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Sensory evaluation of coffee cultivars in the Campo das Vertentes Mesoregion, Minas Gerais

Bruno Batista Ribeiro[1], Antonio Nazareno Guimarães Mendes[1], Alex Mendonça de Carvalho[2*], Francisco Mickael de Medeiros Câmara[1] and Renato Ribeiro Lima[1]

[1]Departamento de Agronomia/Fitotecnia, Universidade Federal de Lavras – UFLA, Lavras, Minas Gerais, Brasil.
[2]Departamento de Agronomia, Universidade Estadual Júlio de Mesquita Filho – UNESP, Registro, São Paulo, Brasil.

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The objective of this study was to evaluate the sensory characteristics of coffees from *Coffea arabica* L. groups, in municipalities located in the Campo das Vertentes mesoregion, in the State of Minas Gerais. Natural and parchment coffees, after drying, consisted of 100% mature fruits. The experiment was carried out on 14 coffee farms located in the municipalities of Carmo da Mata, Oliveira, Santo Antônio do Amparo and Bom Sucesso, in the 2016/17 agricultural crop. In order to conduct the study, coffee fruit collections of nine groups of commercial cultivars were submitted to two types of post-harvest processing, known as "terrarium nut" and "parchment", combinations that resulted in 250 samples. Sensory analysis was performed according to the protocol of the Specialty Coffee Association - SCA, with panelists accredited by the Coffee Quality Institute - CQI. The natural post-harvest processing (terrarium nut) showed higher scores for most groups of cultivars when compared to parchment processing. Cultivars Topázio, Bourbon Amarelo, Catucaí Amarelo, Icatu Amarelo and Icatu Vermelho stood out with the highest averages for all sensory attributes.

Key words: *Coffee arabica* L., sensory analysis, Specialty Coffee Association (SCA), quality.

INTRODUCTION

Understanding, making viable and improving evaluations is some of the technical requirements used in coffee growing that can aid producers in trade competitiveness. Producing economically viable coffees, coupled with preservation of sensory quality and physical aspects can be an indispensable tool in improving batch pricing. Producers have increasingly sought to know the quality of their coffees, contributing to crop management, pre-harvest, harvest, post-harvest and especially commercialization decisions.

Considering studies on climate change, it is suggested that higher altitudes may become one of the prime factors for the production of quality coffees, as mild temperatures allow slower fruit maturation and, consequently, the accumulation of flavor precursors in the beverage (Worku et al., 2018). This statement may depend on the expression of the sensory qualities of coffee cultivars, according to the planting implantation altitude (Ribeiro et al., 2019).

Increasing efforts by coffee-consuming countries to

*Corresponding author. E-mail: alex.carvalho@unesp.br.

Table 1. Edaphoclimatic characteristics of the municipalities of Santo Antônio do Amparo, Bom Sucesso, Carmo da Mata and Oliveira, in the State of Minas Gerais-Brazil.

Municipality	Climate (Köppen-Geiger classification: Cwa)	Average altitude (m)	Coordinate
Santo Antônio do Amparo	Humid subtropical	935	Latitude: -20.9552, Longitude: -44.9167 20° 57' 19" South, 44° 55' 0" West
Bom Sucesso	Humid subtropical	930	Latitude: -21.0336, Longitude: -44.7526 21° 2' 1" South, 44° 45' 9" West
Carmo da Mata	Humid subtropical	800	Latitude: -20.5559, Longitude: -44.8625 20° 33' 21" South, 44° 51' 45" West
Oliveira	Humid subtropical	988	Latitude: -20.6971, Longitude: -44.8278 20° 41' 50" South, 44° 49' 40" West

Source: http://pt.db-city.com/2018.

understand the "sensory identity", production traceability and collaboration of the coffee producing region on coffee quality, have moved producing countries to produce more single-source batches of very high quality, corroborating transparency in commercial transactions and, consequently, value addition and regional recognition (Smrke et al., 2015).

