CONILON
Coffee

3rd Edition
Updated and expanded




The Coffea canephora produced in Brazil

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Conilon Coffee Harvesting and Post-Harvesting

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1 INTRODUCTION

Coffee is one of the few agricultural products whose commercial value is linked to quality. The better the appearance, sanity, type and beverage, the higher the prices paid for the product (SILVA; MORELI; VERDIN FILHO, 2015), which will give coffee growers an economic return to invest in production and processing technologies (CORRÊA; OLIVEIRA; BOTELHO, 2015). The search for quality aiming at production valorisation and conquests for more stable and remunerative markets is among the goals to achieve sustainability and competitiveness for those who are engaged in coffee production, be it arabica or conilon coffee (FONSECA et al. 2007).

The coffee quality depends on the species, the chemical composition of the raw grains, the cultivar, the climate, the altitude, the harvesting process, the post-harvesting processing (drying, storage and processing) and the techniques used in industrial processing: roasting, milling and packaging (CORRÊA; OLIVEIRA; BOTELHO, 2015).

Besides the correct handling of the crops, the procedures used in the preparation, processing, drying and storage are fundamental to maintain the product quality after harvesting. Therefore, it is very important to define the method of preparation to which the coffee will be submitted, as well as the guarantee that the infrastructure necessary to attend to this final stage of coffee production is available and suitable for operation (SILVA; MORELI; VERDIN FILHO, 2015). The care to be observed in the storage phase are also important, since, according to Corrêa, Oliveira and Botelho 2015, coffee naturally tends to reduce its quality over time stored.

In Brazil, the total strip harvesting method predominates. The harvested coffee consists of a mixture of green, mature, ripe or cherries, raisins, dried, leaves, branches and, when harvested on the ground, sticks and stones (SILVA et al., 2011). According to Silva et al. (2011), the presence of each of these constituents and their proportion in the coffee to be processed can help in the definition of the care to be adopted in the processing, thus contributing to the final quality of the product.

In general, all the defects found in a coffee sample to be classified as type may influence more or less intensely in the definition of its beverage, no matter if the defects are intrinsic or

extrinsic and more or less compromising.

The use of the most appropriate practices for post-harvesting and processing and storage do not influence the improvement of coffee quality, but they are decisive in maintaining the product quality until commercialization, thus contributing to the fact that this characteristic is not compromised by non-compliance of the procedures and care to be employed, from the simplest to the most elaborate, or even in the correct size of the infrastructure required for each particular case (FONSECA et al., 2007).

2 HARVESTING

As the timing of the coffee harvesting approaches, some precautions should be taken to preserve fruit quality during post-harvesting procedures in order to obtain a more competitive and higher value-added product.

2.1 MATURATION STAGES

To achieve good quality, the fruits must be harvested after they have completed their maturation period. Due to the occurrence of several flowerings, there are fruits at different stages of maturation in the same crop at a specific time (FONSECA; FERRÃO, M.; FERRÃO, R., 2002). In the conilon coffee, there is the advantage that the fruits are more adhered to the plant in comparison to the arabica, not easily falling when mature (RENA et al., 1994). Thus, it is opportune to wait for the moment when the majority of the fruits are ripe to begin the harvest (Figure 1), always beginning with the terrain or the lines formed by the clones with earlier maturation. It is also possible to opt for the selective harvesting of ripe fruits, a system that may be of interest to small family farmers (FONSECA et al., 1995b).

On the other hand, the greater the permanence of the fruits in the crop after their complete maturation, in the tree or on the ground, the greater the incidence of black and red grains considered, together with the greens, the worst defects of the coffee beans due to negatively interfering with the type and quality of the beverage (SILVA, 1999).

Figure 1. Coffee with high ripeness ripeness percentage, under adequate conditions to be harvested.

Green, immature fruits do not present the maximum accumulation of dry matter, nor do they still have the desired balance between their components. Green harvested fruits will, at best, give rise to green grains, which, in addition to being defects that depreciate the type of coffee, weigh much less than normal, and can

significantly reduce production. Matiello (1998) compared weight loss with the harvesting with different percentages of green fruits and concluded that an average of 18.8% of the processed coffee final weight is lost when the harvesting is performed with a green fruits percentage superior to 95%. In arabica coffee, the weight reduction provided by the harvesting of green fruits is even greater, being able to reach values higher than 25%.

Souza, Santos and Venezianos (2005) verified that coffees of the conilon and robusta varieties, harvested with 50% or more of green fruits, always present more than 360 defects, that is, less than acceptable type for consumption.

