**QUALITY OF NATURAL COFFEE AND PULPED IN THE FUNCTION OF TEMPERATURE ALTERNATION DURING MECHANICAL DRYING**

**ABSTRACT:** The research evaluates the sensorial quality of processed and dried coffee beans in different ways. Two types of processing were performed: dry and wet; And seven drying methods: drying in the terrier, and mechanical drying with heated air at 50ºC until coffee reaches 30% water content, followed by drying with air heated to 35ºC until reaching 11% water content; drying in fixed-layer dryers with heated air at 45 ° C until the coffee reaches 30% water content, followed by drying with heated air at 35 ° C until reaching 11% water content; and drying in fixed layer dryers with heated air at 40 ° C until coffee reaches 30% water content, followed by drying with heated air at 35 ° C until reaching 11% water content; drying in fixed layer dryers with heated air at 35 ° C until the coffee reaches 30% water content, followed by drying with heated air at 50 ° C until reaching 11% water content; drying in fixed-layer dryers with heated air at 35 ° C until the coffee reaches 30% water content, followed by drying with heated air at 45 ° C until reaching 11% water content; drying in fixed-layer dryers with heated air at 35 ° C until the coffee reaches 30% water content, followed by drying with heated air at 40 ° C until reaching 11% water content. The mechanical drying system consisted of three dryers of fixed layer, allowing the control of temperature and drying flow. The cafes were tasted according to the evaluation system proposed by the American Specialty Coffee Association (SCAA). Analyzes of the physical-chemical composition and physiological quality of the grains were carried out, involving: acidity grease, potassium leaching, electrical conductivity, color and germination. The results show that the pulped coffee is more tolerant to drying than the natural coffee, regardless of how it was dried.

**Index terms**: post-harvest, sensory analysis, alternate drying

**1. INTRODUCTION**

Coffee is one of the products of great importance in the world agribusiness. According to the International Coffee Organization - ICO (2013), raw coffee consumption was in the order of 142 million bags and could reach 148 million in 2016. The quality of the coffee is mainly determined by the taste and aroma formed during toasting. According to Flament (2002), approximately 300 chemical compounds present in the raw grain yield more or less 850 compounds after toasting. However, the presence of these precursors depends on genetic, environmental and technological factors (Alvariz & Berter, 2004; Farah et al., 2006).

There are two processing methods for coffee: dry and wet. In moist processing, three types of coffee can be produced. The peeled coffees, of which the remaining mucilage of the husking is not removed from the grains; the pulped coffees, originating from mechanically peeled fruits and the remaining mucilage is removed by fermentation; and those demucilated, those in which the mucilage is mechanically removed. In dry processing, the fruits are submitted to drying intact, without exocarp removal.

Acidity in coffee beans has been pointed out as a good indication of the quality of the product, in which small amounts of organic acids are necessary to confer essential acidity to the coffee beverage (SOARES, 2003). The content of free fatty acids can be used as an indicator of grain deterioration. Thus, the use of the fatty acid test is of great importance in the monitoring of seed quality, since maturity, because the fall of vigor precedes the loss of viability.

Zonta (2007), studying the viability of coffee seeds, observed that, during the drying process, the seeds undergo physical changes, caused by temperature and humidity gradients, which reduce the percentage and speed of germination, besides increasing the percentage of abnormal seedlings.

The method of sensorial evaluation of the Specialty Coffee Association of America (SCAA, 2008) has been emphasizing to evaluate the quality of the drink of the special coffees. The method is based on a quantitative descriptive sensory analysis of the beverage, performed by a selected and trained team of judges, using the unstructured scale from 6 to 10 for the evaluation of the fragrance of the powder, aroma, defects, acidity, bitterness, flavor, residual taste, astringency and beverage body, with final evaluation of the overall quality and quality of coffee according to the terminology presented by Lingle (2011).

In addition to sensory evaluation, the physico-chemical evaluation of coffee beans can become a valuable tool for assessing the quality of your beverage. Selmar et al. (2004) and Bytof et al. (2007), observed biochemical changes during processing related to germination metabolism, whose extent depends on the treatment, whether wet or dry. The authors, however, did not correlate with drying methods. Drying of coffee, if poorly conducted, may intensify the degradation of cell membranes, which can be consistently indicated by potassium leaching tests and electrical conductivity (AMORIM, 1978; PRETE, 1992). Marques et al. (2008) and Borém et al. (2008b), showed greater damage in the cellular membranes system of the grains with the increase of drying temperature.

The drying rate has a significant effect on the quality of the agricultural products and is influenced by several factors, such as temperature and drying air flow, relative humidity and ambient air temperature, initial and final water content of the product (RIBEIRO et al., 2003; BORÉM, 1992). These parameters are not independent, influencing the drying process simultaneously.

