Original Article

EFFECT OF INTERMITTENT DRYING AND STORAGE ON PARCHMENT COFFEE QUALITY

EFEITO DA SECAGEM INTERMITENTE E DO ARMAZENAMENTO NA QUALIDADE DO CAFÉ EM PERGAMINHO

Flávio Meira BORÉM[1]; Eder Pedroza ISQUIERDO[2]; Pedro Damasceno OLIVEIRA[3]; Fabiana Carmanini RIBEIRO[4]; Valdiney Cambuy SIQUEIRA[5]; José Henrique da Silva TAVEIRA[6]

1. Professor, Doutor, Universidade Federal de Lavras - UFLA, Lavras, MG, Brasil.; 2. Pós-doutorando em Engenharia Agrícola, Universidade Federal de Lavras – UFLA, Lavras, MG, Brasil. eder.isquierdo@yahoo.com.br; 3. Doutorando, Universidade Estadual Paulista "Júlio de Mesquita Filho", Botucatu, SP, Brasil.; 4. Professora, Doutora, Universidade de Brasília - UNB, Brasília, DF, Brasil.; 5. Professor, Mestre, Universidade Federal da Grande Dourados – UFGD, Dourados, MS, Brasil.; 6. Doutorando em Engenharia Agrícolas, Universidade Federal de Lavras - UFLA, Lavras, MG, Brasil.;

ABSTRACT: This work aimed to evaluate the effects of intermittent drying on the quality of the coffee, after twelve months of storage. The parchment coffee was submitted to two days of pre-drying on the ground, and soon afterwards, mechanically dried until reaching a moisture of 16%, 20% and 24% (wb); later, the coffee remained under tempering for two, six and twelve days in wooden boxes. After each tempering period, the drying was completed until the coffee reached a moisture of 11% (wb). The control consisted of continuous drying up to 11% (wb). After the drying until an 11% (wb) moisture, the coffee was stored for twelve months. After that period electric conductivity, potassium leaching, total reducing and non-reducing sugars, total titratable acidity analyses and sensorial analysis of the coffee were conducted. The values of electric conductivity indicated that the coffees submitted to two and six days of tempering until the restart of the drying, independent of the moisture when the drying was interrupted, presented lower degradation levels of the cellular membrane system, when compared with the coffees submitted to the continuous and intermittent drying, with twelve days of tempering until the resumption of drying. It was verified that, for the other analysis there was no significant difference among the treatments.

KEYWORDS: *Coffea arabica* L. Moisture content. Tempering time. Sensorial analysis. Chemical analysis.

INTRODUCTION

The quality of the coffee is determined by the flavor and aroma formed during roasting, from chemical compounds present in the green coffee (FAGAN et al., 2011). The chemical compounds responsible for the flavor and aroma of the beverage are accumulated by the beans during their development on the plant. However, during the coffee drying and storage stages alterations in the chemical composition can occur in the bean, influencing the final flavor and aroma of the beverage (BORÉM et al., 2008).

The intensity of the metabolic activities, as well as the occurrence of microorganisms during the storage, affects the chemical composition of the beans and their sensorial characteristics. The intensity of those alterations during storage will depend on the initial conditions of the coffee, in other words, on the damage caused to the beans during processing and drying. Coffees damaged in previous stages are more subject to undesirable alterations during storage (CORADI et al., 2007; REINATO et al., 2007).

The levels of reducing and non-reducing sugars possess a positive association with the coffee quality and they can undergo alterations during the drying and storage processes. Those compounds participate in important chemical reactions that occur during the roasting of the coffee, such as the Maillard reaction that originates compounds responsible for the formation of the distinctive color, flavor and aroma of the beverage (KLEINWÄCHTER and SELMAR, 2010).