The quality of the coffee from the Campo das Vertentes - MG Mesoregion, located in the Southeast region of Brazil, has been a national and international highlight among buyers, consumers and connoisseurs. Understanding the coffee quality potential of cultivars from this region can bring many benefits, contributing to geographical indication processes, enabling post-harvest techniques, and improving communication mechanisms. One of the ways to evaluate coffee quality is by the SCA (Specialty Coffee Association) sensory analysis, which allows a quantitative and qualitative description of the beverage. It is one of the most respected analyses in the world conducted by CQI (Coffee Quality Institute) trained and accredited panelists, who delineate trade guidelines between specialty coffees or commodities, sensory particularities of batches, as well as an open and descriptive communication about their potential.

Thus, this study aimed to evaluate the sensory attributes of nine arabica coffee groups, implanted in municipalities located in the Campo das Vertentes Mesoregion in the State of Minas Gerais and to characterize the qualitative contributions of different post-harvest processing methods, wet and dry. The sensory profiles were described by accredited panelists for use of the Specialty Coffee Association - SCA protocol.

MATERIALS AND METHODS

The study was carried out in the State of Minas Gerais - Brazil, in the region called Campo das Vertentes, comprising 14 coffee farms distributed in the municipalities of Santo Antônio do Amparo, Bom Sucesso, Carmo da Mata and Oliveira (Table 1).

First, the boundary space of each crop was delimited, respecting three initial rows after the "carrier" and three plants in the row to start the collection; the quadrant for the collection was a maximum of 5 ha crop. The ripe fruits were harvested manually and selectively in "zig and zag" in the middle and upper third of the plants, totaling approximately 25% of the harvested crop area, for the composition of each sample. After the fruits were collected, the samples were reviewed and the remaining green fruits were removed. It is noteworthy that the collections were planned according to the natural maturation of the crops, without the application of ripeners. Each sample resulted in 20 L of ripe fruits, emphasizing that, on farms that adopt the wet processing 10 L of coffee were peeled to comprise the wet sampling and the other 10 L for the dry route. For farms that have only dry processing, 10 L of ripe fruits were collected.

Commercial cultivars of the species *Coffea arabica* L. belonging to nine groups were evaluated; these are genetic materials widely found in the producing regions of Brazil. The cultivar groups under study are: Acaiá, Bourbon Amarelo, Catuaí Vermelho, Catuaí Amarelo, Catucaí Amarelo, Icatu Amarelo, Icatu Vermelho, Mundo Novo and Topázio.

For sample drying, wooden frames with 0.80 x 0.80 cm shading screens were used, and the entire procedure was performed on the properties that participated in the project. The drying layer for natural coffees was "fruit to fruit" in the early days, until the husk darkened. For parchment coffees, the procedures of 3 cm thick endocarp bean layer ("parchment coffee") were adopted at the beginning of drying, with 4 daily revolves until the remaining mucilage on the parchment was dry. Subsequently, the drying layer was thickened to 6 cm, the samples were rolled 8 times a day and the cover was received.

All samples were covered at about 3.30 p.m. to take advantage of the heat retained in the fruit mass, during the day, at night and discovered at 8 a.m., to avoid the absorption of local moisture by the fruits, consisting of raffia bag (for retention of condensed water by the fruit mass) and canvas (thermal insulation), both clean.

These procedures were followed until the coffee samples reached a humidity of 11 to 12% (b.u), measured by a G939 STD Gehaka equipment. The samples carefully benefited from the Coffee Post Harvest Technology Pole – Universidade Federal de Lavras - UFLA.

For the sensory analyses, only the beans retained in the 16/64-inch sieve were used. All extrinsic and intrinsic defects were removed, in addition to the mocha beans, for

a better sample roasting uniformity.

