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Effects of anaerobic fermentation on arabica coffee quality

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Abstract:

Background*: Fermentation is a natural process in which microorganisms such as yeasts and bacteria consume and metabolize components such as sugars and acids present in coffee cherries. The objective of this research was to evaluate the anaerobic fermentation of coffee and its influence in relation to the quality of the drink. Thus, this study aimed to evaluate the effects of anaerobic fermentation on the quality of Arabica coffee drink.*

Materials and Methods: *The coffee used was the cultivar Mundo Novo, a 10-year-old crop, installed in a 3x0.90 m spatial arrangement. For the installation of the experiment, the coffee was harvested manually, and the following treatments were installed: treatment 1 (Green coffee, cherry and raisin, and submitted to anaerobic fermentation), treatment 2 (Green coffee, cherry and raisin, drying on cloth), treatment 3 (Cherry coffee, and submitted to anaerobic fermentation), treatment 4 (Cherry coffee, drying on cloth). Each treatment was installed in 6 replications, totaling 24 experimental plots in a randomized block design, dry until reaching 11.5% moisture and benefited. The characteristics evaluated were according to the SCAA methodology were: fragrance and aroma, uniformity, absence of defects, sweetness, flavor, acidity, body, finish, harmony which make up your final grade.*

Conclusion: *It was concluded that anaerobic fermentation did not affect the quality of the coffee.*

Key Words*: Fermentative processes, grain stages, drink, post-harvest, drying.*

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I. Introduction

Coffee is a plant of African origin belonging to the Rubiaceae family. Two coffee species dominate the world market: Coffea arabica (arabica) and Coffea canephora (robusta / conilon) [18]. Arabica is a genetically complex species, and is more economically valued for being aromatic and with a mild flavor[1].

Although the most recent publication by the International Coffe Organization (ICO), from July 2020, shows that the global coffee production of 2019/2020 had a 2.9% reduction compared to last year, Brazil remains the largest producer of grain, with an annual average of 53 million bags of 60 kg, between 2013/14 and 2018/19, followed by Vietnam, Colombia, Indonesia and Ethiopia [15][16]. In the past two decades, domestic consumption in producing countries has grown at a faster rate than consumption in export markets. Even with decreased exports, it is the second most important commodity exchanged on world markets, behind only crude oil [14][15], with Brazil standing out as the main producer and exporter of Arabica coffee being the second largest consumer of the beverage globally [15].

The quality of the coffee drink, which is represented by the flavor and aroma, are influenced by different factors before and after the harvest that guarantee the final expression of the product's qualification, which according to [12] the quality of the drink is affected by several factors, such as species, handling, climate and post-harvest procedures.

In relation to post-harvest aspects, enzymatic and microbial fermentations stand out, processing processes for processed coffee, blends (mixtures of arabica and camphor beans) and the roasting of the beans[7]. The choice of processing and drying methods varies considerably between producers, depending mainly on technological, climatic, economic characteristics and the demands of the consumer market [17]. The substantial aroma and flavor of the coffee drink are the result of the combined participation of a series of volatile and non-volatile chemical elements, including acids, aldehydes, ketones, sugars, proteins, amino acids, fatty acids and phenolic compounds, also embracing activity enzymes, in some of these items, which generate reactions and compounds that influence the taste of the cup [7].

Fermentation is a natural process in which microorganisms such as yeasts (Saccharomyces cerevisiae) and bacteria (Lactobacillus) consume and metabolize components such as sugars and acids present in coffee cherries. As a result, these components are broken down into acids and alcohols [13]. There are three methods for fermentation: wet, dry and semi-dry. The coffee fruits immediately after harvest are processed by one of these three methods, to allow spontaneous or induced fermentation to occur. Depending on the type of processing, the time required for fermentation varies. The main objective of the fermentation process, regardless of the method, is to remove the mucilage layer, which is rich in polysaccharides (pectin), and to decrease the water content of coffee beans. However, if well managed, fermentation also has a positive impact on coffee quality attributes [14]. Mucilage consists of pectic materials, consisting of protopectin (33%), reducing sugars - integrating glucose and fructose (30%) -, non-reducing sugars - such as sucrose (20%), cellulose and ash (17%) [29].

