum. Adding ¼ of a gram gypsum per liter of water will raise the calcium level of your water by 60 ppm. Be careful not to over-adjust the calcium.

Turn on the propane burner and heat the water to 50ºC.

Add the ground-up grain to the heated water in the mash kettle and stir/agitate the mash periodically.

Slowly continue heating the mash kettle until a temperature of 64ºC has been attained. Be sure to stir the mash frequently and check the temperature frequently. At 64ºC, turn off the heat, place the lid on the mash kettle and let the kettle and its contents rest for 30 minutes.

Re-start the propane heater. Slowly resume heating and stirring until a temperature of 74ºC has been attained. Shut off the heat, place the lid on the mash kettle and leave to rest for 30 minutes.

Using a tea strainer, take a sample from the mash kettle and drop some liquid on the lens of the refractometer. Check the Brix reading. You are aiming to see a Brix reading of 20-23º Brix. If at this juncture, the Brix reading falls shy of the desired range, let the mash rest a while longer to ensure complete starch to sugar conversion.

As the mash is resting, clean and rinse your copper coil immersion chiller.

Using your cleaned chiller, reduce the temperature of the mash to 30ºC.

As you are cooling the mash, clean and rinse your fermentation vessel.

Add your yeast to a small sanitized dish of warm water (at 30-33ºC) and allow the yeast to re-hydrate for 10 minutes.

Once the mash is cooled to 30ºC, dump the contents into the fermenter vessel, add the yeast, add the nutrient, cover the vessel and place it in a spot where the temperature is in the range of 20-23ºC. Fermentation will take about 5-7 days. Recall that the length of ferment time can influence final flavor profile. Give some thought to deliberately using a longer or shorter fermentation time. Also, don’t be afraid to play with different yeasts, mixtures of yeasts or amounts of yeast. Earlier in this text I discussed the amount of yeast to add. Consider doing some trials to explore the taste profile effects of differing amounts of yeast.

Mashing – Malted Grain & Un-Malted Grain

The mashing procedure for a mix of malted and un-malted grains is as follows. This example uses malted barley and un-malted rye with an option of flaked corn. It is assumed that there is no sparging involved. Fermentation is on the grain.

Weigh out the grains using your digital weigh scale.

Grind the malted barley using a hand-cranked roller mill.

Grind the rye grain using a VitaMix blender.

If flaked corn is being used, no need to grind it. It can be used as is.

Clean and rinse out your mash kettle using a cleaning agent of your choosing.

Add the water to the mash vessel. If need be, adjust the pH down to about 6.8.

Adjust calcium if needed.

Turn on the propane burner and heat the water to 50ºC.

Add the alpha amylase enzyme. Add the bioglucananse enzyme which breaks down endosperm call wall glucans.

Add the un-malted grains to the heated water in the mash kettle and stir/agitate as heating gets underway.

Slowly continue heating the mash kettle and stirring the mash until a temperature of 80-85ºC has been attained. Once temperature has been attained, turn off the heat, place the lid on the mash kettle and let the kettle and its contents rest for 60 minutes.

Using a tea strainer, take a sample from the mash kettle and check the Brix reading using a refractometer. At this point you should see a reading of about 15-18º Brix. If at this juncture, the Brix reading falls shy of this desired level. let the mash rest a while longer to ensure complete starch to sugar conversion.

As the mash is resting, clean and rinse your copper coil immersion chiller.

Using your cleaned chiller, reduce the temperature of the mash to 68ºC.

Add the malted barley and stir into the mash kettle. Let rest for 20 minutes.

Add the final saccharification enzyme. Stir the contents of the kettle to distribute the enzyme. Put lid on the kettle and let rest for 45 minutes.

After this 45 minute rest period, take a sample and check the sugar content with the refractometer. You should now be seeing a reading of at or just over over 20º Brix.

As you are resting the mash, clean and rinse your fermentation vessel.

Add your yeast to a small dish of warm water and allow the yeast to re-hydrate.

Once the mash is cooled to 30ºC, dump the contents into the fermenter vessel, add the yeast, add the nutrient, cover the vessel and place it in a spot where the temperature is in the range of 20-25ºC. Fermentation will take about 5-7 days.

Mashing – Un-Malted Grain

The mashing procedure if using all unmalted grains is as follows. It is assumed no sparging is involved. Fermentation is on the grain.

Weigh out the grains using your digital weigh scale.

Grind the un-malted grain using a VitaMix blender.

Clean and rinse out your mash kettle using a cleaning agent of your choosing.

Add the water to the mash vessel. Use a 3:1 water to grain ratio. If need be, adjust the pH down to about 6.8.

Adjust Calcium if needed.

Turn on the propane burner and heat the water to 50ºC.

Add the alpha amylase enzyme. Add the bioglucananse-type enzyme which breaks down endosperm call wall glucans.

Add the un-malted grains to the heated water in the mash kettle and stir/agitate as heating gets underway.

Slowly continue heating the mash kettle and stirring the mash until a temperature of 80-85ºC has been attained. Once temperature has been attained, turn off the heat, place the lid on the mash kettle and let the kettle and its contents rest for 60 minutes.

Using a tea strainer, take a sample from the mash kettle and check the Brix reading using a refractometer. At this point you should see a reading of about 15-18º Brix. If at this juncture, the Brix reading falls shy of this desired level. let the mash rest a while longer to ensure complete starch to sugar conversion.

As the mash is resting, clean and rinse your copper coil immersion chiller.

Using your cleaned chiller, reduce the temperature of the mash to 60ºC.

Add the final saccharification enzyme. Stir the contents of the kettle to distribute the enzyme. Put lid on the kettle and let rest for 45 minutes.

After this 45 minute rest period, take a sample and check the sugar content with the refractometer. You should now be seeing a reading of at or just over 20º Brix.

As you are resting the mash, clean and rinse your fermentation vessel.

Add your yeast to a small dish of warm water and allow the yeast to re-hydrate.

Once the mash is cooled to 30ºC, dump the contents into the fermenter vessel, add the yeast, add the nutrient, cover the vessel and place it in a spot where the temperature is in the range of 20-25ºC. Fermentation will take about 5-7 days.

Distilling - al-Ambic Pot Still

The distillation procedure if using a copper al-Ambic pot still is as follows:

After fermentation is complete, strain the mash through a mesh bag or through a strainer to remove solids.

Add the strained liquid to the al-Ambic still. Secure lid onto the still. Seal the joint with a rye flour paste.

Gently heat the pot still using a propane fired burner. Remember – there is no rush. Low and slow.

Collect and discard the first portion of the distillation run – the heads.