The sensory analyses were performed in the 2016/17 agricultural season, by two accredited expert panelists, to evaluate specialty coffees (Q-Graders), using the methodology proposed by the Specialty Coffee Association - SCA (Lingle, 2011). The analyzed samples were roasted within 24 h in a Probat TP2-Leogap roaster prior to tasting for CO_2 release, with a color profile ranging from #58 for roasted beans to #63 for roasted and ground beans, verified by the Mbasic Agtron equipment.

Roasting time was conducted from 8 to 12 min, with an average roasting time between samples of 9 min and 15 s. Importantly, after the roasting process, the samples were immediately cooled exclusively by air and stored in airtight containers for 24 h until tasting. The beans called “quakers” were removed from the roasted sample due to their depreciating characteristics to the sensory attributes.

In addition to the roasting profile, the SCA sensory evaluation form enabled the verification of 10 important attributes with scales and intensities: fragrance, flavor, finish, acidity, body, balance, uniformity, clean cup, sweetness and overall impression.

According to the sensory evaluation form of the SCA, the accredited panelist determined the different sensory characteristics among the different samples, besides describing the scores of the identified flavors. This becomes a valuable tool for targeting the different quality standards of coffees from around the world. The evaluation form consists of the attributes fragrance/aroma, taste, finish, acidity, body, balance and overall impression, with ¼ point (0.25) between the numerical values “6” and “10”, and “0” to “10” for uniformity, clean cup and sweetness; both units represent the construction of coffee quality levels.

The following sensory attributes were evaluated: Aroma/ Fragrance, Flavor, Finish, Body, Acidity, Balance, Uniformity between cups, Absence of defects, Sweetness and Overall Impression. The sum of the scores obtained in the attributes resulted in the final scores.

Initially, descriptive statistics of the sample scores were obtained, as well as the detailed description of the data. In addition, a histogram of the total sample scores was obtained to demonstrate the frequency of the final scores, besides the survey of the minimum and total maximum scores for all cultivar groups.

Variance analyses were performed for each of the evaluated attributes. The effects of panelist, municipality, property, cultivar group and post-harvest processing were considered. In these analyses, the panelist effect was considered as random and the others as fixed.

After analysis of variance, if the F test for the cultivar groups were significant, the Tukey test, considering 5% significance, was applied to identify the cultivar groups that presented higher average scores. The processes that guaranteed higher average scores of each cultivar group were also identified. However, in the latter case, the F test is conclusive, and it is not necessary to use another means test, such as Tukey, since there are only two different processing forms. Statistical analyses were performed using the R software (R Core Team, 2017).

Principal component analysis - PCA was performed using the PAST3 software, with the grouping performed by the k-mean analysis using the Euclidean distance (Hammer et al., 2001).

RESULTS AND DISCUSSION

The scores given for the characteristics uniformity between cups, absence of defects and sweetness were identical and corresponded to the total score (10) for all samples, as the panelists did not find any differences between the coffees and/or depreciation. Thus, the use statistical analyses would not be justified in this case. This finding highlights the seriousness of proper management regarding the collection and processing of coffee samples.

Table 2 presents the sensory behavior of coffee from the analyzed cultivars regarding the attributes fragrance, finish and flavor.

Topázio, Bourbon Amarelo and Catucaí Amarelo cultivars got the highest scores for fragrance, highlighting the cultivar groups Icatu Amarelo, Icatu Vermelho and Catuaí Vermelho (Table 2).

According to Bhumiratana et al. (2011), coffee aromas are probably one of the most important factors in differentiating quality. Cultivars Acaiá, Catuaí Amarelo and Mundo Novo had the lowest averages. The volatile compounds present in coffee represent a signature of the biochemical composition of coffee beans and their development in the plant (Bertrand et al., 2012).

For flavor, only ‘Mundo Novo’ differed statistically by the Tukey test (Table 2). Flavor characterizes what coffee has in its potential and is one of the attributes of greater weight in judging by verifying basic to complex flavors, their intensity and quality.