The total titratable acidity (TTA) in coffee beans has been pointed to as a good indicator of the product quality, varying according to the fermentation levels reached in the beans, the number of defects and also with the maturation state. The high TTA usually is associated to poor beverage quality because of the occurrence of undesirable fermentation and the increase of the number of defects (da SILVA et al., 2009).

The high drying temperatures have been considered main factors responsible for the loss of coffee quality, during the postharvest. Various research works have been demonstrating that temperatures, in the coffee mass, above 40°C cause damage to its quality due to physical, chemical and

Received: 21/09/12
Accepted: 20/02/14

sensorial alterations (BORÉM et al., 2008b; MARQUES et al., 2008, SAATH et al., 2010).

The drying, when poorly conducted, can have a significant effect on the degradation and destructuring of the coffee bean cellular membrane system, allowing the occurrence of chemical and biochemical reactions that depreciate its quality (MARQUES et al., 2008). That damage can be verified through electric conductivity and potassium leaching tests. Various pieces of research demonstrate that lower quality coffees present higher potassium leaching and electric conductivity values (BORÉM et al., 2008; MARQUES et al., 2008; SANTOS et al., 2009).

The interruption of the drying process of coffee with high water content, and the completion of drying after a certain period of rest, is a technique commonly adopted by farmers (ISQUIERDO et al., 2011).

During the drying, as the moisture of the beans is reduced, an increase in the moisture gradient between the interior and the surface of the beans occurs. As a consequence, the water reduction rate decreases and the temperature of the beans tends to equal the temperature of the drying air. It is in this stage the possibility of thermal damage occurrence increases. The rest during drying makes the reduction of the moisture gradient in the bean possible because of the translocation of water from the interior to the surface, reducing the occurrence of that damage. However, when beans and seeds with high moisture are submitted to tempering periods for hours or days, they run the risk of the occurrence of undesirable chemical and biochemical reactions and the development of microorganisms (ISQUIERDO, 2008).

Martin et al. (2009) studying the intermittent drying of parchment coffee, alternating 12 hours of hot-air drying at 50°C, with 12 hours of tempering, observed a 24.56% reduction in the effective drying time of the coffee, when compared with the continuous drying. However, regarding the beverage quality of coffee, research results that support the use of that technique are scarce.

The aim of the present work was to evaluate the effect of intermittent drying, evaluating the chemical, physiologic and sensorial characteristics of the parchment coffee, stored for twelve months after drying.

MATERIAL AND METHODS

The product used was *Coffea arabica* L. coffee, Acaiá Cerrado cultivar, picked in the Federal University of Lavras, UFLA. Only ripe fruits were used, selected manually, and mechanically pulped.

After processing, the coffee was spread on concrete ground in approximately 0.07 m thick layers, being turned over every 30 minutes, for two days. After the pre-drying period in the ground, the coffee was dried with 12 cm of thickness, in fixed bed dryer with an air flow of 20 $m^3.min^{-1}.m^{-2}$ and temperature in the mass maintained at 40 °C.

When the coffee reached a moisture content of 16% ± 2%, 20% ± 2% and 24% ± 2%, wet base, the drying was interrupted and the coffee was submitted to tempering periods for two, six and twelve days, in wood boxes inside storage bins under ambient conditions, simulating a coffee storage granary. The control (additional factor) was made up of the pre-drying of the coffee for two days in yard, followed by the continuous drying in a dryer without tempering until the coffee reached the moisture content of 11% ± 1% (wb).

The initial and final moisture of the coffee was determined by the International Organization Standardization (ISO) 6673 standard method (1983).

To determine the interruption point of the drying process, the mass equivalent to the moisture content at which the drying should be interrupted was calculated applying the equations 1 and 2. Each portion was weighed once an hour, until reaching the calculated final mass, when the coffee was removed from the dryer to begin the tempering. After the three tempering periods, the coffee returned to the dryers and the drying continued until the coffees reach a mass equivalent to 11% moisture (wb).

$$BP = \left[\frac{(Iw - Fw)}{(100 - Fw)} \right] \times 100 \qquad (1)$$

$$Fm = Im - \left[Im \times \left(\frac{BP}{100} \right) \right] \qquad (2)$$

where: Fm: final mass (kg); Im: initial mass (kg); BP: Break Percentage (%);Iw: initial moisture (% wb); Fw: final moisture (% wb).

