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Terminology for the descriptive sensory analysis of cachaça produced using cell recycling of commercial yeasts

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Abstract

Why was the work done: Yeast strain selection and biomass recycling are used during cachaça production, yet the impact on the sensory profile remains poorly understood. This study assessed how successive recycling of strains of commercial *Saccharomyces cerevisiae* influences the sensory characteristics of unaged cachaça.

How was the work done: Twenty four cachaça samples were produced with four commercial strains of *S. cerevisiae* subjected to successive cycles of recycling and periodic yeast renewal. A trained sensory panel developed a descriptive sensory lexicon and evaluated the samples using quantitative descriptive analysis. Analysis of variance and principal component analysis were used to identify the sensory attributes that differentiated the samples of cachaça.

What are the main findings: Thirty seven sensory descriptors were established for characterisation of cachaça. Alcoholic sensation and ethanol aroma predominated across all samples; however, significant differences were observed for selected sensory attributes. DistilaMax CN and CA11 were associated with fruity and floral notes, whereas DistilaMax RM and DistilaMax SR showed greater pungency and oily characteristics. Increased cycles of yeast recycling were associated with the increased intensity of undesirable attributes, particularly rancid and vinegar aromas.

Why is the work important: The results demonstrate that yeast strain selection and management of biomass recycling influence the sensory profile of cachaça, supporting the optimisation of fermentation strategies to improve product consistency and quality. In addition, the sensory lexicon developed in this work provides a framework for future sensory studies and quality control of sugarcane spirits.

Keywords

cachaça; sensory; lexicon; quantitative descriptors; analysis; yeast; fermentation; recycling.

Introduction

Descriptive sensory analysis enables the identification of sensory characteristics which are perceptible and important to the quality of food. Such analysis relies on trained human assessors acting as ‘measurement instruments’, which determine the characteristics of products in terms of appearance, aroma, flavour, and texture. These attributes can be quantified in terms of intensity, creating the sensory profile of the product (Dos Santos Navarro et al. 2012).

With beverages, sensory science plays an important role in understanding consumer preferences, product profiling and the creation of new products. Quantitative and qualitative tests are fundamental to sensory communication and product description. The development of attributes enables a qualitative fingerprint which can be quantified to provide information on intensity. Descriptive analysis is a widely used technique to quantify and optimise sensory attributes (Marques et al. 2022).

In the evaluation of beverages, flavour characterisation is conducted through both chemical and sensory analyses. These identify the presence or absence of defects with the overall balance of sensory properties relying on assessment by panels of trained tasters. The perceived quality of the product is directly related to its sensory complexity, which results from the interaction and synergy/antagonism among the compounds in the beverage (Vilela 2021).

For cachaça, sensory testing is of importance as it provides a multidimensional measurement of the product. Advantages include the ability to identify perceptible differences, describe characteristic sensory sensations, detect features that cannot be identified through analytical procedures, and assess product acceptance. The interaction among the aroma and flavour compounds defines the sensory profile of cachaça, directly influencing its market acceptance (Bortoletto 2023).

Although yeast selection is one of the main factors affecting fermentation performance and the formation of volatile compounds in beverages, little is known about how successive yeast recycling influences the sensory characteristics

of cachaça. This limits the understanding of whether changes in chemical composition are translated into perceptible differences in beverage quality. A recent study investigated the effects of successive recycling of commercial *Saccharomyces cerevisiae* strains on the physicochemical characteristics and volatile composition of cachaça, demonstrating that yeast strain and fermentation management influence the formation of key aroma compounds (Carvalho et al. 2025).

Chemical analyses alone cannot explain how compositional changes are perceived sensorially, as sensory evaluation is necessary to determine whether differences in volatile composition are reflected in the sensory quality of the beverage. Accordingly, the aim of this study was to develop a sensory lexicon and characterise the sensory profile of cachaça produced with different commercial yeast strains subjected to successive recycling cycles. By combining descriptive sensory analysis with chemical analysis, this study provides a more comprehensive understanding of the effects of yeast recycling on cachaça quality. The findings may contribute to improving yeast selection and fermentation management strategies, supporting improved product and sensory consistency in both artisanal and industrial cachaça production.

Methods and materials

The project was subject to the Human Research Ethics Committee to assess the safety, compliance with Brazilian legislation, and protocol ethics involving the sensory panel assessment of cachaça. This was approved (CAAE: 21491119.0.0000.5395/Opinion no 3.603.243).

Cachaça production

In all, twenty four cachaça samples were produced with different yeasts, fermentation cycles, and treatments (Table 1). Fresh sugarcane juice was extracted and prepared as described by Carvalho et al (2025). The juice was adjusted to a soluble solids content of 18° Brix and fermented using commercial active dried yeasts from Lallemand Biofuels and Distilled Spirits (DistilaMax RM – DRM, DistilaMax SR – DSR, and DistilaMax CN – DCN) and from LNF Latino Americana (CA11). All four yeasts are strains of *Saccharomyces cerevisiae* used in the fermentation

of sugarcane juice (DRM, DCN and CA11) or sugar beet juice (DSR). The fermentations using 12 L fermenters under static conditions were conducted in the same location, raw material, and hygienic practices.

Table 1. Cachaça samples produced with different yeasts, fermentation cycles, and treatments.