Higher drying rates caused by high temperatures can cause damage to coffee quality due to damage to cell membranes (Marques et al., 2008; BORÉM et al., 2008b). Borém et al. (2008b) verified through ultrastructural scanning electron microscopy studies that the natural and pulped caffeine endosperm, during drying at 40 ° C and in ground, maintained the integrity of the cell membranes and that these membranes were damaged only between water contents of 30% and 20% (bu), when the natural and pulped coffee were dried at a temperature of 60 ° C.

High water reduction rates are desirable in reducing the risk of fermentation in the early stages of drying and reducing energy consumption. However, when using the technology currently available for the drying of coffee, the increase of the drying rate is obtained by increasing the temperature. However, it has been proven by several scientific reports that coffee when subjected to drying temperatures above 40ºC suffers serious damage to the cell membrane system of the seed endosperm, with negative reflections on the quality of the beverage, when these are used in the final stages of mechanical drying.

The objective of this work was to evaluate the effects of different methods of processing and drying on physiological and physical-chemical quality of coffee beans, analyzing their interrelationship with the quality of the beverage.

**2 MATERIAL AND METHODS**

**2.1 Experimental procedure**

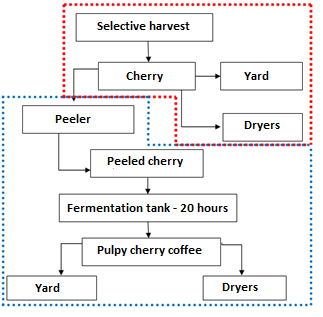
The experiment was carried out with coffee cherry (*Coffea arabica* L. cv. Catuai 62), harvested at the Santa Clara farm, which has an altitude of 1,270 meters, located 10 km from the city of Carmo de Minas (Latitude: 22 ° 4'14.80 "South; Longitude: 45 ° 7'17.77" West), in the mountain range of Mantiqueira. The fruits harvested were taken to the city of Lavras - Minas Gerais, where this journey took about 2 hours.

After arriving at the Federal University of Lavras, the coffee was processed through dry (natural) and wet (pulped), separating only the cherry fruits. After processing, the coffee was dried in seven different conditions (Table 1).

**Table 1 -** Experimental design.

|  |  |
| --- | --- |
| **Processing** | **Method of Drying** |
| NATURAL | On Ground |
|
| 35/40°C |
| 35/45°C |
| 35/50°C |
| 40/35°C |
| 45/35°C |
| 50/35°C |
| PULPED | On Ground |
|
| 35/40°C |
| 35/45°C |
| 35/50°C |
| 40/35°C |
| 45/35°C |
| 50/35°C |

After drying, the physiological, physical-chemical and sensorial analyzes were carried out at the Post-Harvest Technology Pole Laboratory of the Federal University of Lavras. Figure 1 summarizes the whole experimental process.

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**Figure 1 -** Flowchart used to obtain the raw material (Dotted lines in red indicate dry processing; Dotted lines in blue indicate wet processing).

**2.2 Dry processing**

For dry coffee processing, which results in the natural coffees, the fruits were washed and separated hydraulically, by density difference, for the removal of the float and dried fruits present in the plot. Then, the ripe fruits were again manually selected to ensure uniformity of the sample with respect to the maturation stage. After this procedure, a portion of the natural coffee was taken to the yard for complete drying and the other portion subjected to mechanical drying in the dryers.

**2.3 Wet processing**

For the processing of wet coffee, mature fruits from selective harvesting were again manually selected and peeled mechanically in a green separator of the brand Pinhalense Ltda., Model Eco - 6. After the peeling, the coffee was submitted to fermentation in water to remove the mucilage, under ambient conditions, with an average temperature of 20ºC, for 20h. After this period, the parchment coffees were washed with water until the mucilage was completely removed. When the mucilage was completely removed, a portion of the parchment coffee was taken to the yard for complete drying and the other portion subjected to mechanical drying in the dryers.

**2.4 Drying on ground**

For drying on ground coffee after processing remained under ambient conditions. It was used for this drying on ground one type suspension. These coffees were sprayed in fine grain-to-grain layers, and with drying the layer was folded, according to the methodology proposed by Borém et al. (2008).

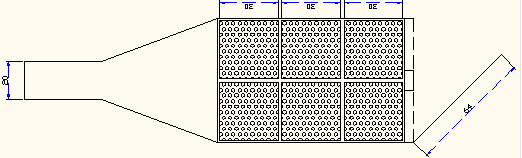
The maximum, minimum, average, and precipitation and relative humidity during the drying period, which lasted from August 16 to 27, 2013, are presented in Table 2. Both the natural coffee and the pulped coffee remained under these conditions until reaching the water content of 11 ± 0.2% (bu).