After complete drying until a moisture content of 11% (wb) the coffee was processed, conditioned in polyethylene packaging and stored for twelve months, from August, 2007 to July, 2008, in storage camera, with temperatures between 18 and 22°C and relative humidity between 65 and 75% and after that storage period it was submitted to the chemical, physiological and sensorial analyses.

The experiment was conducted in 3x3 factorial outline and an additional factor (control), in a random block design, with three blocks, represented by the harvest of the same crop and same planting on three different days. Every harvest day was considered as a block, each treatment being represented once in each block.

The chemical, physiological and sensorial analyses were conducted in sample portions of beans classified above sieve 16, free from defective beans.

The sensorial analysis was carried out by three Certified Special Coffees Judges (SCAA Certified Cupping Judges). The sensorial analysis protocol of the American Association of Special Coffees was used, according to the methodology proposed by Lingle (1986), for sensorial evaluation of special coffees, with attribution of scores, in an interval from 6 to 10 points for fragrance/aroma, acidity, body, flavor, aftertaste, sweetness, uniformity, clean cup, balance and global impression.

The electric conductivity of the raw beans was determined according to the methodology proposed by Prete (1992). Fifty beans of each sample were used, which were weighed to a 0.001g precision and immersed in 75 ml of deionized water in plastic 180 ml capacity cups. Soon afterwards, these containers were taken to a forced-air oven regulated to 25°C, for five hours, and then the solution's electric conductivity was measured in a Digimed CD-20 apparatus. From the results obtained, electric conductivity was calculated and the results were expressed in $\mu S.cm^{-1}.g^{-1}$ of sample.

The leaching of potassium ions was conducted with raw beans, according to the methodology proposed by Prete (1992). After the electric conductivity reading, the solutions were submitted to the determination of the amount of leached potassium. The reading was conducted in a Digimed NK-2002 flame photometer. With the obtained data, the leached potassium calculations were made, the result being expressed as ppm per gram of coffee.

Total and reducing sugars were extracted by the Lane-Enyon method, cited by Association of Official Analytical Chemists (AOAC) (2011) and determined by the Somogy technique, adapted by Nelson (1944). The non-reducing sugars were determined by the difference between the total and reducing sugars.

The total titrable acidity was determined by titration with NaOH 0.1N, adapting the methodology cited by AOAC (2011). A two gram sample of ground coffee was weighed and 50mL of distilled water added, agitating for one hour. Soon afterwards, it was filtered in filter paper and 5 mL of the filtered solution removed and placed in an erlenmeyer, with about 50 mL of distilled water. Three drops of phenolphthalein were added and the solution was titrated until turning point with NaOH 0.1N. The result was expressed in ml of NaOH 0.1N, per 100g of sample.

The data obtained from the chemical, physiological and sensorial analyses were submitted to the variance analysis, and when significant differences were registered, the averages of the treatments submitted to the intermittent drying were compared amongst themselves by the Tukey test, at a level of 5% significance, and with the control averages (continuous drying) through the Dunnett test, at a level of 5% of significance.

RESULTS AND DISCUSSION

The average moisture of the coffee at the beginning of the mechanical drying was 38% (wb). In Table 1 the moistures content of the coffee are presented at the moment of drying interruption (beginning of tempering), at the moment of drying re-start (after tempering), at the conclusion of mechanical drying and after the twelve months of storage.

