Physical-chemical characterization and sensory evaluation of coffees submitted to different post-harvest processing

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Abstract

Coffee is one of the agricultural products whose processing requires special attention, in order to maintain its qualities preserved, in the post-harvest, different grain patterns can be obtained due to the adoption of techniques and the use of equipment that enable the separation of fruits by maturation stage, thus enabling the formation of more homogeneous coffee batches when compared to the coffee batch without this separation (fruit mixture). The chemical composition of the coffee bean depends on genetic and environmental factors and pre and post-harvest management conditions. The present work aimed to characterize the physical-chemical attributes of the different coffee patterns obtained during the post-harvest of the fruits. Thirteen patterns were obtained, being: mix of dried fruits in high wind, mix of dried fruits in low wind, more mature green, natural float, natural raisin, float, natural cane green, natural ripe, natural ripe fermenting in water, natural ripe dried fermented, peeled, ripe peeled and pulped, in three random repetitions. The evaluated attributes were: Brix, total titratable acidity, pH, and ash content. The Natural Mature (MN) treatment was the best processing evaluated, as it provided the highest Brix value and the lowest titratable acidity value. The mature peeled, pulped mature, and natural mature treatments showed better sensory values, so they are recommended for post-harvest management to obtain a good drink quality.

Keywords: Coffea arabica. Qualities. Treatment.

Introduction

Coffee is one of the most traditional cultures of Brazilian agriculture. Having started its cultivation more than 200 years ago, it is considered a culture of great economic expression in the country (FAGAN *et al.*, 2011). However, it is one of the agricultural products whose processing requires special attention, in order to maintain its qualities preserved (NOBRE *et al.*, 2011). Because of this, coffee can be processed in two ways: dry, which produces coconut coffee; and wet way, which produces pulped and pulped coffee (BORÉM *et al.*, 2013).

In the form of dry preparation of the beans, it provides natural or yards coffee, where the fruit is fully processed (ARRUDA; HOVELL; REZENDE, 2011), that is, with the exocarp (peel), resulting in a coffee with higher levels of soluble solids, reducing and total sugars (RIBEIRO *et al.*, 2011). In wet processing, exocarp and mesocarp (mucilage) are eliminated, which are sources of fermentation and which delay drying (MATIELLO *et al.*, 2010). The following can be produced: the peeled cherry coffees, the result of the mechanical removal of the peel and, partially, the mucilage of the fruit; pulped cherry coffees, originating from mechanically peeled fruits with the remaining mucilage removed by fermentation; and demucilated cherry coffees, the result of mechanical removal of both the skin and mucilage (BORÉM *et al.*, 2013).

The coffee industry currently has a growing segmentation as to the quality characteristics of

coffee that are related to its origin and preparation methods, which depend on intrinsic and extrinsic factors; the interaction between these factors guarantees the final expression of the drink's flavor and aroma characteristics (PIMENTA et al., 2009).

Recently, the demand for differentiated coffees has intensified and the coffee sector has been investing, more and more, in the production of quality coffees due to the demand of the consumer market (ABRAHÃO et al., 2010). Offering quality to the Brazilian consumer has not been an easy task for agents involved in the production chain, especially regarding to the historical background of coffee agribusiness in Brazil, as the domestic market consumes coffees considered to be of inferior quality to those of quality standards "Special", where they are classified for exports. However, in the last 10 years, Brazil is slowly beginning to have a presence in the world of quality coffees (SCHOLZ et al., 2011).

The coffee drink is the determining factor for product remuneration (NOBRE et al., 2011). The interactions between genetics, the environment, and cultural management have a direct influence on the quality of the drink, with great importance for the operations carried out after harvesting the fruit. Once the process is carried out properly, sensory analysis is the best way to identify whether coffee has characteristics that meet the requirements of the consumer market (FANTE et al., 2015).