**Table 2 -** Averages of maximum, minimum and average ambient temperatures, precipitation and relative humidity - Lavras - 2013.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Maximum Temperature  (° C) | Minimum  Temperature  (° C) | Average Temperature  (° C) | Precipitation (mm) | Relative Humidity (%) |
| 31,8 | 13,15 | 18,85 | 0,014 | 58,6 |

**2.5 Drying in dryer**

The mechanical drying plots were conducted to three dryers (Figure 2) with a fixed layer, which allow the control of the flow and temperature (T) of the drying air with precision, through an electronic panel. The grain layer reached the thickness of 30 cm for the natural coffee and 20 cm for the pulped coffee.



**Figure 2 -** Top view of the dryers used in the experiment.

The air flow was controlled at 20 m³ min-1 m-2, corresponding to a velocity of 0.33m s-1 (SILVA, 2000).

The moment of transition from one temperature to the next, in the case of treatments with heated air at 50/35 ° C, 45/35 ° C, 40/35 ° C, 35/50 ° C, 35/45 ° C and 35/40 ° C , was determined as follows:

The control of the water content of the grains during drying was done from the initial water content of the coffee from on ground, which made it possible to monitor the variation of mass in the respective samples. The water content of the coffee was determined leaving the fruits for a period of 24 hours, subjected to a constant temperature of 105 ° C. After this period its humidity was determined by the difference of the initial and final people.

To determine the time of transition of the air temperature, each tray containing the experimental plot was weighed every hour, and the water content was determined by mass difference applying equations 1 and 2. When each drawer reached the relative mass at the water content of 30% ± 2% (bu) the temperature was changed, remaining until the coffee reached 11% (bu).

(1)

(2)

On what:

Mf: final mass (kg);

Mi: initial mass (kg);

PQ: percentage of break (%);

Ui: initial water content (% b.u.);

Uf: final water content (% b.u.).

After drying and cooling, the parchment and natural coffee remained stored in polyethylene bags in an environment with a temperature of 10 ° C and 50% relative humidity, and it was only used when the physiological, physicochemical and sensorial to evaluate the quality of coffee, which happened after a minimum of 90 days of rest, minimum time for coffee to have consolidated its sensorial attributes (BORÉM, 2008).

**2.6 Characterization of coffee quality**

**2.6.1 Sensory analysis**

The sensorial analysis was performed at the Nutrade Quality Laboratory, located in the city of Varginha / MG. For this purpose, portions of the samples of grains classified in the above 16 sieve were used, with discs of malted and defective grains according to Normative n ° 8 (BRASIL, 2003).

Sensory analysis was performed by two Certified Special Coffee Judges (SCAA- Certified Cupping Judges). The sensorial analysis protocol of SCAA was used, according to the methodology proposed by Lingle (2011), for the sensorial evaluation of special coffees, with the assignment of notes, in the range of 6 to 10 points for fragrance, acidity, body, taste, Finish, sweetness, uniformity, clean cup, balance and finish. The roast was made with coloration corresponding to 58 points of the Agtron scale, for the whole grain, and 63 points for the ground grain, with a tolerance of ± 1 point. To obtain the ideal toasting point, the samples were standardized for the weight (110 g), grain size (sieve 16 and above), as well as the temperature and toasting time (between 8 and 12 minutes). According to Normative n ° 8 (BRAZIL, 2003).

At each sensory evaluation, five representative cups of coffee were sampled from each sample, and a sensorial analysis session was performed for each repetition, totaling three replicates for each treatment. Due to the presence of different sensorial characteristics, the sensorial analysis of the natural and pulped coffee was carried out separately, in order to minimize any possible negative or positive interferences. The final results of the sensorial evaluation were constituted by the sum of all the attributes.

**2.6.2 Physiological and physicochemical analyzes**

The physiological and physicochemical analyzes were performed in the Laboratory of Seed Analysis of the Department of Agriculture of the Federal University of Lavras. For the physiological analyzes, four sub-samples of grains with no apparent defects were used, for each repetition of the respective treatments.

**2.6.2.1 Germination test**

It was performed with four sub-samples of 50 seeds, distributed in germinated paper with water equivalent to two and a half times the mass of the dry substrate and placed to germinate at 30ºC. The evaluations were performed 30 days after sowing, according to the Rules for Seed Analysis (BRASIL, 2009), and the results expressed as a percentage.

**2.6.2.2 Electrical Conductivity**

The electrical conductivity of the raw grains was determined by the methodology proposed by Krzyzanowski et al. (1991). Four replicates of 50 grains of each plot were used, which were weighed to an accuracy of 0.001g and immersed in 75 ml of distilled water inside plastic cups of 180 ml capacity. Afterwards, these containers were taken to BOD with forced ventilation regulated to 25 ° C for five hours, and the electrical conductivity of the soaking water in BEL W12D was read. With the data obtained, the electrical conductivity was calculated by equation 3, expressing the result in μS cm-1 g-1 of grains.

