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Sugar cane spirits: cachaça and rum production and sensory properties

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Abstract: The production of cachaça, a distilled spirit made directly from sugar cane juice and rum obtained by fermenting molasses, a by-product of the sugar industry, are comparatively presented. The main differences, from raw material to fermentation, distillation and aging process are pointed out, in order to explain the resulting composition and distinct sensory characteristics of these two beverages and to show the importance of the sensory quality control, during all the production process.

Key words: cachaça, rum, sugar cane, molasses, fermentation, distillation, sensory quality control.

17.1 Introduction

Cachaça, the most traditional and popular alcoholic beverage produced in Brazil since the middle of the sixteenth century, is produced by distilling fermented fresh sugar cane juice. Rum, produced in various countries, is already recognized as one of the most traditional spirits derived from sugar cane.

According to Brazilian legislation, the term cachaça is reserved for sugar cane spirit having 38–48% alcohol (v/v) at 20 °C, made by distilling fermented fresh cane juice, only in the Brazilian territory (Brasil, 2002). Rum, according to the same legislation, is a distilled alcoholic beverage, having 38–54% alcohol, produced by distilling fermented molasses, or molasses mixed with sugar cane juice, and aged in oak or other wooden casks (Brasil, 1997).

17.2 Raw materials

Cachaça and rum are both derived from the same sugar cane plant (*Saccharum officinarum*).

The raw material used to produce cachaça is the juice squeezed from the sugar cane stalks, while rum is mainly obtained from the molasses, a by-product of the industrial sugar process. The juice extracted to make cachaça can also be heat-evaporated to obtain a concentrate, similar to industrial molasses, to make so-called agricultural rum. Thus rum and cachaça, though coming from the same plant, are in fact obtained from distinct raw materials: cachaça is made directly from the sugar cane juice, while rum production is mainly based on sugar cane molasses.

17.2.1 Must preparation

The sugar cane juice as extracted from the stalks, the raw material for cachaça, is itself a natural must. However, to achieve better fermentation and more economic results, some procedures are carried out before fermentation. The juice is first left standing in a settling tank, to separate the dense impurities by gravity. It is then diluted with water, in order to adjust the sugar concentration and the fermentation yeast capacity, preventing inhibition of the yeast by high alcohol levels, as well as reducing waste and preventing bacterial fermentation of the remaining sugar.

Usually, the juice temperature is adjusted to 30 °C, sulphuric acid is added to lower the pH (5.5–4.5), and nutrients are used to promote fermentation. In some cases, disinfectants and antibiotics are also used in the must preparation, to eliminate undesirable microorganisms.

The molasses provided by the sugar industry, as already mentioned, is the main raw material for rum production. Its most important constituent is sugar (55–56% w/w), but other components, such as sulphated ash, nitrogen compounds, gums and unfermentable sugars, may also affect the quality of the molasses (Nicol, 2003). Given that molasses, coming directly from the sugar refinery, is delivered hot at the distilleries, it is recommended that its stored temperature never exceeds 45 °C, to prevent Maillard reactions and occasional spontaneous combustion (Chen, 1985).

In order to partially remove the suspended solids and avoid contamination, the molasses is first diluted to 45 °Bx and the temperature raised to 70 °C. At this stage sulphuric acid is added to lower the pH and encourage sedimentation. The diluted and acidified molasses is then transferred to a settling tank and the supernatant (clarified molasses) is decanted from the sludge, diluted to the desired working specific gravity (16–20 °Bx), pumped to the fermenter, enriched with nutrients and finally pitched with yeast (Nicol, 2003, Delavante, 2004).

17.3 Fermentation

In the old traditional technique for cachaça and rum production, the fermentation process occurred naturally by the action of yeasts and bacteria present in the air, contaminating the dilution water and the sugar cane juice or lying dormant in the

molasses. Nowadays, besides this traditional technique, pure or mixed cultures are being more and more employed (Rosa *et al.*, 2009).

The sugar cane juice fermentation for cachaça production is a very robust process that can occur even under technically adverse conditions, owing to the high adaptative capacity of the yeast used (mainly *Saccharomyces cerevisae*). The use of selected yeasts is common in large distilleries, to ensure predictable flavor and process time, but many small-scale production units still use baker's yeasts or the so called 'fermento caipira', natural or wild yeast mixtures, developed in the distilleries themselves (Faria *et al.,* 2003a).

