Qualities of coffee beans, from ripe fruit, kept in clean water for up to five days

Qualidades do café, de frutos maduras, conservados em água limpa por até cinco dias

DOI: 10.34188/bjaerv5n4-040

Recebimento dos originais: 06/05/2022
Aceitação para publicação: 30/06/2022

Juarez de Sousa e Silva
PhD em Engenharia Agrícola pela Michigan State University - USA
Instituição: Universidade Federal de Viçosa / Avenida P.H. Rolfs, SN – 36570-900 - Viçosa-MG
Endereço: Rua Nagib Balut 100 apt 101 – Clélia Bernardes Viçosa-MG -36570 – 298
E-mail: Juarez@ufv.br

Aldemar Polonini Moreli
Doutor em Produção Vegetal pela Universidade Federal do Espírito Santo
Instituição: Instituto Federal do Espírito Santo / Campus Venda Nova do Imigrante
Endereço: Av. Elizabeth Minete Perim, 500 -Bairro São Rafael, Cidade – Venda Nova do Imigrante - ES, Brasil
E-mail: aldemar.moreli@ifes.edu.br

Sammy Fernandes Soares
Doutor em Agronomia pela Universidade Estadual Paulista - UNESP
Instituição: Embrapa Café/EPAMIG
Endereço: Vila Gianetti, 46 - Centro, Viçosa – MG, Brasil
E-mail: sammy.soares@embrapa.br

Sérgio Maurício Lopes Donzeles
Doutor em Engenharia Agrícola pela Universidade Federal de Viçosa
Instituição: Empresa de Pesquisa Agropecuária de Minas Gerais -EPAMIG
Endereço: Vila Gianette casa 46, Campus da UFV, Bairro Centro, Cidade – Viçosa-MG, Brasil
E-mail: slopes@epamig.br

Kênia Barbosa do Carmo
Engenheira Agrônoma pelo Instituto Federal de Educação do Espírito Santo - Campus Santa Teresa
Instituição: Carmo Consultoria Agronômica
Endereço: Cabeceira do Imbiruçu, 00 - zona rural, Mutum – MG, Brasil
E-mail: keniabcarmo@gmail.com

Douglas Gonzaga Vitor
Engenheiro Agrônomo pela Universidade Federal de Viçosa
Instituição: Empresa de Pesquisa Agropecuária de Minas Gerais -EPAMIG
Endereço: Vila Gianette casa 46, Campus da UFV, Bairro Centro, Cidade – Viçosa-MG, Brasil
E-mail: dgonzagavitor@gmail.com

ABSTRACT

The use of compatible techniques, which allow family coffee growers to form larger batches of coffee, to be dried in commercial dryers and within their production reality, is very important in view of the scarcity of labor and demand for superior quality. As natural drying, depending on climatic conditions, may not produce high quality coffees, it is necessary that farmer maintain small daily harvests in conditions that can be transformed into a larger batch compatible with the capacity of conventional dryers, offered by the Brazilian industry. The acquisition of a dryer, which does not meet the entire harvest, can derail the process, with increased costs of acquisition, operational and incompatibility of the harvest / post-harvest systems. If the dryer capacity does not meet the harvest schedule at the peak of coffee maturation, when there will be a need for extra labor to avoid fruit fall, there will be losses due to reduced product quality. To solve the problem, this work was carried out on a farm with potential for coffee of superior quality, with 1100 meters of altitude located in the district of Embiruçu in the municipality of Mutum-MG, using the water storage technique, proposed by Machado (2005) for coffee harvested by hand striping, and confirmed by (Coelho et al., 2019) in the treatment of green coffee fruits, originated in wet processing. The results of this work show that the technology of immersion of fruits, recently harvested in water, for up to five days, did not impair the quality of the cup-proof and positively influenced the physical parameters used in the evaluation of the coffee type, indicating the possibility of aggregating small batches to enable the use of conventional dryers in the small coffee farms.

Keywords: Temporary storage, immersion, mature coffee, quality, volume reduction.

