CONILON Coffee

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Updated and expanded

The Coffea canephora produced in Brazil

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Quality and Classification of Conilon Coffee

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1 INTRODUCTION

The search for quality is one of the main concerns in the various productive segments in Brazil, and particularly in the conilon coffee production chain, where great attention has also been giving in order to obtain a coffee that is compatible with the contemporary market demands. The results obtained so far characterize very significant advances in the product quality and have given it an increasingly important presence in the different forms of coffee consumption around the world (FERRÃO et al., 2013; SILVA; MORELLI; VERDIN FILHO, 2015).

The necessary care for the production of quality coffees, whether arabica or conilon, begins even before planting, when choosing the most appropriate areas for cultivation, defining the cultivar, the cultivation system, and the planting and management operations. After the implementation and proper management of crops, the efforts to achieve a better coffee quality standard should be concentrated, mainly, on pre-harvesting, harvesting and post-harvesting operations, focusing especially on factors that most interfere in the quality of the product, in each particular region (FONSECA; SILVEIRA; BRAGANÇA, 1995), with the purpose of reducing to the max its negative influence (CARVALHO, 1998; ABIC, 2004; BORÉM, 2008).

Also important for the quality of the coffee to be commercialized are the conditions for the beans storage, since naturally, coffee tends to lose its quality over time. Thus, it becomes of fundamental importance the full knowledge of the variables involved in this stage aiming to maintain the beans quality as close as possible to their initial conditions (CORRÊA; OLIVEIRA; BOTELHO, 2015).

Thus, the evaluation of the attributes of a particular coffee becomes essential for the proper marketing of the product all over the world. The clear, objective and standardized evidence of its most striking aspects assume great importance for the product dissemination and can give it a fairer price. For this reason, the processes of coffees evaluation and classification, following protocols accepted by all segments of the chain in different parts of the world, are constantly being improved and extended, with due restrictions, to the species *Coffea arabica* and *Coffea canephora*, so that they can reach more demanding markets that recognize and better pay for the aggregation of certain characteristics required in the different parts of the world by the beverage consumers.

The coffee quality can be influenced by a set of factors that interfere in its physical properties, as well as in the chemical composition of the beans, among which it is possible to point out the genetic characteristics (species and cultivar), environmental conditions (soil, climate, altitude, exposure to the sun), cultural (management, spacing, pest and disease control, irrigation use), harvesting method (selective harvesting, strip harvesting on the ground or with the use of sieves), post harvesting treatment (dry or wet process, peeled or demucilated, drying method), the storage, processing and even transport (CLIFFORD, 1985a; PRETE, 1992; TEIXEIRA, ALDIR; TEIXEIRA, ANA, 2001; MACÍAS; RIAÑO, 2002; MALTA; NOGUEIRA; GUIMARÃES, 2002; MALTA et al., 2003; CHAGAS; MALTA; PEREIRA, 2005; BORÉM et al., 2008; EUGÊNIO, 2011; CORRÊA; OLIVEIRA; BOTELHO, 2015).

The sensory quality of the coffee beverage is, as a rule, defined by its aroma and flavor developed during roasting, from precursors present in the raw beans made up of several chemical compounds. The presence of these precursors depends, in turn, on genetic, environmental and technological factors interacting in the course of the production process, and their transformation into aromatic compounds is very dependent on the conditions under which the roast is made (BORÉM et al., 2008).

Despite the unquestionable importance of characterizing the beverage to classify a coffee, whether it be *C. arabica* or *C. Canephora*, this should not be the only criterion to define the quality, since it involves a number of other aspects that need to be considered together. There are no absolute criteria to properly define the quality of a coffee considering the points of view of all the segments involved (RIBEYRE, 2007).

In this way, the quality of a coffee, in general, is defined considering from the intrinsic attributes of the product to the characteristics of the process through which it was obtained. Some quality attributes of green coffees are related to physical characteristics, such as bean size (sieve) and number of defects (type) in the sample; to sensory characteristics such as bitterness, acidity and sweetness, and technological characteristics like extractability. The economic, social (fair trade) and environmental factors (organic and ecological coffees) as well as production processes (good agricultural practices) are also used as criteria for the quality definition. The descriptions related to the criteria considered to guarantee the food safety of the product may also be appropriate (TEIXEIRA; ALDIR; TEIXEIRA; ANA, 2001; RIBEYRE, 2007; BORÉM et al., 2008).

A coffee is classified as good quality, when it meets the criteria established by the buyers who, by properly valuing the product of their interest, stimulate investments to obtain and maintain the quality, as well as the offer stability. Palacin et al. (2005) summarize that the quality of a coffee in the market can be defined as being the sum of the presence of all the attributes that satisfy the consumer's needs.

The species *C. canephora*, although introduced in Brazil at the beginning of the 20th century, only began to be commercially exploited from the 60s (FONSECA, 1999; FERRÃO M.; FERRÃO R., 2002). Its greatest expression came more effectively from 1970. This species cultivation has been expanding remarkably in recent years due to its increasingly frequent and expressive participation in the blends of roasted and ground coffee and the significant increase in the consumption of soluble coffee all over the world, as well as the appearance of a number of alternative forms of consumption, bearing in mind that *C. canephora* is more attractive to industries due to its higher profitability in the production of these consumption forms (FONSECA et al., 2015).

The species, contrary to what may seem at first, gives the final product an expressive capacity of competition in the market, having in mind its higher industrial yield and its properties, which can substantially aid in the final composition of *blends*, with more balanced acidity, more pronounced body and thicker cream in *espresso* coffees, as well as in its commercialization, due to lower prices in the market compared to the arabica coffees (FONSECA, 1999; FONSECA et al., 2015). It can also be used in the production of cakes, candies, sweets, ice creams, biscuits, in the composition of isotonic or alcoholic *drinks*, in cold drinks, ready for consumption or in sachets and even in cosmetics, among other uses.

