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Effect of post-harvest processing on the chemical and sensory characteristics of coffees from Chapada de Minas region

Efeito do processamento pós-colheita nas características químicas e sensoriais de cafés da região Chapada de Minas

Miriam Andrade Santos Oliveira[1], Otávio Henrique Ferreira de Oliveira[2], Raphael Marques da Silveira[3], Nathália de Andrade Neves[4], Alexandre Soares dos Santos[5], Tatiana Nunes Amaral[6], Cíntia Lacerda Ramos[7]

Abstract

The objective of this study was to evaluate the effect of four different post-harvest processing methods on the chemical and sensory characteristics of Arabica coffees from the Chapada de Minas region. The experiment was conducted in a completely randomized design with four processing methods and four replicates, yielding 16 trials. The processing methods were: natural; semi-wet; self-induced anaerobic fermentation (SIAF) without husk (wet); and SIAF with husk. The coffees processed by all treatments were classified by a Q-Grader and subjected to a medium roast. Carbohydrate and organic acid analyses were performed for the green coffees obtained by the different treatments. Sensory analysis was also performed using a Q-Grader, the hedonic scale, the attitude scale, and the CATA acceptance method. All coffees obtained by the different treatments were considered specialty coffees. There was no significant difference (p>0.05) in the concentrations of organic acids and sugars of coffees obtained by the different trials. Coffee from the SIAF treatment with husk was the most acceptable among tasters for appearance and aroma (7,48±0,36) and also received the highest score from the Q-Grader (85.5 points). This study demonstrates that post-harvest coffee processing can influence the beverage's sensory properties, as perceived by untrained consumers. However, the absence of microbiological and volatile compound analyses represents a limitation of this study, and further studies are needed to elucidate the effects of different postharvest treatments on final coffee quality.

Keywords: Sensory Analysis; Arabica Coffee; Fermentation; SIAF; Chapada de Minas.

Resumo

O objetivo deste estudo foi avaliar o efeito de quatro diferentes métodos de processamento pós-colheita nas características químicas e sensoriais de cafés Arábica da região da Chapada de Minas. O experimento foi conduzido em delineamento inteiramente casualizado com quatro métodos de processamento e quatro repetições, totalizando 16 ensaios. Os métodos de processamento foram: natural; semiúmido; fermentação anaeróbica autoinduzida (SIAF) sem casca (úmido); e SIAF com casca. Os cafés processados por todos os tratamentos foram classificados por um classificador Q-Grader e submetidos a uma torra média. Análises de carboidratos e ácidos orgânicos foram realizadas nos cafés verdes obtidos pelos diferentes tratamentos. A análise sensorial também foi realizada utilizando um classificador Q-Grader, a escala hedônica, a escala de atitudes e o método de aceitação CATA. Todos os cafés obtidos pelos diferentes tratamentos foram considerados cafés especiais. Não houve diferença significativa (p>0,05) nas concentrações de ácidos orgânicos e açúcares dos cafés obtidos pelos diferentes ensaios. O café proveniente do tratamento SIAF com cascas foi o mais aceitável entre os provadores em termos de aparência e aroma (7,48±0,36) e também recebeu a pontuação mais alta do Q-Grader (85,5 pontos). Este estudo demonstra que o processamento pós-colheita do café pode influenciar as propriedades sensoriais da bebida, conforme percebidas por consumidores não treinados. No entanto, a ausência de análises microbiológicas e de compostos voláteis representa uma limitação deste estudo, sendo necessários estudos futuros para elucidar os efeitos dos diferentes tratamentos pós-colheita na qualidade final do café.

Palavras-chave: Análise Sensorial; Café Arábica; Fermentação; SIAF; Chapada de Minas.

[1]Universidade Federal dos Vales do Jequitinhonha e Mucuri, Brasil.
E-mail: miriam_miandrade@hotmail.com
https://orcid.org/0000-0002-4235-1939
http://lattes.cnpq.br/6356305197572933

[2]Universidade Federal dos Vales do Jequitinhonha e Mucuri, Brasil.
E-mail: otavio.oliveira@ufvjm.edu.br
https://orcid.org/0009-0006-8921-2203
http://lattes.cnpq.br/7341568610342956

[3]Universidade Federal dos Vales do Jequitinhonha e Mucuri, Brasil.
E-mail: raphael_agronomo@hotmail.com
https://orcid.org/0009-0003-7863-5030
http://lattes.cnpq.br/0000000000000000

[4]Universidade Federal dos Vales do Jequitinhonha e Mucuri, Brasil.
E-mail: nathalia.neves@ict.ufvjm.edu.br
https://orcid.org/0000-0001-6936-2171
http://lattes.cnpq.br/1616378535279690

[5]Universidade Federal dos Vales do Jequitinhonha e Mucuri, Brasil.
E-mail: alexandre.soares@ufvjm.edu.br
https://orcid.org/0000-0003-2417-8084
http://lattes.cnpq.br/5728597199020574