Wet fermentation, or anaerobic, processing is widely used for arabica coffee. Right after the harvest, the ripe coffee fruits go through a flotation process to clean debris and remove low density fruits, which float in the water. The coffee is then peeled (pulping) before drying, and placed, or not, in a fermentation process in an underwater tank for 24 to 48 hours, and dried until the moisture content reaches 10% –12% [24]. In dry processing, the coffee fruits are cleaned and the low density ones are separated immediately after harvest, and all the coffee is dried in the sun on platforms and / or on the ground without previous removal of the pulp [25]. It consists of drying the whole fruit, that is, with its exocarp (peel), mesocarp (pulp and mucilage) and endocarp (parchment), then having the coffees called "unwashed or natural".

Semi-dry processing is a combination of both methods, in which the coffee fruits are pulped, but the fermentation process takes place directly under the sun on a platform [26] and the choice of the processing method it will depend on economic or environmental conditions, such as areas subject to high relative humidity, during the coffee harvest and drying period. It is also necessary to consider the impositions or preferences of the markets to which the production will be sent [7].

Fermentation is a metabolic process that uses sugar, both in the absence (anaerobic) and in the presence (aerobic) of oxygen [14]. In this chemical process, complex molecules are broken down into simpler molecules, producing liquid products and gases (volatile compounds). Anaerobic processes build more homogeneous results and are more easily controlled, by monitoring temperature, pH, alcohol, etc., since they are made in closed containers [22].

It is interesting to note that the fermentation of coffee by anaerobic means came from practical necessity, and not as an alternative to modify the coffee drink. Explains [3] that while arabica coffee, with its origin in a subtropical climate, entered tropical areas, the incident of an excessive fermentative system of the cherry fruits was identified successively after the harvest, negatively reflecting on the characteristic of the final product. With the intention of avoiding this problem, extraction of the mesocarp that has abundant sugar started to be made. For this reason, the targeted fermentation of coffee in this process is primarily intended to facilitate the removal of the seed mucilage layer [4].

The method has been a standard in producing countries in Central America and the Caribbean, especially Colombia and Costa Rica, for over 50 years. Due to the very humid climate, fermentation was accepted as a condition to remove mucilage biologically, so that drying was more controlled and quick. Over time, they realized that, in addition to helping in the drying process, the grains acquired positive sensory changes [22].

In anaerobic fermentation, coffee is normally placed in a closed tank, without the presence of oxygen and with a valve that provides the release of carbon dioxide (CO_2). This method gives the producer more control over the chemical reactions in progress [13], as the coffee skin and pulp are removed mechanically, leaving the mucilage adhered to the beans[28].

[3] explains that this process includes the phases of harvesting the grains; washing and separation of the floating grains, which will be processed separately; peeling, pulping or demucilating the fruits; fermentation or use of commercial enzymes or chemical substances to remove mucilage stuck to the grain; washing to remove mucilage residue and drying and processing grains. In this technique, natural grains or peeled cherries are placed in hermetically sealed tanks or drums, which may or may not have water. In this process there is a need to use Airlock valves to release the CO_2 produced during the fermentation process, to attenuate the internal pressure. It is very similar to the beer fermentation process, but in the case of beer, the wort is boiled at 100 ºC, which eliminates all natural microorganisms, thus adding yeasts specific to each style, making the process more controlled and repeatable. In the case of coffee, there are still no experiments that eliminate these natural microorganisms, which makes it more unpredictable, which is why constant monitoring of fermentation temperature, pH and time are so crucial [22].

From the quality panorama, [7] argue, that the anaerobic fermentation phase requires compatibility with fixed parameters: first, the grain mass must integrate parchment coffee uniformly, with the least possible number of crushed grains, husks and unpolished coffee; second, fermentation should be completed as soon as possible after sufficient mucilage degradation; then, after washing, the mucilage must be removed completely, before drying. The peeled product, generated without any attempt to remove the mucilage, with the peeled beans being quickly dried, can enable a coffee of the highest quality, this is a partially recent processing technique, developed in Brazil, but which requires peculiar handling conditions of coffee throughout drying to achieve the desired quality goals. It must be taken into account that the mucilage adhered to the grains can constitute a risk of the development of microorganisms, which have a detrimental influence on the qualification of the product.