(3)

**2.6.2.3 Leaching of potassium**

The leaching of potassium ions was carried out in the raw grains, according to the methodology proposed by Prete (1992). After the electrical conductivity reading, the solutions were subjected to the determination of the amount of leached potassium. The reading was carried out in a flame photometer Digimed NK-2002. With the obtained data, the amount of potassium leached according to equation 4 was calculated, expressing the result in ppm.

(4)

**2.6.3 Acidity grease**

For this analysis, samples of coffee stored for 3 months were used (MARQUES et al., 2008) in a cold room with a temperature of 10 ° C. The acidity of the grease was determined by titration according to the method described by the American Association of Cereal Chemists - AACC (1995). They were weighed 40g of ground coffee sample and added 100 mL of toluene was added to stir for 1 hour and 30 minutes. Then there was the filter with filter paper. Were mixed, in a conical flask, 25 ml of the filtered solution 25 ml of ethanol (95% v / v) over phenolphthalein (0.04% w / v) and then the solution was titrated with (KOH) in concentration of 0.025 mol L-1 until it reaches the turning point. The result of the acidity content of the grease was expressed in ml of KOH / 100 g of MS. Calculated according to equations 5 and 6.

(5)

(6)

On what:

PS: mass of the dry sample (g);

PC: coffee weight (g);

U (b.u): water content in wet basis (%);

V: KOH spent volume in the titration (extract + indicator) in ml;

AG: acidity grease (ml KOH / 100 g MS).

**2.7 Statistical analysis**

The experimental design consisted of a factorial scheme 2x7, completely randomized, being two forms of processing (natural and pulped) and seven drying treatments. Three replicates were performed for each treatment.

The data obtained from the physiological, physical-chemical and sensorial analysis of coffee were also submitted to analysis of variance using the Assistat 4.0 software, according to Silva & Azevedo (2009) and the means compared by the Scott-Knott test, at the level of significance of 1%.

**3 RESULTS AND DISCUSSIONS**

**3.1 Characterization of drying conditions**

The maximum, minimum, average ambient temperature and precipitation and relative humidity during the drying period, which ran from August 16 to 27, 2013, are shown in Table 3.

**Table 3** - Averages of maximum, minimum and average ambient temperatures, precipitation and relative humidity - Lavras - 2013.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Maximum Temperature  (° C) | Minimum  Temperature  (° C) | Average Temperature  (° C) | Precipitation (mm) | Relative Humidity (%) |
| 31,8 | 13,15 | 18,85 | 0,014 | 58,6 |

Table 4 shows the mean values of water content at the beginning and at the end of the mechanical drying and the total drying time, for dry and wet processed coffee. It can be seen from Table 4 that the drying treatment with higher temperatures at the end of the process had a lower total drying time when compared to the other mechanical drying treatments. This fact results from the greater difficulty of water removal when the fruits are at lower water contents (OLIVEIRA et al., 2012).

**Table 4** - Mean values of water content and total drying time, for each drying and processing treatment - Lavras - 2013.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Drying Treatment | Processing | Average water content | | Average drying time (h) | |
| (% b.u.) | |
| Initiate | End | Before | Total |
| Dry half (b.u.) |
| 35/40°C | Pulped | 46,5 | 11,6 | 20 | 32 |
| 35/40°C | Natural | 65 | 11,4 | 48 | 113 |
| 35/45°C | Pulped | 46,5 | 11,7 | 20 | 29 |
| 35/45°C | Natural | 65 | 11,1 | 48 | 97 |
| 35/50°C | Pulped | 46,5 | 11,3 | 20 | 28 |
| 35/50°C | Natural | 65 | 11,1 | 48 | 91 |
| 40/35°C | Pulped | 48 | 11,5 | 18,5 | 37 |
| 40/35°C | Natural | 64,4 | 11,2 | 40 | 139 |
| 45/35°C | Pulped | 48 | 10,7 | 15,5 | 35,5 |
| 45/35°C | Natural | 64,4 | 11 | 28 | 117 |
| 50/35°C | Pulped | 48 | 10,8 | 12 | 34,5 |
| 50/35°C | Natural | 64,4 | 11 | 20 | 107 |
| On Ground | Pulped | 46,5 | 10,9 | - | 145 |
| On Ground | Natural | 64,4 | 11,8 | - | 251 |

It can also be observed that the higher total drying times of the coffee beans occurred in the treatment on ground, due to the lower time of exposure of these coffees to high temperatures and greater relative humidity of the ambient air, to which these coffees were submitted (Table 3).