This chapter aims to discuss the issues related to the quality and classification of conilon coffee, focusing, especially, on its physical, chemical and sensory properties and seeking, naturally, to establish parallels with arabica coffee, in addition to paying attention to the peculiar characteristics of *C. canephora*.

2 THE IMPORTANCE OF COFFEE QUALITY AND CLASSIFICATION

2.1 HISTORY

The coffee classification in Brazil began in the nineteenth century, more precisely in 1836. The first classification reference was regulated in the then Province of Rio de Janeiro, with the Law 33, which already tried to qualify the coffee in categories for its physical aspects, that is, color and beans integrity. In general, for a long time, the coffees were designated by the ports of embarkation, and those coming from Brazil were known as: Rio coffees, Santos coffees, Bahia coffees and Ceará coffees (TEIXEIRA; PEREIRA; PINTO, 1974).

In the international market, the milestone for the definition of evaluation criteria for the coffee beans quality was in the USA, a major buyer of the product, and where the New York Stock Exchange in 1885 established a table for the classification of Brazilian coffees. It was based on counting the defects eventually contained in processed coffee samples. In this way, a definition of quality was created by types possible of being measured and expressed in figures. This table divided coffee into nine types. Types 10 and 9 were suppressed a few years later, when it was forbiden the entrance of worse coffees than type 8 in that country. This prohibition was reflected in Brazil through a Federal Decree (Nº 19.318 from August 27th, 1930), in which it was prohibited to transport, trade and export coffee inferior than type 8 (TEIXEIRA; PEREIRA; PINTO, 1974).

The consolidation of the use of the "Defect Equivalence" tables and classification by type, currently adopted, occurred through Decree Nº 27.173 from September 14th, 1949 (BRASIL, 1949), which repealed all the previous ones and determined the use of the tables adopted in the port of Santos, since 1907 (TEIXEIRA; PEREIRA; PINTO, 1974).

Also established in the mentioned decree, the classification "by description", in which, in one of the items, defined the evaluation of the coffee beverage quality through tasting. At that time, it only classified as a"soft" beverage and taste free "Rio" (TOLEDO, 1998). However, the evaluation of the arabica coffee drink through the "coffee cupping" has been carried out since 1917, three years after the installation of the Bolsa Oficial de Café e Mercadorias de Santos (Santos Official Coffee and Commodities Exchange) (SILVA, 2005).

In 1952, the newly created Instituto Brasileiro de Café - IBC (Brazilian Coffee Institute) assumed the function of establishing coffee policy in Brazil, also accumulating the function of controlling and regulating the type and quality of coffee in the domestic and international markets (TEIXEIRA; PEREIRA; PINTO, 1974). This Institute established in 1971 by 535 resolution, the broader classification for arabica coffee beverage (*C. arabica* L.) as a fine beverage with its subgroups and phenicated drinks, also with its subgroups and presenting a typical taste of iodoform in distinct graduation (SILVA, 2005). These documents constitute the methodological basis used by many professionals for the coffee classification.

The coffees mix to obtain *blends*, being of the same species or not, is a common practice of the Brazilian industry. This procedure is adopted for a number of reasons, such as to achieve greater production uniformity, more balanced products, or even cost reductions, since the price of the conilon bean is routinely below that of the arabica bean (FERNANDES et al., 2003). The fact that the beans after roasting and milling are indistinguishable provide this mixture (DIAS, 2005). Conilon coffee is added to arabica in order to obtain more balanced *blends* and rich in certain characteristics that are peculiar to them, helping to reduce industrialization cost with a consequent increase in income (EUGENIO, 2011).

In recent years, the requirement for quality conilon coffee has been considerably increasing, which requires actions to characterize and recognize the beans of this species quality. A number of quality contests have already been held for conilon in the State of Espírito Santo, some of which include the criterion of beverage evaluation. Since 2003, one of the most traditional farmers' cooperatives, the Cooperativa Agrária dos Cafeicultores de São Gabriel da Palha -Cooabriel (Agricultural Cooperative of the Coffee Farmers of São Gabriel da Palha), has been conducting a quality contest specifically for the conilon.

Several protocols or evaluation methodologies have been used to evaluate the conilon beverage quality, which makes it difficult to reach a consensus or standardization of adopted criteria, being the buyers responsibility to establish their evaluation criteria, often misunderstood by their suppliers, considering that each company often has its own protocol or regulation for quality standardization.

Cortez (2000) proposed a specific methodology for the classification of *C. canephora* coffees. However, this proposal was not considered when, in 2003, through the Normative Instruction Nº 8 of June 11, 2003, a type table was defined for the two species and it was suggested to classify the conilon coffee beverage defining them by the attributes Excellent, Good, Regular or Abnormal (BRASIL, 2003). Obviously, an insufficient characterization to meet the requirements for the constitution of an identity for this species, especially when considering the aspects most related to the production of soluble coffee, in which other characteristics that are decisive for the product valuation need to be considered.

The Specialty Coffee Association of America (SCAA), published the book *The Coffee Cuppers' Handbook* (LINGLE, 2011), which establishes an evaluation protocol of coffee qualities, which is already being widely used for arabica coffee in Brazil . What contributes to a standardization of the evaluation, however, does little to contribute to the perception of a proper identity for conilon coffee, since it is common for arabica coffee traditional tasters to seek analogy of flavors between the two species, which ends up implying inferior notes to the conilon.

Robusta or conilon coffee has historically been less valued than arabica, both domestically and internationally, because it was mistakenly considered to be a worse quality product, which is why it did not receive the same price awards and motivation for quality improvement, common in the market of specialty arabica coffee. Much of the conilon coffee reputation, however, is the result of defects that can be fully corrected, since most of them come from factors related to its cultivation, harvesting and processing (CQI/UCDA, 2015).