The characteristics of the coffee drink are influenced by changes in the beans attributed to physiological disorders and microbial fermentations that degrade the sugars of the fruit mucilage in the plant, forming alcohols or carboxylic acids (FAVARIN et al., 2004). The taste and aroma of coffee are complex parameters that are part of the quality of the drink (ABRAHÃO et al., 2010).

Commonly, coffee is evaluated for quality through sensory analysis, known as cup tasting

(FAGAN, 2011). There is a classification of coffee by drink that occurs according to the taste and aroma that the coffee presents in the cup tasting and shows characteristics of very mild and sweet taste, attenuating the quality up to the category river zone, of intolerable flavor and odor to the taste and smell (MACEDO et al., 2016).

In addition to the genetic, environmental factors and those related to the conduction and management of the coffee crop, it is believed that the differences in the taste and aroma of coffee are due to several physical-chemical, physiological and biochemical changes that occur in coffee beans during processing (RIBEIRO et al., 2009). It is known that pH is indicative of possible transformations of coffee fruits, such as the undesirable fermentations that occur in the pre or post-harvest, causing defects (SIQUEIRA; ABREU, 2006).

The chemical composition of the raw coffee bean depends on genetic and environmental factors and pre and post-harvest management conditions and, according to the authors, roasting is an essential step for the production of compounds that confer the aroma and flavor characteristics of the coffee. The main compounds associated with the quality of the coffee drink are carbohydrates, proteins, lipids, chlorogenic acids, water-soluble tannins, caffeine, and trigonelline (SCHOLZ et al.; 2011). Among them, sugars and proteins from raw beans are the main compounds that contribute to the taste and aroma of roasted coffee (LICCIARDI et al., 2005). The coffee bean is rich in mineral salts (3 % to 5 %) such as potassium, magnesium, calcium, sodium, iron, manganese, rubidium, zinc, copper, strontium, chromium, vanadium, barium, nickel, cobalt, lead, molybdenum, titanium, and cadmium (ENCARNÇÃO; LIMA, 2003).

The technical processes, together with the adoption of chemical and physical-chemical methods, guarantee the quality of the coffee (CARVALHO et al., 1994). Countless studies

have attempted to correlate the final quality of the coffee drink with the chemical composition of the bean, suggesting that coffees of lower quality have lower levels of sugars and proteins and higher levels of total titratable acidity and, mainly, contents of phenolic compounds (ABRAHÃO et al.; 2010). Thus, the objective of the present work was to evaluate the influence of post-harvest processing on the physical and chemical characterization of roasted coffee, following sensory evaluation.

Material and methods

The experiment was carried out in the experimental area of the Coffee Industry Sector of the Federal Institute of Education, Science, and Technology of the South of Minas Gerais – Campus Muzambinho, Minas Gerais. The municipality is 1033 meters high, 21 ° 22'33 'south latitude and 46° 41'32' west longitude, with an average temperature of 23° C (FUNDAÇÃO PROCAFÉ, 2017).

Coffee (Coffea arabica), yellow Catuai cultivar, were harvested by manual tilling on the cloth, in crops of the IFSULDEMINAS Campus Muzambinho. In the post-harvest sector, the following operations were carried out to obtain the treatments: 1) low fruit mix (MFLB); 2) fruit mix had read high (MFLA); 3) natural float (BN); 4) 35 % green + Ripe (VM) 5) float (B); 6) natural pass (PN); 7) natural mature (MN); 8) dry fermented mature (MFS); 9) mature fermented in water (MFA); 10) peeled mature (MD); 11) pulped mature (MDP); 12) peeled raisin (PD); 13) cane green (VC), the evaluation was made in three replicates per treatment.

The density of 30 liters of coffee per square meter was adopted as the standard for the high windmill and 10 liters of coffee per square meter for the low windmill. The MFLA and MFLB treatments were taken directly for drying on a suspended terrace.