[6]Universidade Federal dos Vales do Jequitinhonha e Mucuri, Brasil.
E-mail: tatiana.amaral@ict.ufvjm.edu.br
https://orcid.org/0000-0002-3967-0947
http://lattes.cnpq.br/2562370808880500

[7]Universidade Federal dos Vales do Jequitinhonha e Mucuri, Brasil.
E-mail: cintia.ramos@ufvjm.edu.br
https://orcid.org/0000-0002-8096-2300
http://lattes.cnpq.br/1668255505773668

1 INTRODUÇÃO

Coffee is a globally appreciated beverage whose beans can be processed in different ways, including natural, wet, semi-wet, and self-induced anaerobiosis fermentation (SIAF) (Pereira *et al.*, 2022; Mota *et al.*, 2020; Lee; Cheong; Curran; Yu; Liu, 2015; Schwan; Wheals, 2003). In the natural (dry) process, the whole fruit is dried with husk (Schwan; Wheals, 2003), while in the wet process, also known as the washed method, the fruits are mechanically depulped, followed by storage in fermentation tanks with water for residual mucilage remotion, and then dried (Lee; Cheong; Curran; Yu; Liu, 2015; Schwan; Pereira; Fleet, 2014). The semi-wet process (also referred to as semi-dry or honey) consists of mechanical depulping of fruits and drying, with the residual mucilage adhering to the parchment (Lee; Cheong; Curran; Yu; Liu, 2015; Schwan; Pereira; Fleet, 2014). In the SIAF method, coffee undergoes fermentation in closed bioreactors, where oxygen is consumed and CO_2 is gradually produced as a result of the metabolic activity of microorganisms naturally present in the coffee microbiota or added as starter cultures (Pereira *et al.*, 2022; Mota *et al.*, 2020). During SIAF, progressive oxygen depletion creates a selective environment that favors the growth of facultative and anaerobic microorganisms, particularly yeasts and lactic acid bacteria. These microorganisms metabolize sugars and other compounds in the mucilage, producing metabolites such as organic acids, alcohols, esters, and other volatile compounds that can diffuse into the coffee beans, influencing their chemical composition and sensory characteristics of the coffee (Mota *et al.*, 2020; Pereira *et al.*, 2022). All processes are followed by drying the beans to a moisture content of 11–12%.

The type of coffee processing is a critical step that directly influences the beverage's sensory quality, chemical composition, and commercial value (Bernardes; Coelho; Martins; Schwan, 2024; Schwan; Pereira; Fleet, 2014; Tieghi *et al.*, 2024). Regardless of the processing method, fruit fermentation takes place, thereby altering the chemical characteristics of the beans and the sensory attributes of the beverage (Schwan; Pereira; Fleet, 2014). However, the processing method is closely related to the microbial activity present during fermentation, which affects the formation of compounds that may enhance or impair the sensory quality of coffee (Bernardes; Coelho; Martins; Schwan, 2024; Mota *et al.*, 2020). The choice of processing method determines distinct interactions among microorganisms, mucilage, and the bean, resulting in distinct chemical and sensory profiles and, consequently, affecting the quality of the final beverage (Bernardes; Coelho; Martins; Schwan, 2024; Mota *et al.*, 2020).

Brazil is the worldś largest coffee producer and exporter, with Minas Gerais as the leading Arabica producer. Eight coffee-producing regions are recognized, including Campo das Vertentes, Chapada de Minas, Cerrado Mineiro, Mantiqueira de Minas, Forests of Minas, Mountains of Minas, North and Northeast of Minas, and South of Minas Gerais (SCA, 2021). Southern Minas Gerais is the largest coffee-producing region in the state, whereas Chapada de Minas has the lowest production among the other regions (CONAB, 2025). The Chapada de Minas region, located in the Jequitinhonha and Mucuri valleys of Minas Gerais, Brazil, is an important emerging coffee-producing region characterized by altitudes ranging from approximately 700 to

1,300 m and climatic conditions that favor specialty coffee production. The combination of altitude, climate, and production practices contributes to the development of coffees with distinctive sensory characteristics, including pronounced aroma, balanced acidity, sweetness, and body (ICCM, 2026; BRASIL, 2021). Specialty coffees produced in Minas Gerais have demonstrated distinct sensory profiles and quality potential (Paiva, 2005). However, there are few studies on the chemical, sensory, and microbiological characteristics of coffees from this region, which may be due to a lack of awareness of the products and the regionś potential, thereby hindering the attraction of new producers and investments.

Therefore, the present study was based on the hypothesis that different post-harvest processing methods yield distinct chemical and sensory profiles in Arabica coffees from the Chapada de Minas region, likely associated with differences in fermentation conditions and microbial activity during processing. Thus, combining chemical analyses of key coffee quality compounds with professional and consumer sensory evaluations is an important strategy for a comprehensive assessment of the effects of post-harvest processing methods on coffees produced in the Chapada de Minas region. The objective of this study was to evaluate the effect of different post-harvest processing methods on the chemical and sensory characteristics of Arabica coffees from the Chapada de Minas region. Specifically, the study aimed to: (i) characterize the carbohydrate and organic acid profiles of coffees subjected to different processing methods; (ii) assess coffee quality through Q-Grader sensory evaluation; and (iii) investigate consumer perception, acceptance, and sensory characterization using focus groups, hedonic and attitude scales, and the CATA method.