Rum fermentation is mainly conducted by *Saccharomyces cerevisae, Saccharomyces bayanus, Schizosaccharomyces pombe* and various strains of competing bacteria in the 'dunder', the natural ferment foam residue of a previous rum batch, which is used as the inoculum.

17.3.1 Fermentation process

The fermentation process is usually carried out in cylindro-conical fermenters with domed tops or in cylindrical open-topped vessels with sloping bases. At the end of the process, there are a lot of suspended solids from the raw materials and the yeast cells that need to be separated before distillation.

Cachaça fermentation, depending on several interfering factors, can take from 20–30 hours to be completed, while the rum (molasses) fermentation takes around 24 hours and yields 5–7% (v/v) alcohol, depending on the original settling gravity (Rosa *et al.*, 2009).

In both cases, stainless steel is the material of choice, but fermenters made of wood, mild steel and other materials, are still often used.

17.4 Distillation

When the compositions of sugar cane juice and molasses are compared, it is easy to understand why the products resulting from the two fermentations are quite distinct.

The fermented molasses, due to its more complex composition, certainly requires a more carefully controlled distillation to separate the undesirable compounds from the distillate, which can explain why the distilling apparatus and procedures used for rum and cachaça are not the same.

17.4.1 Pot still distillation

Pot still cachaça or 'cachaça de alambique'

In view of the composition of the sugar cane 'wine', the use of one simple pot still, also called alembic and usually made of copper or stainless steel and copper, is enough to separate and concentrate the desired distilled compounds from the residual wine components.

Fig. 17.1 Cachaça pot stills.

The alembics used for cachaça distillation (Fig. 17.1) may have distinct shapes and sizes, but in all cases the main objective is to separate the head fraction, which has the more volatile compounds, from the heart and tail fractions. The heart, which contains about 80–85% of the total distilled volume and has from 40–48% (v/v) alcohol, can already be bottled and consumed (Faria *et al.*, 2003a), while the head (first) and tail (last) fractions should be discarded.

A double distillation process as shown in Fig. 17.2, or even using the same alembic, has also been proposed, to obtain a spirit with a lighter aroma and taste, which would be further aged (Novaes, 1999; Bizelli, 2000; Rota and Faria, 2009).

Pot distilled rum

In order to obtain a distillate of fine sensory characteristics from fermented molasses, the traditional approach is double distillation, an effective way of removing undesirable components and bringing the strength of the spirit to about 65% (v/v) alcohol.

However new systems of distillation, such as the retort still developed in Jamaica can, in a single distillation, bring the strength up to 85% (v/v) alcohol, with the desired character (Delavante, 2004).

The cachaça, distilled in alembics, like the pot still rum, usually has a more complex composition than distillates obtained by column distillation, mainly due to the reactions among the volatile compounds that occur during the distillation process, catalyzed by the copper of the still (Cole and Noble, 1995).

Fig. 17.2 Double cachaça pot stills.

17.4.2 Column distillation

After the invention of the original Coffey still, the use of continuous column distillation became a practical alternative for spirit production. The main advantages of this kind of spirit distillation are: fine distilling selectivity, increased production, energy savings, decrease of sensory defects and better standardization of the distillate.

Cachaça distilled in columns or 'cachaça de coluna'

As mentioned above, column distillation allows greater distilling control than the single alembic units, making it easier to remove the undesirable compounds (produced by defective fermentations) and resulting in lighter, standardized and cheaper products (Fig.17.3).

The sensory characteristics of cachaça distilled in a column are different from those of pot-still cachaça. This fact, together with the diversity of regional and technical practices, may explain the great range of characteristics of cachaça, readily perceived all over Brazil.

Rum column distillation

The two-column still, patented by Coffey in the nineteenth century, is still used to produce lighter-flavored rums with up to 95% (v/v) alcohol, as well as a new three-column still, used to produce an even lighter spirit (Delavante, 2004).

A new column patent French Savalle still can also be used to produce very distinctive products from light- to medium-flavored rums, as well as rectified spirits for vodka and gin production (Nicol, 2003).