2.2 HARVESTING METHOD

Harvesting must be carried out on the cloth or on sieves or even by pruning the plagiotropic branches on canvas or on the ground and then collected manually or mechanically. In any case, it should be expected that at least 80% of the fruits are ripe. The fruits so harvested shall not be mixed with those of sweeping, fallen on the ground before the beginning of the harvesting.

After harvesting, the coffee must go through the pre-cleaning process, which consists of removing impurities, such as sticks, stones, dirt, leaves, etc. This operation can be done still in the field, by manual shaking or later in mechanical screens (Figures 2 and 3).

Figure 2. After harvesting, the coffee cleaning in the field.

Figure 3. Mechanical separation of impurities in the field (A), and in the processing unit (B).

The practice of "passing on", that is, harvesting the fruits that remained in the plant - to reduce the infestation of the next harvest fruits by the coffee-borer - and the removal of

those fallen on the ground, is of great importance. However, it is not recommended in any circumstance to join them to hand stripping the coffee because they, due to the prolonged exposure to the environment and/or the contact with the soil and the microbiota in it, have a high probability of fermentation during processing and may depreciate the whole batch of coffee. With regard to coffee borer reinfestation, the fruits that remain in the plant are much more harmful than those fallen on the ground. Thus, good harvesting is an efficient method to control this pest, which is one of the most important, both economically and from the point of view of conilon coffee quality (MATIELLO, 1998).

It is recommended to pack the fruits in sacks made of tow, raffia or baskets, in the harvest and to keep the coffee under the shade, until its transport to the farmyard, that must be done every day. This operation preserves the initial quality of the coffee, avoiding undesirable fermentation. The use plastic bags and leaving the coffee bagged in the garden, is not recommended, not even from one day to the next.

3 POST-HARVESTING PREPARATION OF CONILON COFFEE

Once harvested, post-harvesting processing operations should be started as soon as possible, always on the same day of harvesting.

In the recent past, all Brazilian conilon coffee was prepared exclusively through drought. However, the percentage of so-called PCs or peeled cherries has increased significantly.

Despite the physical, chemical, biological and commercial quality standards differences between arabica and conilon, post-harvesting technologies, which have long been applied to arabica coffee production, could, with some adaptations, be successfully applied to conilon coffee. Currently, some Capixaba producers already work with these technologies and with encouraging results.

In addition to being a major producer of arabica coffee, Espírito Santo is also the state that most develops research and produces technologies to improve the conilon coffee quality. Unfortunately, despite having competence and working seriously in the process of knowledge transfer, the number of small and medium producers that, without a cost evaluation and the technologies offered by the Research/Extension, are directly influenced by the "Outsourced processors" and continue to deliver the production to be processed by them and not being interested in acquiring their own equipment (classifiers, scrubbers, peelers, dryers, processors, etc.) to prepare the coffee in the property.

In this form of partnership, that is, with the post-harvesting operations outsourced, the coffees, without proper care also in the harvesting, remain bagged in disposable containers for several days, close to the crop, before being transported to the farmyard of the "Outsourced processor"until they can enter the drying system. These partners, in order to gain time and bill as much as possible, dry the coffees at very high temperatures, usually above 250 ° C, in rotary dryers, with a drying time of less than 20 hours and without any environmental control, such as is shown in Figure 4.

Figure 4. Type of drying with very high temperatures and lack of environmental control.

In outsourced drying and processing, the coffee grower pays for services and, according to information from a producer of Pinheiros/ES, this payment is made through a discount of 4 kg of coffee per bag processed, and income verification is made at the end of the processing by the "Outsourced Processor" himself.

Considering that the quotation on December 6, 2014, of conilon type 6/7 was R$265,00 the processed, the producer paid the equivalent of R$17,66 or 6.6% of the weight in coffee. So, it is this value, apparently low, that induces the small producer to use the outsourced services and not to consider the quality of conilon that is commercialized, according to Matiello (1998), based only on the sieve value and number of damaged beans.

As the conilon production of southern Bahia and the state of Rondônia has its origins in the experiences acquired by the producers of Espírito Santo, in those states, coffee growers proceed the same way and, most of the times, in even more precarious conditions.

According to Silva, Donzeles and Vitor (2013), the drying cost of arabica coffee, depending on the drying system, was around 8.5% of the processed bag value. Since the amount of energy and other costs involved for the conilon drying should be similar to the arabica coffee drying, there is probably something wrong with the value charged by "Outsourced processors" in Espírito Santo. Besides the low demand concerning quality, the false low cost appearance of drying is what makes the small conilon grower to continue resistant to the adoption of appropriate post-harvesting technologies on the farm. Fortunately, the number of coffee growers adopting their own technologies and equipment has grown, and they already admit that the future basis for the commercialization of conilon will not be made only in number of damaged beans and classification by sieves. Characteristics such as appearance, color, density, bean size and shape, uniformity of drying and beverage may be part of the future commercial classification of conilon destined to the formation of *blends* with arabica coffee.