2 MATERIAL AND METHODS

2.1 Coffee Samples and Experimental Design

Arabica coffee of the Catuaí IAC 144 variety was obtained from Agrofel Farm (geographical location $18^\circ\ 4'\ 37''$ S, $43^\circ\ 14'\ 49''$ W), situated at 920–970 m altitude in Felício dos Santos (MG), Brazil. Ripe cherries were hand-harvested and processed according to four treatments: natural, semi-wet, SIAF with husk, and SIAF without husk. Only fully ripe red cherries were manually harvested. Immature (green), overripe, dried, insect-damaged, and defective fruits were removed before processing. In the SIAF method, 50 kg of cherries were fermented at room temperature (18–22 °C) in polypropylene bioreactors containing 20 L of water, sealed for 36 h to induce anaerobiosis.

The experiment followed a completely randomized design with four coffee processing methods (natural, semi-wet, SIAF with husk, and SIAF without husk) and four independent replicates per treatment, totaling 16 experimental units. Each replicate consisted of an independent batch of ripe coffee cherries harvested and processed separately. All coffees were dried on suspended raised beds under natural environmental conditions with periodic turning of the coffee mass until reaching 11.5% moisture content, measured using a portable moisture meter. The coffee was hulled on the farm and sent to the Fruit and Vegetable Processing Laboratory (ICT-UFVJM), where they were portioned and packed. Samples from each treatment were sent to LAB37 Microtorrefação (Lavras, MG) for test roasting. Roasting was conducted by a certified Q-Grader master roaster (LAB37 Microtorrefação, Lavras, MG, Brazil) following the SCA sensory analysis protocol (BSCA, 2023). All samples were roasted under standardized conditions using the same roasting profile to minimize variation among samples and preserve the intrinsic sensory characteristics of each coffee. After roasting, samples were cooled, stored in airtight containers, and ground immediately before beverage preparation.

2.2 Chemical Analyses

For quantification of organic acids and sugars, green coffee samples (prior to roasting) were extracted in water at room temperature, centrifuged (Spinlab SL5GR) at 9500 g for 10 min, and filtered through 0.45 µm PTFE syringe filters.

The carbohydrates glucose, fructose, and organic acids citric, lactic, acetic, malic, succinic, and tartaric acids were quantified by High-Performance Liquid Chromatography (HPLC) using a Shimadzu Prominence UFLC 20A system equipped with a Rezex ROA-Phenomenex column (300 × 7.5 mm), maintained at 60 °C. Elution was performed with 0.0025 mol/L H_2SO_4 at 0.6 mL/min. Automated 5 µL sample injections were analyzed. Refractive index detection was used for monosaccharides, while UV-vis detection was applied for organic acids. External standards were used for both qualitative and quantitative determinations. Quantification was performed using external calibration curves prepared from analytical standards at five concentration levels. Calibration curves showed coefficients of determination (R^2) greater than 0.99 for all compounds. Results were expressed as g/L of the aqueous extract obtained from green coffee samples. Analytical determinations were performed in triplicate.

2.3 Sensory Analyses

Sensory analyses were approved by the Human Research Ethics Committee of UFVJM (CAAE 54567921.7 .0000.5108) and carried out at the Sensory Analysis Laboratory of the Institute of Food Science and Technology (UFVJM).

Samples from the four treatments were portioned under Good Manufacturing Practices, packed individually in disposable containers, weighed uniformly, and coded. Preparation followed SCA protocols (SCA, 2021). Sensory evaluation included specialty coffee classification by a certified Q-Grader (LAB37), descriptor generation through a focus group, and acceptance testing using a hedonic scale, purchase intent, and Check-All-That-Apply (CATA). The certified Q-Grader evaluation was conducted as an exploratory professional assessment in accordance with SCA protocols and was not used as the sole basis for sensory conclusions.

For descriptor generation, a remote focus group session (60 min, via Google Meet) was conducted. Participants (n=14), pre-selected based on coffee consumption habits and knowledge of filter brewing, received four coded samples (10 g each), a beaker for water measurement, and a paper filter. They were guided in sample preparation and encouraged to discuss sensory perceptions (appearance, aroma, taste, mouthfeel, and associations), with equal opportunities for participation. The session was moderated by an experienced facilitator following a pre-defined discussion guide (Carey, 2015).

