

## Full Length Research Paper

# The permanence in the plantation after harvest damages physical characteristics of Conilon coffee grains

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The permanence of harvested fruits in the plantation can cause irreversible damage to Conilon coffee quality, possibly increasing the overall number of defects, causing losses to crop yield and changing the organoleptic properties of the product. The objective of this study was to quantify the changes caused by permanence time of the Conilon coffee in the plantation after harvest over the mass and classification of the product. The experiment followed a completely random design, with 8 treatments and 4 repetitions, using standardized bags of mature fruits of *Coffea canephora* Pierre ex Froehner that were kept in the plantation field for periods of 0, 1, 2, 3, 4, 6, 8 or 10 days after manual harvest of the grains. After these periods, the coffee was dried, processed and weighted to quantify losses. The samples from each parcel were used to classify the resulting coffee regarding grain size in standardized classification sieves (sieves 12, 11 and 10 for round grains; sieves 17, 15 and 13 for flat grains), grain defects (brocaded, sour, black, defective percentage and total number of defects) and yield losses (dried coffee weight and processing ratio). The results showed that keeping the harvested fruits in the plantation causes losses over mass and over the overall product classification, affecting grain size and increasing the number and type of defects. This reinforces the recommendation to transport the harvested coffee for drying as soon as possible after harvesting.

**Key words:** *Coffea canephora*, harvest, grain defects, quality, physical classification.

## INTRODUCTION

Known as one of the most popular beverages in the world, coffee is a very important commercial commodity,

being only surpassed by oil in terms of value of amount traded worldwide (Sunarharum et al., 2014). The

increasing demand for specialty coffees in the Brazilian and international markets, the quality of the product is an essential factor for the maintenance and conquest of consumer markets. The quality is directly related to the physical and chemical aspects of the grains, which are responsible for the appearance of the roasted grain, and also for the flavor and aroma of the beverage. Different factors are responsible to determine the coffee quality in the end of the production process, among them are mentioned edaphoclimatic factors, coffee species and cultivars, crop management, moment of harvesting, and post-harvest procedures (Franca et al., 2005; Monteiro and Farah, 2012; Sunarharum et al., 2014).

In Brazil, the coffee classification is based on the type, sieve, color and sensorial characteristics of the beverage. The physical classification is preponderant information for the valorization of the product, because in this process, one can identify the amount of defective grains in the original product (Matiello et al., 2010). The defective grains often are responsible for changes in the homogeneity of the grain mass, affecting the roasting process and degrading the quality of the beverage.

Since coffee harvesting tend to generate a peak in labor need, sometimes the harvest fruits are stored in raffia bags and left in the middle of the Conilon coffee plantations (*Coffea canephora* Pierre ex Froehner). The period of time in which these fruits remain bagged in the coffee plantation, until they are transported to drying and processing, can greatly interfere in the quality of the final product. These conditions can favor fermentative processes in the fruit mass since it create a favorable environment to sustain and promote the biological activity (Borém et al., 2006; Isquierdo et al., 2012).

According to Verdin Filho et al. (2016), the increase in the permanence time of harvested fruits of Conilon coffee in the plantation can promote significant losses in sensorial aspects of the coffee beans, contributing greatly to the decrease of the quality of the final product and degrade the beverage quality.

Sunarharum et al. (2014) describe that flavor is undoubtedly the most important feature of the coffee beverage, and this characteristic is developed in conjunction with grain formation and influenced by the harvest and post-harvest processes. Thus, it is possible that the permanence of coffee fruits in the plantation can contribute to processes that will damage the grains, promote grain defects, cause losses in yield and change organoleptic traits of the product.

In this context, the present study was developed with the objective of quantifying the changes caused by permanence time of the Conilon coffee in the plantation after harvest over the mass and classification of the

product.

