Article

Physicochemical and sensory characterization of coffee from the Guerrero Mountain

Tiburcio Juárez González[1]
Yanik I. Maldonado Astudillo[1]
Ricardo González Mateos[1]
Manuel Octavio Ramírez Sucre[2]
Patricia Álvarez Fitz[3]
Ricardo Salazar[3§]

[1]Center for Innovation, Competitiveness and Sustainability-Autonomous University of Guerrero. Street Pino s/n, Col. El Roble, Acapulco, Guerrero, Mexico. CP. 39640. (tgonzalez_68@hotmail.com; yaixma@gmail.com; ricardoglezm@yahoo.com.mx). [2]Center for Research and Assistance in Technology and Design of the State of Jalisco, AC-Southeast Unit. Highway Sierra Papacal-Chuburna Puerto, Yucatan, Mexico. (oramirez@ciatej.mx). [3]CONACYT-Autonomous University of Guerrero. Av. Javier Méndez Aponte no. 1, Fracc. Agrarian Server, Chilpancingo del Bravo, Guerrero, Mexico. CP. 39070. (paty_fitz@hotmail.com).

[§]Corresponding author: rsalazarlo@conacyt.mx.

Abstract

In this study, the physicochemical and organoleptic characteristics of coffee produced in the municipality of José Joaquín Herrera, Guerrero were evaluated to increase its added and commercialization value. Coffee (*Coffea arabica* L. variety Caturra) was processed using four methods of beneficiation: traditional, natural honeying, controlled fermentation and natural washing. Color, hardness, moisture, water activity, ochratoxin A content, and the presence of defects in green coffee beans were measured. In addition, 10 organoleptic attributes were evaluated following the protocol of the Speciality Coffee Association of America. The samples were similar in L^* (41.98-46.23) and H° (87.21-88.71), indicating a semi-dark yellow coloration of the beans. Hardness was higher in honeyed coffee beans (102.81N) and lower in traditional coffee (87.85N). Similar values of a_w (0.48-0.51) were obtained, regardless of the method of beneficiation and a moisture percentage between 8.65-9.71. The coffees presented sensory quality scores ≥80. Coffee obtained by controlled fermentation was classified as specialty coffee because it showed the best cup quality (84) and absence of primary defects in beans. The coffee samples presented concentrations of OTA between 1.3 and 1.61 $\mu g\ kg^{-1}$, which are within the range established for commercialization. The benefit of the beans by alternative methods to the traditional one allowed to obtain coffee with better physicochemical and sensory attributes, increasing its final quality in the cup and proving to be a viable alternative for the generation of coffees with added value.

Keywords: alternative methods of beneficiation, cup quality, OTA.

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Introduction

Coffee is a basic product of agricultural origin with great relevance in the world economy and is only surpassed by oil in activity and commercial value. This grain is grown in its different varieties in tropical areas and is harvested in more than 70 countries around the world, with the main producers being Brazil, Vietnam, Colombia, Indonesia and Ethiopia. Currently, it is estimated that around seven million tonnes of coffee beans are produced per year and their consumption exceeds three billion cups per day (Slavova and Georgieva, 2019).

Mexico is one of the main international exporters of coffee and is in the eleventh position as a producer of this grain globally, with a 2.01% share of world production. Mexican coffee farming is distinguished as a strategic activity of great economic, social and environmental importance, because its production mainly involves small low-income producers and around 30 indigenous groups, allowing the generation of foreign exchange, employment and the conservation of biodiversity when grown under shade.

The main states that concentrate coffee production are Chiapas (34%), Veracruz (30%), Puebla (12%) and Oaxaca (11%) (Jáuregui-Arenas *et al*., 2017). In the state of Guerrero, coffee is the second largest perennial crop, with 47 000 ha of planted area corresponding to the Arabian variety in the regions of Costa Grande, Costa Chica, Mountain and Central region. Coffee production levels in the state position it in fifth place as a producer in the country, with approximately 49 000 t on average and an average yield of 1.64 t ha^{-1}, which is equivalent to 4% of the national production.