RESUMO

O uso de técnicas compatíveis, que possibilitem aos cafeicultores familiares formarem lotes maiores de café, para serem secados em secadores comerciais e dentro de sua realidade de produção, é muito importante diante da escassez de mão de obra e demanda por qualidade superior. Como a secagem natural, dependendo das condições climáticas, pode não produzir cafés de alta qualidade, é necessário que o cafeicultor mantenha pequenas colheitas diárias em condições que possam ser transformadas em um lote maior e compatível com a capacidade dos secadores convencionais, oferecido pela indústria. A aquisição de um secador, que não atenda toda a colheita, pode inviabilizar o processo, com aumento dos custos de aquisição, operacionais e de incompatibilidade dos sistemas colheita / pós-colheita. Caso a capacidade do secador não atenda ao cronograma de colheita no pico da maturação do café, quando haverá necessidade de mão de obra extra para evitar a queda dos frutos, haverá perdas devido à redução da qualidade do produto. Para solucionar o problema, este trabalho foi realizado em uma fazenda com potencial para café de qualidade superior, a 1100 metros de altitude localizada no distrito de Embiruçu no Município de Mutum-MG, utilizando a técnica de armazenamento em água, proposta por Machado (2005) para o café colhido por derriça, e confirmado por (Coelho et al., 2019) no tratamento dos frutos verdes do café, originado no processamento via úmida. Os resultados deste trabalho mostram que a tecnologia de imersão dos frutos, recém-colhidos, em água, por até cinco dias, não prejudicou a qualidade da bebida e influenciou positivamente os parâmetros físicos, usados na avaliação do tipo do café, indicando a possibilidade de agregar pequenos lotes para viabilizar o uso de secadores convencionais na pequena cafeicultura.

Palavras-chave: Armazenagem temporária, imersão, café maduro, qualidade, redução de volume.

1 INTRODUCTION

Producing high quality coffee is a challenge to be faced mainly by the family coffee grower who is unable to compete in quantity in the conventional coffee market. To increase family income, using scarce resources such as land and capital must produce a coffee with greater added value. Even in the production of "commodity coffee" the coffee grower must meet the new qualitative aspects required in commercial transactions that, according to Santos et al. (2008) requires socio-environmental compliance along the production chain and minimum quality standards. If the family coffee grower wants to overcome the barriers imposed by modern marketing, he should look for low-cost technologies that produce coffee without the risks of quality reduction, within its reality of production and financial conditions. In addition, must highlight the adjustment between the volume harvested daily and the capacity of processing units currently supplied by the Brazilian industry.

To obtain quality coffee, the cadence between the harvest and post-harvest processes is essential, especially if the technologies in the post-harvest are very dependent on climatic conditions such as drying with solar energy.

The maximum quality of coffee is found in the fruit at the ripe cherry stage, when the endosperm and chemical precursors are fully formed (Arruda et al., 2011). Thus, the mastery of techniques for the handling of coffee fruit, which considers variations in the volume harvested throughout the harvest, the uniformity of maturation and the climatic conditions, should be carefully considered.

Regardless of the type of coffee to be produced, freshly harvested fruits should not be stored or piled at room temperatures for prolonged periods to avoid undesirable fermentation. On the other hand, some operational aspects, such as the management of the flow of fruits harvested with the capacity of the post-harvest, are difficult to solve. According to Machado (2005), the problems associated with crop characteristics, availability of human resources and infrastructure can also lead to a low efficiency in processing caused mainly by the poor packaging of freshly harvested fruits that is aggravated, even more, in family coffee farming that does not have minimal tolerable infrastructure.

The inadequacy of washing, peelers and commercial dryers to small production, results in high cost of implantation and difficulty in operating the equipment with the proper efficiency. On the other hand, if the system is not sufficient to meet the peak harvest, it is difficult to accumulate newly harvested lots in ideal conditions for the maintenance of pre-harvest quality.

As is shown in the work done by Machado (2005), studies relating quality reduction with waiting for processing were performed by PIMENTA E VILELA (2003), OLIVEIRA et al. (2003), and BATISTA et al. (2003).

In the work carried out by MACHADO (2005), the presence of Ochratoxin A was not detected in any of the samples analyzed.

