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ANALYSIS OF SENSORY ASPECTS IN THE QUALITY CONTROL OF THE ALEMBIC CACHAÇA INDUSTRY

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ABSTRACT

Cachaça de alembic is a Brazilian drink composed mostly of ethyl alcohol, water and a mixture of natural substances formed in the production process that add the sensory characteristics responsible for the quality of this product. However, the still very artisanal production has little technology to manage and control the preparation of the beverage on an industrial scale due to the process variables being presented, in general, as "immeasurable and intangible". Due to this scenario, a way out to carry out quality control is the use of sensory analysis in all stages of the production process, which are passed on through simple training for all employees on the "factory floor". This work aims to analyze the importance of the use of sensory analysis in the manufacture of cachaça in an industry located in the district of Galante, Campina Grande/PB through the daily monitoring of its production. After three months of qualitative evaluation, it was seen that sensory analysis is an easily disseminated and efficient tool to assist the quality control of the final product, mainly because it is simple and applied by all employees.

Keywords: Cachaça Production. Quality Control. Sensory Aspects.

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INTRODUCTION

According to Law No. 8,918, of July 14, 1994, regulated by Decree No. 6,871, of June 4, 2009 of the Ministry of Agriculture, Livestock and Supply (Mapa), cachaça is the sugarcane brandy, produced in Brazil, with an alcohol content of 38-48% (v/v), at twenty degrees Celsius, obtained by distilling the fermented must of sugarcane juice with peculiar sensory characteristics, sugars up to 6g/L can be added.

The beverage described is composed mostly of ethyl alcohol and water, but the "peculiar sensory characteristics" come from a mixture of substances natural to the process, called congeners, such as higher alcohols, esters, aldehydes and organic acids. In addition to the components of the drink, there are also some contaminants, such as methanol and ethyl carbamate, toxic and carcinogenic, respectively.

Normative Instruction/MAPA No. 13, of June 29, 2005, establishes the limits for both congeners and contaminants, which requires attention from producers to control these in the beverage. However, these components are formed during the fermentation process and distillation, through spontaneous reactions and/or poor hygiene in the production environment.

Due to these facts, it becomes more difficult to perform quantitative control in loco, since we are analyzing intangible and immeasurable factors and the quantification methods have a high cost and are performed only by specialized laboratories. Quality management in the sugarcane sector is based on Good Manufacturing Practices (GMP) and Standard Operating Procedures for Operational Hygiene (PPHO) regularized by Ordinance/Anvisa No. 326 of July 30, 1997.

However, there are some sensory aspects that can indicate errors throughout the production process, easily identifiable for urgent and emerging decision-making. Deming (1990) states that "what cannot be measured, cannot be managed", and thus, these factors are not considered as part of the quality control of the alembic cachaça industries.

Based on the principle that the chemical composition of cachaça directly influences its quality and that quantitative and instrumental control have a high cost, this work aims to analyze how sensory aspects can be used in the quality control of the final product in an Alembic cachaça industry located in Galante/PB.

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LITERATURE REVIEW

INDUSTRIAL QUALITY CONTROL

According to Maximiano (2006), quality can be described as "application of the best talents and efforts to produce the highest results". From an organizational point of view, it is considered as the set of attributes related to meeting customer demands and the standard of products and services available.

In one way or another, this function of production has undergone an evolution over time and is today one of the most important requirements in both manufacturing and service production. In the age of craftsmen, quality was focused on fully meeting customers' wishes, but production was very low. After the Industrial Revolution, mass production and the large number of failures, waste and work accidents began to require attention beyond final product inspections, applying industrial production standards (SILVA, 2006; SOUZA, 2019).

In this scenario, in which the need to evaluate the production process from start to finish grows, the concept of Quality Control (QC) emerges, which is a set of inspection actions to check and assess whether the characteristics of a product/service comply with its requirements throughout the process.

QC is applied in all activities of the production process to minimize the passage of defective products to the next stages of production. The farther away from the input a quality defect is detected, the more difficult and expensive it is for the company to repair it. By implementing a preventive system, there is a significant reduction in costs related to errors, defects, and scrap, in addition to improving compliance with the characteristics inherent to manufacturing/service itself (SOUZA, 2019).