3.1 DRY PREPARATION

The dry preparation consists of submitting the fruits to drying without removing the mesocarp (or pulp). It is the predominant form of coffee processing in Brazil, whether conilon or arabica. The ideal would be that in coffee dry preparation the washing separator system was used to enable the two types of coffee (cherries and floating beans) to be dried separately. In turn, drying should be started as soon as the coffee is removed from the washer. Special care should be taken so that there is no mixing of different days batches. At the end of the dry drying process, the coffee is called all natural coconut coffee.

Except for hand harvested coffee, which has been washed and dried correctly, it is difficult

to obtain a high quality coffee dry processed. Even performing correctly all the operations, harvesting by removing all the fruit at once makes the denser coffee, which comes out of the washer, to consist of a mixture of ripe fruits and mature fruits or that have not reached complete maturation.

As it is impracticable, in daily practice, this separation of ripe and mature in the dry process, the latter will cause the batch to go from a higher to a lower classification.

3.2 HUMID PREPARATION

Differently from the dry process, in which drying is carried out with the whole fruits, hand stripping or separated in the washer, in the wet preparation, drying will only be performed after the ripe cherries have been peeled. It is also possible, to facilitate the handling during the drying, to remove part of the mucilage adhered to the grains by means of the mechanical mucilage remover. After a correct drying, the coffee beans, protected only by the parchment and the silver layer, are called the PC or peeled cherry (Figure 5). This coffee, when tasted, has a natural flavor and aroma.

Although it requires more initial investments and a processing water disposal system, humid coffee preparation in the long run is more economical and can easily be used with great success by the small Brazilian producer.

Figure 5. In sequence, aspects of conilon coffee with its mucilage removed, natural and peeled cherry.

It can be said that the production of peeled or demucilled cherries, besides quality, has the advantage of needing a smaller farmyard, a lower capacity dryer and, finally, a shorter drying time with a consequent reduction in fuel consumption. Another important factor is the reduction in the amount of containers (bags), the volume of silos or barns, necessary for the storage on the farm and can be reduced by up to 50%. These advantages are due to the removal of the peel, the grains uniformity and the smaller amount of water to be removed during drying, among others.

Verdin Filho et al. (2013) concluded that the humid processing of conilon can lead to a gain of up to 5.8% in the final yield by total weight in a single batch of coffee when compared to the dry process and using a direct fire dryer.

3.3 THE DRYING PROCESS

The conilon drying is a process that requires care so that there is no compromise in the coffee quality.

Although lower concentrations than in arabica, the amount of sugar in the mucilage and

the high initial water content of the conilon (60%), right after after harvesting, makes the deterioration rate at the beginning of the drying process to be high.

3.3.1 Care in drying

Whatever the drying methods used, the following aspects must be observed in order to be successful in post-harvesting operations (SILVA, 2008):

a) Avoiding fermentation before preparation and during the coffee drying.

b) Avoiding high temperature reaching more than 250 °C, as it has been happening with the use of rotary dryers. Studies show that high temperatures have negative effects on chemical composition and physical properties, such as color and density of conilon coffee (FONSECA et al., 2007).

c) Drying the grains, avoiding the harmful effects of temperature in the shortest possible time, until the moisture content of 18% b.u. (below this moisture content, coffee is less susceptible to fast deterioration).

d) Looking for obtain a product which has uniform color, size and density. Preliminary works with the simultaneous harvesting/pruning system carried out by Incaper/UFV/Epamig researchers showed that conilon dried on farmyards and in dryers with temperatures below 60 °C resulted in coffees with physical characteristics very similar to those of arabica after separated by size. After being submitted to the two drying processes mentioned above, the conilon grains, after being processed, presented a green-blue coloration and physical characteristics very similar to those of arabica and therefore, very different from brown coffee, common characteristic of fermented or subjected to rapid drying at high temperatures (really above 100 °C) conilon.

In Brazil, according to the technological aspects involved, two methods are basically used to coffee drying:

- **drying in farmyards**: the product is scattered on the ground, which should preferably be cemented to make the hygiene and repairs easier, and

- **drying in dryers**: regardless of the model, in the mechanical dryers, the heated air is forced by a fan to pass through the coffee and perform the drying.