Collect the hearts portion of the distillate from condenser into a graduated cylinder. Insert a hydrometer into the cylinder. Collect distillate until the reading on the hydrometer is about 50%. You will have to make the ultimate determination based on taste and aroma. Once you have deemed that it is time to start collecting tails, remove the graduated cylinder and continue collecting distillate for a another 20 or so minutes. This distillate (tails) can be added to the still on the next distillation run that you do.

To increase the alcohol strength, it will be necessary to re-distill what you have just collected. You can distill the collected quantity by itself or you can do several runs like this to collect a larger amount.

Add collected distillate (plus any collected tails) to the still. Seal the lid with rye paste. Gently heat the pot low and slow with the propane heater.

The distillate coming off the still on this second run will start at about 80% abv. Stop collecting the hearts once your hydrometer reads 60% abv.

Distilling - Electrically Heated Column Still

The procedure if using an electrically heated column still is:

Add the strained liquid to the pot. Note – if your pot is large you may have to add several fermented batches to make it worth your while.

Gently heat the pot using an energy input of about 15 amps. No rush, nice and easy.

You will soon learn from experience how much water flow to direct to the dephlegmator section of the still. Generate too much reflux in the column and you will strip away too much of that delicious Whisky flavor.

Collect and discard the first portion of the distillation run – the heads.

The hearts distillate coming off the still will usually start with the hydrometer in the parrot reading about 88%. Continue collecting distillate until the hydrometer reads 60%. You may even want to keep collecting until it reads 55%. Let taste and aroma guide you. Once you are done collecting hearts, continue collecting distillate (tails) for a while. The tails can be added to future distillation runs.

Grain Recipes

Malted Barley/Wheat Whisky

6.4 kgs malted spring wheat (White Wheat)

1.6 kgs 2-row malted barley

24 liters of water (passed through a 10 micron water filter cartridge)

pH adjustment

11-12 grams distillers yeast

5-6 grams yeast nutrient

100% (un-malted) Rye Whisky

You can substitute un-malted wheat, un-malted barley or un-malted triticale grain in place of the rye grain in this recipe.

8 kgs rye grain (either winter rye or spring rye will suffice)

24 liters of water (passed through a 10 micron filter cartridge)

1 teaspoon (~5 mls) thermostable alpha amylase enzyme

1 teaspoon (~5 mls) protein busting enzyme

1 teaspoon (~5 mls) amyloglucosidase enzyme

gypsum (if required)

pH adjustment

11-12 grams distillers yeast

5-6 grams yeast nutrient

cleaning agent

Washington’s Whisky

This is the recipe that George Washington reportedly used in the late 1700s when he was distilling at his estate at Mount Vernon. I have included this recipe to show you how you can use a combination of malted and un-malted grains.

4.8 kgs rye grain (either winter rye or spring rye will suffice)

2.4 kgs flaked yellow corn

0.8 kgs 2-row malted barley

1 teaspoon thermostable alpha amylase enzyme

1 teaspoon bioglucanase enzyme

1 teaspoon amyloglucosidase enzyme

24 liters of water (passed through a 10 micron filter cartridge)

gypsum (if required)

pH adjustment as required

11-12 grams distillers yeast

5-6 grams yeast nutrient

cleaning agent

After fermentation is complete, strain the mash through a mesh bag or through a strainer.

Lentil Whisky

4 kgs red lentils

2 kgs malted wheat

2 kgs 2-row malted barley

1 teaspoon thermostable alpha amylase enzyme

1 teaspoon protein busting enzyme

1 teaspoon amyloglucosidase enzyme

24 liters of water (passed through a 10 micron filter cartridge)

gypsum (if required)

pH adjustment

11-12 grams distillers yeast

5-6 grams yeast nutrient

cleaning agent

Maker’s Mark Bourbon Clone

The following is said to be the mash bill used in the manufacture of Maker’s Mark Bourbon.

5.6 kgs flaked yellow corn

1.2 kgs malted hard red winter wheat

1.2 kgs 6-row malted barley

1 teaspoon thermostable alpha amylase enzyme

1 teaspoon protein busting enzyme

1 teaspoon amyloglucosidase enzyme

24 liters of water (passed through a 10 micron filter cartridge)

gypsum (if required)

pH adjustment

11-12 grams distillers yeast

5-6 grams yeast nutrient

cleaning agent

Jack Daniel's Whisky Clone

The mash bill said to be used in the manufacture of Jack Daniels Whisky is 80% corn, 12% barley and 8% rye. Consider using the following recipe and following the same procedure as with Maker's Mark Bourbon Clone.

6.4 kgs flaked Yellow Corn

0.96 kgs malted Hard Red Winter Wheat

0.64 kgs 6-row malted Barley

1 teaspoon thermostable alpha amylase enzyme

1 teaspoon protein busting enzyme

1 teaspoon amyloglucosidase enzyme

24 liters of water (passed through a 10 micron filter cartridge)

gypsum (if required)

pH adjustment

11-12 grams distillers yeast

5-6 grams yeast nutrient

cleaning agent

Purple Wheat Vodka

Purple Wheat is a special strain of wheat that has a high content of anthocyanins, otherwise known as anti-oxidants. It is doubtful that these healthy constituents survive the heat of mashing and distilling. What does come through in the finished product though are lipids and complex methyl esters which together impart a silky texture to the vodka. Purple Wheat vodka was the subject of my M.Sc. thesis research. My personal experience using this raw material at home says this distillate is very delectable in vodka martinis.

8 kgs Purple wheat

1 teaspoon thermostable alpha amylase enzyme

1 teaspoon protein busting enzyme

1 teaspoon amyloglucosidase enzyme

24 liters of water (passed through a 10 micron filter cartridge)

gypsum (if required)

pH adjustment

11-12 grams distillers yeast

5-6 grams yeast nutrient

cleaning agent

Fruit Recipes

(1)

Cognac Clone

20 liter pail of French Colombard white grape juice

11-12 grams wine yeast

5-6 grams yeast nutrient

For an interesting way of using this distilled product, take 200 mls of the finished, proofed product. Add 6 grams of grapefruit zest (avoid the bitter, inner art of the peel called the pith). Add 6 grams of orange zest, again taking care to avoid the inner pith. Add 20 mls of honey. Let rest for 3 days in a sealed container. After 3 days, remove the peels. Filter through a coffee filter if necessary. This is called Forbidden Fruit Brandy and was very popular in England 100 years ago.

Apricot Brandy (Schnapps)

9 kgs apricots

10 liters of water (passed through a 10 micron filter cartridge)

7.5 kgs corn sugar (available at any home brew retail store)

11-12 grams distillers yeast

5-6 grams wine yeast nutrient

Acid Blend (if needed)

Lafazyme (optional)

cleaning agent

Clean a plastic pail using your cleaning agent.