Additionally, the proportion of mountain coffee areas, the adaptation of coffee under shade and the use of dry or traditional beneficiation as the main method of obtaining green coffee show the potential of the state to produce and commercialize specialty coffees (Polito and Ruiz, 2018). Despite its relevance, in recent years the coffee sector has experienced a recurrent crisis due to the fall in prices in the international market due to global overproduction (Reyes-Landa *et al*., 2018).

This crisis induces producers to look for alternatives to add value to their product and venture into unconventional markets that allow them to ensure better prices and have greater control in the face of market instability. Among the different alternatives that have been developed in this situation, the production of high-quality differentiated coffee with specific physical characteristics and sensory attributes stands out (Jáuregui-Arenas *et al*., 2017), as a strategy that allows producers to advance in the coffee production chain and provide added value through the differentiation of their product.

In this sense, the method of coffee beneficiation or primary transformation is the most important step during the productive flow of quality coffee, since it allows preserving or degrading the sensory attributes of the beverage. Therefore, the objective of this study was to evaluate the effect of different methods of beneficiation on the physicochemical and sensory characteristics of coffees from the Mountain of Guerrero to provide information to producers to improve their production and commercialization process.

Materials and methods

The study was carried out in the plot 'Tlatenti' with productive management of *Coffea arabica* L., variety Caturra of low size, with pruning treatment, without application of agrochemicals, located in the upper part of the Mountain, at an altitude of 1 420 m, with coordinates 17° 26' 14.98" north latitude and 98° 59' 45.44" west longitude, in the municipality of José Joaquín Herrera, Guerrero. The coffee production of the plot during the period 2019-2020 corresponded to 500 kg of cherry coffee.

Natural or traditional beneficiation

The coffee beans were generally harvested between ripe, half ripe cherries, green and dried beans. After harvesting, whole coffee cherries were manually separated from impurities (branches, leaves, soil, etc.) and dried in full sun spreading in asphalt yards in enclosed spaces to prevent pets or rodents from accesing. The cherries were stirred manually and weighed in digital scale (Torrey®, L-PCR 40; Mexico) every 24 h until a moisture content of less than 12% was obtained and the drying time necessary to obtain the capulín coffee or natural coffee was determined.

Processing of coffee cherries

For the processing of coffee by the natural honeying beneficiation, controlled fermentation and natural washing, coffee cherries located in the center of the coffee branches, 1.7-2 g in weight, with optimal ripening and a concentration of sugars between 22 and 26 ºBx, which was determined using an Atago Pal-1® refractometer (Atago Co., Ltd., Tokyo, Japan), were manually selected. The freshly harvested coffee cherries were deposited in water vats for a first washing and classification. They were constantly stirred in a circular fashion with a wooden paddle and damaged grains, green fruits, leaves and branches were separated by flotation, as well as soil residues by decantation. Subsequently, the coffee cherries were separated into three lots for their beneficiation.

Natural honeying beneficiation

The whole fruits of the coffee were spread in layers of approximately 2 cm thick, on ecological drying beds of mesh fabric with wooden structure at 70 cm in height to facilitate ventilation. The coffee cherries were subjected to continuous drying in sun exposure for 9 h a day and stirred with rake every 2 h to balance the moisture content. The coffee cherries were weighed every 24 h until reaching a moisture content of less than 12% and the drying time necessary to obtain the honeyed coffee beans was determined.

Controlled fermentation beneficiation

The whole fruits were mechanically pulped by detaching the exocarp by means of a pulping machine (Aipec, Ecomaqmx®, Puebla, Mexico) with a disc opening of 1.5-2 cm, obtaining grains covered with parchment with mucilage attached. Subsequently, the grains were subjected to 18 h of controlled fermentation in a tank with 10 L of water at ambient temperature (17-25 ºC) and stirred every 2 h, to allow microbial degradation of the mucilaginous layer.

The grains were then washed to remove mucilage residues and soluble substances that formed during the fermentation process. They were spread in layers of 2 cm thick on ecological beds of mesh fabric with wooden structure at 70 cm in height to facilitate ventilation. The parchment grains were subjected to continuous drying in sun exposure for 9 h a day and were stirred manually every 3 h. The coffee beans were weighed every 24 h until obtaining a moisture content of less than 12% and the drying time necessary to obtain the natural fermented coffee beans was determined.