## MATERIALS AND METHODS

The experiment was conducted in an 8 years old plantation of *Coffea canephora* Pierre ex Froehner (established in 2004), with plants spaced 3.0 x 1.0 m, located in the municipality of Marilândia, in Espírito Santo State, Southeast region of Brazil. The climate of the site is tropical, classified as Aw (Köppen and Geiger, 1928), typically rainy from November to February; partially dry in March, April and October and dry from May to September, accumulating an average of 1,164 mm of annual rainfall and presenting average annual temperature of 24.2°C (13.9 to 33.5°C). The altitude of the site is 202 m above sea level, the topography is hilly and the soil is classified as dystrophic Oxisol (Embrapa, 1997).

The plantation was cultivated following the recommendations for Conilon coffee in Brazil (Ferrão et al., 2007; Prezotti et al., 2007; Ferrão et al., 2012). During the fourth harvest, after over 80% of fruits finish ripening, the plants were harvested manually and the fruits were stored in raffia bags, which were weighted to create a homogeneous collection of bags of 50 kg each.

The raffia bags were tagged with identification and randomly selected to be transported at 0, 1, 2, 3, 4, 6, 8 or 10 days after harvest. The experiment followed a completely random design, with 8 treatments (days of permanence in the plantation after harvest), and four repetitions. Each experimental plot consisted of one bag of 50 kg of green coffee. After the selected time, the fruits were transported to cement fields for post-harvest drying, and processed, following the recommendations for coffee in Brazil (Ferrão et al., 2007; Ferrão et al., 2012; Fonseca et al., 2015).

From each experimental plot, a sample of processed coffee (300 g) was collected, and the grains were submitted to physical analysis to determine the percentage (%) of coffee retained in each class of sieves (separation by grain size and shape): sieves 12, 11 and 10 for round shaped grains; and sieves 17, 15 and 13 for flat grains (Brasil, 2003). From this same sample, the defective grains were identified and counted as insect damaged, sour and black grains (Figure 1).

The defective percentage and the total number of defects per sample were also determined following the recommendations of the Brazilian Official Classification Table (Brasil, 2003). The coffee from each experimental unit (each raffia bags with 50 kg of ripe coffee) was dried and re-weighed before processing to quantify the final mass of dried coffee (kg) after the effect of the permanence times. After processing, the ratio between the mass of processed grains and green coffee was determined, in order to establish the processing ratio (%).

The data were subjected to analysis of variance and, according to their significance, the effect of the permanence times in the plantation were studied by means of regression analysis. All tests were performed at 5% probability and using the statistical software SISVAR (Ferreira, 2011).

## RESULTS AND DISCUSSION

The proportions of grains classified in the round sieves 12, 11 and 10 and flat sieve 13 were directly influenced by the permanence time, being adjusted to model of 1st

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**Figure 1.** Some types of defects in coffee grains: brocaded grains (A), sour grains (B) and black grains (C).

degree linear regression (Figure 2A, B, C and F). The proportions in larger flat sieves (17 and 15) were not significantly altered for the permanence in the plantation (Figure 2D and E).

There was a considerable decrease in the proportion of grains classified in round sieve 12 and 11 sieves (Figure 2A and B) as function of the increase in the permanence time, but a more drastic effect was observed for the proportion of grains classified in round sieve 12, verified by greater value of its the angular coefficient of its regression (-0.5481). In addition, the permanence in the plantation caused an increase in the proportion of grains retained in smaller sieves, as verified by the results of for round sieve 10 and flat sieve 13 (Figure 2C and F).

These results show that as the time of permanence of harvested coffee in the plantation field increases, there is a considerable loss for the sieve classification of the grains. This result directly reflects over the physical quality of the final product, contributing to its economic devaluation. Based on the observations of Brando (2004), it is possible that these grain size losses occurred due to the action of fermenting microorganisms that may have acted both over the husk and mucilage of the fruits, as well as in the grains, in order to promote losses in coffee size and yield.

According to Laviola et al. (2006), it is common to observe higher market value for coffee beans classified in larger sieves and its association with other quality traits. Matiello et al. (2002) report that environmental factors and cultivation conditions are very important for obtaining larger coffee beans and, based on the results of the present study, the permanence time in the plantation field after harvest can also be a relevant factor to influence the homogeneity of grain size.