Cheng et al. (2016) emphasized that, although many studies have been conducted on the influence of genotypes and environments on coffee quality, this is a highly complex process. Through the analysis of averages among the post-harvest processing methods, the statistical difference for ‘Mundo Novo’ is possibly attributed to lower scores obtained by the parchment processing since, for the natural processing (Table 3), coffees had higher scores. It is observed that the sensory expression of coffees can change between harvests, due to several edaphoclimatic factors affecting crops.

Salla (2009) reports that there is a strong interference of genetic constitution in flavor determination. The author evaluated the effects of post-harvest processing methods, genotypes and production environments on coffee quality. The sensory quality of coffee cultivars varied as a function of processing and cultivation environment. However, some cultivars showed high genetic stability for beverage quality in all cultivation sites and different post-harvest processing methods.

For finish and acidity, cultivars Icatu Amarelo, Topázio, Icatu Vermelho, Bourbon Amarelo, Catucaí Amarelo and Acaiá had the highest averages, differing statistically from the other cultivars (Table 2). Fruit coloration, when ripe, may be possibly related to the sensory quality of the coffee. Studies under different environmental conditions have found better sensory quality in yellow fruit cultivars (Ribeiro et al., 2019).

Ribeiro (2013) evaluated the effect of genotype, altitude, slope and processing methods of cultivars Bourbon Amarelo and Acaiá on the relationship between

Table 2. Mean Fragrance and Flavor of coffee beverages as a function of cultivar groups evaluated in the Campo das Vertentes Mesoregion, in the state of Minas Gerais.

Cultivar	Attribute					
	Fragrance	Flavor	Finish	Acidity	Overall score	Total score
Topázio	7.77^{A}	7.40^{A}	7.24^{A}	7.33^{A}	7.45^{A}	81.68^{A}
Bourbon Amarelo	7.73^{A}	7.38^{A}	7.22^{A}	7.25^{A}	7.42^{A}	81.69^{A}
Catucaí Amarelo	7.68^{A}	7.35^{A}	7.21^{A}	7.21^{A}	7.38^{AB}	81.50^{AB}
Icatu Amarelo	7.56^{AB}	7.39^{A}	7.20^{A}	7.28^{A}	7.25^{AB}	81.26^{ABC}
Icatu Vermelho	7.52^{AB}	7.41^{A}	7.17^{A}	7.27^{A}	7.18^{ABC}	81.28^{ABC}
Catuaí Vermelho	7.52^{AB}	7.18^{A}	7.16^{A}	7.24^{A}	7.16^{ABC}	80.28^{BCD}
Acaiá	7.46^{B}	7.20^{A}	7.08^{AB}	7.15^{AB}	7.14^{BC}	80.46^{BC}
Catuaí Amarelo	7.44^{B}	7.28^{A}	6.95^{BC}	7.11^{B}	7.13^{BC}	80.07^{CD}
Mundo Novo	7.43^{B}	6.96^{B}	6.78^{C}	7.04^{B}	7.01^{C}	79.35^{D}
Coefficient of variation (%)	4.58	5.55	5.67	4.76	6.41	2.82

Means followed by the same letter in the column do not differ by the Tukey test ($p<0.05$).

Table 3. Mean fragrance, flavor, body, balance, overall and overall score of coffee beverages as a function of cultivar groups and post-harvest processing, parchment (CD) and natural, evaluated in the Campo das Vertentes Mesoregion, in the state of Minas Gerais.