Natural washing beneficiation

The coffee cherries were pulped in a similar way to what was described in the previous subsection. For the removal of mucilage, the parchment grains were placed in vats of water and stirred in a circular fashion for 30 min in 3 sessions for 6 h at ambient temperature (17-25 °C). Next, the grains were dried in full sun in layers 2 cm thick on ecological beds of mesh fabric with wooden structure at 70 cm in height and stirred manually every 3 h. The coffee beans were weighed every 24 h until reaching a moisture content of less than 12% and the drying time necessary to obtain the natural washed coffee beans was determined.

Yield

The coffee yield obtained by wet beneficiation was calculated as the ratio between the weight of the dried parchment coffee obtained and the weight of processed cherry coffee, multiplied by 100. The yield of coffee processed by dry beneficiation was calculated as the weight of dried cherry coffee obtained, divided by the weight of processed cherry coffee, multiplied by 100.

Physical analysis

The color characteristics of the green coffee beans were determined by a portable sphere colorimeter (X-Rite spectrophotometer, Model Ci62, Grand Rapids, MI, USA), with a 10º observer and a D_{65} illuminant, using the parameters of the CIE L^*, a^*, b^* system. From these values, the Hue angle (Hº) was determined by considering: $H^o = \tan^{-1} (b^*/a^*)$, where a^* = [negative (green) to positive (red)] and b^* = [negative (blue) to positive (yellow)].

The average density was evaluated as the ratio between the weight of 100 coffee beans in each sample and the volume occupied by the beans. Hardness was measured using a TA-XT2 texture analyzer (Texture Technologies Corp., Scarsdale, NY, USA) with a cylindrical punch of 1 mm in diameter and a tip angle of 22º, at a test speed of 2 mm s^{-1}. Water activity (a_w) was assessed using an Aqualab® 4te water activity meter (Decagon Devices, Inc., Pullman, WA, USA). The moisture of green coffee was determined by the gravimetric method. Ten grams of sample was dried in triplicate in a forced convection oven (Luzeren, DHG-9070A, Beijing, China), at 105º C for 24 h until constant weight.

Analysis of ochratoxin A in coffee beans

Quantitative analysis of ochratoxin A (OTA) was performed using the competitive enzyme immunoassay of the commercial kit Ridascreen® Fast (R-Biopharm AG, Darmstadt, Germany). The coffee beans were finely ground, and 5 g of sample were mixed with 12.5 ml of 70% methanol. The samples were vigorously stirred for 3 min. The extract obtained was filtered through whatman No. 1 paper and 1 ml of the resulting filtrate was diluted with 1 ml of distilled water.

Subsequently, 50 ml of standard sample was placed in individual wells and 50 µl of enzymatic conjugate and 50 µl of anti-OTA antibody solution were added. The plate was stirred and incubated at ambient temperature (17-25 ºC) for 10 min. Then, three washes were performed using 250 µl of distilled water and 100 µl of substrate/chromogen mixture was added to each well. Finally, 100 µl of stop solution was added and absorbance was measured at 450 nm in a microplate reader (Stat Fax-2100, GMI-Inc., Miami, FL, USA).

Presence of defects

The content of damaged grains was determined in a sample of 300 g of green coffee from each batch. The grains were manually sorted and separated into primary defects (completely black, completely sour, foreign matter, fungal damage, severe insect damage) and secondary defects (partially black, partially sour, shells, broken or bitten, slight insect damage) according to SCAA requirements.

Roasting and grinding

The dried cherry and parchment coffee beans were threshed in a threshing machine (Ecomach, EM-120 kg, Chiapas, Mexico) to obtain green coffee (gold). Subsequently, the green coffee beans were roasted for 20 min at 190 °C ±10 in medium grade using a traditional cylinder roaster (RicoCafé, T3, Puebla, Mexico), and ground (RicoCafé, ASIN-7T, Puebla, Mexico) to a particle size of 700-900 µm, with a maximum of 30 min prior to the preparation of the infusion for cupping.