Wash the apricots in clean water. As you are doing so, visually inspect them for signs of mold, rot or fungus. Remove any such evidence using a sharp knife.

Slit open each apricot and remove the stone pit. As you weigh and accumulate pitted Apricots, run them through a VitaMix blender or food processor to pulverize them. Add them to the clean plastic pail you have prepared.

Take a small quantity of the pulverized apricot in a container. Perform a pH reading. You should get a reading of 3.3 to 3.9. Anything higher than 3.9 will require the addition of a small amount of Acid Blend to reduce the pH. (available at any home brewing retail store).

Once you have completed pulverizing all the apricots, transfer them to your mash kettle. Take another pH reading. If required, add a small amount of Acid Blend and re-check the pH. Repeat until pH is 3.3 to 3.9.

Add water and corn sugar. Stir the entire mixture using your drill and paint stick assembly.

Add ¼ teaspoon of Lafazyme. Stir into contents of mash kettle. This is an enzyme often used in fruit winemaking to help extract more flavors form the fruit.

Using a tea strainer take a sample of liquid from the mash kettle and check the Brix reading using the refractometer. You are aiming for a reading of 18-20º Brix. Add more corn sugar or more water to adjust Brix level accordingly.

Heat mash kettle to 40ºC. Turn off heat and let rest for 30 minutes.

As contents are resting, clean your copper coil immersion chiller and fermenter pail.

Cool contents of mash kettle to 30ºC. Add to fermenter pail.

Add yeast and nutrient and allow fermentation to proceed. Fermentation will take about 7 days.

Apple Liquor

10 kgs apples

15 liters of water (passed through a 10 micron filter)

7.5 kgs corn sugar (available at any home brew retail store)

11-12 grams wine yeast

5-6 grams yeast nutrient

Acid Blend (if needed)

Lafazyme (optional)

cleaning agent

Clean a plastic pail using your cleaning agent.

Wash the apples in clean water. As you are doing so, visually inspect them for signs of mold, rot or fungus. Remove any such evidence using a sharp knife.

Cut each apple into quarters. As you weigh and accumulate apples, run them through a VitaMix blender to pulverize them. Add them to the clean plastic pail you have prepared.

Take a small quantity of the pulverized apple mixture. Perform a pH reading. You should get a reading of 3.3 to 3.9. Anything higher than 3.9 will require the addition of a small amount of acid blend (available at any home brewing retail store).

Once you have completed pulverizing all the apples, transfer them to your mash kettle. Take another pH reading. If required, add a small amount of

Acid Blend and re-check the pH. Repeat until pH is 3.3 to 3.9.

Add water and corn sugar. Stir the entire mixture using your drill and paint stick assembly.

Add ¼ teaspoon of Lafazyme. Stir into contents of mash kettle. This is an enzyme often used in fruit winemaking to help extract more flavors form the fruit.

Using a tea strainer take a sample of liquid from the mash kettle and check the Brix reading using the refractometer. You are aiming for a reading of 18-20º Brix. Add more sugar or more water to adjust Brix level accordingly.

Heat mash kettle to 40ºC. Turn off heat and let rest for 30 minutes.

As contents are resting, clean your copper coil immersion chiller and fermenter pail.

Cool contents of mash kettle to 30ºC. Add to fermenter pail.

Add yeast and nutrient and allow fermentation to proceed. Fermentation will take about 10 days. I have only ever used a column still when working with this recipe.

Molasses Recipes

Sugar Beet Rum

6 kgs sugar beet molasses (from your local animal feed store)

4 kgs cane sugar

22 liters of water (passed through a 10 micron filter cartridge)

11-12 grams distillers rum yeast

10-12 grams yeast nutrient

cleaning agent

Weigh out the cane sugar and the molasses using a digital scale.

Add the water to the mash kettle. Add the cane sugar and molasses.

Heat to 50ºC to thoroughly dissolve the ingredients.

Once temperature has been attained, shut off heat.

Clean the fermenter pail and the copper immersion chiller.

Cool contents of mash kettle to 30ºC.

Add contents to fermenter pail.

Add the Rum yeast, nutrient and allow fermentation to start. Fermentation will take 7 or so days and it may be aggressively frothy. Do not overfill your fermenter pail or you may have a serious mess to clean up.

Double Pot Distilled Fancy Molasses Rum

5 kgs fancy molasses

3 kgs cane sugar

water (passed through a 10 micron filter cartridge)

15 grams distillers rum yeast

20 grams yeast nutrient

cleaning agent

Weigh out the cane sugar and the molasses using a digital scale.

Add the water to the mash kettle. Add the cane sugar and molasses. Add water in increments and using a graduated cylinder and hydrometer from your beer brewing equipment arsenal, aim for a specific gravity of 1.080-1.085.

Heat to 50ºC to thoroughly dissolve the ingredients.

Once temperature has been attained, shut off heat.

Clean the fermenter pail and the copper immersion chiller.

Cool contents of mash kettle to 30ºC.

Add contents to fermenter pail.

Add the rum yeast, nutrient and allow fermentation to start. Fermentation will take 7 or so days and it may be aggressively frothy. Do not overfill your fermenter pail or you may have a serious mess to clean up. I used an al'Ambic still when working with this recipe.

Gin Recipes

The following are recipes that either I have dreamed up and used or that have been created by people attending my Gin Master classes.

Gin #1

1200 mls of your hi-proof vodka (95% abv)

1000 mls water

70 grams Juniper berry

35 grams Coriander seed

4 grams dried Lemon peel

4 grams dried Orange peel

10 grams Lavender flowers

20 grams diced up Apple (fresh)

1 gram Cinnamon (ground or whole)

Add ingredients to container holding the vodka and the water. Let this mixture soak for 24 hours.

Pour this mixture into the copper al-Ambic still.

Place lid on still and seal with rye paste.

Gently heat the pot still using a propane fired burner. Remember – there is no rush. Low and slow.

Collect distillate from condenser into a graduated cylinder. Insert a hydrometer into the cylinder. Collect distillate until you have recovered 1000 mls of distillate. The aroma of this recovered distillate will unmistakably gin. The heat during this re-distillation has drawn the essential oils out of the botanicals.

Proof the collected distillate down to 40% to 44%, based on your taste preference. You be the judge. If the distillate turns cloudy during proofing, this is the water reacting with the essential oils. A craft distiller encountering this issue would filter his Gin. But for home consumption, this extra work is not always necessary.