The grain moisture normally accepted as being suitable for storage and commercialization of conilon is 13%. Excessive drought causes weight loss and grains breakage in the processing, while, on the other hand, the of excess moisture favors the formation of mold (fungi) in storage.

3.3.2 Coffee management on farmyards

When drying is carried out exclusively in farmyards, the quality of the product is more dependent on the climatic conditions prevailing in the region, especially concerning the occurrence of rainfall, temperature, relative humidity and insolation.

Special attention should be payed to avoid undesirable (butyric and propionic) fermentation, which are usually associated with the highest air temperature and humidity conditions and the

time required to dry the beans until they reach the appropriate moisture to be stored. Thus, it is a preparation form that should be used in regions with lower relative humidity, in which the time required for drought is lower, which facilitates the obtaining of good quality natural coffees by favoring the occurrence of lactic and acetic fermentation, which are desirable.

When arriving at the farmyard, preferably after washing and separating the different batches (Figure 6), the coffee should be scattered in thin layers, 3 to 5 cm thick, forming small lines always east-west direction, according to the sun movement (Figure 7). When revolving the coffee, the worker has to be guided by his shadow, which must be projected behind or ahead according to his movement. These furrow need to be "broken" in the longitudinal direction by the action of the squeegees, so that the portion of the farmyard moistened by the furrows becomes exposed to the sun and, thereby, drying and heating the grains more quickly accelerating the process (Figure 7).

Batches with higher percentage of green fruits require special care. They should be spread preferably in the shade, in higher layers, so that they lose more slowly the water excess. Only after the grains are really wilted they should be treated as indicated for the already ripe fruits remembering not to expose them to very high temperatures. This procedure tends to originated the so-called black-green grains, which are more serious defects (2:1) than the green grains. When the grains, still green, are submitted to drying in excessively high temperatures, the film around them becomes black, although its interior remains green. Their identification at the time of classification is done by grain friction on a rough surface.

Figure 6. Washing and separation of green and ripe fruits from the dry ones, by density.

Guarçoni et al. (1998), working in a mechanical dryer with distinct percentages of conilon fruits that were harvested green, demonstrated that the temperature of the conilon coffee mass can be maintained around 60 °C without significant transformation of greens into black-greens. It should be emphasized that the drying temperature in farmyards also needs to be monitored and kept within the recommended limits for the case of the mechanical dryers. There is a need for the coffee to be constantly revolved, along the day, at least every hour, to favor the exchange of water with the atmosphere alternating the fruits location, sometimes more exposed to the sun and sometimes closer to the farmyard surface, especially when the percentage of green grains is high.

Drying, exclusively on the farmyard, under the conditions prevailing in the coffee conilon producing regions of the State of Espírito Santo, requires, on average, 9 to 12 days to complete the process, much shorter time than the required for the arabica coffee drying. This fact is due to the lower mucilage amount found in the *Coffea canephora* species and to the climate conditions found in the arabica producing regions.

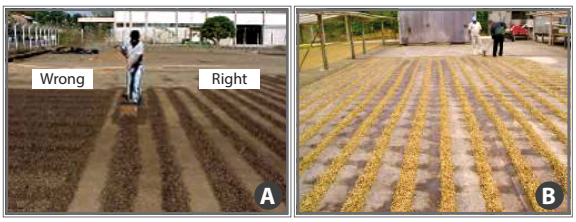

Figure 7. Revolving the furrows looking for exposing the moist parts of the farmyard to the sun (A); and its distribution in the dry and heated parts of the farmyard (B).

However, in places where the prevailing conditions are unfavorable to perform the drying exclusively in the sun, the drying process on farmyards may be associated with mechanical dryers. In any case, when arriving at the farmyard, after washing and separating the batches, the coffee must be immediately scattered for the removal of excess moisture and only taken to the mechanical dryers to finish the process. This avoids, among other problems, the constant clogging of the dryer's ventilation channels, the sharp transformation of greens into black-greens, as well as helping with the important process of "homogenization", which consists in establishing a balance in the water or moisture content between the grains and their inner and outer parts. For greener batches, there is usually a need for longer time on the farmyard.

About three days after the beginning of drying, in the end of the afternoon, furrows of 15 to 20 cm in height should be formed and undone on the day after morning, avoiding the serene to moisture excessively the coffee. In case of rain, larger slopes should be made and always in the declivity direction. These furrows need to be replaced as many times as possible to avoid fermentation.