In the in-water storage method proposed by MACHADO (2005), the lots harvested each day should be stored, in clean water, for periods of one to seven days, with daily water exchange. The author concluded that there is viability in the use of immersion as a technique for previous storage of fruits harvested by hand striping (cherry, greenish and buoy), without prejudice to the final quality of coffee when compared to the control under the same drying method in tray dryers with heated air. It was concluded that there is not difference in quality between in-water storage periods or in the mixing of coffees stored for different periods in clean water. In addition, it was verified that the water from the processing generated from the immersion of the fruits showed high levels of nutrients such as phosphorus, nitrogen, and potassium, thus presenting potential for its use in fertigation.

Coelho (2019) applied the method proposed by MACHADO (2005) to store green coffee, out of the pulping, to be reprocessed. Obtained 62 percent peeling and the "Peeled Green", received the same qualitative evaluation of the "Peeled ripe fruits" produced on the farm where the samples were collected.

With the purpose of verifying whether the methodology proposed by MACHADO (2005) can be applied to ripe cherry coffee, with potential for higher qualities and with the possibility of mixing lots harvested in different days, this work was carried out that considered the technical feasibility as pre-treatment to drying in suspended terrace, covered by a ventilated transparent cover and possibility of mixing lots stored for different periods.

2 MATERIAL AND METHODS

The experiment was conducted in farm "Jasminum" - Cabeceira do Imbiruçu, Mutum-MG district, whose coordinates are 41º 24' 53.54 W and 20º 10' 03.58 S and altitude of 1100 meters. Coffee fruits from the 2018/2019 harvest of the yellow Catuaí variety, end of harvest, were used. The fruit was harvested in a single day (02/06/2019), by manual striping in sieve.

2.1 PRODUCT

A batch with 250 liters of ripe coffee fruits, with the green fruits separated manually and the buoy fruits by flotation, constituted the basis of the experiment.

The coffees freshly harvested and received during the afternoon were submitted to hydraulic separation, to obtain the ripe fruits fractions for the basis of this work. Withdrawing the control samples, the coffee was immersed in water for up to five days, in a tank with clean water, having three portions of three liters removed daily. The tank was equipped with a valve to enable daily drainage of storage water. The amount of water deposited in the tank was enough to cover the mass of cherries by 2 to 3 cm. The storage water was removed and replaced at each 24 hours, always at 18:00 h, after sampling to represent the daily portions for drying and the water for analysis.

2.2 IMMERSION IN WATER (EXPERIMENTAL DETAILS)

The experiment was carried out in a randomized block design, with three replications and treatments consisting of immersion in water of ripe fruits of the Yellow Catuaí variety for six periods: 0, 24, 48, 72, 96 and 120 hours.

After each immersion period the fruits were placed for drying in a "screened" table dryer protected by a transparent and naturally ventilated cover. Thus, it worked with simple samples (fruits harvested in a single day) and submitted to different immersion periods that ranged from 24 to 120 hours according to each experimental plot.

2.3 WATER CONTENT AND PHYSICAL CHARACTERISTICS OF THE PRODUCT

Samples were collected in triplicates for each day of storage and at the end of the process. The samples had the final weight, the initial volume, final volume, and other physical characteristics determined after equilibrium in controlled environment with temperature at 22 ºC and relative humidity at 60%. The average final water content (11.86% w.b), was determined by the Standard Oven Method at 105 $\pm$ 1 ºC, for 48 hours, with samples of approximately 30 g and three replications (BRASIL, 1992). The initial fruits water content due to the on farm experimental difficulty was evaluated by weighing difference. Differently from what was determined by MACHADO (2005) and difficulty of performing the experiment on the farm, far from the laboratory, the drying curves were not determined.

2.4 DRYING

After immersion periods, all plots were submitted to natural drying in a "screened" table dryer under transparent and naturally ventilated cover. The samples final characteristics from zero (0) to (120) one hundred and twenty hours of immersion time were formed, after equilibrium in a controlled environment with relative humidity and temperature at 60% and 22 ºC, respectively.