Cultivar	Attribute											
	Fragrance		Flavor		Body		Balance		Overall		Overall score	
	Processing											
	CD	Natural	CD	Natural	CD	Natural	CD	Natural	CD	Natural	CD	Natural
Acaiá	7.38^{A}	7.55^{A}	7.03^{B}	7.35^{A}	7.20^{B}	7.42^{A}	6.92^{B}	7.19^{A}	6.98^{B}	7.32^{A}	79.57^{B}	81.36^{A}
Bourbon Amarelo	7.53^{B}	7.93^{A}	6.99^{B}	7.75^{A}	7.17^{B}	7.58^{A}	7.08^{B}	7.49^{A}	7.17^{B}	7.74^{A}	79.74^{B}	83.42^{A}
Catuaí Vermelho	7.56^{A}	7.68^{A}	6.98^{B}	7.38^{A}	6.97^{B}	7.42^{A}	6.78^{B}	7.23^{A}	6.99^{A}	7.28^{A}	78.98^{B}	81.35^{A}
Catuaí Amarelo	7.22^{B}	7.55^{A}	7.11^{A}	7.43^{A}	7.04^{B}	7.43^{A}	6.96^{A}	7.14^{A}	7.08^{A}	7.24^{A}	79.74^{A}	80.92^{A}
Catucaí Amarelo	7.59^{B}	7.78^{A}	7.22^{B}	7.48^{A}	7.29^{B}	7.46^{A}	7.12^{B}	7.25^{A}	7.15^{B}	7.37^{A}	80.74^{B}	81.79^{A}
Icatu Amarelo	7.36^{B}	7.78^{A}	7.05^{B}	7.72^{A}	7.10^{B}	7.58^{A}	7.06^{B}	7.49^{A}	7.21^{A}	7.57^{A}	79.85^{B}	83.16^{A}
Icatu Vermelho	7.51^{A}	7.53^{A}	7.53^{A}	7.28^{A}	7.06^{B}	7.56^{A}	7.36^{A}	7.21^{A}	7.12^{A}	7.23^{A}	81.42^{A}	81.06^{A}
Mundo Novo	7.33^{A}	7.54^{A}	6.75^{B}	7.16^{A}	7.05^{B}	7.28^{A}	6.99^{A}	7.02^{A}	6.97^{A}	7.06^{A}	78.66^{A}	80.05^{A}
Topázio	7.61^{B}	7.93^{A}	7.30^{B}	7.49^{A}	7.25^{B}	7.56^{A}	7.17^{A}	7.38^{A}	7.35^{A}	7.49^{A}	81.03^{A}	82.36^{A}
Coefficient of variation (%)	4.58		5.55		4.32		4.87		6.16		2.68	

Means for each variable followed by the same letter in the line do not differ by the F test.

the levels of chemical compounds analyzed with the sensory quality of specialty coffees. The author reports that 'Bourbon Amarelo' obtained more expressive sensory scores at the highest altitude, referring to the crop location area.

For the sensory attribute body, there was no statistical difference when comparing the nine cultivar groups studied (Table 2). Climatic diversity can cause variations in coffee characteristics (acidity, body and aroma), even in regions that favor the production of specialty coffees (Avelino et al., 2005).

The consistency of panelists regarding the overall score was that cultivars Bourbon Amarelo and Topázio had the highest averages, followed by Icatu Amarelo, Catucaí Amarelo, Icatu Vermelho and Catuaí Amarelo (Table 2). For the total score, cultivars Bourbon Amarelo and Topázio also showed the highest averages, with 81.68 and 81.69 respectively. It is worth mentioning the contribution of fragrance to the final score, since most cultivar groups that have the highest scores for this attribute, obtained the highest final scores. This can be of great relevance, demonstrating that not always are the quality of acidity and body the precursors with the highest importance in the final score.

With a commercial approach, coffees with scores above 80 points are classified as specialty coffees, enabling better pricing. Strategically for producers, it is essential to perform a sensory evaluation in the batches so that there is no mixing of coffees with different qualities. It is important to note that even coffees with scores below 80 points can achieve good commercial placing on the market, as long as they meet buyers' preferred qualities or even in the face of seasonal fluctuations in coffee supply and demand and their qualities.