Sample Code	Strain	Cycle	Treatment
1	DistilaMax RM	1 st	T1
2	DistilaMax RM	4 th	T1
3	DistilaMax RM	7 th	T1
4	DistilaMax RM	10 th	T1
5	DistilaMax RM	2 nd /Week 1	T2
6	DistilaMax RM	2 nd /Week 3	T2
7	DistilaMax CN	1 st	T1
8	DistilaMax CN	4 th	T1
9	DistilaMax CN	7 th	T1
10	DistilaMax CN	10 th	T1
11	DistilaMax CN	2 nd /Week 1	T2
12	DistilaMax CN	2 nd /Week 3	T2
13	Distilamax SR	1 st	T1
14	Distilamax SR	4 th	T1
15	Distilamax SR	7 th	T1
16	Distilamax SR	10 th	T1
17	Distilamax SR	2 nd /Week 1	T2
18	Distilamax SR	2 nd /Week 3	T2
19	CA11	1 st	T1
20	CA11	4 th	T1
21	CA11	7 th	T1
22	CA11	10 th	T1
23	CA11	2 nd /Week 1	T2
24	CA11	2 nd /Week 3	T2

The commercial active dry yeasts were rehydrated according to the manufacturers' recommendations. The rehydrated yeast was transferred to sugarcane juice at 5° Brix and incubated at 30°C for 24 h. This starter culture was inoculated into sugarcane juice adjusted to 18° Brix. The inoculation rate differed: DistilaMax RM and DistilaMax SR were inoculated at 0.6 g/L (dry weight), DistilaMax CN at 0.5 g/L, and CA11 at 1 g/L.

Fermentation was performed using a yeast recycling system (Carvalho et al. 2025). At the end of each fermentation cycle, the yeast was recovered by decantation and reused as the inoculum for the subsequent fermentation cycle. After fermentation, the yeast biomass was allowed to settle naturally, the fermented wine (or 'wash') was removed for distillation, and the recovered biomass was reused as the inoculum for the subsequent fermentation cycle.

In Treatment 1 (T1) fresh sugarcane juice was added to the recovered biomass (without any treatment), allowing ten consecutive fermentation cycles. In Treatment 2 (T2), the yeast biomass was replaced with freshly rehydrated commercial yeast every seven days, enabling the evaluation of the effects of periodic yeast renewal on cachaça quality. All fermentations were conducted under the same processing conditions (sugarcane juice, temperature, inoculum preparation, and distillation procedures).

Each yeast strain underwent 10 fermentation cycles, with the 1st, 4th, 7th, and 10th cycles from Treatment 1 (T1) selected for sensory analysis. During these 10 cycles. In Treatment 2 (T2), two cycles were evaluated in which the yeast biomass (starter culture) was replaced every seven days to assess the need for such renewal. For the sensory analysis, the second cycles from week 1 and week 3 were chosen. Fermentation was complete at 0° Brix. The fermented wine was then distilled in a copper still and the 'heart' fraction diluted to 40% v/v ethanol using distilled water for sensory analysis (Carvalho et al. 2025).

Sensory analysis

Each sample was coded with three random letters and presented to the panellists in a random order, following the Williams Latin Square design (Williams 1949). To minimise sensory fatigue due to the alcoholic strength of the samples, each panellist tasted 12 mL of each sample. The experiment was conducted in triplicate.

The samples were served in ISO 3591:1977 glasses (transparent, smooth glasses made of crystal with a maximum of 9% lead, a rim diameter of 4.6 cm, width 6.5 cm, and height of 15 cm). Panellists were instructed to drink water between each tasting to refresh the palate and remove residual flavour from the previous sample. The methodology used to define the sensory profile of the cachaças was based on Descriptive Analysis and conducted according to the following stages.

Participant recruitment

Participants were recruited using an online form targeted at cachaça consumers with no prior experience in descriptive analysis of distilled

beverages. Individuals who reported being regular consumers of distilled beverages and who expressed appreciation for the product were included. Exclusion criteria included individuals under the age of 18, those with chronic illnesses, pregnant or breastfeeding women, individuals taking medication, those who did not enjoy the product, or anyone who reported any form of substance dependency. Alcohol consumption were minimal, with participants instructed not to swallow the product during the sensory analysis session.

Candidate pre-selection

Following recruitment, 15 individuals aged between 20 and 39 years, all consumers of unaged cachaça, were selected. Candidates were initially familiarised with a set of sensory references representative of the basic tastes and sensations commonly found in alcoholic beverages. The references were served in glasses covered with watch glasses and labelled as 'sweet,' 'bitter,' 'sour,' 'salty,' 'umami,' 'metallic,' and 'astringent.'

A second set of solutions was provided, coded with three digit numbers and containing the same references as the first set, but presented in a random order. Participants were instructed to evaluate the second set and identify which sample from the first set corresponded to each of the samples in the second set, assigning them with the previously presented descriptor terms. The reference solutions used for this are detailed in Table 2.

Table 2. Taste and sensation references used in candidate pre-selection.

Descriptor	Class	Reference compound	Concentration in water (g/L)
Sweet	taste	Sucrose	10 (1%)
Salty	taste	Sodium chloride	2 (0.2%)
Bitter	taste	Caffeine	0.3 (0.03%)
Sour	taste	Citric acid	0.3 (0.03%)
Umami	taste	Monosodium glutamate	0.6 (0.06%)
Metallic	sensation	Ferrous sulfate (7 H ₂ O)	0.01 (0.001%)
Astringent	sensation	Tannic acid	1 (0.1%)

After familiarisation with the basic tastes, the ability of panellists to recognise aromas present in the Cachaça Sensory Wheel (Bortoletto 2023) was assessed. For this, eight aroma reference samples were provided (Table 3), coded with three digit numbers in porcelain containers with - to prevent visual identification - perforated aluminium lids.

Using their sensory memories the candidates were instructed to describe each aroma and record their responses in an online form.

Table 3. Aroma references used in candidate pre-selection.

Descriptor	Class	Subclass	Reference
Fruity	Tropical	Banana	30 g of sliced banana
Vegetal		Cut Grass	Handful of freshly cut grass (20 mm in length)
Woody		Vanilla	0.02% vanillin solution in ethanol (analytical grade)
Chemical	Aggressive	Acetic	50 mL of vinegar
Vegetal		Fermented	Fleischmann dry yeast – 1g/20 mL water at 30°C
Sweet		Honey	5 mL of honey
Spices		Anise	4 units of star anise
Chemical	Off flavours	Ethyl acetate	10% v/v ethyl acetate solution in ethanol (analytical grade)

Subsequently, each panellist was assessed evaluated using the triangle test (Sinkinson 2017). Three samples of commercial unaged cachaça were served (Table 4), two of which were identical and one different. The panellists analysed the samples using visual, olfactory, and gustatory parameters, indicating which one differed. Only panellists who achieved accuracy rates in the triangle test above 65% proceeded to the next stage.