The role of microorganisms in modifying the sensory peculiarity of coffee, in anaerobic processing has been the subject of discussions. Of the numerous errors attributed to problems that occurred during the fermentation, the most relevant are “fermented taste”, “burnt” and “dark green”. The fermented taste has variations of fruity aldehydes. The burning taste is similar to the onion, and the dark green grain gives a prominent unpleasant taste [7].

Elements that favor this fermentation method in obtaining peeled cherry coffees are supported by the reduction of the area occupied in the terraces. What enhances the use of mechanical dryers due to the removal of the peel and the reduction of processing and drying costs [3]. In addition to providing better preservation of the intrinsic qualities of coffee and the achievement of more homogeneous lots with less defects. In addition, the final product prepared by wet and semi-dry methods has better quality compared to the dry process [11].

Controlled fermentation of coffee can result in drinks with a special sweet, citrus, fruity and roasted smell and flavor, which add value and consistency to the quality of the product. In coffee fermentation technology, we need to control the temperature, the water quality, the quality and health of the coffee and the time of the fermentation process [5], because if there is a lack of control in the fermentation the same it can cause a negative impact, having an aroma and taste of moldy, phenolic, expired, moist and fungi, therefore, this process has a complex relationship with the quality of coffee [19].

Temperature is one of the most influential parameters in anaerobic digestion. It affects the growth and metabolic activities of microorganisms. Anaerobic microorganisms work in three temperature ranges: psychrophilic (<20ºC), mesophilic (20–45ºC) and thermophilic (45–60ºC). The rapid change in temperature is harmful to methanogens, especially for thermophiles [6].

Several models are applied to describe the effect of temperature on the anaerobic fermentation rate. The Arrhenius model, for example, was applied to estimate bacterial growth and the rate of product formation. However, the limitation of the model was the indefinite increase in the rate of growth with increasing temperature. Another example, are Ratkowsky's models, however, predict that the rate of bacterial growth increases with increasing temperatures, from the initial to the ideal temperature, and decreases when the temperature increases even more [6].

The objective sensory evaluation methodology of SCAA (Specialty Coffee Association of America), used worldwide, and also in Brazil, by the Brazilian Association of Special Coffees - BSCA, and establishes special coffee as all that reaches at least 80 points on the methodology score scale, whose maximum score is 100, the parameters being evaluated: fragrance and aroma, uniformity, absence of defects, sweetness, flavor, acidity, body, finishing, harmony [9]. Each of these attributes is scored on a scale between zero and ten.

II. Material and Methods

The survey was carried out from May to June 2020, in the municipality of Paraguaçu-MG, Sitio São Pedro, located at coordinates Latitude: 21° 30'30”S, Longitude: 45° 42' 19” W, altitude: 859 m, the predominant climate in the area is warm and temperate, with an average annual temperature of 20.5 °C and an average annual rainfall of 1461mm [8].

The coffee used was Mundo Novo cultivar, a 10-year-old crop, installed in a 3x0.90 m spatial arrangement, 3,703 plants / ha^{-1}.

For the installation of the experiment, the coffee was harvested manually, when they had 85% of cherry fruits, for the installation of the cherry treatments, a manual selection was made, where the coffees were matured and the following treatments were installed:

T1: Green coffee, cherry and raisin, and submitted to anaerobic fermentation.
T 2: Green coffee, cherry and raisin, drying on cloth.
T 3: Cherry coffee, and submitted to anaerobic fermentation.
T 4: Cherry coffee, drying cloth.

Each treatment was installed with 6 repetitions, in a randomized block design, totaling 24 experimental plots. When installing the tests, Brix was evaluated with the aid of a Lorben GT427 refractometer with precision 0.2 (brix), in which the mature grains were 22%, and the average of the treatments can be seen in Table 1.

Table 1. Brix degree averages of treatments

Treatments		
	RIX	B
1: Green coffee, cherry and raisin, and submitted to anaerobic fermentation.		2
	1%	
2: Green coffee, cherry and raisin, drying on cloth.		2

	0%	
3: Cherry coffee, and submitted to anaerobic fermentation.		2
	2%	
4: Cherry coffee, drying on cloth		2
	1,3%	

For treatments 1 and 3 in fermentation, 6 gallons of 20 liters were used to be fermented, plus 6 2liters pet bottles containing drinking water.