The *Coffee Quality Institute* (CQI), a nonprofit organization founded in 1996 by Ted Lingle and others, began its operations in several coffee producing regions around the world searching for promoting the development of nations and the coffee growers quality of life by improving the quality of the product, carrying out various training and quality evaluation actions. To meet the demand of the *C. canephora* producing countries its protocol was adapted with the cooperation of the *Ugandan Coffee Development Authority* (UCDA). Thus, the first specific protocol for evaluating *C. canephora* coffees was created, and it will be referred in this publication as CQI (CQI/UCDA, 2015).

As proven by the success in the market of specialty arabicas, the differentiation of quality for the robusta can increase consumer appreciation and rise the consumption, as well as provide better income for the producers and the necessary incentive to further advances of the coffee industry. Coffees classified according to the CQI criteria may receive a quality certification issued by the institution, through a licensing agreement and accreditation of evaluators, providing them with the best and fairest marketing conditions (CQI/UCDA, 2015).

There is, in the State of Espírito Santo, a network of classification centers installed in partnership between the Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão - Incaper (Capixaba Institute for Research, Technical Assistance and Rural Extension) and city halls and cooperatives. These centers aim at the descriptive physical and sensory classification of coffee, but only a small part of their rooms are dedicated to the conilon classification. The initiative has been contributing significantly to encourage the production of better quality coffee in Espírito Santo. The reports issued attesting the classification of each sample analyzed allow the responsible technician to indicate the main measures to be adopted by the coffee growers so that the defects found can be avoided during the production, harvesting and post-harvesting processes of the next crops.

It is worth mentioning that the great current challenge is to constitute an identity for conilon coffee respecting its own characteristics, discovering a number of organoleptic attributes, recognizing its potential and giving due value to its quality.

2.2 QUALITY ATTRIBUTES FOR CONILON COFFEE

It is quite common among Brazilian conilon coffee producers the belief that the product quality improvement does not reflect significant price differences. The analysis to be made, however, must take into account, at the same time, a number of other aspects.

It is essential to consider that the coffee market in the world has become increasingly demanding and that, both the current markets recovery and the increasingly number of new buyers and the greater participation of conilon in all forms of coffee consumption, require that the preferences of these markets are observed, that they have many alternatives of competitive suppliers and quite in tune with such demands. In addition, it is necessary to consider, also, that the great majority of the attitudes that mean an improvement of the coffee quality does not demand so expressive additional costs as to make it impossible to meet the current demands and that, when it evolves in quality, there is a parallel increase in the productivity reached, since all the defects that compromise the coffee beans quality become, substantially lighter than the normal beans (FONSECA et al., 2007).

The conilon quality should not be understood exclusively as a criterion related to the characteristics of the beverage (cup), but must also involve other criteria required or even imposed by the market, that is, the product quality should be evaluated taking into account a set of attributes (RIBEYRE, 2003; PALACIN et al., 2005).

According to Ribeyre (2003), the main attributes that have been considered in the most demanding markets for the definition of conilon coffee quality have been: a) physical characteristics (e.g. beans defects); b) beverage characteristics (e.g., body and bitterness); c) technological characteristics (extractability); d) social criteria observed in the production process; e) criteria regarding the environment; f) food security; g) constant and stable offer; (h) origin; and i) price.

Figure 1, presented by Ribeyre (2003), illustrates some of the striking features in the distinction between the conilon coffee and the arabica coffee. It is observed that, while the arabica has higher acidity and fruity flavors, the conilon is characterized by a much more pronounced body, as well as greater astringency and greater bitterness.

Additionally, special attention has been given to other criteria related especially to the bean composition (caffeine content, chlorogenic acids content, trigonelline, proteins, sugars and minerals). Additionally, Palacin et al., (2005) affirm that there has been increasing concern about food safety, which in this way constitutes an important factor as a qualitative standard of coffee.

Although not yet payed with as significant prices as in the case of better quality arabica coffees, numerous and efficient ways of improving the conilon quality in relation to more traditional forms of coffee production. There are records in the State of Espírito Santo of differentiated quality of conilon coffee commercialization with payment of goodwill of the order of 10% to 20%, regardless of the method of preparation, that is, whether it is a peeled cherry

(PC) or natural, dried in cement yards or in greenhouses coffees. Nevertheless, undoubtedly wet processing in the production of conilon PC, whether demucilated or not, is a form which greatly facilitates the reaching of the desired quality. This is due to the fact that it provides a reduction in the risk of product depreciation, which occurs when processing to obtain natural coffees, and therefore has also been commercialized expressively overpriced (SILVA; MORELLI; VERDIN FILHO, 2015).

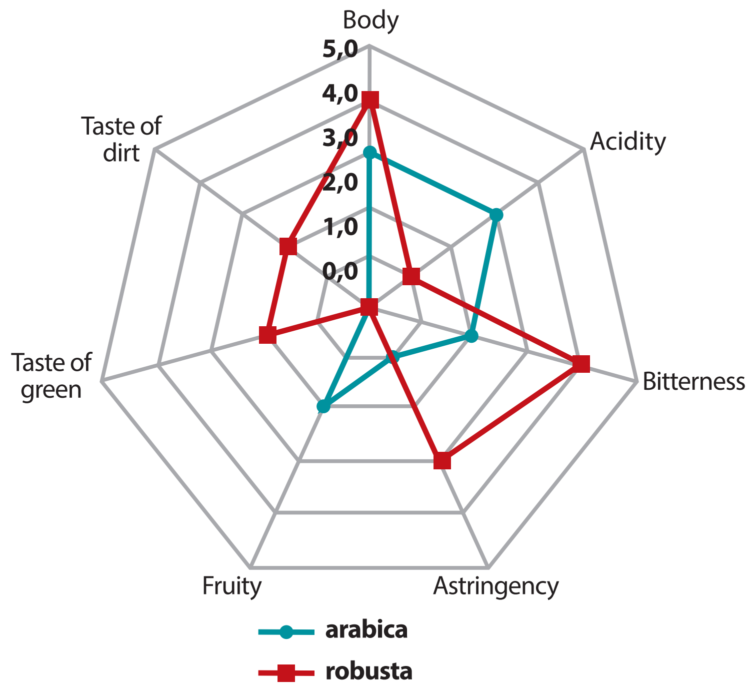

Figure 1. Some emblematic differentiation characteristics between arabica and robusta coffees.
Source: Adapted from Ribeyre (2003).

