

QUALITY OF NATURAL COFFEE SUBJECTED TO DIFFERENT REST PERIODS DURING THE DRYING PROCESS

Qualidade do café natural submetido a diferentes períodos de repouso durante a secagem

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ABSTRACT

Rest periods during the coffee drying process may help improve the final coffee quality and reduce power consumption. The objective of the present study was to evaluate the effect of the moisture content of coffee fruit at the point when the drying process is temporarily interrupted on the quality of natural coffee using sensory analysis and electrical conductivity and potassium leaching tests. Ripe coffee fruits were manually and selectively harvested, sun-dried in a concrete yard for two days and subjected to mechanical drying in fixed-bed dryers. When the coffee reached moisture contents of 20%, 17% and 14% (wet basis, wb), the drying process was interrupted, and the coffee was allowed to remain at rest for 5, 15 or 30 days. Following this rest period, the coffee was dried in mechanical dryers until reaching a moisture content of 11% (wb). The control condition was complete drying in the yard. The combination of lowest moisture content with greatest period of rest and the combination of greatest moisture content and shortest period of rest resulted in the lowest values of potassium leaching. The beverage quality gradually improved as the duration of the rest period increased. Coffee subjected to a rest period at moisture contents of 17% and 20% (wb) did not alter the quality compared to that from drying in the yard.

Index terms: Parceling of the drying, dry method processing, sensory analysis.

RESUMO

O parcelamento da secagem pode ser eficiente tanto no que diz respeito à qualidade final do café, quanto na redução do consumo específico de energia. Diante disso, objetivou-se, com o presente trabalho, avaliar o efeito do teor de água dos frutos no momento da interrupção da secagem e do período de repouso até a retomada da secagem na qualidade do café natural, por meio da análise sensorial e dos testes de condutividade elétrica e lixiviação de potássio. Frutos de café maduros foram colhidos manual e seletivamente e, em seguida, secados ao sol em terreiros de concreto por dois dias e, então, submetidos à secagem mecânica em secadores de camada fixa. Quando o café atingiu os teores de água de 20%, 17% e 14% (base úmida, bu), a secagem foi interrompida e o café permaneceu em repouso por cinco, quinze e trinta dias e, posteriormente, foi secado em secadores mecânicos até o teor de água de 11% (bu). O controle constituiu-se na secagem completa em terreiro. Observou-se que as combinações entre o menor teor de água e o maior período de repouso e entre o maior teor de água e o menor período de repouso, proporcionam menores valores de lixiviação de potássio. A qualidade da bebida melhora progressivamente com o aumento do período de repouso. A interrupção da secagem com teores de água de 17% e 20% (bu) não altera a qualidade do café natural, comparativamente à secagem completa em terreiro.

Termos para indexação: Parcelamento da secagem, processamento via seca, análise sensorial.

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INTRODUCTION

Coffee beverage quality is of utmost importance for competitiveness in the highest paying markets for the product, and the demand for specialty coffees continues to increase in the global market.

Coffee quality is primarily determined by its flavor and aroma produced during the roasting process and results from the chemical compounds present in the raw bean. The presence of these precursors in the raw bean depends on genetic, environmental and technological

factors, including the processing and drying methods used (FARAH et al., 2006).

The choice of processing method (dry or wet process) depends on technological, economic and consumer market considerations relative to the desired product characteristics (BORÉM, 2008). Coffees processed using the dry method produce beverages with fuller body, greater sweetness and lower acidity, and they are essential ingredients for espresso coffee blends (BORÉM, 2008). Several reports in the literature have associated dry-

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process coffees with the lowest quality beverages (BORÉM et al., 2006; CORADI; BORÉM; OLIVEIRA, 2008). This poor quality often results from carelessness during harvest and especially during the drying process. Nevertheless, the production of excellent quality coffee produced using the dry method may be accomplished with the following approaches: harvesting small quantities of unripe fruits; removing defects including overripe, perforated and empty locule fruits by water separation; and using an appropriate method for drying followed by efficient cleaning, hulling, grading and sorting.