According to Borém et al. (2006) and Ribeiro et al. (2003), the exposure time, the drying air temperature and flow, the initial and final water content of the product, the ambient air temperature, are factors that affect the drying dynamics, and have a significant effect on the quality of agricultural products. Removal of the exocarp and mesocarp in the wet processing of coffee contributes to the drying time of these coffees.

The increase in air temperature results in a greater difference between the vapor pressure of the drying air and the product, making the water easier and faster to remove (SIQUEIRA et al., 2012). The increase in temperature reduces the viscosity of the water, directly influencing the resistance of the fluid to the flow. The decrease in viscosity facilitates the diffusion of the water molecules in the capillaries of the product, besides providing an increase in the vibration level of the water molecules, which also contributes to the increase of the drying rate (CORRÊA et al., 2010).

**3.2 Sensory analysis**

Considering this type of evaluation, the analysis of variance of the data was done for the overall grade.

The overall grade for each type of processing is shown in Table 5 and the overall grade for each drying method in Table 6.

**Table 5** - Mean values of the overall grade for each drying treatment - Lavras - 2013.

|  |  |
| --- | --- |
| Processing | Global Note |
|
| Natural | 80,50 A |
| Pulped | 79,60 A |

Means followed by distinct letters, upper case in columns, differ by Scott-Knott's test at 1% probability.

**Table 6** - Mean values of the overall grade for each drying treatment - Lavras - 2013.

|  |  |
| --- | --- |
| Drying treatment | Global Note |
|
| On Ground | 82,70 A |
| 35/40°C | 81,20 A |
| 35/45°C | 78,83 B |
| 35/50°C | 77,55 C |
| 40/35°C | 81,54 A |
| 45/35°C | 79,42 B |
| 50/35°C | 80,04 B |

Means followed by distinct letters, upper case in columns, differ by Scott-Knott's test at 1% probability

It is observed that the processing had no significant effect for the overall grade. But if we analyze each attribute that composes the overall note, it was perceived by tasters that, the natural coffees have higher grades have terms of the body and sweetness attributes. The pulped coffees presented higher grades in the acidity and finishing attributes. This fact is directly related to the type of processing used. As the overall grade is the sum of all attributes, there were no significant differences for these coffees, even though we knew that for our taste the coffee was different.

Regarding drying treatments 50/35 ° C and 35/50 ° C, there are differences between the average values of the overall grade, regardless of the type of processing used, whether it is depulped or natural. The highest values for overall grade were found in the drying treatment 50/35 ° C. It is noted that the use of heated air at 50ºC after half-dry was extremely detrimental in maintaining its sensorial characteristics, indicating a higher sensitivity of these coffees to the increase of the drying temperature at the end of the drying process. According to Borém et al. (2008) and Saath et al. (2012), the cell membranes of the coffee beans are especially damaged when the water contents of the coffee are between 30% to 20% (b.u.), using a constant drying temperature of 60 ° C for the pulped and natural coffee.

The highest values for the total grade were found in the coffees dried on ground, 35/40 ° C and 40/35 ° C, when compared to the other drying treatments with heated air. This fact indicates a possibility of new managements that reduce the costs because we will have a greater final quality of the product. For specialty coffees some producers are using lower temperatures.

It can also be observed that the increase in drying temperature, before or after half-dry, was detrimental to the sensorial attributes of these coffees. Borém et al. (2006), Coradi et al. (2007) and Marques et al. (2008), studying the effect of grain mass temperature on sensorial quality, reported that the increase in drying temperature was detrimental to the maintenance of sensorial quality of parchment and natural coffee.

**3.3 Physiological and physicochemical analyzes**

**3.3.1 Electrical conductivity, potassium leaching and germination**

Table 7 shows that the type of processing and drying of the coffee had a significant influence on the physiological evaluations. The lower values of germination were found in the natural coffees, indicating that more intense physiological damages occurred in the beans of these coffees, due to the longer period of exposure to high temperatures. A similar result was observed by Taveira (2009), indicating the higher tolerance of these coffees to the high drying temperatures when compared to natural coffees. For the natural coffees, only the coffees dried in terreiro presented values indicative of the presence of physiological activity in the grains. For the drying treatments with heated air the values were low, indicating the death of the embryos of the natural coffee beans during the drying process, reinforcing the sensitivity of these coffees to drying with high temperatures (TAVEIRA, 2009).

**Table 7 -** Mean values of the physiological and physico-chemical evaluations for the interaction drying treatment and type of processing, data in percentage (%) - Lavras - 2013.



Means followed by distinct, lowercase letters in the rows and capitals in the columns differ from Scott-Knott's test at 1% probability.

The drying treatments 35/40 ° C, 40/35 ° C, 35/45 ° C and 45/35 ° C, for the pulped coffees, are presented as a good alternative for the drying of seeds of wet processed coffee, in order to maintain their physiological quality (germination and EC).