Table 4. Cachaça used in the candidate pre-selection triangle test

Cachaça	Quantity
Cachaça Silver Princesa Isabel (Espírito Santo)	12 mL
Ypióca Silver sugarcane spirit (Ceará)	12 mL

Attribute survey and descriptive terminology

The panellists then assessed a survey of descriptive terms. Six samples were served in each session, and the panellists compared them based on differences and similarities. The terms used in the sample description were 'appearance,' 'aromas,' 'basic tastes,' 'aftertaste,' and 'mouthfeel.'

The descriptor 'mouthfeel' involves attributes such as oral warming, astringency, and mouth coating. The perception of these is related to the stimulation of mucous membranes, which are soft tissues lining the inside of the nose, lips, mouth, and throat. Oral warming, characterised by subtle burning or stinging sensations, occurs primarily due to the presence of ethanol (Jack 2021).

After the evaluation and under the supervision of the panel leader, the panellists met in two sessions to discuss the terms raised, with the objective of eliminating similar, redundant, or less frequently cited terms. By consensus, the terms that best described the samples were selected. The panellists also suggested reference samples, which were later used for training purposes. Finally, the panel established a list of terms that best described the cachaça samples that had been evaluated.

Panellist training

The training of the panellists aimed to reinforce the sensory meaning of each defined term. For each term, a high intensity reference sample was used to isolate the descriptor as much as possible to facilitate understanding and retention. This was conducted over ten sessions, during which the panellists were presented with the reference samples to memorise the sensory attributes to be evaluated (Tables 5a, b).

Final selection of the panellist team

After sensory training, each panellist evaluated three samples, with three repetitions. The selected cachaça samples were produced using different yeast strains and showed moderate variation across most of the attributes (nos 2, 15, and 19 in Table 1). The samples were served in a random order, with water taken between samples. This process sought to assess discrimination, repeatability, and reproducibility, and to verify that samples could be distinguished, reproducibly with consensus with the rest of the panel. Subsequently, as discrepancies were found, a further three group training sessions were held to align the parameters where disagreements had occurred. Ten panellists were selected based on their discriminatory ability, reproducibility, and consensus judgment.

Sample evaluation

To define the sensory profile of each cachaça sample, the panellists evaluated 24 samples in triplicate. The sensory characteristics were analysed using a categorical scale, with intensity indicated at the extremes. In each session, six samples were presented, distributed according to a complete block experimental design, to minimise possible effects of sample order on perception.

Statistical analysis

The sensory data collected was analysed using XLSTAT statistical software, using the following three steps: (i) Analysis of Variance (ANOVA), considering two sources of variation - samples and panellists; (ii) Tukey's Honestly Significant Difference (HSD) test, with a significance level of 5%; and (iii) Principal Component Analysis. The Principal component analysis (PCA) was performed using the sensory descriptors that exhibited significant differences according to ANOVA ($p < 0.05$). This approach was adopted to improve the interpretability of the multivariate model by excluding non-discriminatory variables.

The individual results of each panellist, for each attribute, were statistically analysed using ANOVA, by considering samples and repetitions as sources of variation. For each attribute and panellist, p-values of the F-tests related to the sample and repetition effects were calculated. All analyses were conducted at a 5% significance level.

Results and discussion

Descriptive terminology

The panel defined 37 descriptive terms to characterise the similarities and differences of the 24 samples of cachaça. These descriptors constituted the sensory lexicon that was used for descriptive analysis. The definition of these descriptors and the intensity references used to establish the upper extreme of the scale during panellist training are presented in Tables 5a,b.

Sensory profile

The mean intensity scores for the 38 sensory descriptors that characterised the cachaça samples are reported in Supplementary Information Table S1. From this, radar charts were created based on the mean values for each strain; DRM (Figure 1), DCN (Figure 2), DSR (Figure 3) and CA11 (Figure 4). Overall, the sensory profiles of the 24 cachaça samples were broadly similar, reflecting the standard conditions that were used for fermentation and distillation with yeast strain and recycling as the main experimental variables.

However, differences were observed for selected sensory descriptors, indicating that yeast strain

Table 5a. Descriptive terminology for cachaça

Classification	Term	Definition	Reference
Appearance	'Low leg' formation	Few droplets running down the glass	Distilled water (20 mL) served in ISO glass
	'High leg' formation	Many droplets running down the glass	Cachaça (20 mL) aged in French oak served in ISO glass
	Clear	Transparent, bright appearance, free of particles	Distilled water
	Hazy	Opaque appearance or presence of particles	Starch (5 g) in 100 mL distilled water
Taste	Sweet	Sucrose	Sucrose (2 g) in 200 mL neutral alcohol (Emfal - 40% v/v)
	Salty	Sodium chloride	Sodium chloride (0.8 g) in 200 mL neutral alcohol (40% v/v)
	Bitter	Caffeine	Caffeine (0.17 g) in 200 mL neutral alcohol (40% v/v)
	Lactic acidity	Lactic acid	60 mL of lactic acid (0.6%) solution in 200 mL neutral alcohol (40% v/v)
	Acetic acidity	Vinegar	Vinegar (10 mL) in 200 mL neutral alcohol (40% v/v)
	Umami	Monosodium glutamate	Monosodium glutamate (0.32 g) in 200 mL neutral alcohol (40% v/v)
Aftertaste	Bitter	Caffeine	Caffeine (0.17 g) in 200 mL distilled water
	Umami	Monosodium glutamate	Monosodium glutamate (0.32 g) in 200 mL distilled water
Mouthfeel	Metallic	Ferrous sulfate heptahydrate	Ferrous sulfate (0.008 g) heptahydrate in 200 mL distilled water
	Pungent	Burning sensation of the throat mucosa	Vinegar (30 mL) in 150 mL neutral alcohol (40% v/v); cachaça with >100 mg/mL acetic acid in anhydrous ethanol
	Velvety	Gentle, non-aggressive sensation on the mucosa	Carboxymethylcellulose (CMC, 0.5 g) in 250 mL distilled water
	Oily	Fatty sensation; soft coating on the tongue after swallowing	Glycerin (8 g) in 200 mL distilled water
	Astringent	Drying mouthfeel associated with high tannin wine	Blended cashew pulp (200 g) (Qualitá) in 200 mL water
	Watery	Low body sensation; short flavour duration	Distilled water (200 mL)
	Alcoholic	Tingling/burning sensation of the oral mucosa	Neutral alcohol (200 mL) (40% v/v)