This is very clear in the specific case of alembic cachaça, in which quality requirements are directly linked to its composition and sensory perception. The only complete quality analysis carried out is that of the final product, where batch samples are sent to authorized laboratories that perform physicochemical analyses in accordance with the requirements of IN/MAPA No. 13, of June 29, 2005. If any parameter is out of the standard, the result is the disapproval of the batches and financial loss for the company. In order for these requirements to be met, there are several control measures (such as cleaning vats between fermentations, pH and temperature measurement, etc.) that can be taken to ensure that the quality of the final product is in accordance with the requirements of the legislation. These are linked to Critical Control Points and Good Manufacturing Practices.

STANDARD OF IDENTITY AND QUALITY OF CACHAÇA

Normative Instruction No. 13, of June 29, 2005 of MAPA describes the Technical Regulation for Setting Identity and Quality Standards for Sugarcane Brandy and Cachaça, conceptualizing the beverage as follows:

> Cachaça is the typical and exclusive denomination of Sugarcane Brandy produced in Brazil, with an alcohol content of 38% vol (thirty-eight percent by volume) to 48% vol. (forty-eight percent by volume) at 20ºC (twenty degrees Celsius), obtained by distillation of fermented must from sugarcane juice with peculiar sensory characteristics, It can be added sugars up to 6g/l (six grams per liter), expressed as sucrose.

In the third paragraph of the same Normative Instruction cited in item 2.1, MAPA establishes the chemical composition and quality requirements of the beverage, which is basically composed of water, alcohol and non-alcoholic substances (GARCIA, 2016).

These non-alcoholic substances form a set of aromas and flavors that make up cachaça, known as a bouquet. Among them are higher alcohols (alcohols with more than 2 carbons), organic acids, aldehydes and esters (RIBEIRO, 2016; GARCIA, 2016). The legislation allows the presence of these compounds and even determines a concentration limit, according to Table 1:

Table 1 - Limits for congeners established by the cachaça quality standard.

CONGENERS	MINIMUM	CEILING
Volatile Acidity	Not Applicable	150mg Acetic Acid/ 100mL of Anhydrous Alcohol
Total Esters	Not Applicable	200mg Ethyl Acetate/ 100mL Anhydrous Alcohol
Total Aldehydes	Not Applicable	30mg Acetaldehyde / 100mL Anhydrous Alcohol
Furfural + Hydroxymethylfurfural	Not Applicable	5mg Furfural + Hydroxymethylfurfural / 100mL Alcohol Anhydrous
Alcohols Superior	Not Applicable	360mg Isobutyl Alcohol + Isoamyl + n-Propylic/ 100mL of Anhydrous Alcohol
[1]Coefficient of Congeners	200mg /100mL of Anhydrous Alcohol	650mg/100mL Anhydrous Alcohol

Note: [1] is the value resulting from the sum of all congeners./Source: IN/MAPA n° 13 of 06/29/2005.

Congeners are substances inherent to the production process of the beverage, that is, they are formed naturally and are part of its compositional, sensorial and quality

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characteristics. On the other hand, paragraph 5 of IN/MAPA No. 13 describes the limits (Table 2) for contaminants that may be present in the beverage, substances that are formed due to errors, lack of monitoring or process hygiene and are harmful and/or toxic to human health:

Table 2 - Limits for contaminants established by the cachaça quality standard

ORGANIC CONTAMINANTS	CEILING
Methanol	20mg/100mL Anhydrous Alcohol
Ethyl Carbamate	150µg / 100mL Anhydrous Alcohol
Acrolein	5mg/100mL Anhydrous Alcohol
Sec-butyl alcohol	10mg/100mL Anhydrous Alcohol
N-butyl alcohol	3mg/100mL Anhydrous Alcohol
INORGANIC CONTAMINANTS	CEILING
Copper (Cu)	5mg/L Anhydrous Alcohol
Lead (Pb)	200µg/L Anhydrous Alcohol
Arsenic (As)	100µg/L Anhydrous Alcohol

Source: IN/MAPA n° 13 of 29/06/2005.

Congeners (or secondary compounds) are substances formed naturally during the production process of alembic cachaça, usually during fermentation, through both the normal metabolism of Saccharomyces cerevisiae (yeast) and spontaneous reactions between newly formed compounds (SACZK; NELSOB and ANJOS, 2011; GARCIA, 2016).