With respect to the maintenance of coffee quality, drying is the most critical post-harvest processing step (BORÉM et al., 2008a). Due to the large amount of time required for the drying of natural coffee, the use of temperatures in the coffee mass of up to 45° C has been recommended. Contrary to the recommendation, however, temperatures above 40° C may cause serious damage to natural coffee (BORÉM et al., 2008b; CORADI; BORÉM; OLIVEIRA, 2008; SAATH et al., 2010).

Interrupting the drying process of the beans or fruits with high moisture contents for hours or even days and subsequently resuming the drying process represents an alternative method for reducing the effective drying time of agricultural products without the use of high temperatures (IGUAZ; RODRIGUEZ; VISERDA, 2006; MARTIN et al., 2009). Studies have shown that drying with moderate temperatures intercalated with rest periods is an efficient method that helps maintain the final quality of the product and reduce power consumption.

In a study assessing intermittent drying of parchment coffee, Martin et al. (2009) combined 12 hours of drying with 50° C heated air and 12 hours of rest and observed a 24.56% reduction in effective drying time relative to continuous drying.

Isquierdo et al. (2011), also studying the drying of parchment coffee, observed that interrupting the drying process when the moisture content is 24% (wet basis, wb) with a rest period of 2 to 12 days and later drying to 11% (wb) results in lower values of potassium leaching and electrical conductivity and, consequently, greater integrity of the cellular membrane system of the beans compared to coffee subjected to continuous drying to 11% (wb).

Various studies have shown that poor quality coffees have greater values of potassium leaching and electrical conductivity (BORÉM et al., 2006; MARQUES et al., 2008; SANTOS; CHALFOUN; PIMENTA, 2009; RIBEIRO et al., 2011; ISQUIERDO et al., 2011; NOBRE et al., 2011). The membranes of beans may become destructured due to damage induced by insects and

microorganisms, drying procedures and prolonged storage periods. The damaged beans leach a greater quantity of solutes in soaking water, and thus exhibit higher electrical conductivity and potassium leaching values (KRZYZANOWSKY; FRANÇA NETO; HENNING, 1991). The damage to the endosperm cellular membranes of coffee allow previously compartmentalized chemical components to come in contact with hydrolytic and oxidative enzymes, affecting the color, flavor and aroma characteristics of the beverage (MARQUES et al., 2008).

Evaluation of coffee quality has traditionally been performed by means of sensory analysis. Currently, the methodology outlined by the Specialty Coffee Association of America (SCAA) is the one most often adopted for quality coffees. This particular standard evaluates coffee beverages based on descriptive methods and scoring of the following attributes: fragrance/aroma, uniformity, absence of defects, sweetness, flavor, acidity, body, aftertaste, balance and overall impression (LINGLE, 2011).

The purpose of the present study was to evaluate the effect of intermittent drying using different rest period lengths and the interaction with moisture content on the quality of natural coffee.

MATERIALS AND METHODS

The product used was the coffee (*Coffea arabica* L.) cultivar Acaiá Cerrado harvested in the 2008 crop season in the municipality of Ijaci in the southern region of Minas Gerais, Brazil (latitude: 21° 10' 16.38" S, longitude: 44° 58' 42.43" W, altitude: 920 m).

The coffee was selectively harvested, and only ripe fruits were collected. After harvest, the fruits were subjected to water separation, through difference in specific mass, for the removal of overripe, perforated, empty locule and poorly formed fruits. Following this procedure, unripe fruits were manually removed.

The fruits selected had initial moisture contents of $62 \pm 2\%$ (wb), determined by the standard method International Organization Standardization-ISO 6673 (1983). After selection, the coffee was subjected to pre-drying for two days. The fruits were spread out on to a concrete yard in a layer approximately 1.5 cm thick and turned every 30 minutes. Following the pre-drying period in the yard, the fruits had a moisture content of $44 \pm 2\%$ (wb) and were subjected to mechanical drying in fixed-bed dryers with layers 10 cm thick. An air flow speed of $20 \text{ m}^3 \text{ min}^{-1}$ was maintained per square meter of perforated plate, and the temperature in the mass was maintained at $40 \pm 1^\circ \text{C}$.