Table 5b. Descriptive terminology for cachaça

Classification	Term	Definition	Reference
Aroma	Ethanol	Ethanol	50 mL of 70% (v/v) alcohol
	Banana	Banana	Banana purée (30 g) in 50 mL neutral alcohol (40% v/v)
	Rancid	Rancid butter	Stale butter (10 g)
	Vanilla	Vanillin	Vanillin solution (0.02%) in ethanol (analytical grade)
	Musty/Stored	Cork	Crushed cork (50 g)
	Olive	Brined olives	Olives (20 g) in 50 g of brine
	Molasses	Alcoholic molasses solution	Molasses (30 g) in 30 mL neutral alcohol (40% v/v)
	Foliage	Freshly cut leaves	Freshly cut leaves of <i>Syzygium jambos</i>
	Fermentation	Freshly activated yeast	CA11 yeast (1 g, LNF) in 50 mL water at 30°C
	Acetone	Acetone	Acetone nail polish remover (30 mL)
	Medicinal	Herbal liqueur	Jägermeister liqueur (30 mL)
	Sugarcane Juice	Sugarcane juice	Fresh sugarcane juice (30 mL)
	Vinegar	Vinegar	Alcohol vinegar (50 mL)
	Floral	Flowers	'Pear and Freesia' oily essence (1 mL, Vollmens) in 50 mL neutral alcohol (40% v/v)
	Fruity	Sweet fruits	5% isoamyl acetate (5 mL) solution + 5 mL of 'apple and apricot' aqueous essence (Quórum) in 50 mL neutral alcohol (40%, v/v)
	Yellow fruits	Yellow fruits	Pineapple extract (5 mL) + mango extract (5 mL) (Brau Flavours) in 50 mL neutral alcohol (40% v/v)
	Yogurt	Natural yogurt	Nestlé natural yogurt (30 g)
	Ethereal	Aroma of diethyl ether	3 mL of diethyl ether (analysis grade) (3 mL, 95%) in 50 mL neutral alcohol (40% v/v)

and fermentation cycle influenced specific sensory characteristics rather than variations in raw material or processing conditions. In agreement, Oliveira et al (2005), when evaluating the influence of different yeast strains isolated from cachaça

distilleries, concluded that *Saccharomyces* strains showed similarity in the production of volatile compounds responsible for flavour and aroma.

Cachaça samples exhibited high values for attributes

'alcoholic sensation,' 'ethanol aroma,' and 'presence of particles' in all samples. The 'leg formation' attribute showed variation after the tenth fermentation cycle with the DistilaMax RM (DRM) yeast (Figure 1). In the first fermentation cycle, a greater intensity of the 'watery sensation' was observed. These results suggest significant variations in the viscosity of the cachaça samples, with a lower perception in the first cycle and higher perception in the last.

'Legs' (or tears) form via the Marangoni effect (Scriven and Sternling 1960) driven by alcohol evaporation and surface tension differences between ethanol and water. In wine, the presence of legs is considered a visual indicator of alcoholic strength, observed on the inner surfaces of the glass as the liquid flows and stabilises after swirling (Venerus and Nieto Simavilla 2015; Laguna et al. 2017). Mixtures of water and ethanol produce convective effects, driving the liquid upward in thin films and downward in regular rows of droplets ('legs') (Vuilleumier et al. 1995). However, Laguna et al (2017) concluded that although ethanol alters the density and viscosity of the beverage when instrumentally analysed, these changes are not perceptible to consumers in terms of 'body'.