Gin #2

1200 mls of your hi-proof vodka (95% alc)

1000 water

70 grams Juniper berry

35 grams Coriander beed

5 grams dried Lemon peel

5 grams dried Orange peel

6 grams Lavender flowers

5 grams Grains of Paradise

5 grams Angelica root

Add ingredients to container holding the vodka and water. Let this mixture soak for 24 hours. Follow the instructions as laid out for Gin #1

Note: the Angelica Root will give this gin a slight earthy flavor. The Grains of Paradise will present a spiciness on the finish.

Gin #3

1200 mls of your hi-proof vodka (95% alc)

1000 mls water

70 grams Juniper berry

35 grams Coriander seed

10 grams dried Lemon peel

15 grams dried Orange peel

2 grams of Lime Peel

10 grams of Grapefruit peel (fresh)

5 grams Rosemary (fresh)

2 grams Ginger powder

Add ingredients to container holding the Vodka and water. Let this mixture soak for 24 hours. Follow the instructions as laid out for Gin #1.

Note: the Grapefruit peel in this iteration makes for a most unique finish, especially when this Gin is served with Tonic.

Gin #4

1200 mls of your hi-proof vodka (95% alc)

1000 mls water

70 grams Juniper berry

35 grams Coriander seed

20 grams dried Lemon peel

20 grams dried Orange peel

130 grams fresh Apple

12 grams Lavender flowers

1 gram Orris root

15 grams Rosehips

5 grams Rosemary (fresh)

1 gram Chamomile loose leaf tea

5 grams Angelica root

Add ingredients to container holding the Vodka and water. Let this mixture soak for 24 hours. Follow the instructions as laid out for Gin #1

Gin #5

1200 mls of your hi-proof vodka (95% alc)

1000 mls water

70 grams Juniper berry

35 grams Coriander seed

12 grams Lavender flowers

2 grams Angelica root

150 grams fresh Apple

1 gram Orris root

50 grams Rosehips

6 grams Pink peppercorns

3 grams Sage

Add ingredients to container holding the Vodka and water. Let this mixture soak for 24 hours. Follow the instructions as laid out for Gin #1

Gin #6

1200 mls of your hi-proof vodka (95% alc)

1000 mls water

70 grams Juniper berry

35 grams Coriander seed

18 grams Lavender flowers

2 grams Angelica root

200 grams fresh Apple

5 grams fresh Fennel

1 gram Orris root

15 grams smoked black Cardamom

2 grams Nutmeg (ground or shaved)

10 grams dried Orange peel

8 grams dried Hibiscus flower

40 grams fresh Grapefruit peel

1 gram Cinnamon

Add ingredients to container holding the Vodka and water. Let this mixture soak for 24 hours. Follow the instructions as laid out for Gin #1

Gin #7

1200 mls of your hi-proof vodka (95% alc)

1000 mls water

80 grams Juniper berry

40 grams Coriander seed

18 grams Lavender flowers

2 grams Angelica root

50 grams fresh Apple

5 grams slivered blanched Almond

1 gram Orris root

4 grams dried Orange peel

4 grams dried Lemon peel

4 grams fresh Lime peel

8 grams Licorice root

1 gram Cinnamon

Add ingredients to container holding the Vodka and water. Let this mixture soak for 24 hours. Follow the instructions as laid out for Gin #1

Earl Grey Tea Gin

To 750 mls of your newly created 40% alc gin in a glass jar (mason jar), add 10 grams of good quality, loose leaf Earl Grey tea. Let the tea soak in the gin for about 2 days. Strain the gin through a coffee filter to remove all tea leaves. Put the strained gin back in the bottle. Now, add 3 or 4 tablespoons of simple syrup to sweeten. (Simple syrup is an equal parts mixture of sugar and water, brought to a boil and then cooled). Afternoon tea at your house will take on a whole new meaning.

Rhubarb Gin

To 500 mls of your newly created 40% alc Gin in a glass jar (mason jar), add 300 grams of cut up Rhubarb and 150 grams of sugar to the jar. Let soak for 36 hours. Filter through a coffee filter. The tartness of the Rhubarb has been countered by the sugar. The Rhubarb flavor melds well with the gin flavor. This variation on gin is quite popular in England at the moment.

Apple Gin

To 500 mls of your newly created 40% gin in a glass jar (mason jar), add one cut up Apple and sugar to taste to the jar. Let soak for 36 hours. Filter through a coffee filter. The pleasant flavor of the Apple melds well with the gin flavor. This variation on gin was apparently very popular 100 years ago in England.

Raspberry Gin

To 500 mls of your newly created 40% alc Gin in a glass jar (mason jar), add ten fresh Raspberries. Let soak for 36 hours. Filter through a coffee filter. Adjust sweetness with a couple teaspoons of honey. The pleasant flavor of the Raspberry melds well with the gin flavor.

Gin Liqueur

Take 500 mls of Gin that you have made. Be sure that it is at 60% alcohol (you have not yet fully proofed it down). Make up a batch of less than simple syrup in a saucepan. Simple syrup is an equal parts mixture of sugar and water, brought to a boil and then cooled. Less than simple syrup is a mix that is 1/3 sugar and 2/3 water. In a saucepan, simmer (in water) some cut up fruit of your choice. Filter the solids away through a mesh strainer once you have thoroughly cooked it. Make up a volume of 500 mls of the stewed fruit juice and the syrup solution. The exact proportions are up to you. Add to the 500 mls of gin. You will now have a 30% alc Gin liqueur.

Bitters

Bitters (2)(3) is an alcoholic preparation flavored with botanicals that impart a bitter, sour, or bittersweet flavor. The bitters popularity amongst mixologists and chefs can be explained by the human brain. When we taste something sweet, our brain sends a signal to our body to eat more of whatever that substance was. When we taste something sour, our brain sends a cautionary signal to our body because sour tastes are likely so due to bacteria. When we taste something bitter, our brain goes into over-drive and urgently warns us to take extreme caution, for a bitter substance is very likely toxic to us. With our brain in over-drive, our entire sensory system is carefully evaluating every morsel of the bitter substance we eat or drink. The net result is that we derive more enjoyment from the cocktail or the chef's creation because our sensory system is on alert.

Cucumber Bitters

2 cups of distillate from one of your distillation runs

1.5 cups of chopped English cucumber (fresh)

¼ teaspoon cracked Coriander seed

¼ teaspoon of Allspice

½ teaspoon ground black Pepper

¼ teaspoon sea Salt

¼ teaspoon ground Cumin

¼ teaspoon dried Dill

¾ teaspoon Valerian root or Gentian root or Calamus root.

Add ingredients to a mason jar. Apply lid and seal tightly. Leave ingredients to soak in the jar for 2 weeks.

At the end of 2 weeks, strain the liquid from the solids. Reserve the liquid in the mason jar.