If the entire drying process takes place on the farmyard after the half drying, it is necessary to make the coffee to be lined up still hot and covered with a layer of used bags and an impermeable cover (plastic canvas) at around 3 pm (Figure 8) to only be uncovered on the day after at 9 o'clock, when the farmyard is already dry and warm. After half dry, the coffee can no longer be moistened by rain or dew. Plastic canvas can be used to cover the coffee during the evening, after half-drying, using underneath them, the crop cloths to avoid wetting the coffee with water condensation. Before this drying point, the use of plastic canvas may favor the occurrence of fermentation and harm the final quality of the product. The process continues until the grains reach 12 to 13% moisture. At this point, the coffee can be collected in the morning, still cold, and taken to the barns, where it should remain in coconut (Figure 9) or parchment (Figure 10), until the moment of its commercialization. Between the end of drying and the processing, the coffee must pass through a rest period of at least one week to favor the standardization of grain moisture process.

A good farmyard should be built with short walls without sharp corners (Figure 11) and fitted with movable partitions (Figure 12) to separate the different batches (floating and mature and peeled).

Figure 8. Heaping coffee still hot in the end of the afternoon.

Figure 9. Coffee conilon in coconut to be stored.

Figure 10. Coffee conilon in parchment to be stored.

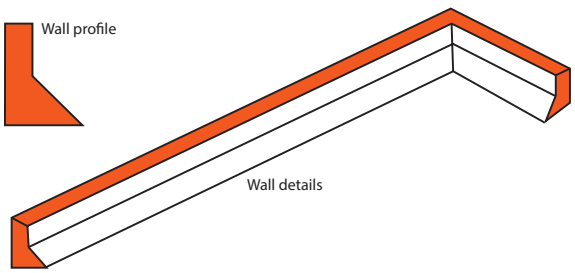

Figure 11. Details of the farmyard lateral wall or fixed partition.

Figure 12. Details of movable partitions for separating different types of coffee.

3.3.2.1 Farmyard Sizing

The farmyard sizing has to be planned and must be done in such a way that the coffee that arrives from the farm can be immediately scattered. There are several ways to estimate the required farmyard area for each particular situation. According to Silva et al. (2001), when information is available, like the number of plants, expected yield and the harvesting period in the region, the farmyard area can be estimated by means of an equation, as in the following case:

If the crop has, for example, 10 thousand plants and each produces an average of 18 liters of coffee, then a total production of 180 thousand liters will be harvested in the period of three months, approximately 75 working days resulting in a daily production of 2,400 liters or 2.4 m^3 of farm coffee.

Assuming an initial layer of coffee in the farmyard equal to 4 cm, in each m^2 will fit 0.04 m^3

of coffee from the farm. And if in the region an average of ten days is spent for the ideal drying of the coffee, it is necessary that the farmyard, for that batch, should have:

$$\mathbf{S = [(2.4\ m^3/day) / (0.04\ m^3 / m^2)] \times 10\ days = 600\ m^2}$$

Or simply by means of the following equation, when we know the average production per plant:

$$\mathbf{S = 3.33 \times P \times T}$$

where:
S = required farmyard area (m^2);
P = average coffee production per plant (liters); and
T = average time for drying in the region (days).

When the farmyard is used only for the pre-drying process, the calculated area above can be reduced to one-third of the calculated total, since the time of use of the farmyard is three to four days.

3.3.2.2 Farmyard construction

The farmyard can be constructed in concrete, asphalt or with ceramic tiles. Concrete construction should be preferred because it lasts longer, easier to handle and has the best cleaning characteristics. Anyhow, the farmyard must be constructed in a place which is dry, ventilated and exposed in the sun (Figure 13), with a slope of 0.5 to 1.5% (SILVA, 1999). It must have short walls without sharp corners (Figure 11) and be provided with movable partitions (Figure 12) to separate the different batches (floating and mature and peeled).

The farmyard wall can also be subdivided into smaller blocks to facilitate the batches separation and contain, in the higher parts, areas protected by short walls, about 5 cm high and shaped like a half moon, that work to heap the coffee, avoiding the rainwater draining under the canvas cover.

Conilon coffee drying in the sun can also be done in suspended yards (Figure 14), covered or not with plastic (Figure 15).

Figure 13. Aspects of a farmyard for drying coffee.

3.3.3 Drying in mechanical dryers

Regardless of the model, in the mechanical dryers, the heated air is forced by a fan to pass through the coffee mass and perform the drying.

More recently, the combined drying has been studied and applied in specific locations for the peeled cherry drying. In this method pre-drying in farmyards or pre-dryers and the complementary drying is performed in silo or dryer barn with natural air. As the importance of

coffee grows with the production increase and with domestic and foreign demand for better quality products, drying with efficient techniques such as combined drying has the following advantages (SILVA, 2008):

Figure 14. Suspended yard.