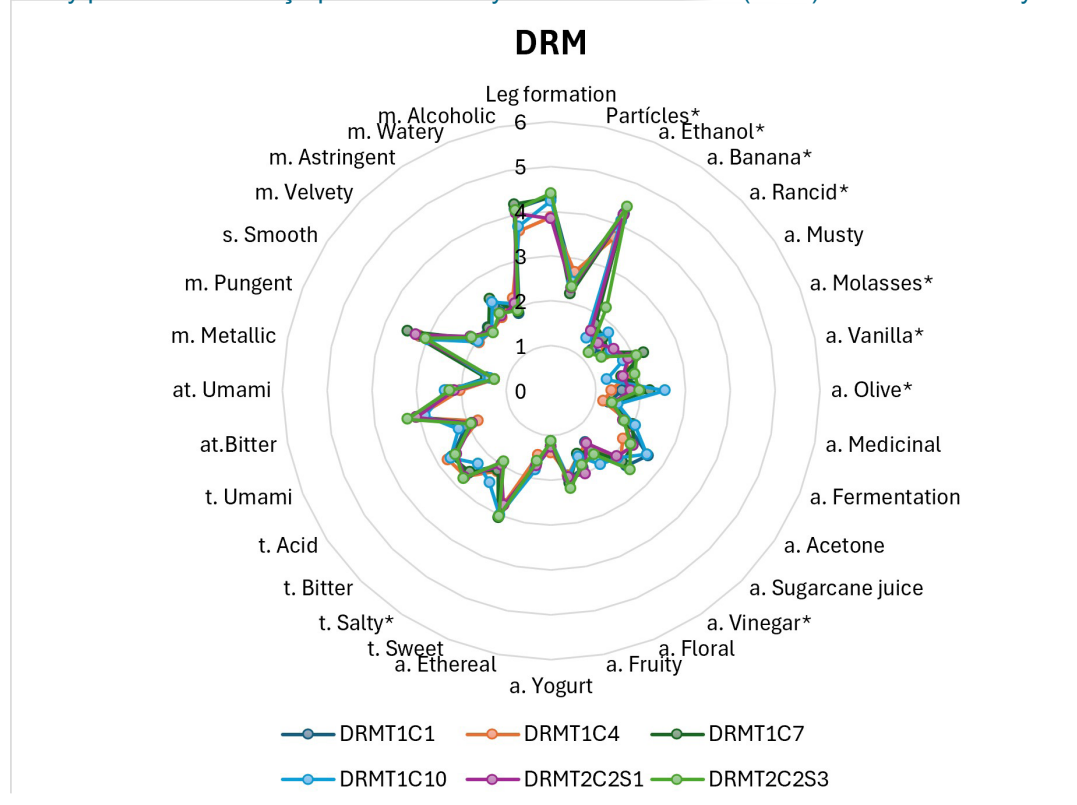
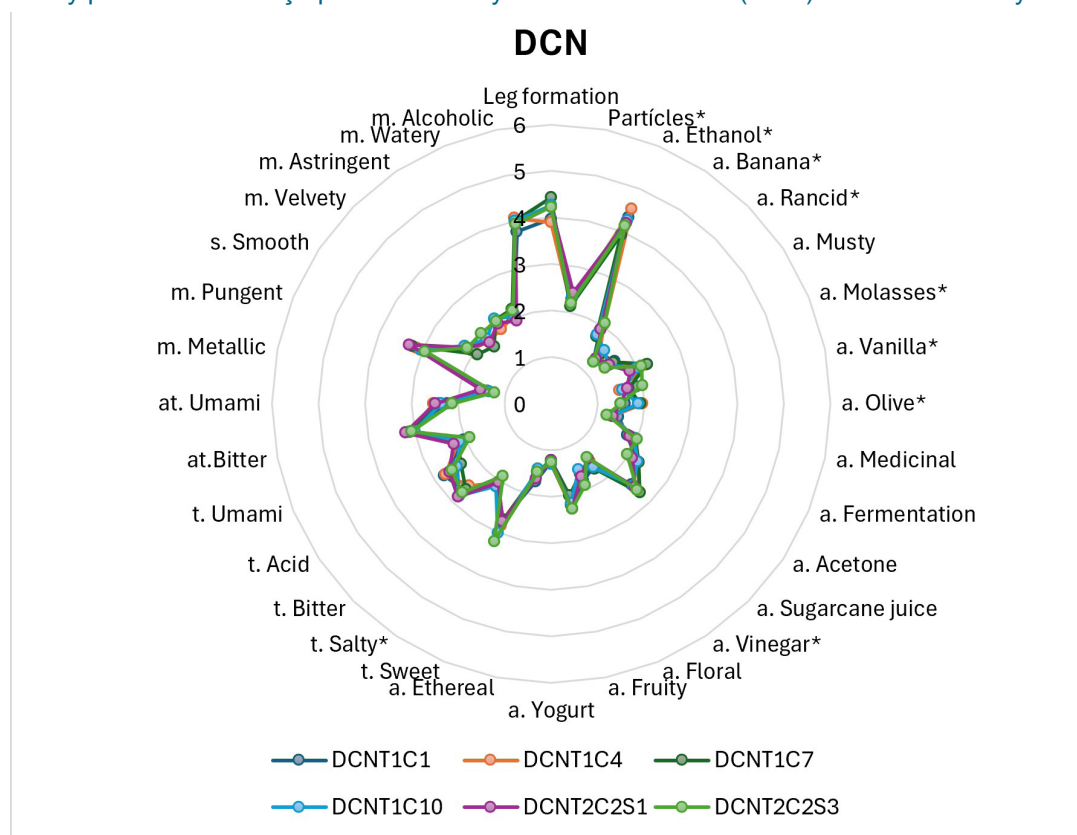
Among the descriptors, the most relevant differences were in the aroma attributes associated with fermentation quality and perception of mouthfeel. The aroma attributes 'musty,' 'rancid,' 'ethereal,' and 'medicinal' appeared at low intensities and were not defining characteristics of the samples. These attributes are generally considered sensory defects (Ratkovich et al. 2023; Corbion et al. 2023).

'Pungent sensation' was perceived with greater intensity in some samples, together with 'acid taste'. Vilela et al (2021) suggested the pungent sensation reflects organic acids such as citric, pyruvic, and malic acids, as well as acetaldehyde and other aliphatic aldehydes with carbon chains fewer than eight atoms, which may be found at higher concentrations in unaged cachaça. In addition, He et al (2022) noted that high concentrations of acetic acid also accentuates the perception of pungency. The profile of basic tastes (bitter, acidic, salty, sweet) appeared at low levels, suggesting balance of the beverage flavour.