2.5 COMMERCIAL QUALITY ANALYSES

Samples of 300g of green coffee beans from each experimental plot were sent to the coffee post-harvest laboratory (IFES-VNI, in Venda Nova do Imigrante – ES) for physical evaluations and cup-proof, according to SCAA standards, by five Q-Graders. The Physical Quality Indexes (PQI) was determined according to COELHO (2019).

3 RESULTS AND DISCUSSION

Due to the difficulty of working in farm conditions, it was not possible to determine the initial moisture content of each plot by the standard oven method. The initial water content was obtained as a function of the initial and final weights of the samples. On the other hand, all final coffee water content, were determined by standard oven method. The initial product presented the following characteristics: Apparent density 669.6 g/liter, 461 coffee fruits per liter and calculated initial moisture content of 62.8 %wb.

Working under special conditions, MACHADO (2005), shows that coffee fruits can gain around seven (7%) points of moisture during 120 hours of immersion in clean water and that it is during the first 48 hours that the highest water gain happens (around 5% points).

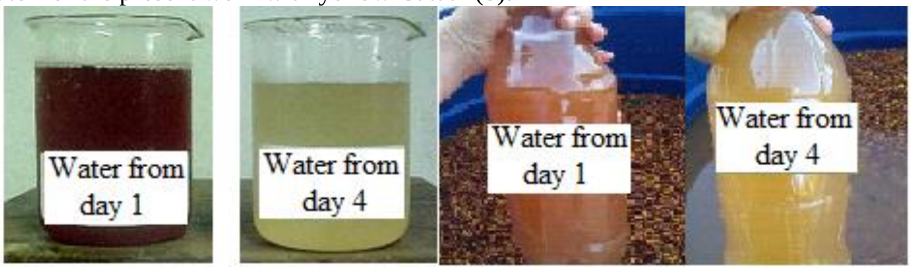
It is known that, under normal conditions, lots of coffee with large differences between initial water content should not be mixed, under the risk of uneven drying. As found by MACHADO (2005) the variation in the final water content of the fruits is practically the same, despite differences in the initial moisture of the fruits. The author shows that the mixture of the different plots does not affect the uniformity of drying at the end of the process; she observed and recorded the change in the color of the fruits from red to brown, working with red Catuaí (Figure 1a).

For the current study, the change in the fruits color, originally yellow, was a light brown (Figure 1 b). These facts show that the pigments that make up the color of coffee fruits are soluble in water as shown in Figure 2

Figure 1: Coloration of freshly harvested fruits and after 96 hours of immersion in water, observed by MACHADO (2005) (a) and yellow Catuai, freshly harvested and after 120 hours of immersion verified in the present study (b).

(a) **(b)**

Figure 2 – First and fourth storage water produced in the work of MACHDO (2005) for red Catuaí (a) and first and fourth storage water for the present work with yellow Catuaí (b).



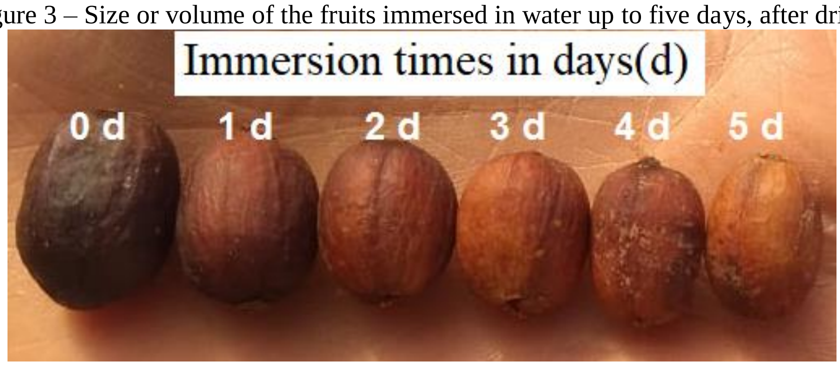
(a) (b)

As is known, the color of the coffee fruit is not relevant to the product, since the qualitative aspect of color refers to the processed grain ready for commercialization and which in international terms is identified as "Green coffee beans". Changing the color of the fruit during the immersion process can be an indication for managing batches in the temporary storage phase or batches that have suffered some qualitative loss due to fermentation.