The first separation was carried out by density in a water tank, giving rise to the 35 % Green + Ripe treatments that sank, and BN, which floated was removed with a sieve. From the BN treatment, three more PN and B treatments were removed, which were separated manually, after the separation they went straight to drying. The PD passed through the peeler first and was then dried. From the 35 % Green + Ripe treatment, 6 more treatments originated, namely: MN; VC that were taken to dry shortly after separation. The MFS and MFA treatments were stored in plastic bags for 18 hours for fermentation to occur. The MFA was submerged in water and the MFS was not.

Finally, the MD and MDP treatments, which were taken to the DC 6 Pinhalense peeler model. After peeling, the MD treatment was carried out to dry and MDP was left in water for 18 hours to remove the mucilage.

The drying of the coffees was carried out in frames made of wood, with a shade at the bottom reinforced with wire, with an area of 1 square meter. The terraces were placed in suspension, and in full sun, the coffees were revolved every 45 minutes (7 to 8 times a day), until they reached 11 % humidity. After drying, the coffees were stored in the sample room for 20 days to rest, then proceeded to process them in the sample peeler model DRC-2 from Pinhalense. After this process, the samples were packed in high-density polyethylene pots and stored at the Coffee Classification Laboratory.

From these samples, 100 g of coffee without defects and with a sieve 16 and above were separated, which were roasted in the sample roaster of the LABORATTO® brand, after roasting, a small portion of these beans was removed to measure the ash contents held at the Bromatology and Water Laboratory located at IFSULDEMINAS, Campus Muzambinho.

In the prepared drink, according to the SCAA protocol, total titratable acidity (ATT), Brix, and

hydrogenionic potential (pH) were evaluated. All evaluations were performed in duplicate. The SST was evaluated by direct reading on the digital refractometer, and the results are expressed in Brix degrees, according to AOAC standards (1990). The pH reading was determined on the beverage using the Digimed pH meter, 2M-21. To achieve the titratable acidity a total of 20 ml of distilled water and 2 ml of the coffee infusion were placed in a container, adding 3 drops of 1 % phenolphthalein indicator and titrating with sodium hydroxide solution 0, 1N until color change, according to the technique described by AOAC (1990). The values were expressed in mL of 0.1 N NaOH, per 100 g of sample, these evaluations were performed in duplicate. The ash values were obtained from 1 g of roasted coffee, incinerated for four (4) hours in a muffle with a temperature of 550 ℃.

The sensory classification was carried out by Judges with "Q-Grader" certification given by the American Specialty Coffee Association (SCAA, 2015), using the protocol described by the same. 100 grams of coffee sieve 16 and above were prepared, which were roasted in the laboratto equipment until they reached the average color corresponding to # 55 to # 65 on the Agtron scale (FANTE *et al*., 2015). After the rest period, the samples were ground and placed in 5 glass cups for each sample, respecting the concentration of 8.25 grams of ground coffee to 150 mL of water heated to approximately 93 ℃ (FANTE *et al*., 2015).

The samples of Arabica coffee were subjected to classification according to different standards of drink quality in terms of cup tasting. The cup tasting was carried out by two professional tasters, following the protocol of the Specialty Coffee Association of America (SCAA, 2015), in which ten attributes were evaluated (aroma/fragrance, uniformity, defects, sweetness, acidity, flavor, body, finish, balance, and final concept) on a scale from zero to ten for each attribute.

The experimental design used was in DIC, containing 13 treatments, with 3 three repetitions per treatment. The evaluations were carried out in the Coffee Classification and Industrialization Laboratories. The data were evaluated using the Sisvar software (FERREIRA, 2014), and subjected to the Scott Knott test (1974) at the 5 % significance level.

Results and discussion

For the variable PH, there was a variation in the results for the different processes used (TABLE 1). It is observed that the treatment with the highest PH value was PN (4.70), followed by treatments BN (4.61), MFLA (4.59), MFS (4.58), which did not differ statistically from each other.

The perceived acidity in coffee is an important attribute for sensory analysis of the product, knowing that its intensity varies depending on the stage of ripening of the fruits, place of origin, type of harvest, form of processing, type of drying, and climatic conditions during harvest and drying (SIQUEIRA; ABREU, 2006).