It is observed in Table 1 that for all of the treatments there was a reduction of the coffee moisture during the tempering period. That loss of water occurs, because at the beginning of the tempering the beans are still hot and they tend to continue the drying process until they enter in thermal equilibrium with the environment, furthermore, the beans at the beginning of the tempering period presented a moisture content above the moisture of hygroscopic equilibrium with the environment. As such, they released water into the environment, tending towards hygroscopic equilibrium.

Isquierdo et al. (2011), working with the same samples, determined the sensorial quality of the coffee at the beginning of storage by the methodology of Brazilian Specialty Coffee Association (BSCA) and observed that the coffees obtained scores between 79 and 81 points, that from the commercial point of view correspond to a 'hard' and 'barely soft' drink, when classified according to the Instruction Norm nº08 of the Ministério de Agricultura, Pecuária e Abastecimento (MAPA) (BRAZIL, 2003).

Table 1. Moisture of the bean at the time of drying interruption, at drying re-start, at the end of drying, and after twelve months of drying and storage.

	Moisture Content (% wb)			
Tempering period (days)	Onset of tempering	End of Tempering	End of Drying	End of Storage
0	Continuous drying		11.5	10.9
2	16.86	15.58	11.5	10.8
2	21.48	18.72	11.6	11.0
2	25.45	23.12	11.7	11.0
6	17.45	15.41	11.5	10.7
6	21.14	18.37	11.7	11.1
6	24.46	21.22	11.9	11.2
12	17.33	15.50	11.4	10.9
12	21.75	19.25	11.5	10.8
12	24.79	20.93	11.4	10.8

In Table 2 the average scores of the sensorial analysis are presented, obtained according to methodology of the SCAA, of the coffees submitted to the intermittent drying and continuous drying, after twelve months of storage.

Table 2. Average scores of sensory analysis of coffees submitted to intermittent drying and continuous drying.

Treatment		
Water content (% wb) at interruption of drying	Tempering period (days)	Score
11	00	73.87 a
16	02	75.58 a
16	06	75.04 a
16	12	74.58 a
20	02	74.83 a
20	06	74.71 a
20	12	75.25 a
24	02	74.71 a
24	06	76.21 a
24	12	76.37 a

Means followed by same lowercase letter in the column do not differ at 5% probability by F test

It is observed in Table 2 that there was no significant difference among the scores of the sensorial analysis of the coffees in function of the drying method. Independent of the drying treatment, all of the coffees obtained scores between 73.87 and 76.37 points by the SCAA methodology, and that range of scores corresponds to coffees classified commercially as ‘hard’ coffee drinks, when submitted to the sensorial analysis by the methodology described in the Instruction Norm nº08 of the MAPA (BRAZIL, 2003).

Those results demonstrate that the drying can be interrupted when the coffee presents moisture of up to 24% (wb) and that the beans can remain under tempering for up to twelve days without harming the beverage quality of coffee, because the coffees submitted to intermittent drying, independent of the moisture at the beginning of the tempering and the time they remained at tempering, did not present significant differences, when compared with those coffees submitted to continuous drying, and they did not present a fermented and 'slightly Rio' drink.

In Table 3 the effects of the tempering time are presented during the intermittent drying of the coffee, in the average electrical conductivity values of the beans.

Table 3. Average electrical conductivity values of the parchment coffee in function of tempering time until the resumption of drying.

Tempering period(days)	Electrical conductivity (μS/cm/g)
6	143.53 a
2	148.95 a
12	158.19 b

Means followed by same lowercase letter in the column do not differ at 5% probability by Tukey test.

In Table 4, the average electrical conductivity and potassium leaching values are presented for the coffees submitted to the continuous drying and intermittent drying.

Table 4. Average electrical conductivity and potassium leaching values of coffees undergoing continuous drying and intermittent drying.