The classification of coffee beans based on their size is fundamental to determine the quality of the beverage, since the quality and effectiveness of the roasting process depends, among other factors, on the homogeneity of the grain mass and, consequently, their size (Nasser and Chalfoun, 2000; Matiello et al., 2002; Mendonça, 2004). The number of brocaded grains,

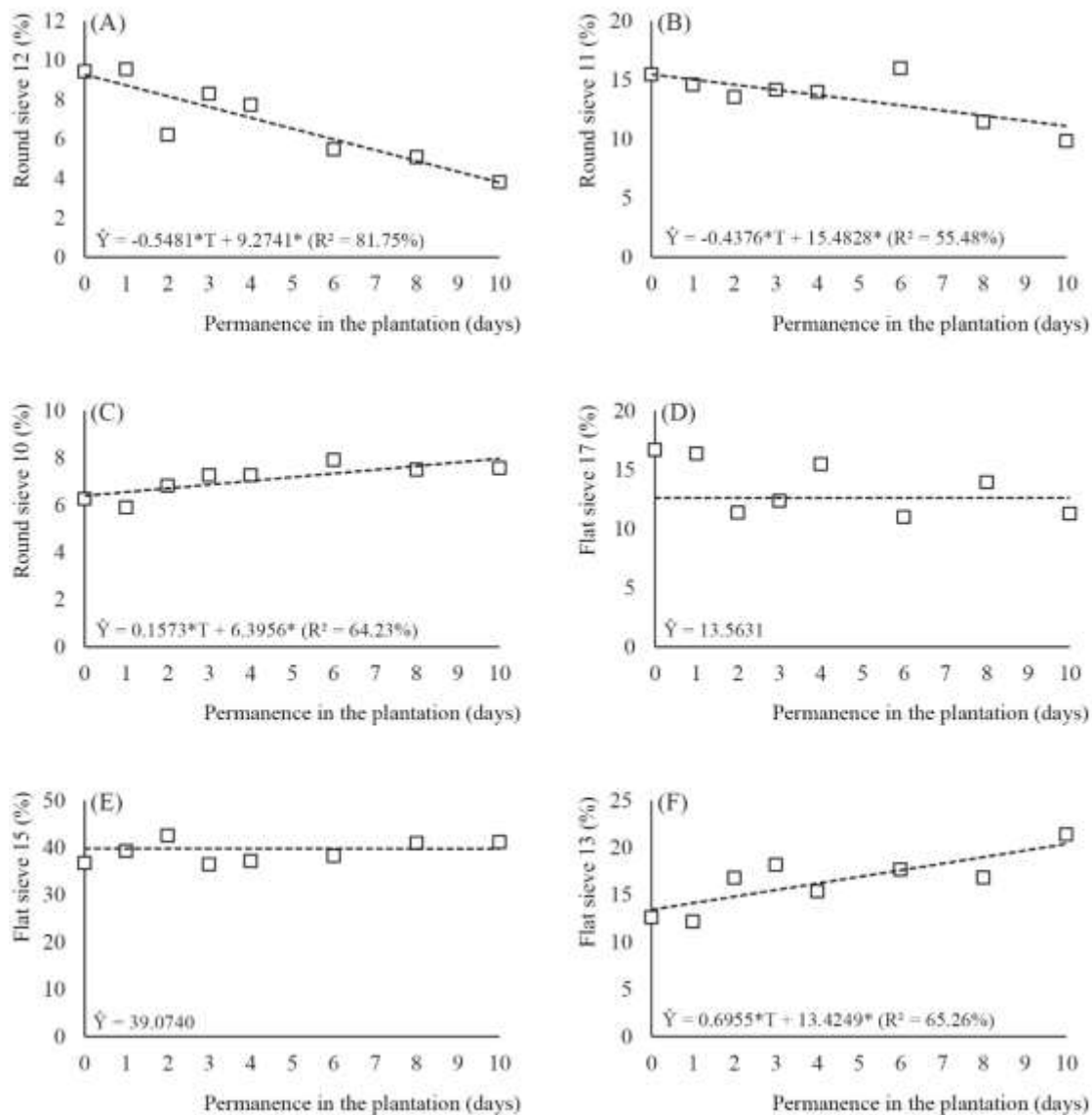
defective percentage and processing ratio (Figure 3A, D and G) presented adjustment to 1st degree linear regression models as function of the permanence time. The number of sour and black grains, total number of defects and dried coffee weight presented adjustment to 2nd degree linear regression model (Figure 3B, C, E and F).