When the coffee reached moisture contents of $20 \pm 2\%$, $17 \pm 2\%$ and $14 \pm 2\%$ (wb), the mechanical drying was

interrupted, and the coffee was subjected to rest periods of 5, 15 or 30 days in wooden boxes within the storage chambers under ambient conditions. The control (additional factor) consisted of complete drying in the yard until the coffee reached a moisture content of $11 \pm 1\%$ (wb).

To determine the point of interruption during the drying process, the mass equivalent of the moisture content at which drying was to be interrupted was calculated by applying equations 1 and 2. The portions were weighed every hour until the recorded mass corresponded to moisture contents of $20 \pm 2\%$, $17 \pm 2\%$ and $14 \pm 2\%$ (wb). At these times, the coffee was removed from the dryer to initiate the rest period. After the duration of the rest period, the coffee was returned to the dryers, and drying proceeded until the beans reached the mass equivalent of a moisture content of $11 \pm 0.5\%$ (wb). Shortly thereafter, electrical conductivity, potassium leaching and sensory analysis tests were performed.

$$PQ = \left[\frac{(U_i - U_f)}{(100 - U_f)} \right] \times 100 \quad (1)$$

$$M_f = M_i - \left[M_i \times \left(\frac{PQ}{100} \right) \right] \quad (2)$$

where

PQ: percent of breakage (%);

U_i : initial moisture content (% bu);

U_f : final moisture content (% bu);

M_i : initial mass (kg); and M_f : final mass (kg).

The experiment was conducted using a randomized block design, with three blocks (3 dryers) in a 3×3 factorial arrangement + 1 additional factor. Three moisture contents corresponding to the time of interruption of drying (14%, 17% and 20% (wb)), three rest periods (5, 15 and 30 days) and a control (complete drying in the yard) were considered.

Physiological and sensory analyses were performed on the portions of coffee bean samples present in sieve screens 16, 17 and 18. Round and defective beans were excluded to ensure sample uniformity and, most importantly, to minimize considerations unrelated to the treatments investigated in the study.

Electrical conductivity of the raw beans was determined by the methodology described by Loeffler, Tekrony and Egli (1988). Four replicates of 50 beans from

each portion were used, which were weighed to a precision of 0.001 g and immersed in 75 mL distilled water in 180 mL plastic cups. These containers were then transferred to a 25°C BOD for 5 hours. Following this incubation, the electrical conductivity of the imbibition water was determined using a benchtop conductivity meter (BEL brand, model W12D). Electrical conductivity was calculated using the data obtained and expressed as $\mu \text{Scm}^{-1}\text{g}^{-1}$ of coffee.

The potassium ion leaching test was performed on raw beans, according to the methodology described by Prete (1992) apud Marques et al. (2008). After the determination of electrical conductivity, the solutions were used to determine the quantity of potassium leached. The reading was performed in a flame photometer (Digimed, model NK-2002). The amount of potassium leached was calculated using the data obtained and expressed as $\text{ppm}\cdot\text{g}^{-1}$ of coffee.

Sensory analysis was performed by three SCAA Certified Cupping Judges. The sensory analysis protocol of the SCAA was used, as previously described by Lingle (2011). Judges assigned 6-10 points for each of the following attributes: fragrance/aroma, acidity, body, flavor, aftertaste, sweetness, uniformity, clean cup, balance and overall impression.

The data obtained from the physiological and sensory analyses were subjected to analysis of variance. Tukey's test was used to assess whether differences among the mean values of the treatments subjected to mechanical drying were statistically significant, and the Dunnett test was used for comparisons to the control treatment (complete drying in the yard). Both tests were performed using a 5% significance level.