Acceptance, attitude, and CATA tests were conducted at the Sensory Analysis Laboratory. Participants for these tests (n = 89) were recruited voluntarily from students, university staff, and members of the local community. Inclusion criteria were being at least 18 years old, healthy, and regular coffee consumers. Participants were not required to have previous experience with specialty coffees. Individuals who reported not consuming coffee or who had restrictions preventing coffee consumption were excluded from the study. Participants received an informed consent form and an evaluation sheet containing the three tests. Samples were presented monadically, one at a time, and identified using random three-digit codes. Water at room temperature was offered between tastings for palate cleansing. Roasted samples were ground (Bialetti electric grinder), brewed at a ratio of 10 g coffee to 100 mL water (∼95 °C) with prerinsed paper filters, and stored in thermal flasks. Each participant (n=89) evaluated the four samples (30 mL). The presentation order of samples was balanced and randomized across participants to minimize order and carry-over effects.

Acceptance tests assessed appearance, aroma, mouthfeel, and taste using a 9-point hedonic scale (Dutcosky, 2011). The attitude scale measured consumption intent on a 7-point scale ranging from “would never drink” to “would always drink” (Dutcosky, 2011). The CATA test consisted of a 21-term descriptor list (affective, descriptive, emotive, and intensity), where assessors selected all applicable terms.

2.4 Statistical Analyses

Organic acid and carbohydrate data (four replicates) were analyzed by analysis of variance (ANOVA) followed by Tukeyś test at 5% significance, using R Studio. Sensory acceptance (hedonic scale) was analyzed by ANOVA and Tukeyś test at 5% significance. Attitude scale results were evaluated by response frequency and presented as histograms (%). CATA results were analyzed by Cochranś Q test (5% significance), and significantly different attributes were further assessed by Principal Component Analysis (PCA) using SensoMaker software.

3 RESULTS

3.1 Chemical Characterization of Coffees

The concentrations of glucose and fructose in coffees processed through different post-fermentation methods were evaluated and are shown in Table 1. It is possible to observe higher concentrations of fructose (approximately 0.71 g/L) compared with glucose (approximately 0.4 g/L) in all samples. No significant differences (p>0.05) were found among treatments.

Table 1 – Concentration of carbohydrates and organic acids detected in green coffees obtained through different processing methods

Treatment	Concentration (g/L)*							
	Glucose	**Fructose**	**Acetic acid**	**Citric acid**	**Tartaric acid**	**Malic acid**	**Succinic acid**	**Latic acid**
Natural	0.38 ± 0.13	0.71 ± 0.17	0.11 ± 0.04	0.64 ± 0.08	0.12 ± 0.08	0.75 ± 0.16	0.19 ± 0.12	0.67 ± 0.08
Semi-wet	0.43 ± 0.10	0.74 ± 0.17	0.09 ± 0.04	0.62 ± 0.13	0.15 ± 0.02	0.66 ± 0.16	0.15 ± 0.10	0.58 ± 0.14
SIAF with husk	0.46 ± 0.08	0.79 ± 0.14	0.10 ± 0.04	0.63 ± 0.09	0.11 ± 0.08	0.67 ± 0.07	0.18 ± 0.09	0.56 ± 0.05
SIAF without husk	0.32 ± 0.05	0.60 ± 0.08	0.11 ± 0.02	0.63 ± 0.13	0.10 ± 0.07	0.72 ± 0.09	0.19 ± 0.07	0.72 ± 0.13

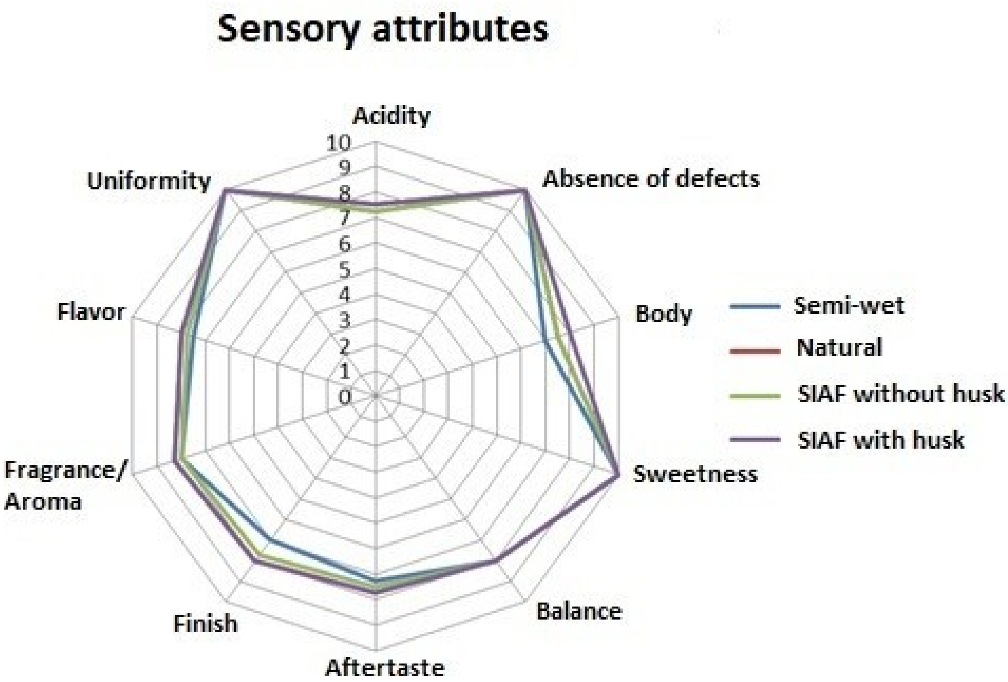
*No statistical differences were found between treatments using the Tukey test ($p > 0.05$).