Treatment		Electrical Conductivity (μS/cm/g)	Potassium Leaching (PPM)
Moisture (% wb) at the interruption of drying	Tempering period (days)		
11	0	174.47	52.42
20	12	164.61	50.50
16	2	160.83	49.94
24	12	156.16	47.37
16	12	153.83	47.01
16	6	149.57 *	48.27
20	2	143.89 *	44.36 *
20	6	143.55 *	44.87 *
24	2	142.14 *	43.40 *
24	6	137.47 *	43.15 *

Averages followed by "*" differ from the control (continuous drying until moisture of 11% (wb) at 5% probability, by Dunnett's test.

It is observed in Tables 3 and 4 that the coffees submitted to two and six days of tempering during the drying, independent of the moisture in the beginning of the tempering, presented electrical significantly lower conductivity values, when compared with coffees that remained for twelve days of tempering until the re-start of the drying and with the coffees submitted to continuous drying, independent of the moisture of the beans at the moment of the drying interruption. Isquierdo et al. (2012) observed that the combination of greatest moisture content and shortest period of rest resulted in the lowest values of potassium leaching in the natural coffee.

Although the coffees did not present significant sensorial differences, the analyses of electrical conductivity and potassium leaching, that are more sensitive tests and detect initial degradation events at a cellular level, indicated significant differences among the coffees submitted to the different treatments. The values of electrical conductivity demonstrated that the continuous drying and the twelve-day tempering period during the drying were harmful to the bean quality, causing the destructuring and disorganization of the cell membrane system, consequently increasing the electrical conductivity values.

In Table 5 are presented summary of analysis of variance for values of total, reducing and non-reducing sugars and those of total titratable acidity, of the coffees submitted to the continuous and intermittent drying.

Table 5. Summary of the analysis of variance for values of total (TS), reducing (RS) and non-reducing (NRS) sugars and total titratable acidity (TTA) of coffees subjected to continuous and intermittent drying.

Sources of variation	Mean square			
	TS	RS	NRS	TTA
Moisture content	1.800 ns	0.00044 ns	1,700 ns	908.56 ns
Tempering	1.950 ns	0.00002 ns	1.313 ns	248.84 ns
Moisture content x Tempering	0.070 ns	0.00040 ns	0.085 ns	309.60 ns
Factorial x Control	0.080 ns	0,00000 ns	0.020 ns	14.49 ns
Block	2.180 ns	0.00131 ns	1.712 ns	1421.87 ns
Mean	6.648	0.119	6.149	269.096
CV (%)	18.60	18.34	18.84	7.31

* Significant, ns not significant at 5% probability, by F test.

It is observed in Table 5 that the parceling of the drying did not have significant effect on the levels of total, reducing and non- reducing sugars and on the titratable acidity of the coffee beans.

The sugars contribute directly with the sweetness of the coffee, one of the most desirable attributes in the drink. These compounds, mainly, the glucose and fructose (reducing sugars), can be consumed by metabolic reactions or by fermentative processes, mainly when the coffee presents a high moisture content, depreciating the final quality of the product (KLEINWÄCHTER; SELMAR, 2010).

The total titratable acidity in coffee beans has been pointed to as a good indicator of product quality, varying according to the fermentation levels reached in the beans (da SILVA et al., 2009).

These results indicate that the up to twelve-day tempering period of the coffee with moisture content of up to 24% (wb), in the beginning of the tempering, did not cause the reduction of the of sugar levels due to the significant increase in the metabolism of the beans, nor the occurrence of undesirable fermentation.

The non-occurrence of undesirable fermentation is reinforced by the values of total titratable acidity, that did not statistically differ in function of the use, or not, of the intermittent coffee drying technique.

From the results of the chemical, physical and sensorial analyses, it is inferred that the use of intermittent coffee drying is a suitable technique for the drying of coffee, because the occurrence of reactions harmful to the coffee quality, in function of its use were not verified. Furthermore, demonstrably, that technique reduces the drying execution time, and consequently, the energy consumption in that stage (ISQUIERDO et al., 2009; MARTIN et al.,2009).