Add solids to a saucepan along with 1 cup of water. Bring to a boil and then reduce heat to simmer for 10 minutes.

Once cooled, add contents of the saucepan to a second mason jar. Apply the lid and seal tightly. Let rest for 1 week.

At the end of 1 week, strain the solids from the liquid. Repeat until no solid particulates are evident.

Combine this liquid with the alcoholic liquid from the first mason jar. Add 2 tablespoons of sugar syrup(*).

Let combined mixture rest for 3 days before giving it a final filter through cheesecloth.

A wee bit of Cucumber bitters adds a new dimension to a Gin martini. Consider adding some to a salad dressing as well.

(*) sugar syrup: mix 2 cups of demerara brown sugar and 1 cup of water. Bring to a boil. Cool and store in a sealed jar in the fridge.

Lime Bitters

1 cup of distillate from one of your distillation runs

1 cup of rum

zest of 4 Limes (fresh)

2 teaspoons dried Lemon peel

1 teaspoon ground black Pepper

½ teaspoon Caraway seed

1 teaspoon hop pellets (from your local home brewing store)

4 tablespoons dried Lemon Grass

¾ teaspoon Valerian root or Gentian root or Calamus root.

Add ingredients to a mason jar. Apply lid and seal tightly. Leave ingredients to soak in the jar for 2 weeks.

At the end of 2 weeks, strain the liquid from the solids. Reserve the liquid in the mason jar.

Add solids to a saucepan along with 1 cup of water. Bring to a boil and then reduce heat to simmer for 10 minutes.

Once cooled, add contents of the saucepan to a second mason jar. Apply the lid and seal tightly. Let rest for 1 week.

At the end of 1 week, strain the solids from the liquid. Repeat until no solid particulates are evident.

Combine this liquid with the alcoholic liquid from the first mason jar. Add 2 tablespoons of sugar syrup(*).

Let combined mixture rest for 3 days before giving it a final filter through cheesecloth.

A wee bit of Lime bitters adds a new dimension to a Gin and Tonic.

(*) sugar syrup: mix 2 cups of demerara brown sugar and 1 cup of water. Bring to a boil. Cool and store in a sealed jar in the fridge.

Orange Bitters

2 cups of distillate from one of your distillation runs

Zest of 3 Oranges (fresh)

1/3 cup dried Orange peel

4 Cloves

30 grains of Cardomom (green)

¼ teaspoon of cracked Coriander seed

¼ teaspoon Allspice

¾ teaspoon Valerian root or Gentian root or Calamus root.

Add ingredients to a mason jar. Apply lid and seal tightly. Leave ingredients to soak in the jar for 2 weeks.

At the end of 2 weeks, strain the liquid from the solids. Reserve the liquid in the mason jar.

Add solids to a saucepan along with 1 cup of water. Bring to a boil and then reduce heat to simmer for 10 minutes.

Once cooled, add contents of the saucepan to a second mason jar. Apply the lid and seal tightly. Let rest for 1 week.

At the end of 1 week, strain the solids from the liquid. Repeat until no solid particulates are evident.

Combine this liquid with the alcoholic liquid from the first mason jar. Add 2 tablespoons of sugar syrup(*).

Let combined mixture rest for 3 days before giving it a final filter through cheesecloth.

A wee bit of Orange bitters adds a new dimension to a Gin martini.

(*) sugar syrup – mix 2 cups of demerara brown sugar and 1 cup of water. Bring to a boil. Cool and store in a sealed jar in the fridge.

New Orleans Bitters (a.k.a. Mortician's Glue)

Don’t let the scary name of this mixture upset you. I found this recipe in an old manuscript I stumbled upon while searching on-line for old recipes.

2 liters of 50% alcohol distillate

12 Mint leaves (fresh)

5 grams Lavender flowers (dried)

8 grams Lemon Grass (fresh)

40 grams slivered Almonds (dried)

6 green Cardamom pods (crushed

10 grams Juniper berry (dried)

2 Cinnamon sticks

14 grams Dandelion root (dug fresh from your lawn)

2 grams Star Anise

12 Cloves

14 grams Coriander seeds (dried)

8 grams Caraway seeds

12 grams Ginger powder

6 grams Nutmeg powder

2 ounces Maple syrup

1 Blood Orange peel (fresh, entire peel)

1 stick of medium plus toasted oak

1 Vanilla pod

Combine all ingredients with the alcohol in a large glass jug. Take the time to cut the ingredients (where necessary) into small bits to provide for optimal flavor extraction by the alcohol). Affix the lid to the jug and tighten well.

Let jug sit for exactly 3 months in a dark place (in your cupboard for example).

You can use this creation in cocktails or in cuisine. I have used this creation to make Vermouth. I went to my local Wine U-Brew store and had a Gewurtztraminer white wine kit made. The alcohol strength of the bitters is 50%, the alcohol strength of the wine was 12%. I blended the two to arrive at a mixture that was near 20% alcohol and tasted delicious.

Vermouth

When I used to conduct workshops in Kelowna, British Columbia, there was an older gentleman working there who had originally come from Poland many decades ago. This is a Vermouth recipe he handed me. The one variable in this recipe to be careful with is the Gentian root. The quantity cited in this recipe is less than what appeared in his suggested formulation.

600 mls of 50% alc distillate

12 grams Wormwood

12 grams Orange zest

12 grams Blessed Thistle

6 grams Mint Leaves

2 grams Angelica Root

8 grams Cinnamon

6 grams Nutmeg

1 gram Gentian root

Soak ingredients in the alcohol for 10 days. Filter through a coffee filter. Get a sweeter white wine (like a Gewurtztraminer) and blend until you achieve a desirable taste profile. Serve in a glass over ice.

Liqueur

Coffee Maple Syrup Liqueur

Brew 3 cups of strong coffee in your kitchen using a whatever style of coffee maker you have.

Add some Maple Syrup until you achieve a desirable taste profile.

Take 300 mls of whisky distillate obtained from any of the Whisky recipes in this section. Blend the Whisky with the coffee/maple syrup mixture until a desirable taste profile is obtained.

Note: if you are using 300 mls of a whisky distillate that is 90% strength, the addition of 600 mls of coffee/maple syrup will give you a 30% liqueur. If you are using 300 mls of an 80% whisky distillate, the addition of 500 mls of the coffee/maple syrup will give you a 30% liqueur

Amaretto Look-Alike

Mention Amaretto to some people and they will lick their lips in anticipation of a sample. Others will run away like their hair is on fire. At issue is the mis-understood amygdalin. This is a compound that occurs in the pits of stone fruits. Take an apricot, cut the flesh off and eat it. Next, take a hammer and smack the remining stone. When it cracks open, you will see a tiny white pit. This pit contains the chemical compound called amygdalin. If you were to eat that pit, the enzymes in your gut would degrade the amygdalin into benzaldehyde and poisonous hydrogen cyanide. If you do not crack the stone open, then the amygdalin is a non-issue.