The gallons were sealed to prevent the passage of air, then the lids were punctured, and a 1/8 hose was placed at the top making a connection between the container with the 2 liters pet bottles containing water (simulating an airlock valve).

After the fermentation was completed, at the moment the bottles with water stopped bubbling (CO_2 being released), the treatments were opened and placed on a cloth separately and taken to the beaten ground to be dried.

Treatments 2 and 4 were placed directly in separate cloths and taken to the beaten ground terrace to dry normally.

All treatments were dried until they reached 11.5% moisture, and subsequently evaluated for quality using the classification according to SCAA methodology [9].

The data of the characteristics obtained were submitted to statistical analysis using the SISVAR® software [2], the significant difference between treatments being determined by the F test, with the means compared by the Scott-Knott test at the level of 5% of significance.

III. Results and Discussion

After drying the batches, they were sent to the Q-gradders and the. average results of coffee classification by SCAA score for the evaluated treatments did not show statistically significant differences, as can be seen in Figure 1.

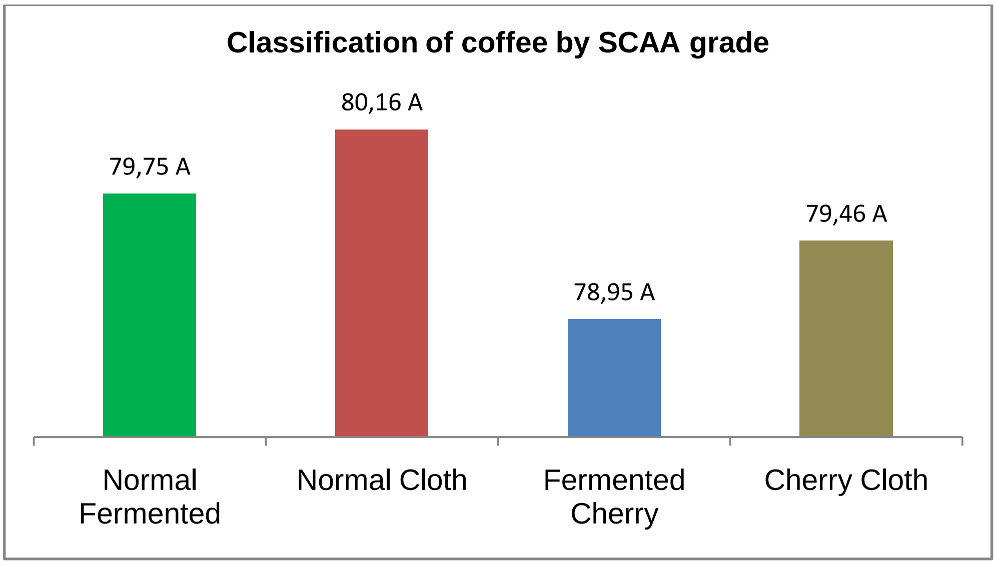

Figure 1: Classification of coffee by SCAA score. Different letters indicate a statistical difference greater than 5% probability by the Scott-Knott test.

In treatment 1, Green coffee, cherry and raisin, and submitted to anaerobic fermentation, repetitions 1, 2, 3 and 5 both had malic acid, as shown in Figure 2. According to [20], immature grains present higher percentages of chlorogenic acid, decreasing as the fruit ripens. This decrease may be a consequence of the sensitivity to oxidation, being greater when the grain is immature than when it is ripe, since the defense mechanism against oxidation is more efficient in the maturation phase[21].

In treatment 2, green coffee, cherry and raisin, drying on cloth, repetitions 4 and 5 had the same final score. [27] observed superior characteristics of the drink for peeled, pulped and demucilated coffees in relation to natural coffee.

In treatment 3, Cherry coffee, and submitted to anaerobic fermentation, repetitions 1 and 4 had the highest score, both had an orange flavor. According to [23] the controlled fermentation process in coffee can be beneficial for the quality of the drink, making the technique, not only in Brazil, but in other producing countries, an excellent alternative for having better coffees and, consequently, greater added value to your final product.