3.1 DRYING OF FRUITS AFTER IMMERSION

The drying of individual plots presented peculiar characteristics. The appearance of samples collected at different immersion times suggests that fruits subjected to longer immersion times would have higher drying speeds due to greater volume reduction (wilt) at the beginning of the drying process (Figure 3), in which one can see the reduction in the fruits volume, according to the immersion time, after the first days of drying. This effect implies in a smaller storage volume for the same amount of dried coffee fruits. To assess this effect, MACHADO (2005) researched the drying curves of some coffee lots in water stored up to seven days. She noted that there are practically no differences between the drying curves for the different soaking periods. In addition, despite similar drying times, she observed that when coffee immersed for 4 days it presents a higher drying rate, close to 30% w.b, with a difference of up to 7% points Percent

Figure 3 – Size or volume of the fruits immersed in water up to five days, after dried.



3.2 CHEMICAL ANALYSIS OF THE IMMERSION WATER

One of the disadvantages of wet processing of freshly harvested coffee is the generation of wastewater which, despite the research recommendation for its use in fertigation, current legislation requires treatments for its disposal in water bodies, according to Resolution 430, of May 2011, CONAMA. Thus, in addition to the environmental problems to be mitigated, the wet preparation requires more complex infrastructure and, therefore, greater initial investment, which makes it difficult for the small coffee producer to use the technique.

To use the technology proposed by MACHADO (2005), the evaluation of the potential and disposal of the wastewater, and the establishment of technical parameters, are important for the feasibility of the process. As shown in Table 1, the water used for daily coffee immersion contains nitrogen, phosphorus, potassium, calcium, magnesium, which, if used in the fertigation close the processing unit, reduces the risk of environmental pollution.

For water analysis, the same methodology used by MACHADO (2005) was adopted. Samples were collected at each change (24 hours) before the daily water change. After each 24 hours, was identified as water from the 1st. replacement; after 48 hours, 2nd replacement, and so on.

Table 1 – Concentrations of (N, P, K and Ca, in mg/L^{-1}), in the immersion water, determined by MACHADO (2005) (M) and in the actual experiment (A).

Nutrients (mg.L^{-1})	Experiment	Soaking time (h)				
		24	48	72	96	120
N	Machado (2005)	331,5	340,5	177,8	123,6	171,8
	Actual	512,4	417,1	202,6	95,3	113,2
P	Machado (2005)	58,0	101,6	49,1	10,5	1,6
	Actual	76,0	54,2	27,3	10,8	9,2
K	Machado (2005)	2572,5	2072,9	836,0	237,4	121,2
	Actual	1859,3	1436,8	895,7	495,9	490,8
Ca	Machado (2005)	880,2	861,3	298,0	99,9	49,3
	Actual	52	45	29	31	30

Sources: MACHADO (2005) and actual experiment.

3.3 COFFEE QUALITY

The results obtained in the cup-proof, following the SCAA methodology, the main physical parameters of economic importance and the Physical Quality Index (PQI) can be seen in Table 2, among other parameters of importance.

The results show that the applied treatment to freshly coffee fruits did not affect the final qualities of the beans (green coffee).

The parameters: number of dry fruits per liter, weight of 100 dry fruits, weight of coffee husk per processed bag (60 kg) and weight of dry fruits per processed bag (60 kg of beans) were significantly and positively influenced by the in-water immersion time (Figures 4a, 4b, 4c and 4d).

The results indicate the need of less storage space for dried fruits and less weight to be handled (Figure 5), easier peeling and the recovery of part of the fertilizers that were dissolved in the storage water for fertigation. Even without wet pre-processing, as demonstrated by (Coelho et al., 2019), this operation will be much easier with the immersion operation, due to the softening of the fruit pericarp to produce parchment coffee.

Table 2: Beverage coffee quality and physical characteristics of fruits and beans obtained from batches of fruits subjected to immediate drying after immersion in clean water, for up to five days, with daily water change.