Sensory analysis

The sensory evaluation of the cup quality of the coffee samples was carried out following the cupping protocol for specialty coffees of the Specialty Coffee Association of America (SCAA) by a taster certified by the Mexican Association of Specialty Coffees and Coffees shops, AC (AMCCE). A total of 10 sensory evaluations were performed for each sample. Each cup was prepared using 6 g of ground coffee in 100 ml of water at 80-90 ºC.

The sensory characteristics evaluated were: aroma/fragrance, taste, residual taste, sweetness, acidity, body, uniformity, balance, clean cup and taster's score. Organoleptic attributes were rated using an ordinal scale from 0 to 10 points and the sample in general was assessed as the sum of the individual score of each attribute on a scale of 0 to 100 points. The taster identified specific notes or descriptors found in cup for taste and aroma attributes. Samples with a score ≥80, with at least one distinctive attribute in body, taste, aroma or acidity and little or no complete defect in grain, were called specialty coffee.

Statistical analysis

Data were statistically analyzed as means ± standard error using one-way Anova in the Statistical Package for the Social Sciences (SPSS Statistics 25) software. The comparison of means was performed using the Tukey test, with a significance level of 0.05.

Results and discussion

Coffee yield and drying time

The different yields and drying times of the coffee processed by wet and dry beneficiation were determined (Table 1). The highest yield in weight was obtained in dry cherry coffee processed by traditional beneficiation (64%) and natural honeying (66%), which is essentially due to the coating of the pulp that the grains present and that increases their weight.

In contrast, the coffee beneficiated by controlled fermentation and natural washing presented a yield of approximately 26% in green coffee, due to the absence of exocarp and mesocarp of the grains. Therefore, it takes about 3.8 kg of cherry coffee to obtain 1 kg of green coffee by wet beneficiation. In general, a rigorous selection and classification of the grains allows increasing the yield of the coffee by discarding the greatest number of defects that affect its processing (Montilla *et al*., 2008).

Table 1. Coffee drying time and yield obtained by the different methods of beneficiation.

Beneficiation	Drying time (days)	Yield (%)
Traditional	15 days	64.37
Honeying	10 days	65.66
Fermented	6 days	25.9
Natural washing	6 days	26.23

The total drying time of the grains reduced with the beneficiation of coffee by alternative methods to the traditional one. The natural washed and controlled fermented coffee presented the shortest drying time (6 days), while for natural and traditional honeying coffee, the drying lasted up to 10 and 15 days, respectively. In principle, drying is affected by a higher initial moisture content in traditional and honeyed coffee, due to the presence of exocarp and mesocarp in cherries.

However, by removing the outer layers of the cherry and leaving only a small portion of mucilage, the drying time of the coffee is accelerated (Poltronieri and Rossi). This was demonstrated by Siqueira *et al*. (2017), who observed an acceleration in the drying process for mucilage-free coffee compared to cherry coffee. Similarly, ecological beds could also favor the reduction in the drying time of the grains, by increasing the area of exposure to sunlight and allowing the air to circulate more easily, achieving a fast and uniform drying.

Physicochemical characterization of coffee beans

The evaluation of the physical and chemical characteristics of green coffee is important to increase the quality of the final product. Table 2 shows the results of the physicochemical characterization of processed green coffee beans.

Table 2. Evaluation of physicochemical characteristics of coffees obtained by the different wet and dry beneficiation methods.

Beneficiation	Luminosity (L^*)	Hue (Hº)	Density (g ml^{-1})	Hardness (N)	Water activity (a_w)	Moisture (%)
Traditional	44.05 ±1.91 ab	88.43 ±0.81 a	0.66 ±1 c	87.85 ±7.83 b	0.48 ± 0 b	8.65 ±0.02 d
Honeying	44.39 ±1.79 ab	87.21 ±1.02 a	0.73 ±1 b	102.81 ±3.18 a	0.48 ±0.01 b	9.17 ±0.1 b
Natural washing	41.98 ±2.73 c	88.71 ±0.63 a	0.74 ±1 a	95.22 ±3.55 b	0.51 ±0.01 a	9.71 ±0.07 a
Fermented	46.23 ±3.19 a	87.83 ±0.63 a	0.74 ±1 a	94.21 ±2.25 b	0.48 ±0 b	8.90 ±0.06 c

Averages with different letters are statistically different. The values indicate the mean ± standard deviation (n= 3).