There is a linear decrease in the number of brocaded grains as the coffee remains longer at the plantation site (Figure 3A). In a way, this is an interesting result to be found, as it indicates the advance of fermentation processes and temperature increase in the grain mass as a function of the permanence in the raffia bags may have created an unfavorable scenario for higher insect infestations. Another hypothesis for this result suggests that infested grains may have been targeted by microorganisms or decomposed in faster rate, causing the remains of the grains to be classified as other defects. This is supported by the results for total number of defects (Figure 3E).

After one day of permanence in the plantation, the harvested coffee already began to show increases in the number of sour grains (Figure 3B) and, after almost three days, there was an increase in the number of black grains (Figure 3C).

These defects greatly contribute to the degradation of the beverage quality, since the chemical constitutions of these grains are different from the normal, the heterogenous nature of the mix and the strange chemical composition significantly impairs the sensorial quality of coffee (Coelho and Pereira, 2002; Silva, 2003). Sour grains include those with brown coloration, due, in large part, to the action of the fermentative process, which certainly was promoted by the permanence of the grain mass in the open environment.

Martinez et al. (2007) reported that black grains are considered as the basis for the defects found in coffee samples, followed by the presence of strange corpses (e.g. sticks, stones), as well as brocades, burnt, conch and broken grains, which can be caused by the decomposition process of grains on the ground, by



**Figure 2.** Regression analyses for the proportion of grains of Conilon coffee classified with round sieve sizes 12 (A), 11 (B) and 10 (C) and flat sieve sizes 17 (D), 15 (E) and 13 (F), as function of the permanence time in the plantation after harvesting ( $\hat{Y}$  significant coefficient by the t-test at 5% of probability).