However, it is important to emphasize that those results were obtained under the specific conditions of our experiment. Future studies are necessary on a real scale, for their proof and validation and recommendation of the technique in practice.

CONCLUSIONS

The results obtained under the conditions of this work allow concluding that:

The coffee can have the drying interrupted with a moisture of up to 24% (wb) and remain in repose for up to twelve days without undergoing fermentation or other reactions that depreciate the sensorial quality of the coffee;

Coffees submitted to two and six days of tempering until the re-start of the drying, independent of the moisture content when the drying was interrupted, present lower electrical conductivity values, when compared with the coffees submitted to continuous drying and the parceling of the drying, with twelve days of tempering until the re-start of the drying. This indicates that the continuous drying and tempering periods over six days increase the degradation levels and disorganization of the cell membrane system of the coffee endosperm.

ACKNOWLEDGMENTS

The authors of this paper acknowledge the support from EPAMIG, and the financial support from CAPES, CNPq e FAPEMIG.

RESUMO: Objetivou-se, no presente trabalho, avaliar os efeitos do parcelamento da secagem na qualidade do café, após doze meses de armazenamento. O café cereja desmucilado foi submetido a dois dias de pré-secagem em terreiro, e em seguida, secado mecanicamente até atingir os teores de água de 16%, 20% e 24% (bu); posteriormente, o café permaneceu em repouso durante dois, seis e doze dias em caixas de madeira e após cada período de repouso, secado até o teor de água de 11% (bu). A testemunha constituiu-se na secagem contínua até 11% (bu). Após a secagem completa o café foi armazenado por doze meses; e então submetido às análises de condutividade elétrica, lixiviação de potássio, açúcares totais, redutores e não redutores, acidez titulável total e análise sensorial. Os valores de condutividade elétrica indicaram que os cafés submetidos a dois e seis dias de repouso até o reinício da secagem, independente do teor de água quando a secagem foi interrompida, apresentaram menores níveis de degradação ao sistema de membranas celulares, quando comparados com os cafés submetidos à secagem contínua e ao parcelamento da secagem, com doze dias de repouso até a retomada da secagem. As demais análises não indicaram diferença significativa entre os tratamentos.

PALAVRAS-CHAVE: *Coffea arabica* L. Teor de água. Repouso. Análise sensorial. Análise química.

REFERENCES

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS. **Official methods of analysis of the Association of Official Analytical Chemists**. 18 ed. Revision 4,. Washington, 2011, 1018 p.

BORÉM, F. M.; CORADI, P. C.; SAATH, R.; OLIVEIRA, J. A. Qualidade do café natural e despolpado após secagem em terreiro e com altas temperaturas. **Ciência e Agrotecnologia**, Lavras, v. 32, n. 5, p. 1606-1615, 2008.

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

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, DF, 13 jun. 2003. Seção 1, p. 22-29.

CORADI, P. C.; BORÉM, F. M.; SAATH, R.; MARQUES, E. R. Effect of drying and storage conditions on the quality of natural and washed coffee. **Coffee Science**, Lavras, v. 2, n. 1, p. 38-47, 2007.

DA SILVA, M. C.; CASTRO, H. A. O.; FARNEZI, M. M. de M.; PINTO, N. A. V. D.; SILVA, E. de B. Caracterização química e sensorial de cafés da chapada de Minas, visando determinar a qualidade final do café de alguns municípios produtores. **Ciência e Agrotecnologia**, Lavras, v. 33, Edição Especial, p. 1782-1787, 2009.

FAGAN, E. B.; SOUZA, C. H. E.; PEREIRA, N. M. B.; MACHADO, V. J. Efeito do tempo de formação do grão de café (*Coffea* sp) na qualidade da bebida. **Bioscience Journal**, Uberlândia, v. 27, n. 5, p. 729-738, 2011.

INTERNATIONAL ORGANIZATION STANDARDIZATION**. ISO 6673:** green coffee – determination of loss in mass at 105 ºC. Geneva, 1983, 17p.