The color of green beans is the first indicator of coffee quality and is used to set classification standards. ISO 4149 (2005) recommends color descriptions associated with grain quality ranging from bluish-greenish-whitish-yellowish-brownish. In the characterization of the color components of coffee, the samples presented average luminosity values (L^*) of 44.05-46.23 and hue angle (Hº) of 87.21-88.71, indicating semi-dark yellow tones that coincide with the uniform coloration of the beans obtained. It has been established that the color of green coffee depends on factors related to botanical origin, processing and storage time (Bicho *et al*., 2014).

The color of the grains can be attributed mainly to the drying conditions, since direct exposure to intense sunlight accelerates the chemical and physical changes that lead to fruit discoloration (Jurinjak *et al*., 2015). This coincides with several authors who claim that the yellow color corresponds to grains that dried too quickly at excessively warm temperatures (Tesfa, 2019). It has also been reported that grain color loss occurs due to prolonged storage before roasting (Bicho *et al*., 2014).

The grains presented density values of 0.66-0.74 g ml^{-1}, where the coffee traditionally beneficiated had the lowest density. These results are comparable to those of Montilla *et al*. (2008), who report that they are within the parameters established for the commercialization and classification of coffee quality. According to Duicela and Corral (2004), grains with a density greater than 0.65 g ml^{-1} are considered of high density, which is associated with a slower and more uniform maturation process, allowing a greater accumulation of important precursors of coffee aroma and flavor.

A lower density, on the other hand, is related to different defects in coffee such as broken, malformed, hollow, fermented grains, attacked by pests, shells, among others. The textural behavior is another important parameter in the acceptance and quality of coffee since it is related to its ability to resist deformation or fracture of its surface. The lowest hardness values were found in the grains obtained by traditional beneficiation (87.85 N), natural washing (95.22) and controlled fermentation (94.21 N), which presented similar values. On the contrary, there was an increase in hardness in natural honeyed coffee (102.81 N), which could be attributed to the coating of the mucilage and residual sugars that these beans present and that protect from the loss of firmness and texture during the storage period, through the reduction of the transpiration process of the grain (Bernardino-Nicanor *et al*., 2018).

Water activity (a_w) and moisture are factors that determine the process of conservation of coffee beans during storage and transport. The green coffee samples exhibited values of a_w between 0.48 and 0.51, indicating that the beans are stable against microbial growth, because the minimum a_w in which microorganisms can grow is 0.6 and below this value, the physiological activities necessary for their development deteriorate. The moisture content ranged between 8.65 and 9.71%, where the coffee obtained by the traditional beneficiation had the lowest moisture value and the natural washed coffee had the highest content.

As recommended by the International Coffee Organization (ICO), the moisture of the marketable green coffee bean should not exceed 12.5%, so the moisture values of the coffees processed by the different methods of beneficiation are within the range established for the export market, ensuring good storage conditions. On the contrary, a moisture content greater than 12.5% facilitates the growth of fungi and the presence of mycotoxins in coffee beans that, in addition to influencing the final quality of the drink, represent a risk to the consumer, while a low moisture content (less than 8%) harms the quality of coffee by generating shrunken beans with an undesirable appearance (Bicho *et al*., 2014).

Analysis of OTA in coffee beans

Coffee processed by the traditional method had a higher concentration of OTA compared to honeyed coffee (1.3 $\mu g\ kg^{-1}$), being similar to the levels of natural washed coffee (1.44 $\mu g\ kg^{-1}$) and controlled fermented coffee (1.4 $\mu g\ kg^{-1}$), which did not present significant differences (Table 3).

Table 3. Concentration of ochratoxin A in coffee samples of the different methods of beneficiation.

Beneficiation	OTA ($\mu g\ kg^{-1}$)
Traditional	1.61 ±0.042 a
Natural honeying	1.30 ±0.131 b
Natural washing	1.44 ±0.109 ab
Controlled fermentation 18 h	1.4 ±0.082 ab

Averages with different letters are statistically different. The values indicate the mean ± standard deviation (n =3).