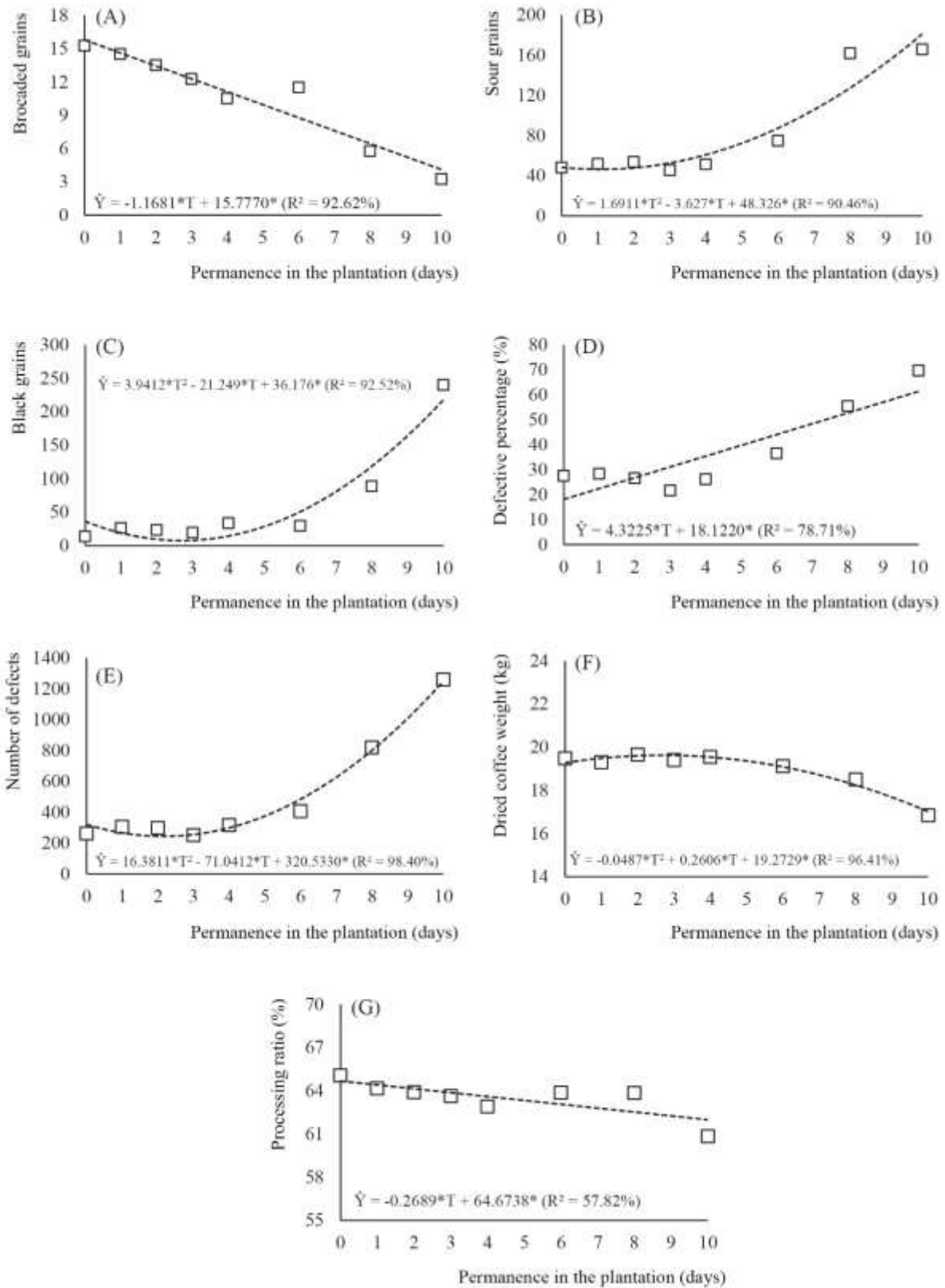
fermentation and by high drying temperatures.

According to Verdin Filho et al. (2016), the permanence of Conilon coffee in the field after harvesting causes chemical changes in the grains, which negatively affect the sensorial quality of the product, causing sharp decreases in the quality of the beverage after the very first day. Oliveira et al. (2006) report that the origin of defects in coffee beans produced in Brazil is mainly due to the harvest system, dropping the fruits on the ground, fermentation and the processing system after harvest.

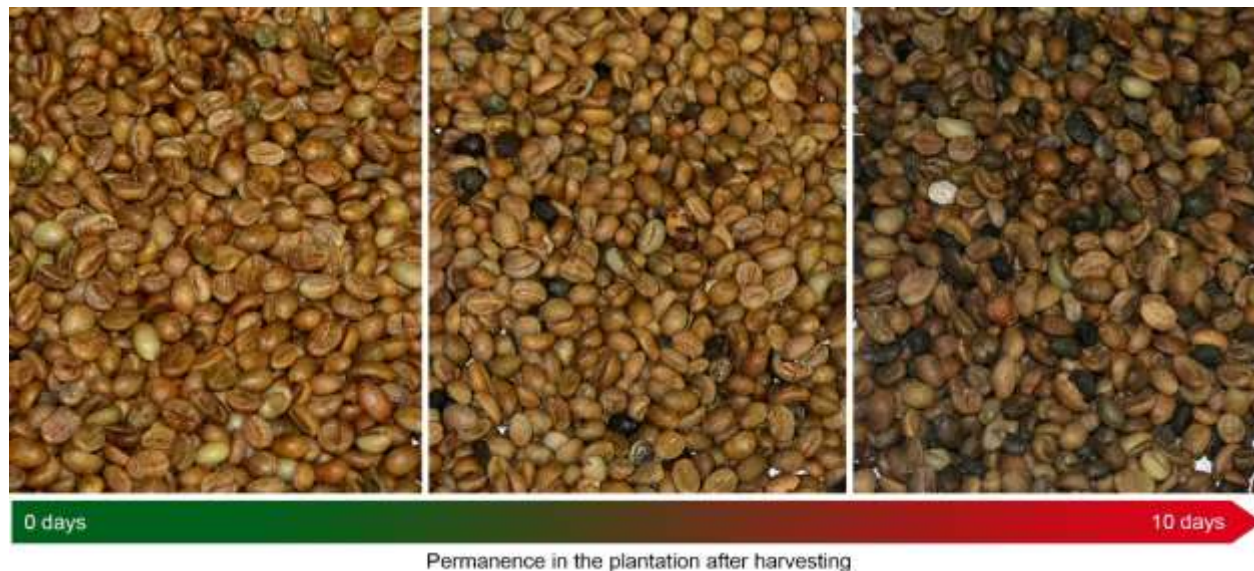
For the defective percentage, there was a linear increase as function of the number of days of permanence in the plantation field (Figure 3E). However, the total number of grain defects presented a sharper