60 Apricots, cut off the flesh and remove the stone

(I save the flesh to later make Apricot jam)

60 dried Turkish Apricots cut into ¼ sections

Add these ingredients to 1 liter of vodka (45% abv)

Add ½ of a Vanilla bean

Combine these ingredients in a sealed glass container and let soak for 2 weeks.

Proof down to about 25-30% using a sugar-water mixture where you have 3 parts water to 2 parts sugar.

Sons of Vancouver distillery in North Vancouver, Canada are turning heads with their Amaretto expressions where they have aged the product in ex-Bourbon casks and ex-Cognac casks. In your travels, try some of their products. You will be elated at the delicious taste profile

Amaro

Amaro is an Italian expression that means ‘bitter’. There is nothing finer than a wee dram of Amaro after dinner to stimulate the digestive juices. Here is the basic recipe I follow. Play around and have fun.

25 grams Rhubarb diced (fresh)

25 grams Bitter Orange peel (dried)

3 gram Gentian root (dried)

Soak these ingredients in 750 mls of 40% abv Vodka for 3 days.

Using a small al Ambic still, I distill off the alcohol. What comes off the still is about 350 mls of a pungent, aromatic distillate at 85%.

Add this distillate to a sealed glass jar with up to 10 grams of yellow Cinchona bark (cinchona calisaya). Let soak for 3 days.

Add some modified sugar syrup made with 3 parts water and 2 parts sugar to proof down to 30% abv.

A word of caution on the Cinchona Bark. Pay attention please. There are two types of Cinchona Bark available from vendors. One bark is Cinchona succirubra (red cinchona bark). This version is loaded with alkaloids which can cause heart palpitations and blood pressure spikes. The US Food and Drug Administration takes a dim view of this stuff. DO NOT USE IT. The other type of Cinchona is the Cinchona calisaya variety (yellow Cinchona Bark). It is approved by the USFDA for use in Amarro spirit drinks, but only in small amounts.

Cream Whisky Liqueur

I am starting to see more and more craft distilled Cream Whisky offerings available. In late 2017, I did some of my own experimentation. I found a vendor in New Jersey called Creamy Creations. They provided me with a small sample quantity of unflavored Dairy Base containing 12.2% fat, 5.8% protein and 204 grams/liter sugar.

In some small scale trials, I added 200 mls of my home-made bourbon (40% alc./vol.) to 270 mls of blending mixture. The blending mixture consisted of 135 mls of the Dairy Base plus 135 mls of a coffee/chocolate solution. The solution comprised 2 teaspoons instant coffee in 120 mls boiling water plus 1 teaspoon chocolate sauce added to the hot water as well. The final result of adding this mixture to my bourbon was a 17% alc./vol. Cream Whisky. Shelf life was over 1 year on this product if the bottles were kept refrigerated.

Boozy Ice Cream

If you enjoy ice cream on a hot day, why not add some of your crafted alcohol to the ice cream?

2 cups Coconut cream

1 cup 18% milk fat coffee creamer

¾ cup sugar

3 egg yolks – whisked in a small dish

Dash of salt

Dash of Vanilla

7 teaspoons of your favorite alcohol (I use rum for my ice creams)

Gently heat the coconut cream, sugar and coffee creamer until the pan just starts to simmer.

Add a tablespoon at a time of this hot liquid to your small dish of whisked egg yolks (chef’s call this tempering).

Add tempered yolk mixture to your pan containing the coconut cream, sugar and coffee cream. Add the pinch of salt. Add the vanilla.

Gently bring to a simmer again.

Remove from heat and place in fridge to cool.

When cool, whisk in the alcohol.

Place pan in the freezer and every 30-45 minutes, visit the pan and give the cooling contents a good stir. After several hours, the contents will have set up and you can enjoy the ice cream.

References

1 Pischl, J. (2015) Distilling Fruit Brandy, Schiffer Publishing, USA.

2 Bitterman, M.(2015) Field Guide to Bitters and Amari, Andrews McMeel Publishing, USA

3 Parsons, B. (2011) Bitters, Ten Speed Press, USA.

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Final Words

Starting a craft distillery is by no means an easy task, as this book has sought to emphasize. But, don’t let the hard work stop you.

Go into the craft distilling arena with your eyes wide open and with a solid grounding in the science of raw materials, mashing, fermenting, distilling, and oak ageing. Take the time to do some preliminary work at home. Design your own recipes, learn how to make your own heads, hearts and tails cuts, become skilled at proofing your own distillate and experiment with oak aging. Give plenty of thought to the image you wish your distillery to project and think about how you will offer value to the consumer. To jump in to a distillery start-up project prematurely will almost assuredly lead to a painful experience that could ruin you financially.

The big beer companies allowed the craft beer ‘horse’ to escape from the barn in the 1990s. The big distillers are guarding the barn door more carefully. They do not want to go through what their fellow brewery CEOs endured. If craft is to succeed in a meaningful way, if the distilling ‘horse’ is to escape from the barn, craft distillers will have to make products that are both better than commercial products and more unique.

As you reflect on these final words, I wish you God speed and all the best. If you ever need any help, feel free to contact me through my website at www.ProhibitionUniversity.com.

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Glossary Of Terms

Acetobacter: bacteria that converts ethanol to acetic acid.

Acrospire: the shoot that emerges from the micropyle end of a grain kernel.

Aerobic: with or in the presence of Oxygen.

Al-Ambic Still: a still design dating to 620 AD comprising a pot and am onion-shaped upper portion. Used today for production of spirits such as Cognac, Armagnac and brandy.

Aleurone Layer: the outer layer in a grain kernel where enzymes are synthesized.

Alpha-Amylase: an enzyme synthesized in a grain kernel. Hydrolyzes the bonds alpha 1,4 between glucose molecules.

Alpha 1,4; the bond responsible for creating linear chains of starch.

Alpha 1,6: the bond responsible for creating branched chains of starch.

Amino Acid: molecular structure contains an amine NH2 group, a carboxyl group COOH and an R side chain.

Amygdalin: a substance present in stones of fruit. Under influence from enzymes, it can break down into cyanide.

Amylose: a linear chain of starch.

Amyloglucosidase: an enzyme capable of breaking alpha 1,6 bonds.

Amylopectin: a branched chain of starch.

Anaerobic: without Oxygen.

Angels Share: that portion of distillate lost each year from an oak barrel due to evaporation.

Anther: male sex organ on a flowering plant.