Even though it is not possible for certain coffee growers to use all the technologies and recommendations presented in this work to improve the conilon quality, especially those in Chapter 20, "Conilon Coffee Harvesting and Post-harvesting", the adoption, even only of few of them, will result in continuous evolution, although in a gradual way aiming at the loyalty of the already existing market and opening of new market opportunities, with the obtaining of a product of differentiated quality (FONSECA et al., 1995).

It is desirable that there be an awakening of coffee growers with regard to appropriate practices in the stages of coffee production so that there is an increasing progress in the activity as a whole, from production to consumption.

3 QUALITY EVALUATION AND CLASSIFICATION OF CONILON COFFEE

As previously mentioned, whether for arabica or robusta coffee, a number of characteristics can be used for assessing product quality including color, shape, processing methods, presence of defects, size and beans uniformity (sieves) and chemical and sensory characteristics (CLARKE;

MACRAE, 1987; BANKS; MCFADDEN; ATKINSON, 1999; FRANCA et al., 2005).

In the evaluations of color quality, aspects related to the bean moisture content, maturation index, time of exposure to light, method of preparation and drying and conditions of the storage environment are considered. Regarding the sieve, the beans size and shape are considered. The aspect takes into account the homogeneity of the characteristics. However, among them, the most important are the evaluations regarding type, sieves and beverage, routinely used in the commercialization of coffee worldwide (CLARKE; MACRAE, 1987; BANKS; MCFADDEN; ATKINSON, 1999; FRANCA et al. al., 2005). These operations details are presented below.

The relative importance of each characteristic lies in the intended purpose of the product, whether for the soluble coffee production, roasted for *espresso*, roasted and ground, pure or for *blends*, among others.

3.1 GENERAL ASPECTS OF THE BRAZILIAN OFFICIAL CLASSIFICATION FOR COFFEE (COB)

The Brazilian Official Classification for Coffee (COB), regulated by Normative Instruction Nº 8, dated June 11, 2003, of Mapa (BRASIL, 2003), aims to define identity and quality characteristics for the processed coffee classification. The processed raw coffee bean is classified according to:

Category. Coffee of the species *C. arabica*: category I; coffee of the species *C. canephora*: category II;

Subcategory. It concerns the raw bean shape: flat or mocha. Each subcategory can also be subdivided according to the sieve (large flat: sieves 19/18 and 17, medium flat: sieves 16 and 15 and small flat: sieves 14 and smaller); large mocha: sieves 13/12 and 11; medium mocha: sieves 10; and small sieves 9 and smaller.

When the coffee is not subjected to separation according to beans size, or when it fits in four or more sieves, it will be considered 'bica corrida' (when the coffee has no sieve separation, or does not fit into four or more sieves)((B/C);

Group. According to the flavor and aroma through "coffee cupping" (Group I: arabica coffees and Group II: robusta/conilon coffees).

Subgroup. According to the beverage quality, the coffee beans robusta/conilon (Group II) can be classified into four subgroups: Excellent, Good, Regular and Abnormal.

Class. Regarding the color: Blue-green and cane-green, Green, Yellowish, Yellow, Brown, Lead, Whitish or Discrepant.

Type. Regarding the number of defects; Intrinsic and extrinsic, present in 300 g of raw beans samples.

Moisture. Regardless classification, the moisture content of raw coffee may not exceed 12.5%.

This Normative Instruction also addresses a number of important issues in product classification: maximum permitted percentages of foreign materials and impurities, items that may disqualify coffee, packaging, labeling, sampling, etc. In addition, it provides a road map for the entire classification and certification process.

The coffee classification as the type, sieve and beverage quality, systematically involves a series of categorizations previously related. And due to the particularities that should guide the conilon coffee classification, will be discussed in more detail in this chapter.

Several alternative proposal of classification have been gaining ground, and becoming frequently used in routine analyses of the product aiming at both domestic and, mostly, international market. Some of these alternatives, which seek to obtain and value premium coffees, of different quality and that meet the preference of more demanding markets and that are willing to pay the prices that properly compensate this effort, have been gaining great credibility among roasters and consumers and, for this reason, they must also receive adequate attention from the productive sector, that may reach, in addition to competitiveness and income increase, the expansion and entering into new markets and the loyalty of the existing ones.

3.2 CLASSIFICATION BY TYPE

The coffee type, according to the Normative Instruction of Mapa (BRASIL, 2003), is defined regarding the number of defects identified in a sample of 300 g of the processed product. In this respect, it can be classified into types ranging from 2 to 8. Coffee with up to four defects are classified as type 2, while those with up to 360 defects as type 8. When they have more than 360 defects, they are considered improper for consumption.

The term 'defect' is used here to denote the presence of defective beans, such as black, green, burnt, perforated, as well as the existence of foreign materials in the samples, such as sticks, stones and clods (BRASIL, 2003).

Thus, the classification by type is based on a sample of 300 g of processed coffee, carefully collected in a representative batch. The classifier evaluates this sample by separating the defects to be counted according to the official equivalence table of intrinsic and extrinsic defects (Table 1). Intrinsic defects are inherent to beans, such as: black, green, burnt, black-green, perforated, broken. And the extrinsic defects refer to the impurities, like: stick, stone, clod, skin, coco etc. Based on the defects count, the official classification by type is done (Table 2), (BRASIL, 2003).