Variáveis	soak time (h)					
	0	24	48	72	96	120
Beverage quality* (final score)	80,72	79,35	79,72	79,90	79,75	79,14
Physical Quality Index	16,7	16,0	15,51	14,97	16,14	15,73
Dried fruits per liter (number)	701	816	879	872	929	911
Weight of 100 dried fruits (g)	59,87	52,9	49,83	48,93	46,8	48,7
Weight of 100 beans (g)	34	33	34	34	33	35
Husk per 60kg bag of beans (kg)	45,23	35,79	26,00	27,21	24,92	23,27
Dried fruits per 60kg bag of beans kg	105,23	95,79	86,00	87,21	84,92	83,27

*Final score of beverage sensorial evaluation using SCAA protocol.

Figure 4 – Weight of one hundred dried fruits (a) Coffee husk weight per hundred of dried fruits (b), Average volume of dry fruit (c) and Coffee husk weight per kilogram of dried fruits (d).

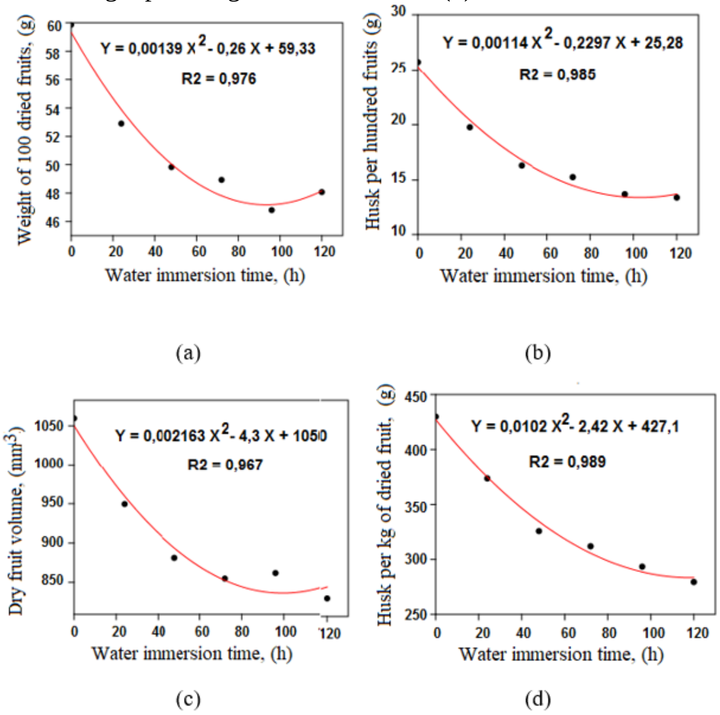
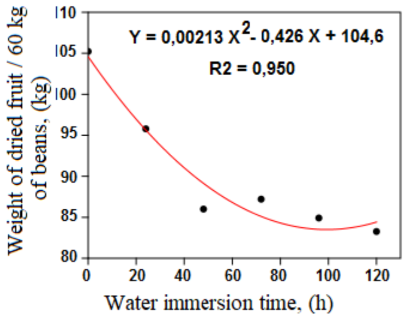


Figure 5 - Dried coffee fruits weight to produce a processed 60 kg bag of green coffee.



4 CONCLUSIONS

Based on the results and conditions established for each experimental plot, it can be concluded that:

1- The storage time in water of newly harvested ripe coffee fruits, for up to 120 hours, does not change the quality parameters usually used to remunerate the product in traditional coffee market (green coffee).

2- The parameters that can economically influence the different steps of pre-processing were positively influenced by the storage, in water, of the freshly picked fruits.

3- Due to the quantities of chemical elements (fertilizer) dissolved in the storage water, shows that it can be used in the fertigation of an area close to the processing unit.

4- Most of the recovered fertilizer can be based on the difference in weight of the control coffee husk (Control plot) by the weight of the coffee husk treated for up to 76 hours, shown in this work and observed in the studies by MACHADO 2005.

5- In addition to reducing the weight of dried fruits, there was a reduction of up to 20% in the volume to be stored and peeled during final processing.

6- Storing ripe coffee fruits in water before pre-processing reduces the weight and volume of the fruits and the weight of the rusk after drying, while the weight of the beans does not change.

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