Due to its high yield and adaptability, cultivar Mundo Novo is widely cultivated in Brazil (Carvalho et al., 2006). However, it presented limitations in the production of specialty coffees when compared to Bourbon Amarelo genotypes, indicating that the quality of its production is dependent on the conditions of the cultivation environment (Figueiredo et al., 2018).

Table 3 presents the averages given by the coffee panelists for the nine groups of coffee cultivars, regarding the post-harvest parchment method, compared to the natural processes. It can be seen from the table that cultivar groups Acaiá, Catuaí Vermelho, Icatu Vermelho and Mundo Novo did not differ statistically in the two post-harvest processing methods for fragrance. The lowest averages assigned by the panelists for fragrance were for cultivars Bourbon Amarelo, Catuaí Amarelo, Catucaí Amarelo, Icatu Amarelo and Topázio, when processed wet (Table 3).

For flavor, most cultivars have higher averages when processed naturally at post-harvest. Only cultivars Catuaí Amarelo and Icatu Vermelho did not differ statistically between the processes (Table 3).

For body, the highest averages were attributed to all groups of naturally processed coffee cultivars (Table 3). An analogy between beverage body and seed germination studies may possibly contribute to the explanation of the results.

Bytof et al. (2007) reported that when peeling coffee fruits for seed production, there is accelerated energy expenditure in the endosperm for embryo germination. Compared to coffee with the pericarp (with the husk), energy expenditure is slower. The length and timing of coffee seed germination processes differed significantly between wet and dry processed beans. The highest germination activity occurred 2 days after the onset of wet processing, while the maximum corresponding to dry processing appeared about one week after the start of post-harvest treatment. This energy results from the use of carbohydrates and lipids, components that constitute tactile perception, beverage viscosity after roasting.

Cultivars Catuaí Amarelo, Icatu Vermelho, Mundo Novo and Topázio did not present statistical differences between the post-harvest processing methods (natural and parchment) for balance (Table 3).

Cultivars Catuaí and Icatu (Table 3) did not differ statistically between parchment and natural processes for overall score. Cultivars Mundo Novo and Topázio are also included in these groups. Natural processing allowed a higher average for most cultivar groups (total scores) with scores above 80 by the SCA protocol.

It is observed that the cultivar groups Acaiá, Bourbon Amarelo, Catuaí Vermelho, Catucaí Amarelo and Icatu Amarelo differed by the means test between post-harvest processing methods. The highest average scores for natural and parchment processing methods were obtained for 'Icatu Vermelho' and 'Bourbon Amarelo', respectively.

The permanence of the husk gives the fruit a more resistant structure and the need for drying time to the ideal storage point, when compared to any other processing method. Besides, greater care and attention are required to avoid depreciation of dried husked coffees due to undesirable fermentation as a function of mucilage.

Analyzing the histogram with the total scores (Figure 1), regardless of coffee cultivar groups and the post-harvest processing methods, it is observed that the highest score frequency given by the panelists is between 82.50 and 85.00 points by the SCA protocol, reinforcing that the Vertentes Region has high quality coffees. This result may be provided by a combination of appropriate crop management techniques, the correct processing of coffee fruits and the genotypic adaptability of cultivar groups, in a favorable environment for the production of specialty coffees. Some coffee samples scored above 89 points, a quality that is highly valued in the specialty coffee market.