For the ATT variable, there was variability in the results obtained (TABLE 1). It is observed that the treatment with the highest ATT value was VC (0.81), followed by treatments VM (0.78), MFA (0.77), which did not differ statistically from each other.

Literature data showed that the decrease in coffee quality is not associated with pH, but with an increase in acidity and this would be associated with the number of defects in the beans (PIMENTA *et al*., 2009).

For the Brix variable, there was variability in the results obtained (TABLE 1). It is observed that among the 13 evaluated processes, only one obtained a higher value, standing out among the others, being the MN (1.73).

Table 1. Results of the comparison test of means of physical/chemical analyzes ATT – Total titratable acidity, PH - Hydrogenionic potential, SST – Total Soluble Solids (Brix), and ash content in yellow *Coffea arabica* Catuaí, submitted to different types of processing. Muzambinho, 2017.

TREATMENT	PH	ATT	BRIX	ASH
MFLA	4.59 B	0.67 E	1.10 D	3.39 A
MFLB	4.48 D	0.64 F	1.26 C	3.50 A
VM	4.46 D	0.78 B	1.26 C	2.97 B
BN	4.61 B	0.68 E	1.33 C	3.03 B
PN	4.70 A	0.67 E	1.06 D	2.72 B
B	4.43 E	0.74 C	1.33 C	3.24 A
VC	4.24 F	0.81 A	0.96 D	3.28 A
MN	4.43 E	0.64 F	1.73 A	3.54 A
MFA	4.43 E	0.77 B	1.53 B	3.37 A
MFS	4.58 B	0.68 E	1.36 C	3.37 A
PD	4.48 D	0.70 D	1.26 C	3.39 A
MD	4.40 E	0.70 D	1.36 C	3.54 A
MDP	4.53 C	0.70 D	1.30 C	3.39 A
CV %	0.49	1.91	0.49	7.18

* Means followed by the same capital letter in the column, do not differ, at 5 % probability, by the Scott-Knott test.

Caption: 1) MFLB – low fruit mix; 2) MFLA – fruit mix had read high; 3) BN – natural float; 4) VM – 35 % green + Ripe; 5) B – float; 6) PN – natural pass; 7) MN – natural mature; 8) dry fermented mature MFS; 9) MFA – mature fermented in water; 10) peeled mature MD; 11) pulped mature MDP; 12) PD – peeled raisin; 13) VC – green cane.

A greater amount of soluble solids is desired, both from the point of view of industrial performance and for its contribution to ensure the body of the drink (MENDONÇA; PEREIRA; MENDES, 2005).

In the ash variable, there was less variation in the results obtained in the evaluated processes (TABLE 1). It is observed that only the treatments VM (2.97), BN (3.03), PN (2.72) obtained results statistically below the other evaluated processes.

In a study carried out by Müller, Huebner, and Souza (2013), whose objective was to characterize physical and chemically different brands of powdered and soluble coffee sold in the Taquari Valley region in the Rio Grande do Sul, comparing them with the established parameters under Brazilian law, the values of all brands evaluated showed values greater than 5 %, the maximum limit recommended by the legislation (BRASIL, 1999). This indicates that there is a high amount of impurities in the samples and that they have changed during the production process (MÜLLER; HUEBNER; SOUZA, 2013). In the present study, it is observed that the evaluated coffees were free of impurities or dirt, as they presented values below 4 %.

A coffee drink is considered of good quality, when there is a balance between sensory attributes such as body, sweetness, acidity, and bitterness, presenting a rich and dense drink. In the classification of the quality of the drink of coffee *Coffea arabica* L. submitted to different management in post-harvest, significant differences were observed within the analyzed parameters.

According to Table 2, for the aroma attribute, there were significant differences ($p < 0.05$), where the natural green (VN) and natural cane green (VCN) treatments were statistically equal and inferior to the other treatments.

Table 2. Means of the sensory attributes of coffees submitted to different post-harvest treatments. Muzambinho, 2017.