OTA contamination derives from the presence of ocratoxigenic fungi in coffee due to inadequate post-harvest handling in the classification, drying, storage and transport stages of the grains. The slightly elevated concentration of OTA of coffee processed for natural beneficiation may be due to the lack of classification of cherries during harvesting, prior to processing, because several authors have pointed out that overripe cherries are a major source of contamination of green coffee by OTA (Taniwaki *et al*., 2014).

All samples had OTA levels below the maximum limits of 5 $\mu g\ kg^{-1}$ established by the European Union (EU) for roasted and ground coffee (EC, 2005). Therefore, the observed values of this mycotoxin in the samples indicate a low incidence of toxigenic fungi in the processed coffee beans, indicating that good agricultural practices were carried out in the post-harvest management of coffee, being suitable for commercialization.

Defects of green coffee

The presence of defects is relevant to establishing coffee quality, as they could be associated with specific problems during harvest and postharvest processing operations, in addition to negatively influencing beverage quality (Oliveri *et al*., 2019). Table 4 shows the quantity of defective coffee beans processed by wet and dry beneficiation.

Table 4. Number of defects in 300 g of green coffee sample beneficiated by different methods.

Defects	Conventional	Natural honeying	Controlled fermentation	Natural washing
Fungal damage	0	2	0	0
Severe insect damage	2	1	0	1
Slight insect damage	5	2	0	2
Partial sour	1	0	0	1
Broken or bitten	11	13	1	4
Total	19	18	1	8
Classification	Commercial	Commercial	Special	Commercial

The highest number of defects was found in conventional coffee (19) and natural honeyed coffee (18), in contrast to wet beneficiated coffee, where controlled fermented coffee had only 1 defect in grains, followed by natural washed coffee with eight defects. Broken or bitten beans were the most frequent defect in dry beneficiated coffee, which can be attributed to the prolonged drying period of conventional and honeyed coffee, as it has been described that bean with excessive drying become brittle and break easily during mechanical shelling (Oliveri *et al*., 2019).

At a minimum, specialty coffee is a coffee without taste defects or defective beans (SCAA, 2015), so only controlled fermented coffee was categorized as specialty coffee (grade 1), having presented less than five secondary defects and no primary defects in 300 g of sample, based on the SCAA classification. On the other hand, conventional, natural honeyed and natural washed coffee are considered commercial grade (grade 3), with 9-23 defects allowed in 300 g of sample for this category. In the same sense, the SCAA does not recommend the export of coffee when there is an excess of 86 defects per 300 g of sample. Therefore, regardless of the method of beneficiation used, processed coffees can be traded in foreign markets.

Organoleptic characteristics of coffee

The processing of coffee by wet beneficiation (controlled fermentation and natural washing) favorably increased its cup quality, highlighting attributes of the drink such as fragrance/aroma, taste and acidity in sensory analysis, compared to dry processed coffee (conventional and natural honeying) (Table 5).

Table 5. Sensory evaluation of coffees obtained by the different wet and dry beneficiation methods.

Attribute	Conventional	Natural honeying	Controlled fermentation	Natural washing
Tasting notes	Apple, walnut, chocolate, almond	Some wood and straw, almonds, milk candy	Cedar, tamarind, pineapple, tangerine, caramel, almond liqueur, vanilla, cognac.	Cinnamon, raisins, fig, vanilla, apple, citrus, walnut
Aroma notes	Caramel nut, almond, macadamia	Honey, apple, caramel, lemon, vanilla, light wood	Cognac, dried fig, winey, papaya, pineapple, tamarind, plum	Apple, almond, raisins, butter, caramel, milk candy
Fragrance/aroma	7.25	7.17	8	7.5
Taste	7.33	7.17	7.92	7.5
Residual taste	7.33	7	7.75	7.58
Acidity	7.42	7.42	7.67	7.67
Body	7.17	7.08	7.25	7.42
Balance	7.33	7.08	7.5	7.5
Uniformity	10	10	10	10
Clean cup	10	10	10	10
Sweetness	10	10	10	10
Taster's score	7.17	7.08	7.92	7.45
Total	81	80	84	82.58
Classification	Commercial	Commercial	Special	Commercial

While natural honeyed coffee was characterized by weak or undefined flavors, samples of conventional, natural washed and controlled fermented coffee were described with pleasant aroma/fragrance notes, as well as intense, defined flavors in cup. Although the intrinsic characteristics of coffee originate mainly in the chemical composition of the bean (Poltronieri and Rossi, 2016), they are also a result of the processing method used.