Figure 15. Covered suspended yard.

a) It allows better programming of the harvesting to obtain the maximum of ripe fruits.

b) Allows storage for longer periods, without the danger of deterioration or loss of coffee quality.

c) Minimizes the product loss in the crop or in farmyards during the rainy periods.

As inappropriate drying negatively affects any type of coffee, the reader should be informed about the moisture content and equilibrium moisture content, air flow and drying speed, coffee

classification and quality, so that it is possible to take full advantage of the drying techniques and reduce production costs.

In general, drying in farmyards is used at least in the initial phase of the coffee drying process. However, in regions with a low drying rate, the exposure of the product to biological agents is unavoidable and generally leads to a reduction in the product quality. On the other hand, even in places where the insolation is favorable, when the hygiene or the correct use of drying in farmyards is not applied, the development of microorganisms on the fruits surface and the product respiration and temperature increase are factors that accelerate the quality deterioration. Also, even when operating the yard correctly, a high probability of unfavorable periods can economically make coffee production unfeasible to compete in the current market, when only the drying in farmyards is used.

3.3.4 Drying in hybrid farmyard or dryer farmyard

For regions where drying in conventional farmyards is not very favorable, the Research Coffee Consortium allowed the development of hybrid farmyard or dryer farmyard (Figure 16) technology to place the newly prepared and moist coffee in 24 hours of pre-drying, in conditions to be brought to the conventional dryer with maximum quality or, after 50 hours of drying, leave the coffee ready for storage. The use of farmyard dryer technology is detailed in Silva et al. (2011), and the details for its construction are found in Silva et al. (2013).

Figure 16. Farmyard dryer with peeled arabica (A); and farmyard still under construction (B) drying natural conilon (Ouro Preto do Oeste/RO).

When it is determined that the objective is to produce coffee with quality and at low cost, the coffee grower should reduce to the maximum the probability of producing batches rated as inferior (in type and beverage). In order to achieve this objective, in addition to working properly all operations before the harvesting, it is necessary to discard or avoid as much as possible any drying technique that depends on the climate conditions.

For the use of any mechanical dryer, it is necessary to observe some important aspects: the first one is the formation of homogeneous batches, that is, with the fruits, approximately, at the same stage of maturation, size and moisture percentage. On the other hand, due to the uneven

conilon fruit size and the fibrous pericarp, peelers, which were designed for arabica coffee, do not work reasonably without the proper adjustments for conilon coffee fruits.

If the harvesting is carried out only with ripe fruit, the production system of the peeled cherry will start being operated more efficiently if between the pre-cleaning and the washer or between the washer and the peeler is adapted to a classifier, such as a rotary sieve, for the separation of fruits by size. With this separation, the cherry peeler cylinder will be operated with the hollow plates appropriate for each class of fruits. The ideal would be to adopt three widths of cracks for the peeling cylinder (SILVA et al., 2013).

So, three classes of cherry peeled by size (large, medium and small) that should in the following operations (drying, storage and processing) be worked and commercialized separately.

During the dryers loading, the fire in the furnace must be extinguished and ascended with the dryer in is already operation, which must work at full load, avoiding heat loss and fuel waste.

After starting the drying procedure, the temperature in the dryer should be increased gradually. Although it is of fundamental importance low temperatures (grain temperature below 40 °C) during the whole drying procedure, especially in the initial stages, in farmyards or in mechanical dryers, the robusta coffee supports, without the same damages that the arabica suffers, temperatures up to 60 °C in the coffee mass, which normally enables to reach proper moisture for storage, about 12 to 13% within approximately from 20 to 22 hours or even a little less than that, in case the coffee has past through an appropriate period of wilting.

Before drying is complete, when the coffee is about 17 to 20% moisture and the beans shake inside the peels, it is advisable to promote a reduction in temperature and keep the dryer in motion, helping to "homogenize" the product.

The most suitable furnaces for the coffee drying are those of indirect fire. Although it requires more time and consumes more fuel for drying, if properly handled, they maintain the desired coffee quality more easily. Dry wood and the type which does not generate smoke must be used in the furnace, otherwise strange smells may be passed on to the coffee, interfering negatively the final quality of the product.

4 STORAGE

After dried, with a maximum moisture content of 13%, the coffee should be stored in jute bags or in bulk in appropriate barns in order to avoid changes in its quality (MATIELO, 1998). Coffee can be stored in coconut or parchment. When stored in coconut, it can be maintained for long periods without loosing its quality, requiring, of course, necessary periodic inspections for corrections and eventual adjustments.