Treatment	Aroma	Flavor	Residual	Acidity	Body	Balance	Uniformity	Clean cup	Sweetness	General	Defects
VN	6.50 b	6.00 d	6.00 c	6.00 c	6.25 c	6.00 c	10.00 a	5.00 b	5.00 d	6.00 a	2.34 a
VCN	6.79 b	6.42 c	6.12 c	6.12 c	6.33 c	6.12 c	10.00 a	10.00 a	10.00 a	7.33 a	0.70 b
B	7.12 a	6.79 b	6.62 a	6.62 a	6.75 b	6.46 c	5.66 b	5.66 b	8.00 b	6.33 a	2.55 a
MFLA	7.17 a	6.83 b	6.54 a	6.54 a	6.67 b	6.46 c	6.71 b	6.66 b	8.33 b	6.38 a	2.34 a
PD	7.21 a	6.96 b	6.87a	6.66 a	6,83 b	6.62 c	8.33 a	8.33 a	9.33 a	6.67 a	0.99 b
35% Green + Ripe	7.25 a	6.91 b	6.46 b	6.46 b	6.75 b	6.62 c	10.00 a	10.00 a	10.00 a	6.58 a	0.70 b
MDP	7.29 a	7,08 a	6.75 a	6.75 a	7,08 a	7.91 a	10.00 a	10.00 a	9.50 a	7.00 a	0.70 b
MNFA	7.33 a	7.12 a	6.54 a	6.54 a	6.67 a	7.08 b	9.16 a	6.66 a	9.66 a	7.00 a	1.09 b
MFLB	7.33 a	6.96 b	6.50 b	6.50 b	6.79 b	6.50 c	9.33a	9.33 a	9.66 a	6.54 a	1.17 b
BN	7.33 a	6.89 b	6.71 a	6.71 a	6.71 b	6.54 c	3.33 c	3.33 c	6.66 c	6.29 a	3.23 a
PN	7.33 a	7.12 a	6.75 a	6.75 a	7.08 a	6.91 b	10.00 a	10.00 a	10.00 a	6.92 a	0.70 b
MNFS	7.37 a	6.87 b	6.38 b	6.38 b	6,75 b	6.50 c	10.00 a	10.00 a	10.00 a	6.54 a	0.70 b
MD	7.42 a	7.39 a	6.87a	6.87 a	7.12 a	7.04 b	9.66 a	8.00 a	8.33 b	7.12 a	0.70 b
MN	7.54 a	7.29 a	6.92 a	6.92 a	6,96 a	7.91 a	9.41 a	10.00 a	10.00 a	7.58 a	0.70 b
CV%	2.42	3.22	3.58	3.58	2.76	6.44	12.54	15.16	10.83	9.70	4.22
Average	7.216	6.900	6.588	6,58	6,82	6.740	8.687	8.261	8.892	6.737	75.621

* Means followed by the same capital letter in the column, do not differ, at 5 % probability, by the Scott-Knott test (1974).

Caption: 1) MFLB – low fruit mix; 2) MFLA – fruit mix had read high; 3) BN – natural float; 4) VM – 35 % green + Ripe; 5) B – float; 6) PN – natural pass; 7) MN – natural mature; 8) dry fermented mature MFS; 9) MFA – mature fermented in water; 10) peeled mature MD; 11) pulped mature MDP; 12) PD – peeled raisin; 13) VC – green cane.

It is possible to notice the lowest values in the natural green parameter with 67.75 in total and 60.50 in the final result. The other parameters show that there were no statistical differences between them.

Malta, Pereira and Chagas (2005) report that among the various factors that affect the quality of coffee, the presence of defective beans, especially green ones, stands out, being known the harmful influence of these in the aspect, roasting and mainly the quality of the drink. This is due to the fact that the aroma in the natural green and natural cane green treatments obtain different values from the others with 6.50 and 6.79.

For the flavor parameter, there was a significant difference between the treatments, and the treatments MDP, MNFA, PN, MD, and MN provided higher averages, not differing statistically from each other.