In the case of contaminants, substances that should not be present in the beverage, the occurrence is related to negligence in production, such as lack of monitoring of process variables, external contamination, and errors in the execution of procedures. Chart 3 gathers some information on the formation of these components in the cachaça production process.

Thus, knowledge about the formation of these compounds is extremely important to be able to carry out quality control in relation to the sensory composition of the beverage required by legislation, as well as consumer protection regarding Food Safety. Mastering the formation pathway of these compounds helps both in the manipulation of the process to induce the production of beneficial substances that add value and quality to the product, keeping them within the required limits; as well as to avoid the appearance of compounds harmful to human health, reducing the quality of the drink (MIRANDA *et al.,* 2007; BORTELLO; SILVELLO & ALCARDE, 2018).

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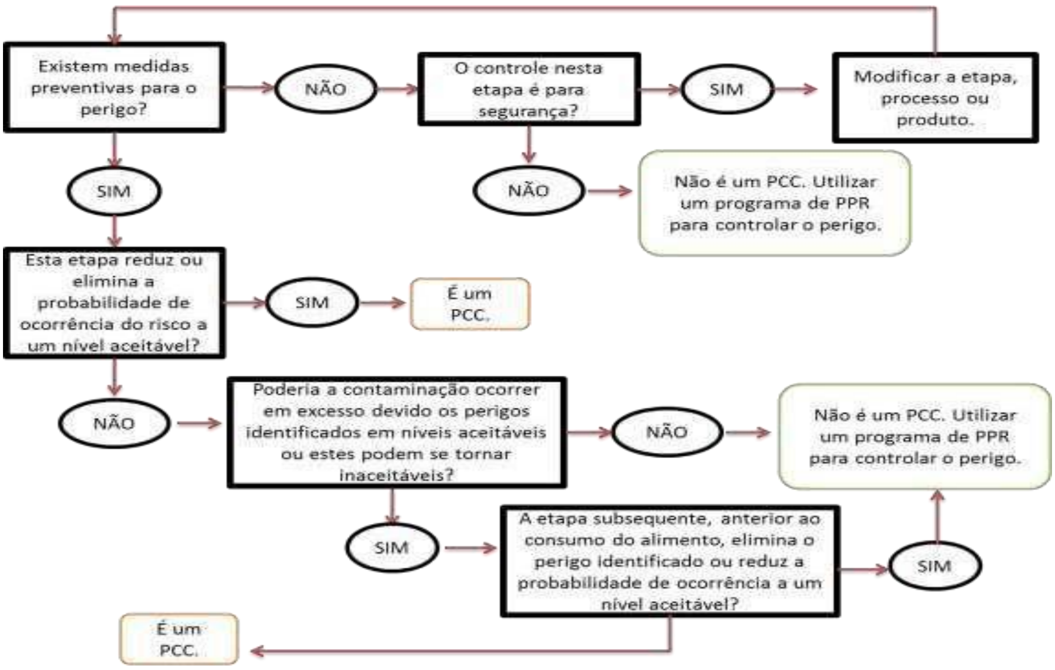
HAZARD ANALYSIS AND CRITICAL CONTROL POINTS

According to Venturini et al. (2011), the Hazard Analysis and Critical Control Points (HACCP) is based on the identification of potential hazards to food safety, as well as on measures to control the conditions that generate these hazards. It is based on seven principles, which are: (a) Hazard analysis and preventive measures, (b) identification of critical control points, (c) establishment of critical limits, (d) monitoring procedures, (e) corrective actions, and (f) verification and registration procedures.

Hazards can be physical (F), chemical (Q) or biological (B) in nature and can be classified as Critical Control Points (CCP) or Prerequisite Program (PPR). To characterize them in the face of adequate management, it is necessary to carry out some evaluations by way of questioning, such as those presented by the Codex Alimentarius Tree for determining control in Figure 1.

The PPR is the set of procedures that include Good Manufacturing Practices (GMPs) and Standard Operational Hygiene Procedures (PPHO), that is, it constitutes a necessary hygienic-sanitary basis suitable for the implementation of the HACCP System. PCCs, on the other hand, are any point, stage or procedure in which preventive containment measures are applied to keep a significant danger that cannot be resolved with PPR under control, with the objective of eliminating, preventing or reducing risks to the consumer's health.

Figure 1 - Food Code Tree for control determination



Source: Prepared by the authors, 2023.