In the dry beneficiation, the final product develops characteristic fruity aromas and flavors, since no layer of the coffee cherries is removed. While, in the wet beneficiation, the elimination of mucilage by the diversity of microorganisms responsible for fermentation produces the release of various volatile aromatic compounds and metabolites that diffuse into the grains, contributing to add flavor, aroma, as well as to increase the acidity and complexity of coffee (De Melo-Pereira *et al*., 2018).

Generally, yeasts, fungi and bacteria have an important role in the fermentation of coffee due to their ability to degrade mucilage through the production of various enzymes, alcohols and acids; it also determines the concentration of sugars and amino acids that will participate in the Maillard reaction to produce desirable aromas and flavors during coffee roasting. A controlled fermentation favors the production of beneficial microorganisms that ensure better aromas and flavors in the cup of coffee. In contrast, prolonged fermentation favors the production of acetic, propionic and butyric acid-producing microorganisms, as well as short-chain fatty acids, which are compounds responsible for strange flavors in the coffee drink (Haile and Kang, 2019).

These results are consistent with those of multiple investigations that demonstrate that processing methods or wet beneficiation are applied for the production of specialty coffees with organoleptic qualities superior to coffee obtained by dry beneficiation (Abubakar *et al*., 2019). It is accepted that this is due to the selective harvesting of coffee cherries, as well as due to the separation of defective beans that takes place during wet processing, limiting the occurrence of factors that could interfere in their final quality in cup. The results of the sensory analysis showed a greater preference and acceptance of the controlled fermented coffee drink (84 points), standing out due to its flavor in a cup, which was described mainly with notes of pineapple, tamarind and cognac, of astringent and dry texture, as well as a medium citrus acidity.

These attributes, together with the evaluation of defects in grain, allowed the coffee fermented at 18 h, to reach the denomination of high-quality specialty coffee. This can be attributed mainly to the controlled process of fermentation of coffee, since, according to several studies, this allows ensuring the development of beneficial microorganisms that produce a high-quality drink with outstanding organoleptic properties (Poltronieri and Rossi, 2016). Under-fermented beans contain mucilage and residual sugar that prevent proper drying and create an environment conducive to the development of fungi, while excessive fermentation also results in the development of spoilage microorganisms that adversely affect the aroma and taste of coffee (Haile and Kang, 2019).

On the other hand, the samples of conventional, honeyed and natural washed coffee obtained a score ≥80 points in cup, indicating that it was possible to obtain good quality coffee, however, they are categorized as commercial coffee, due to the presence of primary defects in grain that were previously identified. From the results presented in this study, it can be established that the quality of coffee is associated with various factors that involve physicochemical, physical and sensory aspects, which are closely related and depend mainly on the method of beneficiation or processing of the grains, where the conditions of selection, drying and storage have great relevance.

Conclusions

This study provided relevant information to improve the production process and provide added value to the coffee of the Mountain of Guerrero. The physicochemical characterization of the coffee processed by different methods of beneficiation revealed that the grins presented values of hardness, density, moisture, water activity and OTA levels acceptable for commercialization purposes. In the sensory evaluation, it was found that the beneficiation of coffee by alternative methods, such as fermentation or natural washing, allowed obtaining coffee with fewer defects in grain and with better organoleptic attributes in cup.

The beneficiation of coffee by controlled fermentation proved to be a viable alternative for specialty coffee production, reducing defects in grains and providing superior organoleptic qualities to the drink. A rigorous selection of the coffee before its processing and establish the appropriate conditions of fermentation and drying are essential to ensure a better final quality of the product.

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