Acetic, citric, lactic, malic, succinic, and tartaric acids were assessed in this study and were identified in all samples after fermentation (Table 1). No significant differences (p>0.05) were observed among treatments. However, citric, malic, and lactic acids were predominant in all samples, with mean concentrations of 0.63, 0.70, and 0.63 g/L, respectively. Acetic acid has also been detected, but in lower concentrations (average of 0.10 g/L).

3.2 Sensory Analysiss

The coffees were evaluated by a certified Q-Grader, who confirmed that all samples were characterized as specialty coffees, as they received scores above 80 points (SCA, 2021) and presented similar sensory attributes (Graph 1).

Graphic 1 – Sensory profile of specialty coffees evaluated by a certified Q-Grader according to different post-harvest processing methods



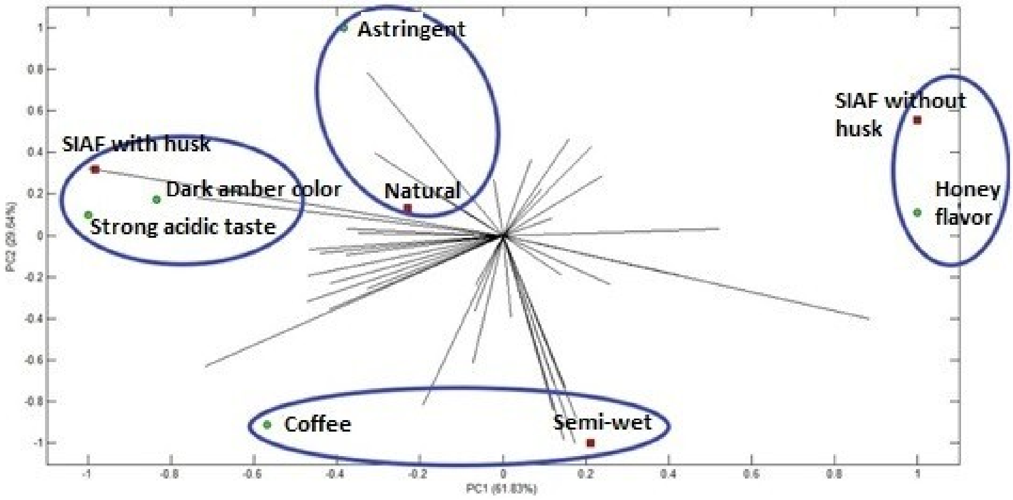
Source: Data produced by the authors.

The semi-wet coffee received a final score of 82 points. According to the Q-Grader evaluation, this coffee displayed a profile characterized by chocolate and fruity notes, slight red fruit, citric acidity, a creamy body, and a short aftertaste. The naturally processed coffee scored 85 points, with sensory descriptors including rapadura, cane molasses, chocolate, fruity notes, yellow fruits, citric acidity, dense body, and short aftertaste. The SIAF-processed coffee without husk scored 83 points and presented attributes of rapadura, chocolate, fruity, refreshing notes, citric acidity, dense body, and short aftertaste. The SIAF processed coffee with husk received the highest professional evaluation, with 85.5 points, and showed descriptors of rapadura, brown sugar, chocolate, fruity notes, red fruits, citric acidity, dense body, and a short aftertaste.

A total of 14 untrained consumers participated in focus group analysis (38% male and 62% female, all over 18 years of age). The group generated a list of descriptors for appearance (light amber, dark amber, turbid, and coffee-like), aroma (sweet, peanut, grassy, acidic, chocolate, burnt, buttery, and coffeelike), mouthfeel (oily, fluid, and astringent), and taste/flavor (mild acidity, strong acidity, cocoa, nutty, peanut, dried fruit, citrus fruit, mild bitterness, and honey), which was subsequently used for the CATA test. The focus group was conducted remotely exclusively for descriptor generation and was not intended for quantitative sensory assessment. Therefore, the information obtained was used only to support the development of the CATA questionnaire. Participants identified sensory differences among the samples and reported that the coffees analyzed exhibited distinct sensory notes compared to traditional coffees they were accustomed to, although no traditional coffee was evaluated in this study.