Within the alembic cachaça production system, most controls can be carried out through PPR procedures and those that do not (highlighted in green) are usually related to chemical hazards.

GOOD MANUFACTURING PRACTICES

Good Manufacturing Practices (GMPs) are the activities and procedures carried out in the company to control possible sources of microbiological cross-contamination and ensure that the product meets the identity and quality requirements required by IN/MAPA No. 13 of June 29, 2005. Among them, the following general aspects must be defined: (a) Planning, control and inspection of cleaning, sanitization of environments and equipment and utensils, (b) Integrated pest control, (c) Standard Operating Procedures for all stages of the process and (d) Standard Operational Hygiene Procedures, such as training in GMPs in accordance with RDC/Anvisa No. 275 of October 21, 2002.

Chart 3 - Formation of congeners and contaminants in the cachaça production process.

SUBSTANCE	HOW IT IS FORMED	REFERENCES
Superior Alcohols	They are formed by the action of enzymes on fermentation reaction intermediates and the amino acids formed by the metabolism of yeast cells.	JANZANTTI, 2004; GARCIA, 2016; RIBEIRO, 2016;
Esters	80% corresponds to ethyl acetate, formed by the esterification reaction between the ethyl alcohol resulting in fermentation and organic acids produced by the cellular metabolism of yeast or during the aging of the drink.	JANZANTTI, 2004; GARCIA, 2016; RIBEIRO, 2016;
Acids	90-93% corresponds to acetic acid, formed by the oxidation of aldehydes or degradation of amino acids. At levels above normal, it is a Evidence of contamination by acetobacteria.	JANZANTTI, 2004; GARCIA, 2016; RIBEIRO, 2016;
Aldehydes	90% corresponds to acetaldehyde, formed by the oxidation of ethyl alcohol formed in fermentation or Oxidative degradation of Strecker during fermentation.	JANZANTTI, 2004; GARCIA, 2016; RIBEIRO, 2016;
	Furfural + HydromethylFurfural (HMF) are formed by the thermal degradation of sugar during distillation (thermal dehydration of pentoses and hexoses, respectively) and during the aging process, due to barrel pyrogenesis.	JANZANTTI, 2004; SACZK; NELSON; DOS ANJOS, 2011; GARCIA, 2016; RIBEIRO, 2016;

Methanol	It is formed through the burning of pectic substances, such as the burning of sugar cane and during distillation, if there is a transfer of bagasse to the pot of the still, or even by degradation during fermentation.	CARUSO; NAGATO; ALABURDA, 2010; SACZK; NELSON; DOS ANJOS, 2011; GARCIA, 2016; RIBEIRO, 2016;
Ethyl Carbamate	It is formed by the reaction of urea, N-carbamyl or citrulline, which react with the ethanol in the wine during distillation. The most common route is through urea,	ANDRADE-SOBRINHO Et al., 2002; CARUSO; NAGATO; ALABURDA,
Ethyl carbamate (cont'd)	Often used as a must supplement for yeast.	2010; SACZK; NELSON; DOS ANJOS, 2011; GARCIA, 2016;
SUBSTANCE	HOW IT IS FORMED	REFERENCES
Acrolein	It is an aldehyde formed by the action of bacteria on glycerol or by the dehydration of glycerol during distillation in a still.	JANZANTTI, 2004; SACZK; NELSON; DOS ANJOS, 2011; GARCIA, 2016;
Copper	It is transferred to the beverage during distillation if holm oak is formed, a basic copper salt resulting from the oxidation of the still.	JANZANTTI, 2004; ALCARDE, 2017; BORTOLETTO; SILVELLO; ALCARDE, 2018;
Arsenic and Lead	They are transferred to the beverage through contact with materials than the Contain in its constitution as welding of equipment or even through the addition of water contaminated with them in the process.	ALCARDE, 2017; BORTOLETTO; SILVELLO; ALCARDE, 2018;

Source: Prepared by the authors, 2023.

Thus, each company must develop its Good Manufacturing Practices plan so that the Prerequisite Program can be developed that works in addition to the HACCP. Hygienic-sanitary conditions are premises for controlling various aspects of production and are also required by current legislation (VENTURINI *et al.,* 2011).