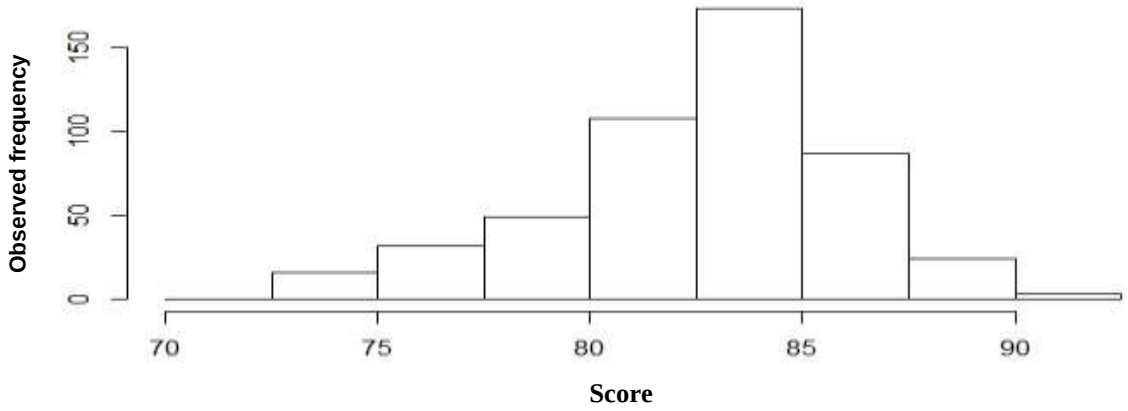

Figure 1. Observed frequency of the total coffee score, evaluated in 9 cultivar groups in the Campo das Vertentes Mesoregion, in the State of Minas Gerais.

Table 4. Minimum and maximum total scores of coffee beverages of cultivar groups evaluated in the Campo das Vertentes Mesoregion, in the state of Minas Gerais.

Cultivar groups	Total score	
	Minimum	Maximum
Bourbon Amarelo	77.00	90.25
Topázio	77.00	88.50
Icatu Amarelo	80.00	89.50
Catucaí Amarelo	73.00	90.75
Icatu Vermelho	74.25	87.50
Catuaí Amarelo	74.00	86.75
Acaiá	74.00	88.00
Catuaí Vermelho	75.00	88.50
Mundo Novo	73.50	89.25

It is noteworthy that all cultivar groups presented wide variation of total scores, and only the group 'Icatu Amarelo' had a minimum total score above 80 points (Table 4). In the item total maximum score, all cultivars had scores above 86 points, which allow the appreciation of coffees above the market price.

In this type of data analysis, it is possible to group the treatments that present similarity in their variables. The largest data variation is in principal component 1, with 87.38%, where the largest distribution of the treatments in the horizontal axis is observed (Figure 2).

In general, Bourbon Amarelo, Topázio and Icatu Amarelo cultivar groups presented the best results for the sensory variables. In addition, naturally processed coffees at post-harvest showed the best sensory responses, since there is a spatial separation of treatments between natural and parchment coffees, and the latter is inversely distributed in the analyzed sensory variables (Figure 2). For 'Mundo Novo', natural processing enables a better correlation with sensory attributes. The groups 'Catucaí Amarelo' and 'Icatu Vermelho' behaved in the same grouping, reflecting the stability in the sensory variables before the two post-harvest processing methods (Figure 2).

Conclusion

(1) 'Topázio' and 'Bourbon Amarelo' groups, regardless of the post-harvest process used, present higher final and general average scores on the coffee beverage produced using them.
(2) 'Topázio', 'Bourbon Amarelo', 'Catucaí Amarelo', 'Icatu Amarelo' and 'Icatu Vermelho' showed higher averages for all sensory attributes considered by the Sensory Analysis Protocol of the Specialty Coffee Association - SCA.