In the CATA test, the results indicated that the attributes astringency, coffee, dark amber color, strong acidity, and honey flavor were distinct according to the treatments ($p < 0.05$) (Annex 1). These attributes were then included in the PCA (Graph 2). The PCA revealed associations between coffee samples and sensory descriptors, explaining more than 91% of the original data variability in two dimensions (Graph 2). The first and second dimensions accounted for 61.83% and 29.64% of total variance, respectively. Consumers associated strong acidity and dark amber color with SIAF coffee processed with husk. This finding is consistent with the Q-Graderś evaluation under SCA standards, which highlighted red fruits and citric acidity, and this sample also achieved the highest acceptance score (Table 2). The naturally processed coffee, on the other hand, was associated with the term astringent and received the lowest acceptance score (Table 2).

Graphic 2 – Principal component analysis (PCA) showing the relationship between sensory attributes and coffee processing methods based on the Check-All-That-Apply (CATA) sensory test. NC: natural coffee; ND: semi-wet coffee; FC: SIAF coffee with husk; FD: SIAF coffee without husk.



Source: Data produced by the authors.

In the acceptance test, the attributes appearance, aroma, mouthfeel, and taste were evaluated, and the results are presented in Table 2. No significant differences were observed for mouthfeel and taste, which were rated between "slightly liked" and "neither liked nor disliked." However, significant differences were found for coffee appearance and aroma. The SIAF-processed coffee with husk obtained the highest acceptance scores for both appearance and aroma, being classified as "liked very much." These findings indicate that coffee processing can influence sensory perception, even among untrained consumers who are not regular specialty coffee drinkers. Furthermore, there was consistency between the evaluations of untrained consumers and professional Q-Graders for the SIAF coffee with husk. This sample received the highest acceptance scores for appearance and aroma (Table 2) in the acceptance test, was associated with strong acidity and dark amber color in the CATA test, and achieved the highest score (85.5) in the QGrader evaluation according to the SCA scale.

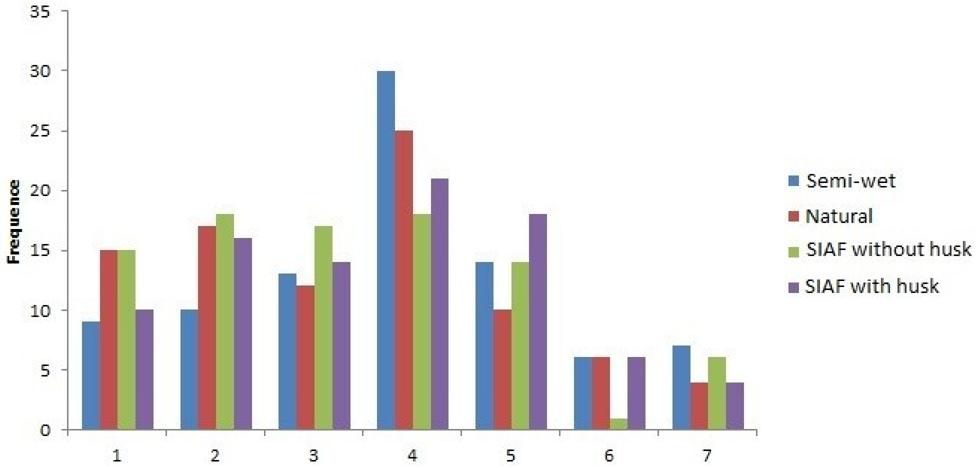
Table 2 – Consumer acceptance scores (9-point hedonic scale) for appearance, aroma, flavor, and mouthfeel attributes of coffees produced using different post-harvest processing methods

Treatment	Appearance	Aroma	Consistency	Flavour
Natural	6.70 ± 0.36^{a}	6.22 ± 0.33^{a}	5.86 ± 0.35^{a}	5.25 ± 0.35^{a}
Semi-wet	6.77 ± 0.36^{a}	6.80 ± 0.33^{ab}	6.30 ± 0.35^{a}	5.88 ± 0.35^{a}
SIAF without husk	6.79 ± 0.36^{a}	6.56 ± 0.33^{ab}	5.70 ± 0.35^{a}	5.11 ± 0.35^{a}
SIAF with husk	7.48 ± 0.36^{b}	7.00 ± 0.33^{b}	6.43 ± 0.35^{a}	5.61 ± 0.35^{a}

Values presented as mean $\pm$ standard deviation. Means followed by the same letter in the column do not differ significantly at 5% probability, according to Tukey's test.

In the acceptance test using the attitude scale, it was observed that although the panelists were not habitual specialty coffee consumers, most were willing to drink the beverage occasionally, particularly semi-washed coffee (Graph 3). This sample received the lowest score among the processing methods on the SCA scale (82.0), but showed the strongest association with the term 'coffee' in the CATA test (Graph 2). This suggests that untrained consumers, who are not accustomed to specialty coffees, may have associated this beverage with their own perception of what they typically recognize as coffee.

Graphic 3 – Consumer attitudes toward coffee consumption obtained through different post-harvest processing methods, measured on a 7-point scale. Scale: 1 = I would never drink; 2 = I would drink very rarely; 3 = I would drink rarely; 4 = I would drink occasionally; 5 = I would drink frequently; 6 = I would drink very frequently; 7 = I would always drink.