METHODOLOGICAL PROCEDURES

The methodology used in the study was exploratory. For Beuren et al. (2003, p. 80), exploratory research has some specific purposes, such as: "to provide more information on the subject that is going to be investigated; facilitate the delimitation of the research theme; guide the establishment of objectives and the formulation of hypotheses; or discover a new kind of approach to the subject." In data collection, bibliographic research and unstructured interviews were used.

The study is also classified as a case study, according to Yin (2005), it is a research strategy that seeks to examine a contemporary phenomenon within its context. It differs, therefore, from experimental designs in the sense that they deliberately divorce the phenomenon under study from its context. Likewise, case studies differ from the historical method in that they refer to the present rather than the past.

In this case, this research was developed in the field at Engenho Bruma Leve, in the city of Galante, District of Campina Grande/PB, in the months of September, October and November 2019.

The research is also classified in terms of bibliographic and documentary purposes, as it is better to know the object of study using as reference documents and primary works or discussions already found in the literature, regardless of which field of knowledge it belongs to.

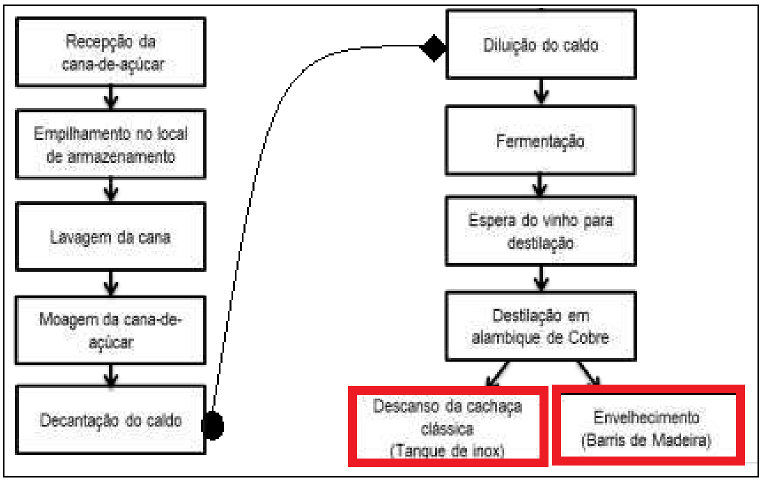
To analyze the importance of using sensory aspects in quality control, daily production monitoring was carried out, with active participation in the company's training. Data were collected through notes resulting from observations, discussion of doubts with employees and sensory evaluation in the stages of the process.

RESULTS AND DISCUSSIONS

PRODUCTION FLOW CHART

The first aspect to be studied in the field was the production process in detail. Every step from the reception of the raw material to the shipment of the final product. Figure 2 brings together all the general stages of the production of Bruma Leve cachaça. In each of them, the control variables involved, the normal aspects sensorially perceptible in the production and the most recurrent errors in the day-to-day process were explored.

Figure 2 - Production flowchart of the Bruma Leve Mill



Source: Prepared by the authors, 2023.

The production flow follows a panorama aimed at rationalizing products and maximizing the production process of alembic cachaça, taking into account the different managerial aspects of the process.

EVALUATION OF CRITICAL CONTROL POINTS AND PREREQUISITE PROGRAM IN THE FIELD

After fully acknowledging the production process, the investigation began in relation to the HACCP analysis described in Chart 4 of section 2.3. Each phase of the production process has dangers associated with the decrease in product quality, and therefore deserves full attention from quality control.

The risks classified with PPR are solved with Good Manufacturing Practices measures described in the industry's own GMP Manual, which includes standard activities such as rigor regarding the purchase and transportation of raw materials, cleaning of environments and utensils, and hygiene and health of its workers.

The critical control points, however, are the most worrisome. They are risks directly linked to the composition of the products, usually of a chemical nature. Cachaça, which is a solution of water and similar in limited quantities, has quality associated almost exclusively with the fulfillment of these sensory requirements and the control of PCCs are extremely complex, and it can be said that in reality they are not controlled, but conditioned not to exceed the required upper limits.

Looking at the points highlighted in green in Chart 4, the first critical point of control is associated with the choice of the type of raw material. The presence of Furfural and Hridroxymethylfurfural (HMF), toxic compounds, are avoided with the acquisition of only green sugarcane, without prior burning.