Table 1. Processed coffee classification from the equivalence of intrinsic and extrinsic defects (impurities)

(to be continued)

Defects	Quantity	Equivalence
1) Intrinsic:		
- Black bean	1	1
- Burnt beans	2	1
- Shells	3	1
- Green beans	5	1
- Broken beans	5	1
- Perforated beans	2 a 5	1
- Wilted beans	5	1

(conclusion)		
Defects	**Quantity**	**Equivalence**
2) Extrinsic (impurities):		
- Coco	1	1
- Beans with remaining parchment	2	1
- Stick, stone, large clod	1	5
- Stick, stone, medium clod	1	2
- Stick, stone, small clod	1	1
- Large skin	1	1
- Small skins	2 a 3	1

Source: Brasil (2003).

Table 2. Official classification of the processed coffee as to the type regarding the defects in sample of 300 g

Type	Number of defects/300 g
2	4
2/3	8
3	12
3/4	19
4	26
4/5	36
5	46
5/6	66
6	86
6/7	123
7	160
7/8	260
8	360
Out of type	Over 360

Source: Adapted from Brasil (2003).

Due to the fact that this classification was based on parameters studied for arabica coffee, Cortez (2000), based on a series of specific properties of robusta coffee, proposed a new classification table for *C. canephora*, in which the categories (2 to 8) are kept and increases the number of defects for each of them. The author proposed the following classification: a) type 2 - up to 6 defects; type 3 - up to 12 defects; type 4 - up to 25 defects; type 4 - up to 50 defects; type 5 - up to 100 defects; type 6 - up to 200 defects; type 7 - up to 400 defects; and type below 8 - above 400 defects. It should be emphasized that this proposal has not been routinely used, although it has been useful in alerting to the need for a particular classification of robusta/ conilon.

The CQI recommends a beverage classification adapted to the conilon coffee for the this species beverage quality, following, however, literally the table of points and defects equivalence of COB (BRAZI, 2003).

The presence of certain defects is almost always related to problems occurring at all production stages, but especially in the harvesting, processing, drying and storage.

Black beans result from physiologically immature fruits of cherry coffee (CLARKE; MACRAE, 1987; FRANCA et al., 2005) or from fruits that fall naturally on the ground due to rainfall or ramaines on the coffee tree longer than the ideal harvesting time (MAZZAFERA, 1999; FRANCA et al., 2005). However, the presence of burnt beans may be associated with excessive fermentation (CLARKE; MACRAE, 1987; FRANCA et al., 2005) and inappropriate drying (SIVETZ; DEROSIER, 1979; FRANCA et al., 2005).

The green beans come from still immature harvested fruits, whereas the black-green beans are those derived from green harvested fruits, fermented or submitted to incorrect drying, at a temperature higher than those recommended (GUARÇONI, 1995; MAZZAFERA, 1999; GUARÇONI et al., 1998; FRANCA et al., 2005).

Defects such as black, green and burnt beans are responsible for significant weight loss of beans in conilon coffee (GUARÇONI, 1995), and are also known to significantly affect the quality of the beverage and are generally referred to as PVA. When present in processed samples, they compromise the beverage aroma and flavor, significantly hampering its quality (CLARKE; MACRAE, 1987; FRANCA et al., 2005). Studying the effect of the inclusion of defective beans in the chemical composition and quality of arabica coffee "strictly soft", Pereira (1997) found that the inclusion of these beans influences the beverage quality and alters the sensory characteristics after roasting.

Works conducted in the State of Espírito Santo in the harvests of 1992 and 1993 showed, at the time, that perforated, green, wilted, and black defects significantly compromised the conilon coffee type produced in the State, of which the first two were responsible by an average of 48.34% and 13.06% of the total intrinsic defects identified in 50 samples collected in 40 municipalities of the State (FONSECA; SILVEIRA; BRAGANÇA, 1995).

These data allowed to direct the technical assistance and rural extension efforts to the most significant defects, so that the activity could glimpse more demanding markets for premium quality coffee in the next harvest. A stratification of the main defects that interfered more significantly in the quality of the coffee produced in the 40 municipalities with more expressive productions in the State (SILVEIRA; FONSECA; DESSAUNE FILHO, 1996) was carried out, so that in each municipality the relative importance of each of the four major defects raised in the 1992 and 1993 harvests (FONSECA; SILVEIRA; BRAGANÇA, 1995).

The stratification obtained allowed directing the actions of technical assistance and rural extension providing more specific guidelines to the coffee growers of each municipality or region, so that they could focus their efforts on minimizing the most frequent problems to improve product quality (SILVEIRA; FONSECA, et al., 1996). This direction undoubtedly led to a positive response for coffee quality, so that in a subsequent survey carried out in municipalities located in the main producing regions of the State, in the 1999 and 2000 harvests, a significant reduction in the average number of intrinsic defects in the sampled region was observed, which went from the 327.85 defects reported for the 1992/1993 harvests to an average of 200 defects in the last biennium studied, 1999/2000 (FORNAZIER et al., 2002; De MUNER et al., 2002). These authors verified a significant reduction of perforated beans, around 14.35%, from an average of 48.35% in the first biennium (FONSECA; SILVEIRA; BRAGANÇA, 1995) to an average of 34% of the total defects observed in the last biennium (1999 and 2000). On the other hand, the percentage participation of green beans in the number of defects found, which represented 13.06% of the average total observed, decreased only by 3.16%, reaching 9.9% in the average of the two harvests mentioned.

According to Souza, Santos and Veneziano (2005), obtaining a better quality conilon coffee has become essential for the coffee growers to ensure its permanence in the activity, in view of the current competitiveness in the world coffee production.

3.3 CLASSIFICATION BY SIEVE

The sieve classification takes into account the beans size and shape, which are evaluated by passing a 300 g coffee sample in a set of sifts, which have round sieves for the separation of flat beans alternating with elongated sieves, which separate the moist beans (BRASIL, 2003).

The purpose of sieve separation is to homogenize the beans sizes, since those whose sizes are different behave differently during the roasting process. Those that have the same size provide a uniform roast, ensuring quality in the process. The smaller beans reach a certain point of roasting faster than the others, thus being able to become charred until the larger size reaches the ideal point. Therefore, it will lead to unpleasant flavor and aroma to the beverage (MATIELLO, 1991; SANTOS, 2008).