Source: Data produced by the authors.

4 Discussion

The quality of a coffee beverage is related to the carbohydrates and organic acids present in the beans. Carbohydrates are precursors to several volatile compounds produced during roasting through reactions such as caramelization and the Maillard reaction, which give the beans their characteristic aroma, color, and flavor (Barbosa, 2002; Barrios, 2001). The higher fructose concentrations than glucose observed in all samples can be attributed to the preferential utilization of glucose by microorganisms during fermentation across all processing methods, resulting in higher residual fructose than glucose (Schwan; Pereira; Fleet, 2014).

Among the organic acids evaluated in this study, citric and malic acids were the predominant ones (>0.6 g/L). These acids, in addition to succinic acid, contribute to the beverage's acidity and are naturally present in coffee, where they are retained throughout the fermentation process (Bressani; Martinez; Evangelista; Dias; Schwan, 2018). Lactic and acetic acids are important indicators of the coffee fermentation process (Schwan; Silva; Batista, 2012) and were detected in the present study. Lactic acid is produced by lactic acid bacteria that metabolize sugars in coffee pulp as a source of carbon and energy for growth (Pereira *et al.*, 2015). The concentration of this acid is influenced by the fermentation environment, with its production being favored under lowoxygen conditions (Mota *et al.*, 2020). Acetic acid can be produced by yeasts, acetic acid bacteria, and heterofermentative lactic acid bacteria that may naturally occur in coffee (Bressani; Martinez; Evangelista; Dias; Schwan, 2018; Schwan; Pereira; Fleet, 2014). This acid is a precursor of fruit- and wine-like aromas and can provide a mild acidity when present at moderate levels (Bressani; Martinez; Evangelista; Dias; Schwan, 2018; Farah; Monteiro; Calado; Franca; Trugo, 2006). Acetic acid significantly influences the flavor of beverages such as beer, contributing to pronounced acidity and vinegar-like notes when concentrations exceed approximately 0.2 g/L (Roos; Vandamme; Vuyst, 2018; Roos; Verce; Vandamme; Vuyst, 2020). However, in coffee, acetic acid levels vary with processing method (approximately 0.08–0.25 g/L) and contribute to the overall perception of acidity, though it is rarely perceived individually by trained tasters (Rune *et al.*, 2023). The present study detected acetic acid in all treatments (around 0.10 g/L).

Sensory analysis is a key tool for evaluating coffee quality. Commodity coffees are assessed according to the Brazilian Normative Instruction No. 8 (BRASIL, 2003), whereas specialty coffees are classified following the protocols of the Specialty Coffee Association (SCA). Alternative approaches to quality assessment include sensory tests such as Check-All-That-Apply (CATA), as well as the association between processing methods and beverage attributes (Lehotay; Hajšlová, 2002; Ribeiro *et al.*, 2020; Neto *et al.*, 2018). In the present study, the coffees were evaluated by a Q-Grader professional, by CATA, and by acceptance tests using hedonic and attitude scales.

Coffees processed with husk, either natural or fermented via SIAF method, generally achieved higher scores. Although no statistical differences were observed in carbohydrate and organic acid concentrations, the sensory analysis suggests that husk retention may influence coffee fermentation and, consequently, the final product's sensory characteristics. In contrast, coffees from dehulled beans without mucilage may exhibit reduced microbial activity, leading to less intense fermentation, cleaner flavors, and lower levels of acidity and fruity notes, without dominance of pulp-derived compounds (Zhang *et al.*, 2019).

Furthermore, even though no significant differences were observed in carbohydrate and organic acid values among treatments, both trained and untrained assessors detected sensory differences between the coffees. This suggests that the sensory distinctions were likely associated with compounds not evaluated in the present study, such as volatile compounds. During fermentation and roasting, carbohydrates and other precursors are converted into volatile compounds that contribute significantly to coffee aroma and flavor (Gloess *et al.*, 2014; Zhang *et al.*, 2019). Different post-harvest processing methods may modify these volatile profiles without significantly altering major non-volatile compounds, such as carbohydrates and organic acids (Lee; Cheong; Curran; Yu; Liu, 2015; Zhang *et al.*, 2019). Further studies integrating sensory analysis and volatile compound profiling are needed to better understand the mechanisms underlying these differences.

In the focus group, panelists described the coffee powder as brown, while the beverage was described as light amber, turbid, and coffee-like. Color is considered the primary attribute influencing product evaluation, as visual impressions often shape taste expectations prior to consumption (Spence, 2019). The Maillard reaction, which occurs during roasting through the interaction of reducing sugars (e.g., fructose and glucose) with amino acids, leads to the formation of aromatic compounds and melanoidins, which are responsible for coffeeś characteristic brown color (Zhang *et al.*, 2019). For aroma, the focus group identified sweet, peanut, chocolate, buttery, coffee, and grassy notes. In terms of flavor, cocoa, nutty, peanut, dried fruit, citrus fruit, and honey were perceived, along with mild bitterness and varying levels of acidity. Bitterness is likely associated with caffeine, the main alkaloid in coffee, which remains stable during roasting (Farah; Monteiro; Calado; Franca; Trugo, 2006). Acidity may be attributed to organic acids present in the beverage and to chlorogenic acids (Rune *et al.*, 2023).