The next PCCs are all due to the formation of undesirable or excess chemical compounds during the fermentation process. The excess of n-butanol and sec-butanol in the beverage due to microbiological contamination as well as the contamination of the wort by lactic and acetic bacteria is controlled by maintaining the average temperature at 32°C, pH ≈ 4.0 and minimum waiting time for distillation. The excess formation of higher alcohols and aldehyde, as well as methanol, is managed by maintaining temperature and pH in the parameters already mentioned and care in the treatment of the juice, such as the removal of bagacillos by sieving.

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In the distillation sector, the contamination of the beverage by copper from the still is managed by maintaining it in the off-season. The separation of the "head" and "tail" fractions ensures the control of excess congeners and contaminants in the final product. The formation of furufural during distillation is conditioned by the presence of remaining yeast cells of the wine, and is decreased by controlling the decanting time of the wine before distillation. The formation of the contaminants acrolein and ethyl carbamate are administered by slow distillation and at sufficiently safe temperatures.

Finally, in the aging section, there is again a concern with the excessive formation of Furfural and Hridroxymethylfurfural (HMF) due to the excessive toasting of the barrels, which is managed by the rigor in the purchase and quality of the barrels.

As can be seen in the description of the previous paragraphs, the critical control points, for the most part, do not allow management by means of measurable variables depending directly on the experience of those responsible for the work to identify the correspondence to the expected requirements for the final product.

SENSORY EVALUATION IN PRODUCTION

The Brazilian Association of Technical Standards NBR ISO 5492:2017 defines that "sensory analysis is the discipline used to evoke, measure, analyze and interpret reactions characteristic of food and materials as they are perceived by the senses of sight, smell, taste, touch and hearing".

Despite being applied to finished products, this type of analysis has extreme value on the factory floor, since the senses are accessible to personnel with any level of technical knowledge, the work routine allows a standard sensory perception to be established (considered normal) for everyone who deals with production and the information to be passed on for minimum training necessary for these analyzes can be made available over time and individually.

Chart 1 brings together the main points in the production chain of alembic cachaça that are controlled by sensory stimuli in real time in production:

Chart 4 - Production controls carried out essentially by sensory analysis

SECTOR	PROBLEM	SENSORY STIMULATION	CONTROL ACTIVITY

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RECEPTION OF RAW MATERIAL	Presence of furfural and HMF that indicates loss of sucrose and addition of these compounds to the final product	Vision	Visual evaluation of color and odors that are indications of burning.
	Biological contamination that facilitates the proliferation of microorganisms.	Vision	Selection of random stalks from the sugarcane lot for visual analysis integrity, presence of sugarcane borer (surface holes) and brown spots on the fibers.
PREPARATION OF THE MUST	Presence of bagacillos that generate methanol in distillation	Vision	In the act of preparing the must and fermentation, supernatant bagacillos are observed on the surface and their removal is carried out with the help of a sieve.
FERMENTATION	Microbiological contamination that generates excess or undesirable chemical compounds in the product Final	Smell	The odor exhaled in the fermentation process is characterized as sweet and slightly acidic (similar to ripe fruits). At the end of fermentation, the fermented must (or wine) smells like the name it bears. Odors of rotten eggs, vinegar and rancidity are indications of microbiological contamination.
PRE-DISTILLATION PERIOD	Excess yeast cells in wine can form furfural and HMF during distillation	Vision	During the wine resting period, samples are taken and left to decant to observe the proportion of cells contained in the whole. In the act of pumping the wine to the still, a portion of it (delimited by the visual evaluation of the height of occupation of the yeast in the flying vat) is discarded so as not to reduce the reach of these cells to the still.
DISTILLATION	Contamination of the product with Copper of the still	Vision	The contamination of the product with copper occurs through the formation of a basic salt of this element called holm oak. This salt is easily detectable on the walls of the pot of the still because it has a blue-green color. Likewise, when distillation begins, the salt detaches from the wall and descends into the reservoir along with the cachaça, being easily detectable.