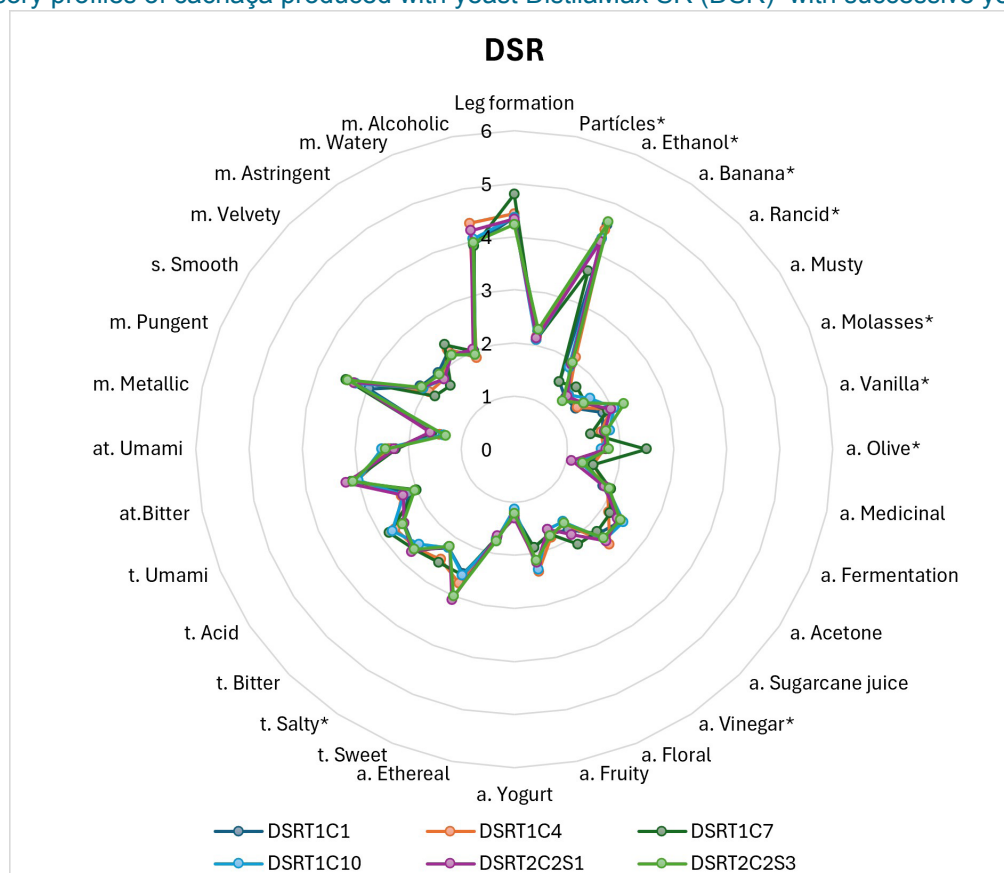
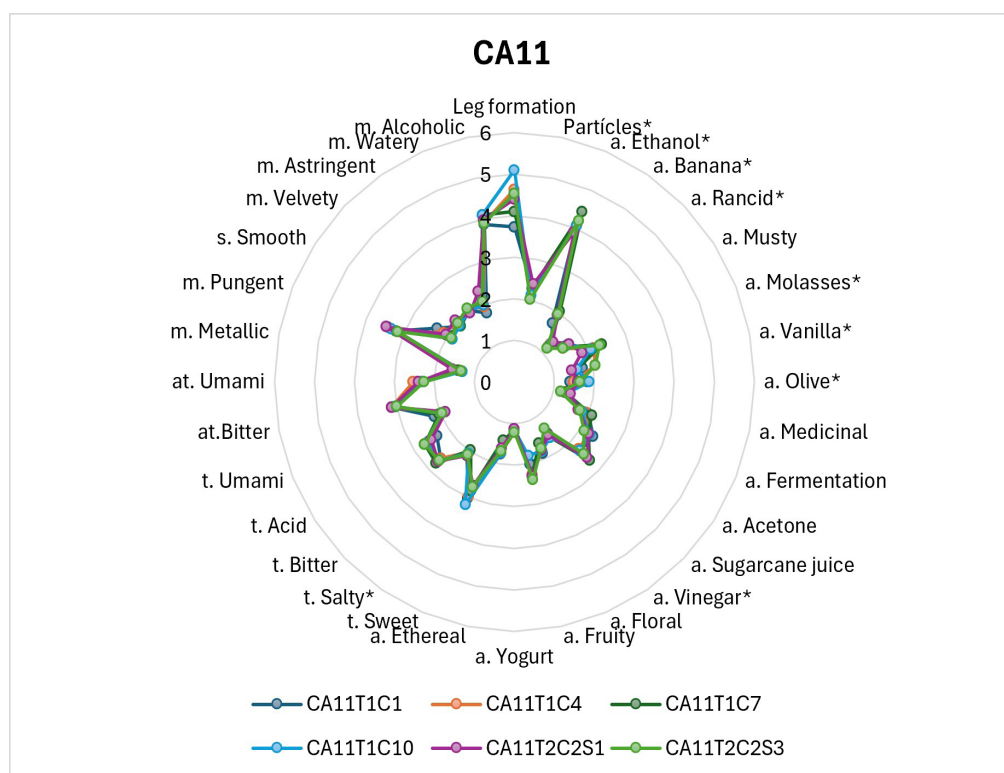
When comparing the four yeast strains, clear sensory trends became evident. DRM (Figure 1) and DSR (Figure 3) presented a higher 'pungent sensation' compared to DCN (Figure 2) and CA11 (Figure 4), suggesting that the cachaça fermented with DCN and CA11 may produce fewer compounds responsible for this sensation. Among them, DCN exhibited a slightly more balanced profile, with less variation across attributes, while CA11 stood out as the most neutral, showing the lowest intensity across all sensory descriptors.

Cachaça from DCN yeast showed a greater perception of fruity and floral notes, suggesting more aromatic esters (Figure 2). In contrast, DRM showed a slight intensification of fermentation-associated aromatic notes, such as those reminiscent of bread (Figure 1). These sensory differences are consistent with our previous study, which demonstrated that yeast strain selection and cell recycling influence the formation of volatile compounds in cachaça, particularly esters, higher alcohols, and organic acids (Carvalho et al. 2025). The agreement between the reported chemical composition and the sensory characteristics reported here reinforces the relationship between fermentation management and the sensory quality of cachaça. According to Bortoletto (2023), esters play an essential role in the aroma of rum and cachaça. The concentration of these compounds in rum can range from 4% to 64%, depending on factors such as the yeast strain, fermentation conditions, and the presence of yeast during distillation.

Principal Component Analysis (PCA) was performed using the sensory descriptors that showed significant differences among samples according to ANOVA ($p < 0.05$). This approach was adopted to improve the interpretability of the multivariate model by excluding non-discriminatory variables. Figure 5 presents the PCA, where each cachaça sample is represented by a blue point and the sensory descriptors are represented by red vectors. The positioning of the samples reflects the mean intensity scores assigned by the sensory panel. Samples located close to one another exhibited similar sensory profiles and were associated with the nearest sensory descriptor vectors. The first two principal components explained 66.32% of the total variability among the cachaça samples.