Body is defined as the tactile perception of viscosity, oiliness, and volume in the mouth, and it is related to the beverageś mouthfeel (Paiva, 2005). Participants reported oily, fluid, and astringent perceptions across the samples. Fruity aromas and acidity were consistently mentioned, which may be related to the presence of organic acids such as citric acid, known to impart fruity flavor and acidity (Vandenberghe *et al.*, 2018).

The analysis showed that SIAF coffee with husk had strong acidity and a dark amber color, whereas natural coffee showed astringency. Further, the SIAF coffee with husk received the highest acceptance scores. The consistency between professional and consumer evaluations reinforces the impact of processing on sensory perception. Interestingly, the semi-wet coffee, although rated lowest by Q-Graders (82 points), was described by untrained consumers as most representative of “coffee,” possibly reflecting greater similarity with conventional coffee profiles. This finding suggests that consumer familiarity plays a role in the acceptance of specialty coffees.

Overall, the results highlight that post-harvest processing may affect the sensory profile and consumer perception of coffee attributes. The integration of professional and consumer evaluations provides a more comprehensive understanding of coffee quality, with implications for developing processing strategies to enhance both specialty coffee scores and consumer acceptance.

5 Conclusion

Coffees obtained through different post-harvest processing methods were classified as specialty. No significant differences in the concentrations of organic acids or carbohydrates were observed among the processing methods evaluated in this study. However, sensory analyses revealed that panelists could distinguish between treatments, both among untrained consumers and among professional Q-Graders. Untrained panelists associated strong acidity and dark amber color with SIAF-processed coffee with husk. This same coffee received the highest acceptance scores for appearance and aroma, as well as the highest SCA score in the Q-Grader evaluation, being associated with red fruit notes and citric acidity. Conversely, the term coffee was predominantly associated with semi-wet samples. These samples achieved the second-highest aroma acceptance rating, which may reflect consumer perception of this attribute as closer to traditional coffee. Nonetheless, this coffee received the lowest SCA score among the processing methods.

The present study demonstrates that post-harvest coffee processing can influence sensory characteristics perceptible even to untrained consumers accustomed to specialty coffees. Furthermore, the results contribute to the characterization of specialty coffees from the Chapada de Minas region, highlighting the influence of post-harvest processing methods on coffee quality and their potential to add value to coffees produced in this emerging coffee-growing region of Minas Gerais, Brazil. However, some limitations should be acknowledged, including the use of a single certified Q-Grader for professional sensory classification, the absence of microbiological and volatile compound analyses, and the evaluation of only one coffee variety from a single farm. Future studies incorporating microbial and volatile compound profiling, multiple trained evaluators, and a broader range of varieties and production sites could provide a more comprehensive understanding of the factors influencing coffee quality development and sensory perception.

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ANNEX 1

Table 3 – Sensory descriptors generated during the focus group session and subsequently used in the Check-All-That-Apply (CATA) questionnaire for the evaluation of coffees obtained through different post-harvest processing methods.

Descriptors	Post-harvest processing*				*p*-value**
	ND	FD	FC	NC	
Astringent	2	15	19	19	0.000475
Mild bitterness	45	46	51	41	0.525910
Coffee-like appearance	46	26	39	40	0.019137
Acidic aroma	9	10	13	19	0.110410
Sweet aroma	15	25	21	19	0.314914
Coffee-like aroma	35	36	38	39	0.928013
Buttery aroma	4	4	1	5	0.440227
Chocolate aroma	3	8	9	2	0.060184
Grassy aroma	14	14	15	15	0.993629
Light amber color	54	59	42	49	0.061572
Dark amber color	14	11	28	12	0.001817
Fluid	20	20	21	22	0.981295
Peanut flavor	3	2	1	4	0.572407
Oily	12	12	11	12	0.994971
Strong acidic taste	26	20	38	33	0.029291
Cocoa flavor	5	7	9	3	0.343030
Nut flavor	6	9	4	6	0.552744
Citrus fruit flavor	3	4	4	8	0.342165
Honey flavor	4	8	0	2	0.011445
Dried fruit flavor	11	9	6	8	0.629549
Turbid	4	7	9	8	0.529878

* ND: semi-wet coffee; FD: SIAF coffee without husk; FC: SIAF coffee with husk; NC: natural coffee.
** Values correspond to the frequency of consumers selecting each sensory attribute ($N = 89$). Statistical significance was determined using Cochran's Q test, with differences considered significant at $p < 0.05$.

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