For the natural coffees, the increase of the drying temperature, before reaching the water content of 30% or later, significantly reduced the germination percentage, being more intense in the drying treatments 35/45 ° C and 35/50 ° C.

The use of high temperatures allows faster drying, however, it can cause a very large water content difference between the periphery and the grain center, generating a high pressure gradient, which can cause disruption in the cellular membranes of the coffee beans, resulting in In the reduction of seed vigor, related to the emergence and development potential of normal seedlings, or even the total loss of viability, defined as the ability to produce normal seedlings.

It can be confirmed, from Table 7, that there were significant differences between the types of processing and drying used in the experiment, in relation to the electrical conductivity. The highest values of electrical conductivity, regardless of the drying treatment, were found in the natural coffees, when compared to the coffees pulped, indicating that this form of processing contributed to the electrical conductivity values being smaller, with consequent maintenance of the cellular structures and the product quality. Another fact that may have contributed to this would be the shorter exposure time of these coffees to the high temperatures when compared to the natural coke exposure times (PRETE, 1992).

Regarding the drying treatments, it was noticed that the increase of the drying temperature resulted in higher values of electrical conductivity, both for coffees processed by dry route and for the coffees processed by wet way. This fact corroborates with the authors' reports Borém et al. (2008) and Coradi et al. (2007), who verified that the increase of the drying temperature causes damages to the system of membranes of the cells of the coffee beans, increasing the electrical conductivity of the exudate of the beans.

It is also seen in Table 7 that the drying treatment which caused the least damage to cell structures was on ground. This fact may be related to the lower exposure time to high temperatures, lower grain mass temperatures and lower drying rates. Regarding the mechanical drying treatments, drying temperatures of 35/40 ° C, 35/45 ° C and 35/50 ° C resulted in the highest values of EC, LK and Germination, indicating a higher compromise of coffee quality compared to drying With temperatures 50/35 ° C, 45/35 ° C and 40/35 ° C. This increase in the electrical conductivity of coffees processed through drought and drought, when using higher temperatures after half-drought, compared to using the same temperatures before half-drought, can be explained by the longer exposure time and Greater disruption of cell membranes when using high temperatures at the time the product is at a lower water content. Similar phenomena were observed by Saath et al. (2005), which analyzed the damage caused by the drying temperature in the cellular structures of coffee beans, found that they occur more intensively between water contents between 30% (bu) and 20% (bu), when using the temperature of 60 ° C on drying.

As in the electrical conductivity test, the highest values of potassium leaching were found in the coffees processed through the drought, again indicating that the time of exposure of these coffees to drying, both in terrarium and in dryers, may have been one of the causers of this phenomenon. The same phenomenon was observed by Taveira (2009), studying the alternation of temperatures during the drying process.

The high temperature at the beginning of the drying, before the half-dry, at the treatment of 50 / 35ºC, and at the end of the drying, after the half-dry in the treatment 35/50 ° C, could have been harmful to the physiological integrity of the grains indicated by high potassium leaching values compared to drying on ground. The highest values of potassium leaching were found in natural and pulped coffees dried at temperatures of 35/45 ° C and 35/50 ° C, indicating the higher sensitivity of the membranes to low water content. At this moment there is a very large energy accumulation inside the grain, which can, depending on the temperature used in the drying, compromise the cellular structures with consequent leaching of solutes.

There is agreement that degeneration of cell membranes and subsequent loss of permeability control is one of the early events that characterize deterioration. According to Malta et al. (2005), any factor that changes the structure of the membrane, such as attack of insects and microorganisms, physiological changes, mechanical and thermal damages, causes a rapid deterioration of the coffee beans. These changes cause chemical reactions that modify the original chemical composition of coffee bean and consequently their sensory and physiological properties.

**3.4 Acidity grease**

Table 8 shows the results of the drying effect of the drying treatment for each type of grain processing on the acidity of the grease.

**Table 8** - Average values of acidity grease for the interaction between drying and processing treatments - Lavras - 2013.

|  |  |  |
| --- | --- | --- |
| Drying treatment | Grease Acidity | |
| Natural | Pulped |
| (ml de KOH/100 g de MS) | (ml de KOH/100 g de MS) |
| On Ground | 3,39 aD | 3,13 bB |
| 35/40°C | 3,49 aC | 3,04 bB |
| 35/45°C | 3,71 aB | 3,23 bB |
| 35/50°C | 3,91 aA | 3,40 bB |
| 40/35°C | 3,32 aD | 3,16 bB |
| 45/35°C | 3,53 aC | 3,35 bB |
| 50/35°C | 3,66 aB | 3,48bB |

Means followed by distinct, lowercase letters in the rows and capitals in the columns differ from Scott-Knott's test at 1% probability.