Aspergillus Niger: a naturally occurring fungus that is used in creating artificial man-made enzymes.

ATP: adenosine tri-phosphate, a free energy compound generated during the glycolysis process.

Azeotropic Point: the mixture ratio of two liquids such that boiling the mixture will not cause further purification.

Bacillus Lichenformis: a naturally occurring fungus that is used in creating artificial man-made enzymes

Beta-Amylase: an enzyme synthesized in a grain kernel. Hydrolyzes the bonds alpha 1,6 between glucose molecules.

Bud Points: those points on a growing grapevine where new shoots emerge form.

Budding: the process by which Saccharomyces Cerevisiae yeast cells reproduce.

Calvin Cycle: ribulose 1,5 bi-phosphate in growing plant fibers interacts with a molecule of Carbon Dioxide from the atmosphere and under the influence of solar energy from the Sun forms a 6 Carbon molecule.

Calyptra: tissue covering the reproductive organs on a flower.

Cellulose: an extremely long chain of 6-carbon molecules. Cellulose is a main constituent of wood.

Chitting: the action of a rootlet starting to emerge from a germinating kernel of grain.

Coleoptile: a sheath protecting the acrospires of a growing kernel.

Coleorhiza: a sheath that protects the root of a growing kernel.

Crabtree Effect: the ability of yeast to start consuming sugar and make alcohol even with Oxygen present.

Cytoduction: taking the cytoplasm components of one yeast strain and transferring them to another strain.

Cytoplasm: the interior 'fluid' of a yeast cell.

Decarboxylation: removal of the C-O-O-H part of a fatty acid.

Diastase: a reference to the naturally occurring enzymes in malted grain.

Distillation: the separation of two miscible liquids by virtue of differences in their respective boiling points.

DNA: deoxy-ribonucleic acid. See nucleic acid.

Dorsal Side: the non-creased side of a grain kernel.

ELISA Test: enzyme related test used to determine gluten content of a liquid.

Embryo: that part of a grain kernel that generates a root and a shoot.

Embryo Sac: contains the ovary on a flowering plant.

EMP: Embden Meyerhof Parnas metabolic pathway responsible for the conversion of glucose into alcohols.

Endosperm: the interior of a grain kernel.

Enzyme: a protein substance that acts as a catalyst for a chemical process.

Ester: combination of a fatty acid and an alcohol molecule. Otherwise known in brewing and distilling circles as flavor or aroma.

Eukaryote: cellular structure with a true nucleus.

Flag Leaf: the final leaf stage of a tiller prior to the growth of the rachis.

Fructose: a saccharide molecule of structure $C6H12O6$.

Gay Lussac: French scientist, mid 1800s, who advanced the understanding of fermentation.

Gelatinization Point: that temperature where the structural integrity of a grain kernel breaks down.

Germinative Capacity Test: a brief test to assess the ability of grain kernels to sprout.

Germinative Energy Test: a brief test to assess the ability of grain kernels to sprout.

Giberellin: hormone responsible for generation of enzymes in a grain kernel.

Glucan: gummy protein substance responsible for containing starch molecules in a grain kernel.

Gluconobacter: a member of the acetic acid family of bacteria. Causes fruit to spoil.

Glucose: a saccharide molecule also of structure $C_6H_{12}O_6$.

Glucosidase: a protein enzyme responsible for breaking down molecular chains of starch.

Glumes: membranes surrounding the spikelet of a growing grain ear.

Golgi Complex: considered to be the traffic switching mechanism governing movement of material within a yeast cell.

Gram Negative Bacteria: bacteria having a cell wall with lesser amount of peptidoglycan.

Gram Positive Bacteria: bacteria having a cell wall with peptidoglycan.

Grist: grain that has been passed through a roller mill or hammer mill.

Hemicellulose: a very long chain of 5-carbon sugar molecules. A main constituent of wood.

Husk: the outer protective layers of a grain kernel.

Invertase: an enzyme generated by yeast through protein synthesis to aid the yeast cell in absorbing maltose and maltotriose.

Klyveromyces Maxianus: a strain of yeast used to ferment lactose in the production of Alpha Vodka.

Lactobacillus: bacteria commonly found in cheeses, yogurts and sourdough bread. Spoilage bacteria of concern to brewers and distillers.

Lactone: cyclic esters of hydroxycarboxylic acids. Typically present in toasted and charred oak wood.

Lactose: a saccharide formed by the combination of a glucose and a galactose molecule. Used in the production of alcohol for Alpha Vodka.

Lectins: fibrils on outside of yeast cell that play a role in flocculation.

Lees: the yeast sediment at the bottom of a fermenter vessel.

Lemma: tissue protecting the embryo of a grain kernel.

Leuconostoc Meserenteriodes: a high alcohol tolerant bacteria.

Lignin: a complex organic polymer found in the structure of wood.

Limit Dextrinase: a protein enzyme responsible for breaking down molecular chains of starch.

Lodicule: tissue beneath the ovary sac of a grain floret.

Maillard Reaction: interaction of an amino acid and a reducing end of a sugar molecule to produce dark pigmented material.

Maltose: two glucose units joined together.

Maltotriose: three glucose units joined together.

Malting: the process in which grain kernels are sprouted.

Marc: the leftover pulp from a grape crush.

Mashing: the process in which grain is taken to above its gelatinization temperature to liberate starch molecules and break down the structure of the kernel.

Megasphaera: spoilage bacteria of concern to brewers and distillers.

Micropyle: the end of grain kernel from which the root and shoot emerge.

Mitochondrion: that part within a yeast cell where Kreb’s Cycle reactions occur.

Molasses: the industry term assigned to the sludge residue remaining after sugar has been extracted from cane juice.

NAD: nicotinamide adenine dinucleotide, a co-enzyme in yeast cells.

NADH: the electron receptor version of NAD.

Nucleic acid: molecular structure comprising a ribose sugar, a nitrogenous base, and a phosphate residue.

Nucleus: that part within a yeast cell where DNA material is stored.

Palea: tissue surrounding the embryo of a grain kernel.

Pectin: a natural polysaccharide occurring in fruits, when heated it causes thickening. A precursor to methanol formation in fruit spirits.

Pectinatus: spoilage bacteria of concern to brewers and distillers.

Pentosan: a 5-carbon sugar.

Peptide: two amino acids joined together.

Pericarp: the tissue layer immediately beneath the husk.

Periplasmic Space: Spacing between plasma membrane and cell wall.

Peroxisomes: small organelles in a yeast cell that perform oxidative reactions.

Pistil: female sex organ on a flowering plant.

Plasma Membrane: the envelope surrounding the interior of a cell.

Pollen: the male sperm cells in the plant world.