According to Normative Instruction N° 8, dated July 11, 2003 (BRASIL, 2003), the coffee initially distinguished by its category, arabica or robusta/conilon, can then be subdivided into subcategories, depending on the shape of the beans (flat or mocha), which in turn are separated by size, according to the sieves in which they are retained.

The flat beans present the convex dorsal surface, and the ventral flat or slightly concave, with the central groove in the longitudinal direction, and the oval shaped mochas, also with central groove in the longitudinal direction.

Thus, beans can be classified as:

Large flat: flat beans retained in the 19/18 and 17 sieves;

Medium flat: flat beans, retained in 16 and 15 sieves;

Small flat: flat beans, retained in 14 and smaller sieves;

Large mocha: mocha beans, retained in the 13/12 and 11sieves;

Medium mocha: mocha beans, retained in 10 sieves;

Small mocha: mocha beans, retained in 9 and smaller sieves.

Normative Instruction No. 8 indicates the following overlapping order of the sieves in order to assist in the classification process: Sieve 19 = flat, Sieve 13 = mocha, Sieve 18 = flat, Sieve 12 = mocha, Sieve 17 = flat, Sieve 11 = mocha, Sieve 16 = flat, Sieve 10 = mocha, Sieve 15 = flat, Sieve 9 = mocha, Sieve 14 = flat, Sieve 13 = flat, Sieve 8 = mocha, Sieve 10 = flat and Flat bottom.

3.4 SENSORY CLASSIFICATION OF COFFEE BEVERAGE

The coffee is an agricultural product, whose market value is based on qualitative parameters varying significantly with its quality improvement (CORRÊA; OLIVEIRA; BOTELHO, 2015), especially when it is destined to more demanding markets. For that, it is necessary to establish standards that are accepted in the domestic and international markets, which clearly define the qualitative aspects of producers, traders and consumers, making the marketing process easier, safer and, above all, more agile.

Due to increasing consumer demands for a number of new attributes that have been incorporated into the concept of quality for coffee, including those without direct link to the intrinsic quality of the product (integrated production, use of good agricultural practices in production and processing, organic products, fair market, economic, environmental and social sustainability, etc.), as well as the constant evolution of the technologies available to obtain products with differentiated quality, the so-called specialty coffees, these standards have been being continually improved in order to attend the market, which is also increasingly differentiated and that, although demanding, considerably compensates for the adjustments provided.

The demand for specialty coffees has been increasing among consumers because it offers a more aromatic and flavorful beverage. This market has been growing year after year around the world, with a tendency for even greater increases for the next decade. On the other hand, traditional coffee, marketed as *commodity*, continues to fall (TEIXEIRA, 2015). According to the same author, specialty coffees are those obtained with higher quality beans, without the presence of capital defects, such as black, green, burnt and black-green, with a clean drink without any undesirable fermentation, with good aroma and flavor, leaving a nice aftertaste in the mouth for a long period. To recognize the quality of a coffee, we must drink it black without any additives like sugar, sweetener, cream, milk and other ingredients.

3.4.1 Classical sensory analysis

According to the Associação Brasileira de Normas Técnicas - ABNT (Brazilian Association of Technical Standards), sensory analysis is defined as the scientific discipline used to evoke, measure, analyze and interpret reactions of food and material characteristics as perceived by the senses of sight, smell, taste, touch, and hearing (TEIXEIRA, 2009).

Sensory analysis has become increasingly important for the food sector, since it makes it possible to evaluate the consumer acceptability to a particular product, as well as its quality. Its main tool are the human being sense organs and therefore, it is of great importance that methodological criteria be adopted in the samples preparation and the tests application (TEIXEIRA, 2009).

Through the sensory analysis, it is possible to carry out the selection of the raw material to be used in a particular new product, evaluate the processing effect, flavor, storage stability, consumer reaction, among other parameters. The existing methods have characteristics that fit the analysis purpose. The result should be expressed in a specific way according to the applied test and it is studied statistically concluding, thus, the product viability (TEIXEIRA, 2009).

The method of sensory analysis of a given food aims to answer three fundamental questions regarding the acceptance, perception of the differences between certain products and the intensities of these differences. Thus, sensory methods can be classified as affective, discriminative and descriptive, respectively in response to the raised questions. Among the characteristics to be considered in affective tests, one of them is that its judges do not need to undergo training and, nevertheless, maintains its importance to express the consumers opinion (DELLA LUCIA; MININ; CARNEIRO, 2006).

Acceptance tests seek to establish preference degrees through the evaluation of several food samples in a specific way to each attribute that is peculiar to it, being in terms of appearance, aroma, taste, texture, etc.(SILVA, MARA; SILVA, MARIA; CHANG, 1998; MONTEIRO et al., 2010). According to Monteiro et al. (2010), the influence of roasting (light, espresso , dark) on the acceptance of the coffee beverage interferes more with the sensory characteristics than the beverage type ("soft", "hard", "rio").

Differences, whether qualitative and/or quantitative between samples, can be described through discriminatory tests (EUGENIO, 2011). Prescot et al. (2005) proposed a method of discriminatory test that has been used by some authors in the evaluation of the coffee beverage, in which it recommends the minimum perception of a certain attribute that could result in rejection by the consumer. As an example, Deliza et al. (2006) used the Triangular Test to estimate the *threshold*, which is defined as being the limit of sensory capacity of defects detection (PVA) in coffee samples.

Descriptive analysis characterizes and describes the sensory properties of a product using a technical language. A disadvantage of this method is that it requires prolonged training of the judges, implying long time of analysis and high cost (EUGENIO, 2011).

Thus, some of the most significant sensory classification initiatives of *C. canephora*, currently available, will be discussed below.