ISQUIERDO, E. I.; BORÉM, F. M.; OLIVEIRA, TAVEIRA, J. H. da S. LOURES, F. A.; DIAS, E. C. Taxa de redução de água e tempo de secagem do café cereja desmucilado submetido ao parcelamento da secagem. **Revista Brasileira de Armazenamento**, Viçosa, Volume Especial, n. 11, p. 37-44, 2009.

ISQUIERDO, E. I.; BORÉM, F. M.; CIRILLO, M. A.; OLIVEIRA, P. D.; CARDOSO, R. A.; FORTUNATO, V. A. Qualidade do café cereja desmucilado submetido ao parcelamento da secagem. **Coffee Science**, Lavras, v. 6, n. 1, p. 83-90, 2011.

ISQUIERDO, E. I.; BORÉM, F. M.; OLIVEIRA, P. D.; SIQUEIRA,V. S.; ALVES, G. E. Qualidade do café cereja desmucilado submetido ao parcelamento da secagem. **Ciência e Agrotecnologia**, Lavras, v. 36, n. 4, p. 439-445, 2012.

ISQUIERDO, E. I. **Secagem e qualidade do café cereja desmucilado submetido a diferentes períodos de repouso**. 2008. 98 f. Dissertação (Mestrado em Engenharia Agrícola) – Universidade Federal de Lavras, Lavras, 2008.

KLEINWÄCHTER, M.; SELMAR, D. Influence of drying on the content of sugars in wet processed green Arabica coffees**. Food Chemistry**, London, v. 119, n. 2, p. 500-504, 2010.

LINGLE, T. R. **The coffee cupper´s handbook: systematic guide to the sensory evaluation of coffee´s flavor**. 2. ed. Washington: Coffee Development Group, 1986. 32 p.

MARQUES, E. R.; BORÉM, 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.) submetido a diferente períodos e temperaturas de secagem. **Ciência e Agrotecnologia**, Lavras, v. 32. n. 5, p. 1557-1562, 2008.

MARTIN, S.; DONZELES, S. M. L.; SILVA, J. N; ZANATTA, F. L.; CECON, P. R. Qualidade do café cereja descascado submetido a secagem contínua e intermitente, em secador de camada fixa. **Revista Brasileira de Armazenamento**, Viçosa, Especial Café, n. 11 p. 30-36. 2009.

NELSON, N. A photometric adaptation of Somogy method for the determination of glucose. **Journal of Biological Chemists**, v. 153, n. 1, p. 75-84, 1944.

PRETE, C. E. C. **Condutividade elétrica do exsudato de grãos de café (*coffea arabica* L.) e sua relação com a qualidade da bebida**. 1992. 125 f. Tese (Doutorado em Fitotecnia) – Escola Superior de Agricultura Luiz de Queiroz, Piracicaba, 1992.

REINATO, C. H. R.; BORÉM, F. M.; SILVA, P. S. da; OLIVEIRA, E. C. Influência da secagem, em diferentes tipos de terreiro, sobre a qualidade do café ao longo do armazenamento. **Coffee Science,** Lavras, v. 2, n. 1, p. 48-60, 2007.

SAATH, R.; BORÉM, F. M.; ALVES, E.; TAVEIRA, J. H. S.; MEDICE, R.; CORADI, C. C. Microscopia eletrônica de varredura do endosperma de café(*Coffea arábica* L.) durante o processo de secagem. **Ciência e Agrotecnologia**, Lavras, v. 34. n. 1, p. 196-203, 2010.

SANTOS, M. A.; CHALFOUN, S. M.; PIMENTA, C. J. Influência do processamento por via úmida e tipos de secagem sobre a composição, físico química e química do café (*Coffea arabica* L). **Ciência e Agrotecnologia**, Lavras, v. 33, n. 1, p. 213-218, 2009.