RESULTS AND DISCUSSION

Table 1 lists the mean values of electrical conductivity, potassium leaching and scores obtained in the sensory analysis of natural coffee completely dried in the yard and natural coffee subjected to different combinations of mechanical drying conditions (moisture content at the time of interruption of drying and duration of the rest period). The table also shows individual comparisons of each treatment with the control based on the Dunnett test at the 5% significance level.

For all of the analyses performed in this experiment, natural coffee dried to a moisture content of 17% or 20%, regardless of the rest period, was not significantly different compared to coffee dried completely in the yard. On the other hand, coffee dried to a moisture content of 14% and subjected to 30 days of rest had a mean electrical

conductivity value significantly less than that of coffee dried completely in the yard. This result indicates that for coffee dried to a moisture content of 14% at the time of interruption of drying, an increase in the rest period is beneficial for maintaining the integrity of the endosperm cellular membranes of natural coffee. The results of the sensory analysis indicate that in combination with interruption of drying at a moisture content of 14%, a 5-day rest period results in reduced quality compared to the coffee completely dried in the yard, which had a significantly greater score than the coffee subjected to this treatment. This result is consistent with the result for electrical conductivity, indicating that an increase in rest time is beneficial for the quality of natural coffee when drying is interrupted at a moisture content of 14%.

For comparisons among the different treatments, the analysis of variance indicated that there were no significant differences among the treatments for electrical conductivity. Nevertheless, significant differences were observed for the potassium leaching values and the sensory analysis scores.

Table 2 lists the effects of the interaction between the moisture content at the beginning of rest and rest period duration on the mean values of potassium leaching.

Coffee dried to a moisture content of 14% (wb) and subjected to a 30-day rest period had significantly lower potassium leaching values compared to rest periods of 5 and 15 days. This result indicates that a prolonged rest period of 30 days has a beneficial effect on natural coffee

Table 1 – Mean values of electrical conductivity, potassium leaching and scores from the sensory analysis for natural coffee subjected to continuous drying and to intermittent drying.

Moisture content (%bu)	Rest (days)	Electrical Conductivity ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	Potassium leaching (ppm)	Sensory Analysis
14	5	169.98	47.80	77.08*
14	15	169.79	48.82	77.67
14	30	147.41*	43.31	78.21
17	5	166.15	47.94	77.62
17	15	175.63	48.24	78.17
17	30	171.05	45.54	78.91
20	5	152.66	42.49	77.25
20	15	173.36	47.97	77.37
20	30	166.98	47.89	79.29
Complete drying in the yard		181.23	48.35	79.62
Mean Value		167.42	46.84	78.12
CV (%)		7.38	5.54	1.26

Mean values followed by an asterisk within a column differ from the control (continuous drying until a moisture content of 11% (wb)) according to the Dunnett test at 5% probability.

Table 2 – Potassium leaching of natural coffee after intermittent drying.

Moisture content (% bu)	Potassium leaching (ppm)		
	Rest (days)		
	5	15	30
14	47.81 aA	48.82 aA	43.32 aB
17	47.95 aA	48.24 aA	45.54 aA
20	42.50 bB	47.97 aA	47.89 aA

Mean values followed by the same capital letter within a row or the same small letter within a column are not significantly different according to Tukey's test at 5% probability.

that has been dried to a moisture content of 14% (wb) by helping to maintain the integrity of the cellular membrane system of the beans.

For coffees dried to a moisture content of 17% (wb), the rest periods analyzed in this study did not have a significant effect on potassium leaching.

For coffee whose drying was interrupted at a moisture content of 20% (wb), however, a 5-day rest period resulted in significantly lower potassium leaching values compared to rest periods of 15 and 30 days. It may therefore be inferred that for coffee dried to a moisture content of 20%, a prolonged rest period promotes chemical and biochemical reactions and the development of microorganisms that degrade the endosperm cellular structure of the coffee. These changes result in increased potassium leaching when the beans are immersed in water. Nevertheless, it should be emphasized that none of the analyses performed in this study indicated a reduction in coffee quality when beans were dried to a moisture content of 20% (wb) prior to the rest period compared to the coffee dried completely in the yard.