3.4.2 Sensory characterization of conilon coffee beverage

As previously exposed, there is a current legislation established by the Brazilian government that defines the standards that should guide the coffee classification. These parameters, which naturally seek to meet the main signals of the domestic and international market, are constantly receiving contributions for their continuous improvement. In the most specific case of conilon coffee, these contributions have been, in general, even more important, considering that the contribution that disciplines this issue, Normative Instruction Nº 8, of June 11, 2013 (BRASIL, 2003) was proposed prioritizing the arabica coffee, since the conilon was still relatively less important at the time.

Many authors report that the sensory characterization of the coffee beverage can be performed through its tasting ("coffee cupping") and by the use of descriptive and quantitative sensory techniques. These methodologies allow the verification of the product quality and the significance of certain factors in positively or negatively influencing its quality: species, harvesting and processing, drying, storage conditions, roasting intensity and conditions, milling granulometry and *blends* composition, among others (FONSECA et al., 2007; LIMA FILHO et al., 2013a).

Descriptive and quantitative sensory studies have shown that conilon coffee presents greater bitterness, higher body, higher astringency, lower acidity and lower fruity flavor when compared to arabica coffee (RIBEYRE, 2003).

In addition to its accentuated use in the production of soluble coffees, conilon has been expanding its presence in *blends* with arabica in both roasted and ground such as in espresso coffees and in other alternative forms of consumption that multiply every year around the world So, studies have also been expanded aiming at the sensory characterization of arabica and conilon coffee *blends*.

Mori (2002) studying the influence of different percentages of conilon coffee in *blends* with arabica coffees classified as “traditional” (high, medium and low) and “premium” (high, medium and low) verified that the mixture with conilon, between 15% and 30%, maintained or improved the classification given to pure arabica, with 5%, 10%, 15% or 25% presence of black, green and burnt defects.

Moura et al. (2007) also evaluated arabica and conilon coffees *blends* for their chemical and sensory characteristics and observed, through quantitative descriptive analysis, a decrease of the grades given to the beverage with the increase of conilon in the blend. It should be noted, however, that the diversity of attributes conilon has presented, this result does not necessarily indicate that all blend will have reduced its acceptance. *Blends* with conilon can also produce excellent results, bringing body, consistent cream and balance. These properties have made the *blends* very attractive to baristas that are adapt the to *Latte Art*[1].

Santos et al. (2013), using a Quantitative Descriptive Analysis (QDA) method, with team trained regarding the attributes that Table 3 describes, analyzed the properties of coffee beverages and observed higher intensity of chocolate aroma, characteristic aroma and flavor, sweet aroma and sweet taste in the 100% arabica formulation, as compared to the *blends* with 10%, 20%, 40%, 60% and 80% of conilon, as well as in the 100% conilon formulation (Table 4). In the latter, 100% conilon obtained greater intensity in the attributes bitter taste, body, cereal aroma and cereal flavor.

[1](*Latte art* or *coffee art* are terms that refer to figures on the surface of *espresso* - type coffee drinks made by baristas).

Table 3. Sensory attributes searched by evaluation team, their respective definitions and references that anchored the extremes of the unstructured scale used during the training phase in Quantitative Descriptive Analysis (QDA)

Attribute	Definition	Beverage reference
Chocolate Aroma	Associated with chocolate aroma.	Absent: 100% conilon beverage.
		Strong: 100% arabica ("soft") beverage.
Aroma and Characteristic Flavor	Coffee aroma and flavor. Absence of strange aromas and flavors.	Weak: 100% conilon beverage.
		Strong: 100% arabica ("soft") beverage.
Aroma and Sweet Taste	Sweetness perception associated with the sugars present.	Weak: 100% conilon beverage.
		Strong: 100% arabica ("soft") beverage.
Aroma and Old Flavor	Smell and taste of old beans stored in burlap bag.	Absent: 100% arabica ("soft") beverage.
		Strong: 100% conilon beverage harvest 2005.
Cereal Aroma and Flavor	Similar aroma to corn or straw.	Absent: 100% arabica ("soft") beverage.
		Strong: 100% conilon beverage
Acid Taste	Associated with the perception of refreshing and effervescent acidity in the beverage.	Weak: 100% conilon beverage.
		Strong: 100% arabica beverage ("M ole") added 0.05% citric monohydrate acid PA (ASC Chemistry group).
Bitter taste	Associated with the beverage bitterness.	Weak: 100% arabica ("soft") beverage.
		Strong: 100% conilon beverage with addition of 0.1% caffeine(Merck).
Astringent mouthfeel	Associated with the dryness sensation left in the mouth after the ingestion.	Absent: 100% arabica ("soft") beverage.
		Very: 100% arabica (hard) beverage added with 0.1% of tannic acid (Merck).
BODY mouthfeel	Tactile sensation of viscosity, filling perceived in the mouth.	Little: Warm water.
		Very: 100% conilon beverage.

Source: Santos et al. (2010) cited by Santos et al. (2013a).

Table 4. Values averageof the coffee beverages sensory attributes obtained in the Quantitative Descriptive Analysis (QDA)

Attributes	Beverages						
	100% arábica (A100)	10% conilon (C10)	20% conilon (C20)	40% conilon (C40)	60% conilon (C60)	80% conilon (C80)	100% conilon (C100)
Chocolate aroma	8.7a	5.5b	4.7b	2.2c	1.3c	1.2c	1.7c
Characteristic aroma/taste	8.5a	5.6c	6.8b	3.8d	2.6e	2.5e	2.5e
Aroma/Sweet taste	7.9a	5.4b	6.3b	3.8c	2.5d	2.1d	2.0d
Aroma/Old flavor	0.4b	1.5b	0.4b	1.0b	0.9b	1.4b	6.6a
Aroma/Cereal flavor	0.5d	2.7c	2.3c	4.2b	5.8a	6.5a	6.7a
Acid taste	5.2a	4.8ab	4.2b	3.4c	2.7d	2.8d	3.1cd
Bitter taste	4.5b	4.5b	3. 6c	4.1b	4.2b	3.5c	5.3a
Astringency	1.1d	1.8c	2.1c	3.1b	3.2ab	3.5a	2.1c
Body	4.5cd	4.5cd	4.3d	4.8bc	4.7bc	5.0ab	5.2a

Source: Santos et al. (2010) cited by Santos et al. (2013a).