Figure 1. Sensory profiles of cachaça produced with yeast DistilaMax RM (DRM) with successive yeast recycling.**Figure 2.** Sensory profiles of cachaça produced with yeast DistilaMax CN (DCN) with successive yeast recycling.

Samples correspond to the 1st, 4th, 7th and 10th fermentation cycles of Treatment 1 (T1), in which the same yeast biomass was recycled without renewal, and the second fermentation cycles from weeks 1 and 3 of Treatment 2 (T2), in which the starter culture was renewed every seven days. Values represent the mean intensity scores assigned by the trained sensory panel using a structured six point intensity scale (0 = absent and 6 = extremely intense). Sensory descriptors are grouped according to appearance (at.), aroma (a.), taste (t.), mouthfeel (m.), and sensation (s.). Descriptors marked with an asterisk (*) differed significantly among samples according to one-way ANOVA ($p < 0.05$).

Figure 3. Sensory profiles of cachaça produced with yeast DistilaMax SR (DSR) with successive yeast recycling.**Figure 4.** Sensory profiles of cachaça produced with yeast CA11 with successive yeast recycling.

Samples correspond to the 1st, 4th, 7th and 10th fermentation cycles of Treatment 1 (T1), in which the same yeast biomass was recycled without renewal, and the second fermentation cycles from weeks 1 and 3 of Treatment 2 (T2), in which the starter culture was renewed every seven days. Values represent the mean intensity scores assigned by the trained sensory panel using a structured six point intensity scale (0 = absent and 6 = extremely intense). Sensory descriptors are grouped according to appearance (at.), aroma (a.), taste (t.), mouthfeel (m.), and sensation (s.). Descriptors marked with an asterisk (*) differed significantly among samples according to one-way ANOVA ($p < 0.05$).

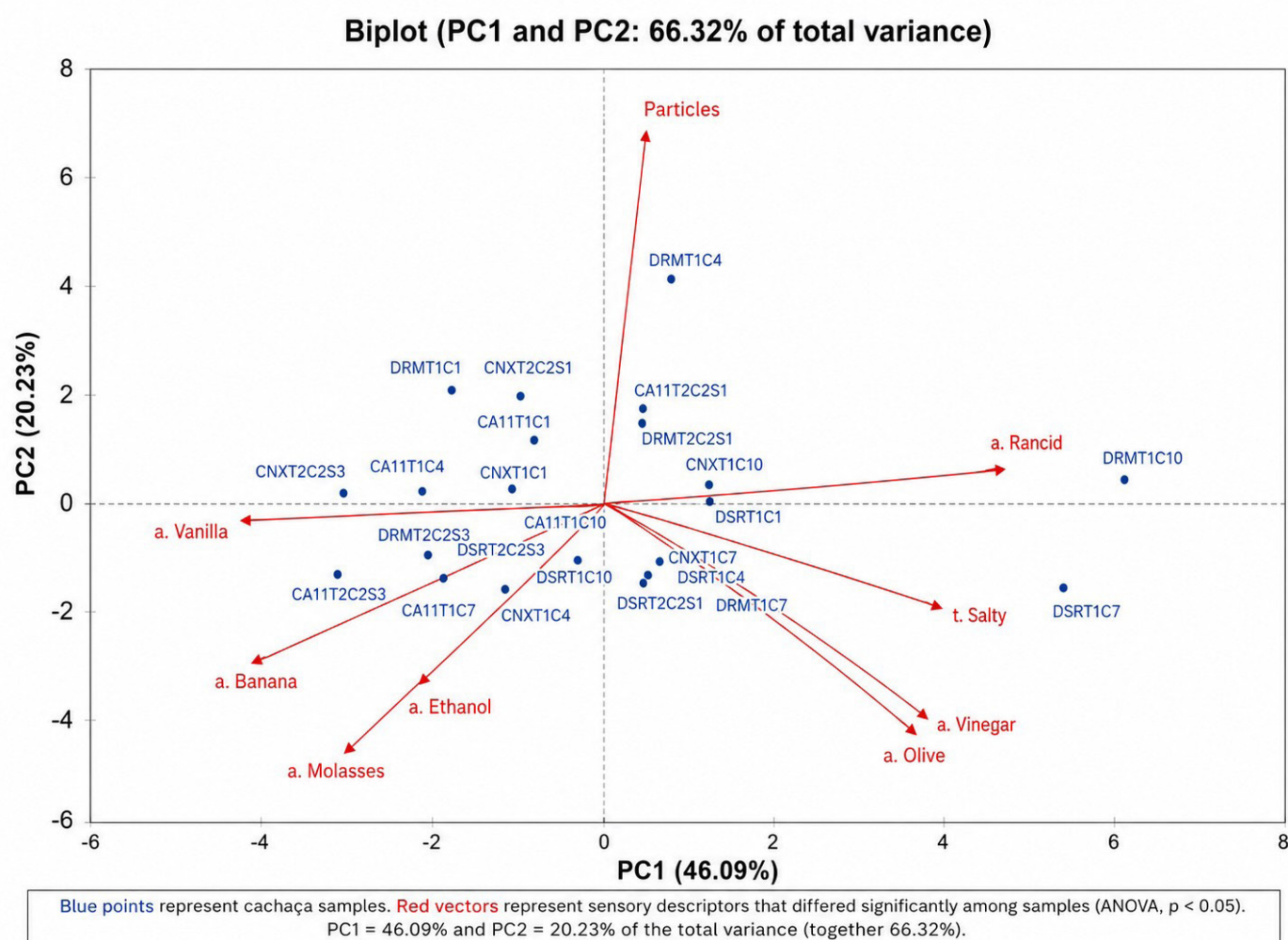
The Principal Component Analysis was used as an exploratory multivariate tool to facilitate the interpretation of the sensory descriptors that effectively discriminated the samples of cachaça. In Figure 5, the active variables (in red) were grouped. 'Salty taste,' 'vinegar aroma,' and 'olive aroma' correlated in the fourth quadrant. In the third quadrant, 'vanilla aroma,' 'banana aroma,' and 'molasses aroma' appear clustered attributes generally associated with sweet and fruity notes (Ickes and Cadwallader 2017; Bortoletto et al. 2021) together with 'ethanol aroma.' 'Rancid aroma' was inversely related to 'vanilla aroma,' suggesting that samples with higher intensity of 'vanilla aroma' exhibit a lower intensity of 'rancid aroma'.