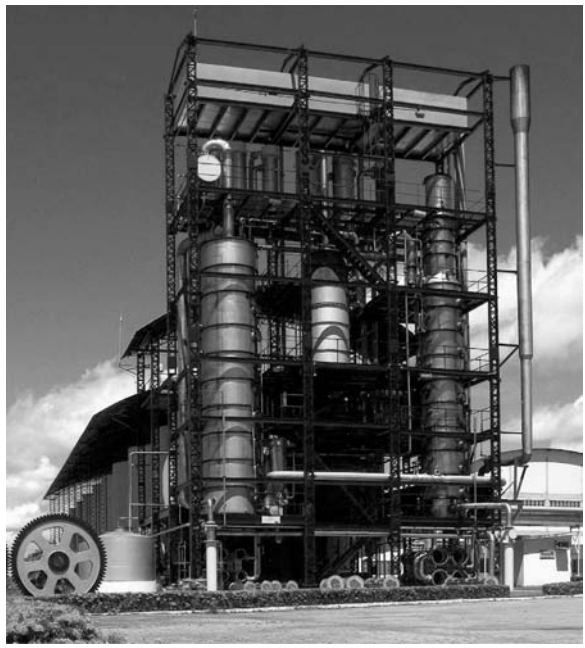

Fig. 17.3 Column distillery with capacity to produce 300 000 l of cachaça per day. (Source: reproduced with kind permission of the Ypioca Group.)

17.5 Maturation

Aging distilled spirits in oak casks (180–700 l) favors the acquisition of good color and taste from the oak and the loss of the harsh sensory characteristics of the new distillates. In some processes the aging or maturation step forms an integral part of the production of distilled beverages.

17.5.1 Cachaça aging

Very few spirits (such as cachaça) have a satisfactory sensory quality straight after being distilled, which could explain why aging cachaça was not a normal practice in the past. However, this process may produce a significant improvement in its flavor (Cardello and Faria, 1998, 1999).

Currently, besides the use of remade oak whiskey casks from North America and Scotland, a great number of Brazilian wood species have been tested and used for aging cachaça (Faria *et al.*, 2003b).

17.5.2 Rum aging

The aging process is normally associated with the processing and definition of rum, and its effects are already part of the sensory characteristics expected in rum.

17.6 Cachaça and rum: similarities and differences

Although obtained from the same raw material and in a very similar way, some features of cachaça and rum production must be pointed out, to explain the observed differences between these two spirits.

The sugar cane juice and the molasses, used to prepare the must to be fermented, already have quite different chemical and microbiological compositions, mainly due to the heat treatment to which the sugar cane juice is subjected, during processing in the sugar industry.

The chemical reactions and the concentration of juice components that occur during heating and even afterwards, will certainly change the original sugar cane juice into a quite distinct by-product: molasses. Also, the fermentation is done with quite distinct yeasts and processing conditions, as already mentioned.

Lastly, in view of the different wine compositions that result, the distillation of cachaça and rum must also be conducted in distinct ways, resulting in distillates that, aged or not, will have very distinct chemical and sensory profiles.

The overall effect of all the differences observed during the production of cachaça and rum may explain their distinct and variable compositions, shown in Fig. 17.4 and 17.5 (Cardoso *et al.*, 2004), where significant differences can be observed among the compositions of commercial samples of cachaça and rum.

Thus, based on the production differences and on the final compositions, it is possible to state that cachaça and rum, while having a common origin, are distinct beverages with well-defined sensory characteristics (Magnani, 2009).