In the residual requirement, the VN and VCN treatments did not differ, presenting the lowest averages. The other treatments showed the highest values for the standard.

The decrease in coffee quality is not associated with pH, but with the increase in acidity and this would be associated with the number of defects in the beans and green beans (BORÉM *et al.*, 2013). The acidity perceived in the sensory analysis of the product is an important attribute, as its intensity varies depending on the stage of ripeness of the fruits, place of origin, form of processing, type of drying, processing, and climatic conditions (SIQUEIRA; ABREU, 2006). Thus, the results show that the lowest values for acidity were for VN and VCN.

For the body parameter, the VN and VCN treatments did not differ statistically from each other, providing lower averages. In the equilibrium

pattern, the MDP and MN treatments obtained the highest averages without statistically differentiating between themselves. In the uniformity requirement, the BN treatment was the one that obtained the lowest average followed by the MFLA, and B treatments that did not differ between them.
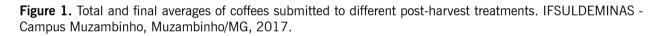
For clean cup, the lowest result found was for BN treatment, followed by VN, MFLA and B with slightly higher averages. In the analysis of sweetness, the lowest result among the treatments analyzed was the VN. According to Borém *et al*. (2013), it can be seen that the increase in drying temperature influences the lower sugar values. This shows that the correct post-harvest management reflects on the final quality of the drink.
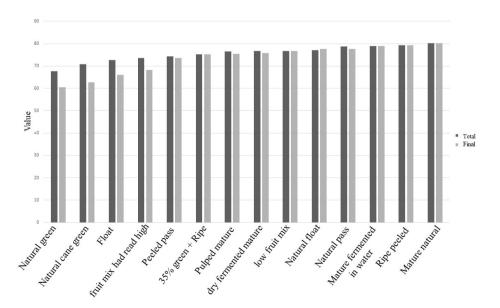
The general pattern had no significant differences between treatments. Although all parameters showed some discrepancies, the results were not sufficient to affect the overall quality of the drink.

In the defects requirement, the highest indices were presented for: VN, B, MFLA, and BN, that is, they were the treatments with the highest amount of defects in which they did not differ from each other and differ from the other treatments. Several factors end up harming the quality of the drink, generating greater quantities of defects, such as climatic conditions, conducting operations in the *terreiros*, uncontrolled fermentation, storage period, or even caused by the drying time in the *terreiro* causing the fruits to lose more moisture.

In all treatments, there is evidence that especially natural green and natural cane green report greater interference through standards. The possible causes of the samples in these cases are of low quality can be attributed to the climatic conditions and green grains (MOLIN *et al*., 2008). At this stage, the fruits have not yet reached physiological maturity, making the practice of pulping difficult and the presence of phenolic compounds in green fruits increases astringency or the "hardening" of the drink (SCHOLZ *et al*., 2011).

Figure 1 shows the results of the total and final means for the treatments, showing the lowest

Figure 1. Total and final averages of coffees submitted to different post-harvest treatments. IFSULDEMINAS - Campus Muzambinho, Muzambinho/MG, 2017.

Source: Elaborated by the authors (2017).

values in the natural green parameter with 67.75 in total and 60.50 in the final result. The other parameters show that there were no statistical differences between them.

Conclusions

It is concluded in the present work that the Maduro natural (MN) treatment is the best evaluated processing because it provided the highest Brix value and the lowest titratable acidity value. The presence of green beans affected the drink quality of *Coffea arabica* L. coffee, influencing the patterns, attributed to the poor ripening of the fruits.

The different treatments evaluated showed that especially natural green and natural cane green showed lower values in the sensory aspect in most of the analyzed patterns, which suggests that this effect is due to green grains.

In view of the results, it was possible to observe that the mature peeled, pulped mature, and natural mature treatments presented better sensory values, so it is therefore recommended for the post-harvest management to obtain a good drink quality.

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