The barns or warehouses, must be constructed in order to store the product away from the sun heat, the light and the rains. It is recommended that they be installed far from ravines and leafy trees, in sunny locations and of easy access. The barns should preferably be made of wood, with a high floor and properly isolated from the ground and with a ceiling of at least 5

m. They must have internal divisions to allow lateral ventilation, with marquees on each of the external parts and should not allow the entrance of animals and birds.

In barns with cement floor and walls, it is necessary that the coffee be deposited on wooden floors, since the cement is not waterproof and does not work as a thermal insulator. The heaps must be made considering the necessity of their distance from the walls, as well as spaces for the necessary internal circulation.

Coffee should not be stored together with other products, especially fertilizers, agricultural pesticides and fuels, as it may absorb undesirable odor, hampering its quality.

Petracco (2002) warns about the importance of preventing the occurrence of fungi in coffee (mold formation). The development of these organisms is associated with the lack of maintenance of the recommended moisture for the correct storage of the beans. However, he affirms that fruit contamination may occur during the harvesting or in post-harvesting operations, regardless of the form of preparation used in both arabica and conilon or robusta coffee.

Taniwaki et al. (2005) verified that the increase in ochratoxin A concentration is proportional to the increase in the number of defects in both arabica and conilon coffee.

In short, it can be said that, for a safe coffee storage, it should:

- Avoid moist locations for the construction of post-harvesting processing facilities;
- Waterproof walls, floors and roofs;
- Design the roof in order to minimize the heat transfer;
- Avoid direct contact of the product with the warehouse walls and floors;
- Properly sanitize equipment, deposits, barns and warehouses, separating waste and avoiding the accumulation of dirt and disposed materials before starting the storage;
- Keep a pest control program;
- Use products (fumigants and insecticides) allowed by legislation and in the recommended quantities;
- Prevent re-contamination, avoiding the contact of processed coffees with peel, dust and damaged packaging or never leave coffee in contact with disposed material;
- Continuously monitor temperature and moisture content during storage at regular intervals so that the relative humidity of the air within the grain mass is kept below 70% throughout the entire storage period;
- Design the roof in order to minimize the heat transfer;
- Avoid re-moisture of the coffee inside the barn or warehouse;
- Separate product portions, apparently contaminated by fungi and send them for analysis.
- Maintain uniform valuesof moisture content in all coffee masses around 13% b.u. In measuring, use calibrated equipment.

Before the commercialization, it is essential that the classification of the product is made to give greater security to the producer at the moment of the negotiation. The coffee price depends on the following aspects associated with beans: income (relation between the dried and processed fruits), moisture, bean size, aspect, color, uniformity and, mainly, type and beverage (FONSECA et al., 1995a).

Processing should only be done after the decision to commercialize the product, since in this condition the quality losses are intensified.

5 REFERENCES

CORRÊA, P. C.; OLIVEIRA, G. H. H. de ; BOTELHO, F. M. *Armazenamento*. In: FONSECA, A. F. A da; SAKIYAMA, N. S.; BORÉM, A. (Eds.). *Café conilon*: do plantio à colheita. Viçosa, MG: UFV. p: 231-257. 2015.

FONSECA, A. F. A. da; FERRÃO, M. A. G.; FERRÃO, R. G. A cultura do café robusta. In: SIMPÓSIO DE PESQUISA DOS CAFÉS DO BRASIL, 1., 2000, Poços de Caldas, MG. *Palestras*... Brasília: Embrapa Café: CBP&D/Café, p. 119-145. 2002.

FONSECA, A. F. A. da; SARAIVA, J. S. T; BRAGANÇA, S. M; BREGONCI, I. S.; PELISSARI, S. A. Classificação, In: COSTA, E. B. da (Ed.). *Manual técnico para a cultura do café no Estado do Espírito Santo*. Vitória, ES: SEAG-ES, p. 131-135. 1995a.

FONSECA, A. F. A. da; SARAIVA, J. S. T; BRAGANÇA, S. M; BREGONCI, I. S.; PELISSARI, S.A. Colheita, preparo e armazenamento. In: COSTA, E. B. da (Ed.). *Manual técnico para a cultura do café no Estado do Espírito Santo*. Vitória, ES: SEAG-ES, p. 121-130. 1995b.

FONSECA, A. F. A. da; FERRÃO, R. G.; FERRÃO, M. A. G.; VERDIN FILHO, A. C.; VOLPI, P. S. Qualidade do café conilon: operações de colheita e pós-colheita. In: FERRÃO, R. G.; FONSECA, A. F. A. da; BRAGANÇA, S. M.; FERRÃO, M. A. G.; De MUNER, L. H. (Eds.). *Café conilon*. Vitória, ES: Incaper, 702p. 2007.