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	Contaminant chemical compounds and mixing between fractions	Smell	The sensory wheel of aromas of cachaça delimits perceptible odors inherent to the final product, and can be easily identified at the outlet of the condenser, where the heart fraction is collected. An olfactory analysis shows if the sample has expected characteristics, or if the odors are similar to those of the head and tail fractions, indicating contamination between them.
STORAGE AND AGING	Furfural and HMF contamination,	Sight and smell	Before using the barrel, it can be opened at the factory for visual inspection for excess toasting, cleaning and ash residues that may pass into the final product. Sample collections throughout aging guide the quality characteristics in terms of color and excessive aromas.
	Proper barrel packaging	Sight and smell	During the period of scarcity of the product in the barrel, it is necessary to put water and keep it always full. However, very long changes can promote internal rotting of the wood, forming substances with putrid odors and coloration ranging from yellow to brown, and which will pass on to the next stored product. These odors are easily identified and can be removed by new distillation.
FILLING	Asepsis of the bottles and solid contaminants in the final product	Vision	After filtering and packaging the product, the bottles pass through an illuminating table where the aspects of color and turbidity are observed, as well as the presence of foreign bodies and dirt inside the final packaging.

Source: Prepared by the authors, 2023.

Controls in the cachaça production process are essential to arrive at a product with organoleptic characteristics acceptable to the consumer market of alembic cachaça.

4.4 SENSORY TRAINING AS A QUALITY CONTROL TOOL IN THE FIELD

In addition to the characteristics evaluated above, the Engenho uses the Cachaça Sensory Wheel, illustrated by Figure 3 to train its employees in the identification of specific odors and tastes that may appear during the production process. With these olfactory

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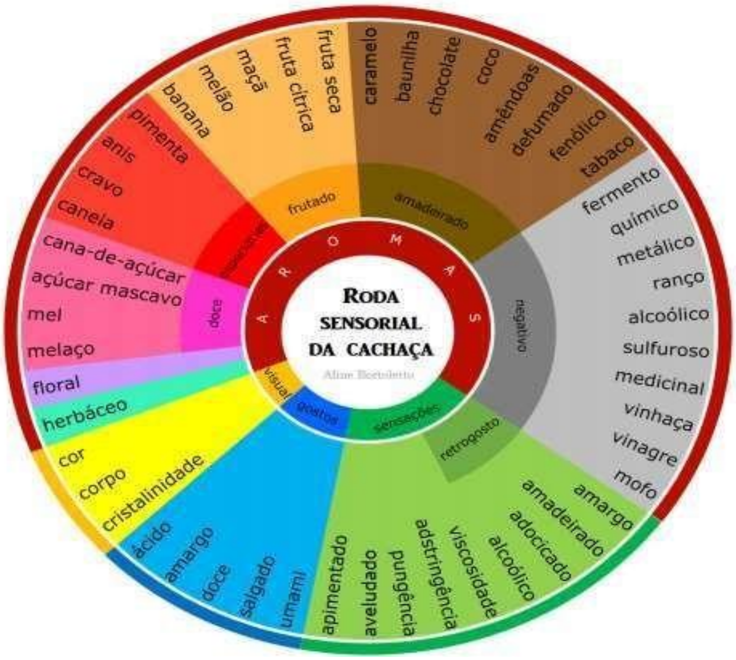
perception tests, quality defects are easily perceived, especially during the fermentation process, in which characteristic odors such as rotten egg (sulfurous) and vinegar indicate yeast contamination and allow early interruption of production.

Figure 3 - Production controls carried out essentially by sensory analysis



Source: Bortoletto, 2016.

Production control through the Sensory Wheel is essential to achieve a quality cachaça that will reach the consumer's table. Especially due to the peculiar characteristics and varied odors that the product can acquire during the production process.

FINAL CONSIDERATIONS

As discussed in this work, the production of alembic cachaça and its control and quality parameters depend heavily on sensory evaluations throughout the production chain. The slow development of technology for these sectors makes it difficult to use equipment to measure measurable variables, making it important to apply simpler and more empirical techniques.

Although sensory evaluations are an intermediate precision technique - since our senses develop in different ways - they are related to actions that require little from their operators and can, through simple training, be used by any and all employees on the factory floor.

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Therefore, sensory evaluations are control activities and quality evaluations that can be used efficiently through quick training and executed concomitantly with production, without prejudice to working hours and improved in the day-to-day production. Throughout the production process, sensory indicators (odors, tastes and visualizations) help in decision-making regarding the quality of the product being formed and, linked to the physical-chemical reports (which prove the characteristics expected for cachaça) regularized by MAPA, make up the ideal scenario for the quality control of the final product.

It is recommended that research be carried out in other cachaça-producing industries in other regions of the country, mainly aiming at the continuous improvement of the production process of this drink, which is typically Brazilian.

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