Significant differences were observed in the acidity content of the grease between the drying and processing treatments. These results are related to the stabilization of the membranes and to the integrity of the cell walls, indicating that a greater degradation of the cell membranes will give rise to the greater amount of free fatty acids (MARQUES, 2006). According to Biaggioni & Ferreira (1998), during storage, the hydrolysis of the fatty material begins before the hydrolysis of carbohydrates or proteins. Therefore, the free fatty acid content can be used as an indicator of grain deterioration.

In relation to the processing of coffee beans, Table 8 shows that the highest values were found in the coffees processed by dry process. It is assumed that the higher exposure of these coffees to high temperatures caused rupture of cell membrane structures, extravasating oils and compromising coffee quality with oxidation processes, demonstrating the higher sensitivity of these coffees at high temperatures (OLIVEIRA et al. 2012).

It can be observed that the results for the pulped coffee with mechanical drying were satisfactory, since the value of its acidity grease was statistically equal to that of the drying on ground, a phenomenon that indicates a greater potential of maintenance of the quality of these coffees when stored, suggesting that removal of the peel in the pulped coffees decreased the amount free fatty acids. The drying treatments 35/50 ° C and 50/35 ° C were those that obtained the highest values of acidity grease, suggesting that this drying treatment damaged the cellular structures of the coffee beans, giving rise to a greater number of free fatty acids.

**4 CONCLUSIONS**

From the results of the present experiment, it was concluded that:

The drying on ground, for the climatic conditions during the experiment, and provides the best physiological sensory quality of the coffee beans when compared with drying with heated air.

The pulped coffee presents better physiological quality.

The temperature of 35 / 50ºC and 50/35 ° C were the ones that obtained the worst results of germination.

The use of higher temperatures after half-dry was more damaging than when used before half-dry in terms of electrical conductivity.

The use of lower temperatures (35/40 ° C and 40/35 ° C) showed similar results to drying on ground.

**5 REFERENCES**

ALPIZAR, E.; BERTRAND, B. Incidence of elevation on chemical composition and beverage quality of coffee in Central America. **In:** 20th International Conference in Coffee Science. Bangalore 2004, ASIC, India – cd-room. 2004.

AMERICAN ASSOCIATION OF CEREAL CHEMISTS. AACC methods 02-02A: fat acidity, rapid method, for grain. In: \_\_\_\_\_\_. **Approved methods of the American Association of the Cereal Chemists**. Saint Paul, 1995. Irregular page.

AMORIM, H. V. **Aspectos bioquímicos e histoquímicos do grão de café verde relacionados com deterioração da qualidade.**  1978. 85 p. Tese (Livre Docência em Bioquímica) – Escola Superior de Agricultura Luiz de Queiroz, Piracicaba.

BIAGGIONI, M. A. M.; FERREIRA, W. A. Variação na germinação e nível de ácidos graxos livres durante o armazenamento de milho colhido mecanicamente. In: CONGRESSO BRASILEIRO DE ENGENHARIA AGRÍCOLA, 27., 1988, Poços de Caldas. **Anais...** Lavras: UFLA/SBEA, 1998. 1 CD-ROM.

BORÉM, F. M. **Efeito da temperatura e da umidade relativa do ar de secagem sobre a qualidade de sementes de milho (*Zea mays* L.), híbrido AG – 303.** 1992. 50 p. Dissertação (Mestrado em Engenharia Agrícola) – Universidade Federal de Viçosa, Viçosa, MG.

BORÉM, F. M. et al. Qualidade do café submetido a diferentes temperaturas, fluxos de ar e períodos de pré-secagem. **Coffee Science**, Lavras, v. 1, n. 1, p. 55-63, 2006.

BORÉM, F. M. **Pós-colheita do café**. Lavras: UFLA, 2008. v. 1, p. 631.

BORÉM, F. M.; MARQUES, E. R.; ALVES, E. Ultrastructural analysis damage in parchment Arabica coffee endosperm cells. **Biosystems Engineering,** Saint Joseph, v. 99, n. 1, p. 62-66, Jan. 2008.

BRASIL. Instrução Normativa n. 8, de 11 de junho de 2003. Regulamento técnico de identidade e de qualidade para a classificação do café beneficiado grão cru. **Diário Oficial [da] República Federativa do Brasil**, Ministério da Agricultura, Pecuária e Abastecimento. Brasília, p. 22-29. 13 jun. 2003. Seção 1.

BRASIL. Ministério da Agricultura e Reforma Agrária. Secretaria Nacional de Defesa Agropecuária. **Regras para análise de sementes**. Brasília, 2009. 399 p.