GUARÇONI, R.; SILVA, J. N.; FONSECA, A. F. A. da; SILVEIRA, J. S. M. Influência de distintos percentuais de frutos colhidos verdes no rendimento do café conilon. *Revista Brasileira de Engenharia Agrícola*, v. 17, n. 13, p. 105-109. 1998.

MATIELLO, J. B. *Café conillon*. Rio de Janeiro: MAA; SDR; PROCAFÉ; PNFC, 1998.162 p.

PETRACCO, M. Melhoramento da qualidade do café pelo combate ao crescimento de mofos. In: SIMPÓSIO DE PESQUISA DOS CAFÉS DO BRASIL, 1., 2000, Poços de Caldas, MG. *Palestras*... Brasília, DF: Embrapa Café/CBP&D/Café, p. 22-38. 2002.

RENA, A. B.; BARROS, R. S.; MAESTRI, M.; SÖNDAHL, M. R. In: SCHAFFER, B.; ANDERSEN, P. C. (Eds.). *Handbook of environmental physiolohy of fruit crops. II. Sub-tropical and tropical crops*. USA: CRC Press, v. 2, Cap. 5, p. 101-122. 1994.

SILVA, J. S. Colheita, secagem e armazenamento do café. In: ZAMBOLIM, L. (Ed.). *Encontro sobre produção de café com qualidade*. Livro de Palestras. Viçosa: UFV, Departamento de Fitopatologia, pt 3, p. 39-80. 1999.

SILVA, J. S. *Secagem e armazenagem de produtos agrícolas*. Viçosa, MG: Aprenda Fácil, 2008. 560 p.

SILVA, J. S.; DONZELES, S. M. L.; VITOR, D. G. *Construção e utilização do terreiro híbrido para a secagem de café*. Brasília, DF: Embrapa Café - Café - Consórcio Pesquisa Café. n. 2, 2013, 8 p. (Comunicado técnico. Embrapa).

SILVA, J. S.; MORELI, A. P.; VERDIN FILHO, A. C. 2015. *Tecnologias pós-colheita para conilon de qualidade*. In: FONSECA, A. F. A. da; SAKIYAMA, N.S.; BORÉM, A. (Eds.). Café conilon: do plantio à colheita. Viçosa, MG: UFV. p. 204-230. 2015.

SILVA, J. S.; SAMPAIO, C. P.; MACHADO, M. C.; MONACO, P. A. Preparo, secagem e armazenagem, In: SILVA, J. de S. (Ed.). *Secagem e armazenagem de café*. Viçosa, MG: UFV, CBP&D/Café, p. 1-60. 2001. Cap 1.

SILVA, J. S.; LOPEZ , R. P.; DONZELES, S. M. L.; COSTA, C. A. da. *Infraestrutura mínima para produção de café com qualidade*: opção para cafeicultura familiar. Brasília, DF: Consórcio Pesquisa Café, 2011. 69 p.

SILVA, J. S.; MORELI, A. P. ; SOARES, S. F.; DONZELES, S. M. L. VITOR, D. G. *Produção de café cereja descascado* - Equipamentos e custo de processamento. Brasília, DF: Embrapa Café - Café - Consórcio Pesquisa Café. n. 41, 2013, 16 p. (Comunicado Técnico. Embrapa).

SOUZA, F. S., SANTOS, M. M., VENEZIANO, W. Análise de qualidade de grãos em duas variedades de café robusta, preparados por via seca com diferentes percentuais de maturação à colheita In: SIMPÓSIO DE PESQUISA DOS CAFÉS DO BRASIL, 4., 2005, Londrina, PR. *Anais*... Brasília, DF: 2005. 1 CD-ROOM.

TANIWAKI, M. H.;TEIXEIRA, A. A.; IAMANAKA, B. T.; FREITAS, M. L. Micobiota e incidência de ocratoxina A nos cafés com defeitos. In: SIMPÓSIO DE PESQUISA DOS CAFÉS DO BRASIL, 4., 2005, Londrina, PR. *Anais*... Brasília, DF: 2005. 1 CD-ROOM.

VERDIN FILHO, A. C.; MAURI, A. L.; FONSECA, A. F. A. da; FERRÃO, R. G.; FERRÃO, M. A. G.; VOLPI, P. S.; RODRIGUES, W. N.; ANDRADE, S. Rendimento do café conilon em função das formas de processamento e secagem. In: SIMPÓSIO DE PESQUISA DOS CAFÉS DO BRASIL, 7., 2013, Salvador, BA. *Anais*... Brasília, DF: 2013. 1 CD-ROOM.

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