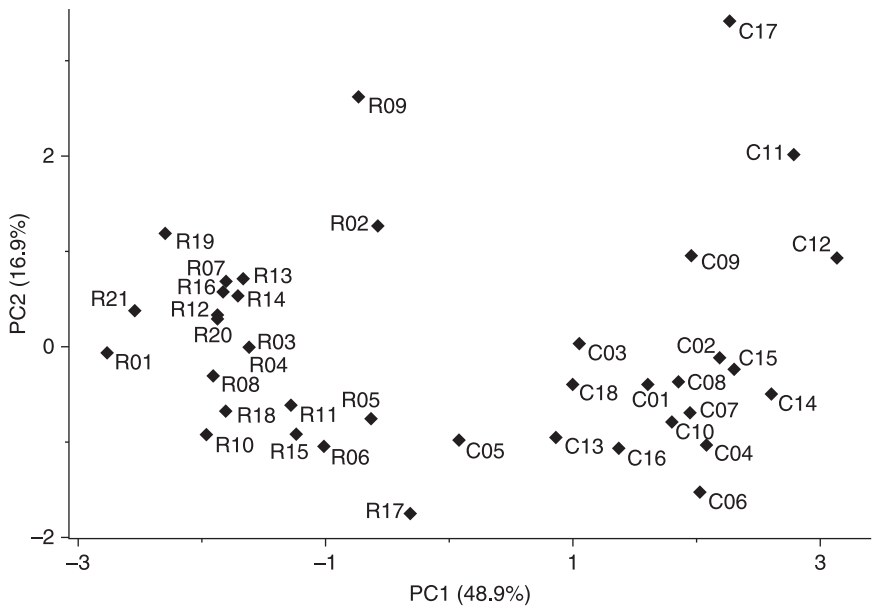

Fig. 17.4 PCA scores plot of cachaça and rum samples using the variables: protecatechuic acid, propanol, isobutanol, copper, magnesium and manganese (Source: Cardoso *et al.*, 2004).

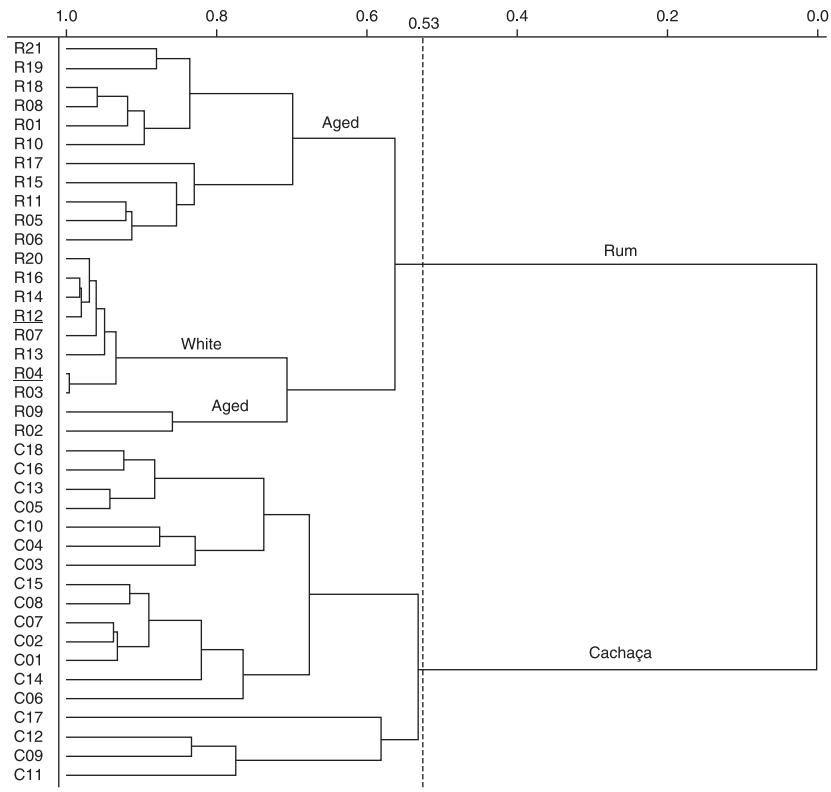

Fig. 17.5 HCA dendrogram of cachaça and rum samples (Source: Cardoso *et al.*, 2004).

17.7 Sensory quality of cachaça and rum

Any distilled beverage is a mixture of all the compounds derived from the raw material and production process that will help define its sensory identity.

Some of these compounds are already known, as well as their positive or negative sensory effects on the quality of the drink (Janzantti, 2004).

The quality control of the process must ensure that the expected good sensory characteristics are present in the final product, and the best and most effective way to achieve this objective must certainly be based on methods of sensory analysis (Maçatelli, 2007). Thus, even during the production process, some sensory tests may be used to indicate whether the fermentation is going well or, for example, when it is time to cut the tail fraction.

The matured spirits, like whiskey, cognac, rum and aged cachaça, have some common sensory characteristics, mainly related to the fermentation and aging processes, but some special and distinct compounds generally define the unique aroma of each spirit.