When considering the effect of the moisture content at the time of interruption of drying for each rest period, the data indicate that coffees dried to a moisture content of 20% (wb) had significantly lower potassium leaching values than coffees dried to 14% and 17% (wb) for the rest period duration of 5 days. One possible explanation for this result is that with the evolution of the drying process, temperature and moisture gradients are formed inside the beans that will be increasingly greater to the extent that moisture content decreases in continuous dehydration processes. These gradients negatively affect the endosperm cellular structure of the coffee and may be indicated by the increase in electrical conductivity. Nevertheless, interruption of drying at higher moisture contents combined with rest periods of up to 5 days may reestablish a uniform water distribution inside the fruits. This allows for a reduction of the moisture gradient and helps maintain the stability and integrity of the membrane system.

The presently observed effect of rest periods during the drying process on the integrity of the membrane system is consistent with the findings of Isquierdo et al. (2011) for the drying of parchment coffee. They observed that the interruption of drying at a moisture content of 24% (wb) combined with rest periods from 2 to 12 days significantly reduced the potassium leaching of beans compared to coffee subjected to continuous mechanical drying to 11% (wb).

The sensory analysis results indicate that the moisture content of the beans at the interruption of drying

did not have a significant effect on coffee quality. Table 3 shows the effects of the rest period on the mean scores of the sensory evaluation.

The results listed in table 3 demonstrate that coffee beverage quality was affected by the rest period. In other words, prolonging the rest period from 5 to 30 days had a significant effect on the increase of the sensory quality of natural coffee. Coffees subjected to 15 days of rest had intermediate scores that were not significantly different compared to the other rest periods.

Table 3 – Mean score values for the sensory analysis of natural coffee for different rest periods during drying.

Rest (days)	Score
5	77.32 b
15	77.74 ab
30	78.81 a

Mean values followed by the same small letter within the column are not significantly different according to Tukey's test at 5% probability.

Although the potassium leaching analysis indicated damage at the cellular level when natural coffee was stored with a moisture content of 20% (wb) for more than 15 days, this difference was not reflected in the sensory analysis performed shortly after the conclusion of drying.

Considering the results of both the potassium leaching and sensory analyses, natural coffees dried to moisture contents of 14% and 17% were of higher quality when the rest period was prolonged to 30 days. Although reduced sensory quality was not observed when the analysis was performed soon after drying, rest periods greater than 5 days are not recommended for coffee dried to a moisture content of 20%. For this moisture content level, the results of the potassium leaching analysis indicate that longer rest periods result in damage and destructuring of the cellular membranes. This type of damage exposes previously compartmentalized chemical compounds within cells to hydrolytic and oxidative enzymes, producing compounds responsible for disagreeable aromas and flavors that depreciate beverage quality. These interactions may ultimately lead to a reduction in sensory quality of natural coffee after longer storage periods.

It should be emphasized that, with the exception of the combination of 14% (wb) moisture content and a rest period of 5 days, the natural coffees subjected to rest periods during drying had scores statistically equivalent to the coffee dried completely in the yard. This result indicates that this

technique may be used for the production of quality natural coffees (Table 1).

Using the SCAA methodology, the mean scores obtained during the coffee cupping ranged from 76.8 to 78.8 points, corresponding to very good coffee quality. Coffees within this range are commercially classified as hard beverage coffee according to the sensory analysis methodology described in Normative Instruction no. 08 of MAPA (BRASIL, 2003).

CONCLUSIONS

The combinations of the lowest moisture content with the greatest period of rest and of the greatest moisture content with the shortest period of rest resulted in lower potassium leaching values;

Beverage quality progressively improved as the duration of the rest period increased;

Interruption of drying at moisture contents of 17% and 20% (wb) combined with rest periods of 5 to 30 days did not alter the quality of natural coffee compared to complete drying in the yard.

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