In treatment 4, Cherry coffee, drying on cloth, the lowest score was 74.25 in repetition 6, malic acid, rubber, soil, mold, smooth body. Carried out the selective collection of coffee and the anaerobic fermentation, using plastic bags and the methodology of time control was 12 hours, 24 hours and 36 hours, provided coffees with scores around 84 to 85 points, according to the SCAA methodology.

The coffees that underwent fermentation had an increase in acidity attributes, in particular the malic. There were also flavors like pepper. It was evident the reduction of attributes that give interesting characteristics to coffee, such as nuts, caramel and chocolate, as shown in the graph in figure 2, which brings an analysis of the four types of treatment performed, and all the sensory attributes found.

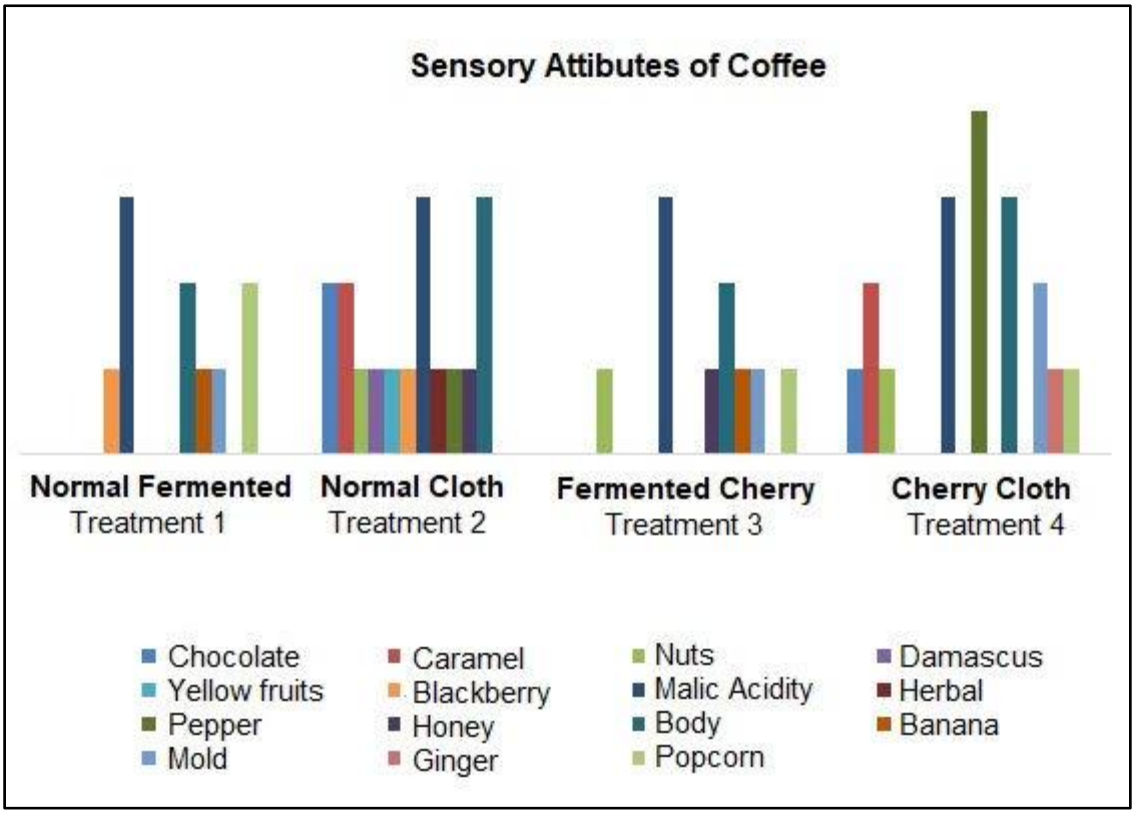

Figure 2: Sensory attributes of coffee

This result largely combines with the research by [10], on the influence of natural fermentation on the quality of the coffee drink, which most of the attributes found referred to chocolate, honey, fruits citrus, caramel and fruity, all treatments had these attributes.

IV. Conclusion

It is concluded that the anaerobic fermentation did not provide effects on the quality of the arabica coffee drink by the SCAA methodology. In relation to its sensory attributes it resulted in a high index of malic acid.

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