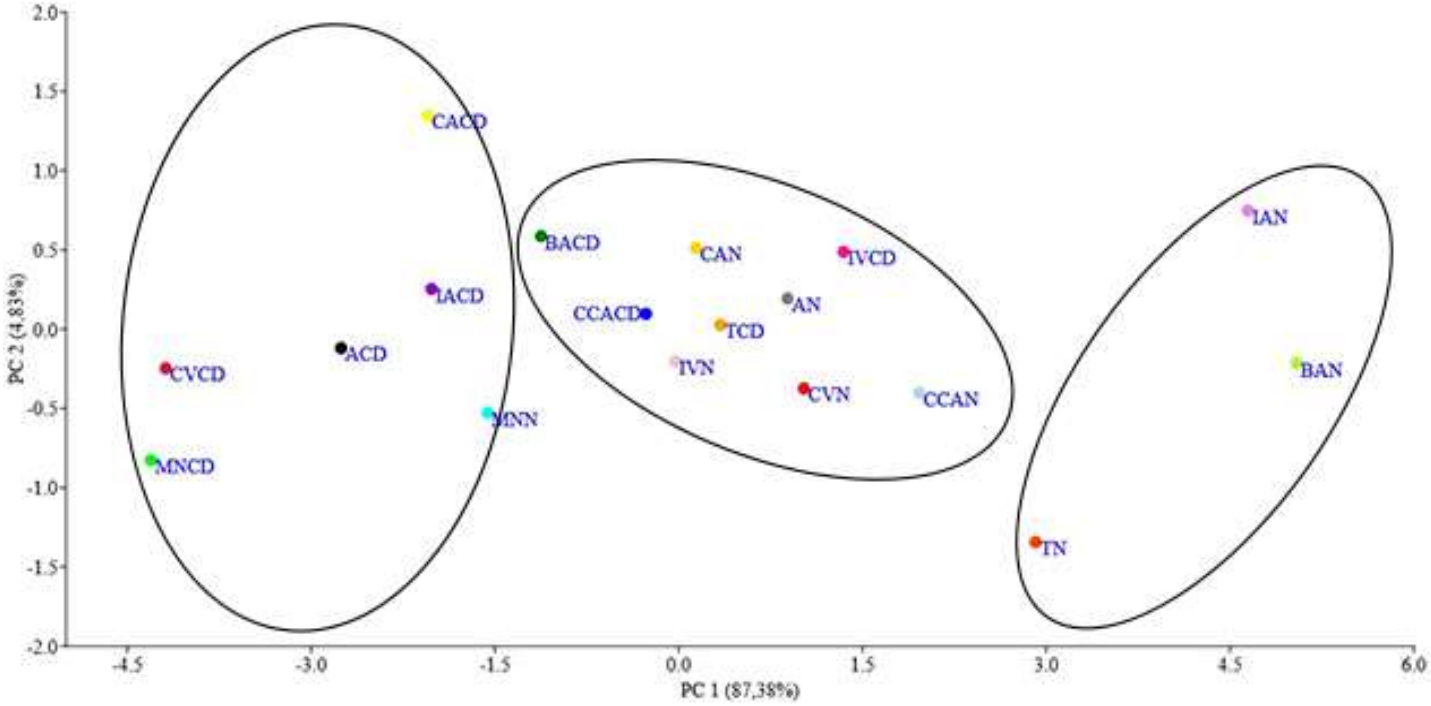

Figure 2. Relationship between the two principal components for cultivar groups and post-harvest processing methods, evaluated in the Campo das Vertentes Mesoregion, in the State of Minas Gerais. ACD=Acaiá Parchment, AN=Acaiá Natural, BACD= Bourbon Amarelo Cereja Parchment, BAN= Bourbon Amarelo Natural, CVCD Catuaí Vermelho Parchment, CVN= Catuaí Vermelho Natural, CACD= Catuaí Amarelo Parchment, CAN= Catuaí Amarelo Natural, CCACD= Catucaí Amarelo Parchment, CCAN= Catucaí Amarelo Natural, IACD= Icatu Amarelo Parchment, IAN= Icatu Amarelo Natural, IVCD= Icatu Vermelho Parchment, IVN= Icatu Vermelho Natural, MNCD= Mundo Novo Parchment, MNN= Mundo Novo Natural, TCD= Topázio Parchment, TN= Topázio Natural.

(3) All cultivar groups present higher average scores for the sensory attribute “body”, when submitted to natural postharvest processing.
(4) Natural processing enables higher total scores.
(5) All cultivar groups have potential for the production of specialty coffees and can obtain maximum scores above 86 points.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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