increase after two days of permanence (Figure 3F). The increase of number of defects is directly related to the decrease in the quality of the beverage (Franca et al., 2005; Verdin Filho et al., 2016), which denigrates the physical appearance of the coffee lot and contributes to devaluate the product (Laviola et al., 2006; Matiello et al., 2010).

Farah et al. (2006) describe that coffee beverage quality declines drastically as the number of defective grains in the sample increases, which justifies the close relationship between the physical quality and the sensory aspects of coffee samples. Regarding the dried coffee weight after the permanence times, a considerable decrease was observed after three days (Figure 3G),



**Figure 3.** Regression analyses for amount of brocaded grains (A), sour grains (B), black grains (C), defective percentage (D), total number of defects (E), dried coffee weight (F) and processing ratio (G) of Conilon coffee as function of the permanence time in the plantation after harvesting (significant coefficient by the t-test at 5% of probability).



**Figure 4.** Physical aspects of conilon coffee grains as function of the permanence time in the plantation after harvesting.

which may be related to the development of fermentative processes throughout the days and consumption of part of the sugars and others compounds stored in the mucilage of the coffee fruits, contributing to the decrease in the weight of the coffee mass.

However, this decrease may affect further than just the mucilage and husk, as the fermentation may also result in losses in the coffee grains. Brando (2004) reports that the fermentation process was able to cause average losses in coffee bean mass in the range of 0.5 to 6.0% (9.0% in extreme cases), depending on local conditions. This finding was reflected in the processing ratio, since the yield decreased significantly as a function of time (Figure 3H). It can be said that the losses in processing yield were mainly due to the progressive increase in the number of defective grains, possibly, due to the action of fermentative processes. These results corroborate with that observed by Pimenta and Vilela (1999), for Arabica coffee.

The gradual and deleterious effects caused by increasing the time of permanence of the conilon coffee in the field after harvesting are visible (Figure 4). The quantity of defective grains and the types of physical defects (especially black and sour grains) increase severely when the time gap between harvesting and transportation is too long. As a result of these negative effects, the organoleptic quality of these grains is surely compromised, which will greatly contribute to the devaluation of the product and affect directly and negatively the rentability for the produced coffee.

## Conclusions

The permanence of harvested fruits in the plantation

causes losses over mass and over the overall product classification, affecting grain size and increasing the number and type of defects. In order to minimize the physical post-harvest losses in Conilon coffee, the recommendation to transport the harvested coffee for drying as soon as possible after harvesting is reinforced. Considering the environmental conditions of this experiment, the maximum time of permanence should never exceed between two or three days in the plantation, since the damage to the physical aspects of the grains sharply increase by this time.

## CONFLICTS OF INTERESTS

The authors have not declared any conflicts of interests.

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