BYTOF, G.; KNOPP, S. E.; KRAMER, D.; BREITENSTEIN, B.; BERGERVOET, J. H. W.; GROOT, P. C.; SELMAR, D. Transient occurrence of seed germination processes during coffee post-harvest treatment. **Annals of Botany,** v. 100, n. 1, p. 61-66, July 2007.

BYTOF, G.; KNOPP, S. E.; SCHIEBERLE, P.; TEUSTSCH, I.; SELMAR, D.Influence of processing on the generation of -aminobutyric acid in green coffee beans. **European Food Research and Technology,** v. 220, n. 3/4, p. 245-250, Mar.2005.

CORADI, P. C. et al. Effect of drying and storage conditions on the quality of natural and washed coffee. **Coffee Science**, Lavras, v. 2, n. 1, p. 38-47, Jan./June 2007.

FARAH, A.; MONTEIRO, M. C.; CALADO, V.; FRANCA, A. S.; TRUGO, L. C. Correlation between cup quality and chemical attributes of brazilian coffee. **Food Ghemistry,** Oxford, v. 98, n. 2, p. 373-380, 2006.

FLAMENT, I. **Coffee flavour chemistry.** England: J. Wiley, 2002.

ILLY, A.; VIANI, R. **Espresso coffee :** the chemistry of quality. London: Academic, 1995. 253 p.

KNOPP, S. E.; BYTOF, G.; SELMAR, D. Influence of processing on the cont of sugars in green arabica coffee beans. **European Food Research and Technology,** v. 223, n. 2, p. 195-201,June2006.

MALTA, M. R.; PEREIRA, G. F. A.; CHAGAS, S. J. de R. Condutividade elétrica e lixiviação de potássio do exsudato de grãos de café: alguns fatores que podem influenciar essas avaliações. **Ciência e Agrotecnologia**, Lavras, v. 29, n. 5, p. 1015-1020, set./out. 2005.

MARQUES, E. R.; BOREM, F. M.; PEREIRA, R. G. F. A.; BIAGGIONI, M. A. M.; Eficácia do teste de acidez graxa na avaliação da qualidade do café arábica (*Coffea arabica* L.) submetidos a diferentes períodos de temperatura e pré-secagem. **Ciência e Agrotecnologia,** Lavras, v. 32, n. 5, p. 1557-1562, set./out. 2008.

PRETE, C. E. C. **Condutividade elétrica do exsudato de grãos de café (*Coffea arábica* L.) e sua relação com a qualidade da bebida.** 1992. 125 p. Dissertação (Mestrado em Agronomia) – Escola Superior de Agricultura Luiz de Queiroz, Piracicaba, SP.

RIBEIRO, D. M. et al. Taxa de redução de água do café cereja descascado em função da temperatura da massa, fluxo de ar e período de pré-secagem. **Revista Brasileira de Armazenamento**, Viçosa, MG, v. 28, n. 7, p. 94-107, 2003.

SAATH, R. et al. Alterações na composição química e sensorial de café (*Coffea arabica* L.) nos processos pós-colheita. **Revista Energia na Agricultura**, Botucatu, v. 27, n. 2, p. 96-112, abr./jun. 2012.

SCAA - SPECIALTY COFFEE ASSOCIATION OF AMERICA. **Backgrounder** **:**  what’s special about specialty coffee? Disponível em: <<http://scaa.org/pdfs/Press-What-is-Specialty-Coffee.pdf.>.>. Acessado em: 23 nov. /2008.

SELMAR , D.; BYTOF, G.; KNOPP, S.E.; BRADBURY, A.; WILKENS, J.; BECKER, R. Biochemical insights into coffee processing: quality and nature of green coffee are interconnected with an active seed metabolism. **In**: 20th International Conference in Coffee Science. Bangalore 2004, ASIC, India – cd-room. 2004.

SILVA, J. de S. **Secagem e armazenamento de produtos agrícolas.** Viçosa, MG: Aprenda Fácil, 2000. 502 p.

SIQUEIRA, V. C.; RESENDE, O.; CHAVES, T. H. Drying kinetics of Jatropha seeds. **Revista Ceres**, Viçosa, MG, v. 59, n. 2, p. 171-177, 2012.

TAVEIRA, J. H. S. **Aspectos fisiológicos e bioquímicos associados à qualidade da bebida de café submetido a diferentes métodos de processamento e secagem**. 2009. 67 p. Dissertação (Mestrado em Ciência dos Alimentos) - Universidade Federal de Lavras, Lavras, 2009.

ZONTA, J. B. **Teste ler café:** adequação e aplicação para avaliar a qualidade de sementes de cafeeiro (*Coffea arabica* L.). 2007. 79 p. Dissertação (Mestrado em Fitotecnia) - Universidade Federal de Viçosa, Viçosa, MG, 2007.