The 'presence of particles' - a visual descriptor that is not related to the other active variables – was explained by the second principal component (F2); The samples located closest to the centre of the chart (CA11T1C1, DCNT1C4, DSRT1C4, DRMT2C2S1) are not directly associated with any active variable, indicating that they are not related to the tested attributes.

The group in the right-hand corner (DSRT1C7, DCNT1C10, DRMT1C10) is aligned with 'rancid aroma,' 'salty taste,' and 'vinegar aroma,' inferring more intense notes for these attributes. These samples may exhibit stronger aromas and flavours, which is expected as they correspond to more advanced fermentation cycles (seventh and tenth).

Figure 5. Principal component analysis (PCA) biplot showing the relationship between cachaça samples (blue points) and the sensory descriptors (red vectors) that differed significantly according to one-way ANOVA ($p < 0.05$).

Cachaça was produced with four commercial yeast strains (DistilaMax RM, DistilaMax SR, DistilaMax CN and CA11) under different yeast recycling conditions. Principal component 1 (PC1) and principal component 2 (PC2) explained 46.09% and 20.23% of the total variance, accounting for 66.32% of the total variability. Samples located close to one another exhibited similar sensory profiles, whereas samples positioned in the direction of a sensory descriptor vector were positively associated with that attribute. The length of each vector indicates its contribution to sample discrimination within the multivariate model.



When yeasts are recycled for prolonged periods, the development of contaminant microorganisms (bacteria or other yeasts) is common and results in cachaça with a more acidic sensory profile. Accordingly, periodic replenishment of yeast across fermentation cycles would be expected to maintain sensory homogeneity during the production season and across harvests, which - in turn - ensures higher quality standards for the beverage (De Cássia et al. 2009).

De Souza et al (2006) conducted a limited analysis to identify aromatic differences between rum and cachaça, using ten descriptors. Of the attributes identified in cachaça, 'vinegar,' 'citrus,' and 'alcoholic' also showed higher intensities.

The cachaça samples located in the lower left-hand corner (CA111T1C7, DRMT2C2S3, DSRT2C2S3) (Figure 5) are close to the vectors for 'banana aroma,' 'vanilla aroma,' and 'molasses aroma,' suggesting that these characteristics are more pronounced. These samples of cachaça have sweet and fruity notes, and associated with a better sensory quality (Bortoletto et al. 2016) and the clustering suggests a high similarity among them.

The Principal Component Analysis corroborated the results obtained from the descriptive analysis, with subtle but consistent differences among the yeast strains. Cachaça derived from advanced recycling cycles was associated with undesirable sensory descriptors, whereas cachaça produced with DCN (Figure 2) and CA11 (Figure 4) were more closely associated with fruity and pleasant sensory characteristics. In the upper area of the chart, only the variable associated with solid particles is present. The sample DRMT1C4 is isolated and aligned within this vector, suggesting that it has a distinct visual aspect (Figure 1).

Although only a subset of the sensory descriptors showed statistically significant differences, the descriptive analysis identified consistent sensory trends associated with yeast strain and recycling strategy. This finding reinforces the usefulness of descriptive sensory analysis for detecting subtle changes in cachaça quality that may not be evident from chemical analyses alone.

It is worth noting that, despite efforts to manage this, the high ethanol concentration (40%, v/v) may have contributed sensory fatigue to some panellists, making it difficult to accurately evaluate the differences among samples. Previous studies have also reported this during the sensory analysis of alcoholic beverages (Ickes and Cadwallader 2017).

Overall, the present study demonstrates that successive yeast recycling has a measurable influence on the sensory characteristics of cachaça, even though the overall sensory profiles remained broadly similar under conditions of controlled fermentation and distillation. The integration of descriptive sensory analysis with reported chemical data (Carvalho et al. 2025) provides a more comprehensive understanding of how yeast strain selection and fermentation management affect beverage quality. From an industry perspective, these findings reinforce the importance of selecting robust commercial yeast strains and implementing appropriate biomass renewal strategies to maintain product consistency throughout successive fermentation cycles. Furthermore, the sensory lexicon developed here provides a tool for future research and quality control, supporting sensory standardisation and product development within the cachaça industry. Future studies should investigate the relationship between sensory perception, volatile compounds, and consumer acceptance under different production conditions and at larger industrial scales.

Conclusions

The descriptive sensory analysis reported here identified 37 sensory descriptors for the characterisation of cachaça produced with different commercial yeast strains under successive recycling cycles. Although the overall sensory profiles were similar, distinct sensory tendencies were observed. DistilaMax CN and CA11 were associated with fruity and floral attributes, whereas DistilaMax RM and DistilaMax SR showed greater pungency and oily characteristics. Increased recycling of yeast resulted in a higher occurrence of undesirable sensory attributes, including rancid and vinegar aromas. These findings demonstrate that yeast strain selection and recycling management influence the sensory profile of cachaça and provide a sensory framework for future studies and quality assessment of sugarcane spirits.

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Luisa Carvalho: conceptualisation; formal analysis; methodology; project administration; writing (review and editing).

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Marcelle Almeida: formal analysis; writing (review and editing).

Maryse Bolzon: conceptualisation; writing (review and editing).

André Alcarde: conceptualisation; funding acquisition; supervision; writing (review and editing).

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