Pomace: the mixture of seeds and skin left after pressing grapes.

Prokaryote: cell structure common to bacteria containing lesser developed internal parts.

Protease: an enzyme generated by yeast through protein synthesis to aid the yeast cell in absorbing maltose and maltotriose.

Protein: a molecular chain of amino acids.

Pyruvate: a key intermediate product in the metabolic conversion of glucose to alcohol.

Quercus Alba: the species of oak also known as American Oak or white Oak.

Quercus Robur: European oak.

Rachis: the growth structure that emerges from the boot of the flag leaf. The rachis will grow and develop nodes as it extends.

Rachilla: from each of the rachis nodes will emerge a structure called the rachilla. From the rachilla will emerge spikelets. Each spikelet will exhibit a floret.

Raoult: French scientist, mid 1800s, who advanced the understanding of distillation.

Recombinant DNA: inserting the DNA material from a foreign plant into a yeast cell to impart new properties to the yeast cell.

Residual Alkalinity: the amount of alkalinity in water that has not been offset by hardness.

Ribosomes: organelles in a yeast cell where proteins are synthesized.

RNA: ribonucleic acid. See nucleic acid.

Saccharomyces Cerevisiae: the dominant species of yeast used in brewing and distilling.

Saladin Box: a box for germinating grain that allows for the flow of moist air through the germinating grain bed.

Scutellum: membrane separating the embryo of a grain kernel from the endosperm.

Shoots: new growth on a grapevine.

Sour Mash: a technique involving the use of stillage in a subsequent grain mash.

Spheroplastic Fusion: removing the cell wall from two yeast cells and merging them.

Spikelet: see rachis

Stamen: appendage supporting the male sex organ on a flowering plant.

Starch: a combination of multiple glucose molecules.

Stillage: the liquid remaining in a still after the completion of a distillation run.

Sucrose: a saccharide molecule formed by the combination of a glucose and a fructose molecule.

Surface Tension: the elastic tendency of liquids that makes them acquire the least surface area possible.

Tannin: naturally occurring polyphenol found in plants, seeds, bark, wood, leaves and fruit skins.

Testa: the tissue layer immediately beneath the pericarp.

Tetrazolium test: the addition of 2,3,5 tetrazolium chloride to a grain kernel to test for its viability.

Tiller: growth part of a plant that supports the ear of grain.

Vacuole: that part of a yeast cell acting as a storehouse of nutrients.

Vapor Pressure: pressure exerted by a vapor in thermodynamic equilibrium with its condensed phases (solid or liquid) at a given temperature in a closed system.

Ventral Side: the creased side of a grain kernel.

Water Sensitivity Test: a brief test to determine if grain kernels are sensitive to water thus rendering them slower to sprout.

Xylanase: the protein enzyme that will break down the glucan gums in grains.

Zymomonas Mobilis: a waterborne bacteria noted for imparting funky aromas as it consumes sugar.

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About The Author

After graduating from Queen's University (Canada) Faculty of Engineering in 1986, Malcolm Bucholtz embarked on a career in the steel industry. With his first paycheque in hand, he went to a local home brewing store where he bought Charlie Papazian's book, The Joy of Home Brewing, along with all the tools and toys needed for making beer at home. Although not realized at the time, this purchase would have lasting and profound implications.

In 1999, Malcolm completed his MBA from the Edinburgh Business School at Heriot Watt University. This opened the door to exciting opportunities over the next 15 years in the financial brokerage industry as well as the junior mining industry. During this time, he started making beer using the all-grain method, he explored making wine from fruit, and he delved into making mead from honey mead.

In early 2014, Malcolm began yearning for new adventures. While contemplating the idea of returning to Heriot Watt University to pursue a graduate degree in Brewing & Distillation, he happened upon the UK-based Institute for Brewing and Distilling (IBD) and instead registered to write their General Certificate Exam in Distilling.

In late 2014, Malcolm began presenting 5-day Distilling workshops. In addition to delivering workshops, Malcolm offers his consulting services to entrepreneurs seeking to launch small craft distilleries. He provides distillers with assistance in creating business plans and marketing strategies. He also assists with recipe development, equipment sourcing, and operational start-ups.

In June 2017, Malcolm was accepted into the Master's degree program in Brewing & Distilling at Heriot Watt University in Edinburgh. In October 2020, his M.Sc. degree was granted. Somehow, he thinks a whole new adventure is just around the corner.

You can find Malcolm at:

Website: www.ProhibitionUniversity.com.

Facebook: @ProhibitionU

Linked In Discussion Group: Craft Distilling Discussion Group.

Malcolm is also the author of The Recipe – Reviving the Lost Art of Home Distilling. The 2nd edition of this book was released in early 2021 and is directed at those hardy souls seeking to become competent home distillers.

Over the past decade, the craft distilling movement has exploded to include over 1800 small batch distillers in the United States, some 250 in the UK, and nearly 200 in Canada. Yet despite this apparent growth, craft distilling has not managed to take a commanding piece of the beverage alcohol market share.

Successfully making beverage alcohol takes more than passion. It demands a solid working knowledge of the science that underpins raw material selection, water chemistry adjustments, yeast microbiology, the fermentation cycle, the physics of fractional distillation, and the ageing reactions that occur in an oak cask. Once a craft beverage alcohol has been created, it must successfully be marketed. The subtle strategic nuances of the marketing process are almost as complex as the science of making the alcohol itself.

This 5th edition of *Field to Flask* represents the culmination of the author's years of practical brewing and distilling experience combined with his considerable educational knowledge. This book is designed both for entrepreneurs contemplating the launch of a craft distilling business and for craft distillers to get better at what they do.

As you turn the pages of this book, you will be taken on a journey that briefly looks at the history of alcohol and then goes on to deeply examine the science of raw materials, water, yeast, fermentation, distillation, oak ageing, and proofing. You will also learn the legal definitions of various spirit types, the legislation that affects the industry, and about the different licenses required. You will gain a solid understanding of the equipment needed to make beverage alcohol and the science of marketing beverage alcohol products. The book wraps up with a series of recipes to jump start your product development.

Whether you are an existing craft distiller looking to gain market share or an entrepreneur thinking about launching a craft distillery, this book is designed for you.

Malcolm Bucholtz, B.Sc., MBA, M.Sc., has been making beer and wine for 30 years. In 2014, the completion of the General Certificate in Distilling exam from the UK-based Institute for Brewing & Distilling (IBD) propelled him headlong into the realm of distilled spirits. Malcolm teaches distillery courses, provides contract distilling services, and assists start-up distillery projects with recipe development and business strategy. Most recently, he completed his M.Sc. degree in Brewing & Distilling at Heriot Watt University in Edinburgh, Scotland.