The sensory profile of cachaça and rum are usually described in terms of the harsh characteristics of new distillates, such as sour, grassy, oily, sulphury, and

also to the mature flavors developed during the aging process, including vanilla, spicy, floral, wood and smooth flavors, as well as some variations in vocabulary.

Some compounds with strong sensory characteristics are often related to the sensory quality or defect of rum or cachaça: aldehydes, higher alcohols, ethyl and higher esters, acids, phenols and acetals, as well as some particular compounds found in specific spirits, such as 2-ethyl 3-methyl butyric acid in rum and dimethyl sulfide, directly related to a sensory defect of cachaça distilled in the absence of copper (Faria *et al.*, 2003c).

Figure 17.6 shows the sensory attributes related to cachaça and rum commercial samples and how it is possible to recognize and compare their sensory profiles.

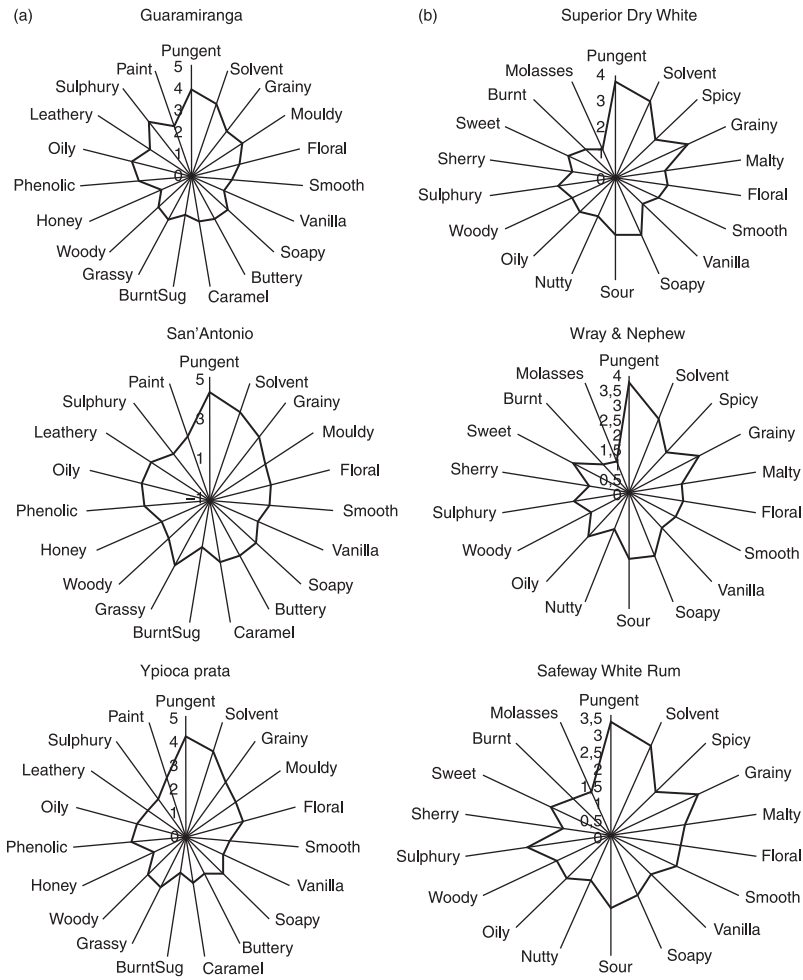

Fig. 17.6 Sensory attributes related to cachaça and rum commercial samples. (a) Commercial cachaça samples. (b) Commercial rum samples.

17.8 The challenge of new markets

Besides the very well established international market for traditional and well-known distilled beverages like rum, spirits like cachaça, new to this market, are showing a great potential for export (Faria *et al.*, 2004).

Unfortunately most of the very large volume of Brazilian cachaça is still produced by traditional techniques and directed to the internal market, where the competition is mainly based on the price and the profit primarily linked to quantity, not quality.

To change this situation, efforts must be made to develop the great sensory quality potential of cachaça. Changes in production technology, research into new sugar cane varieties and selected yeasts, as well the development of new distilling and aging techniques, always supported by sensory analysis (Janzantti, 2004; Maçatelli, 2007), will certainly provide good quality products, the best way to recognize the social and economic importance of this historical Brazilian beverage and to profit with its exportation.

17.9 Sources of further information

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17.10 Acknowledgement

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