However, the study showed that beverages with up to 20% conilon in the *blend* maintained traditionally positive sensory characteristics. It was also possible to show that beverages with proportions up to 40% of conilon beans in the *blends* could still reach a satisfactory acceptance by the consumers, a fact obviously dependent on the quality of the beans used in this species (SANTOS et al., 2013a). Lima Filho et al. (2011) also observed higher intensity of bitter taste in the *blends* containing higher concentration of conilon coffee.

According to Clifford (1985a, 1985b), the bitterness observed in beverages prepared with conilon coffee is due, in addition to the contribution of caffeine, to the thermal degradation of chlorogenic acids, present in a higher concentration in this coffee, resulting in phenolic compounds, that contribute to the bitterness. In their study, Lima Filho et al. (2011) found that the beverage from the peeled arabica coffee (wet process without fermentation) showed a higher intensity of caramelized aroma when compared to beverages from the arabica and conilon *blends*. The highest intensities in attributes, such as sweet aroma, caramelized aroma and sweet taste found in arabica coffee beverages, when compared to conilon, may be due to the higher sugar content found in arabica (TRUGO; MACRAE, 1982; PÁDUA; PEREIRA; FERNANDES, 2001; SALVA, 2007), since sugars, especially sucrose, are among the main precursors of the aroma and taste of roasted coffee and, consequently, the beverage (MENDES, 2005).

For the arabica coffee processing, Lima Filho et al. (2011) found a higher intensity of caramelized aroma in the 100% peeled arabica formulation when compared to the 100% natural arabica formulation (dry process). A similar result was found by Cortez (1996), who verified a higher intensity of aroma in beverages from peeled beans compared to beverages from natural beans. According to Lima Filho et al. (2013b), the key to obtaining premium conilon coffee is the quality of the raw material. The beans processing in the cherry stage and the adequate accomplishment of the post-harvesting stages, avoiding the occurrence of undesirable fermentative processes, allow to obtain a final product within the standards for its classification in the condition of premium coffee.

For Lima Filho et al. (2013b), the great advantage of the wet process is the use of only cherry beans and the greater ease of avoiding undesirable fermentation processes. However, the authors affirm that this work allowed to demonstrate that it is possible to obtain full-bodied and quality-standardized beverage using the dry process (natural coffee), which is more economical than the other processes, provided that only cherry beans are processed and undesirable coffee fermentation is avoided.

Santos (2010) found that the increase of the conilon ratio in the *blends* contributed to the decrease of the acid taste and increase of the astringency of the beverage. The highest astringency perceived in conilon coffee beverages is related to the higher concentration of chlorogenic acid, also observed in this coffee species, when compared to arabica (DE MARIA et al., 1995). According to Cortez (1996), the presence of green beans is also responsible for the greater astringency of the beverage.

As for the roasting degree, Moura et al. (2007) carried out a study on the variation effect of the time x roasting temperature binomial in the sensory characteristics of pure arabica coffee. It was verified that the linear increase of the time and temperature significantly decreased the intensity of the characteristic aroma and flavor, chocolate flavor and sweetness attributes, as well as significantly increased the intensity of the acidity and bitterness attributes.

Monteiro and Trugo (2005) evaluated the bitter taste, fermented flavor and burnt taste of arabica coffee beverages with different beverage classifications(“soft”, “hard” and “rio”) and different roasting degrees (light and dark). The dark roasted samples presented higher intensity and length of the stimulus in the attributes of bitter taste and burnt taste; the light roasted samples obtained lower intensity in such attributes. The “rio” sample obtained with *espresso* roasted beans had the highest intensity of fermented flavor. Schmidt, Miglioranza and Prudêncio (2008), in a study with pure arabica at different roasting and milling points, found that the medium to dark roastings were more widely accepted by consumers. However, although the finer milling had a greater preference for its appearance, tasters did not observe sensory differences in flavor. The increase in the number of studies aiming at the study of the coffee beverages sensory characteristics demonstrates the greater concern with the sensory quality that has been occurring in recent years. The proposal of the Associação Brasileira da Indústria de Café - ABIC (Brazilian Association of the Coffee Industry) to adopt minimum quality criteria for the coffee beverage further evidences this new trend in the search for quality. In this adoption of quality criteria, the organs may adopt the Minimum Quality Level (MQL) equal to or greater than 4.5 points, or refer to the quality categories: Traditional, Premium or Gourmet (ABIC, 2012).

3.4.2.1 Classification of the Brazilian official sensory quality for arabica and conilon coffee

Through NI 08 (BRASIL, 2003), the coffee beverage quality can be classified in:

Arabicas: Group I (Arabica) Fine Beverages - “Strictly Soft”, “Soft”, “Just Soft” and “Hard”.

Group I (Arabica) Phenicated Drinks: “Riada”, “Rio” and “Rio Zona”.

Robustas: Group II Beverages (Robustas): Excellent, Good, Regular and Abnormal.

This standardization proposal, however, is not suitable to the quality classification of the conilon coffee beverage. The coffee market has systematically searched for alternatives that satisfy and are accepted and adopted by all segments of the chain in all parts of the world, especially in recent years, when the growth of the robusta production and consumption of has been experiencing much more significant advances than those presented by arabicas, currently holding around 40% of the total produced and commercialized in the world.

3.4.2.2 Classification of sensory quality proposed by Cortez

Similarly to the classification of conilon coffee as to type, Cortez (2004) also proposed a specific sensory pattern for this species (Table 5), but despite the author’s efforts, it has also not been satisfied and has not been adopted broadly in the coffee trade.

Table 5. Proposal of standardization for the quality evaluation of conilon coffee beverage

Type	Sensory description
Soft	Characteristic conilon coffee taste with soft intensity.
Medium	Characteristic conilon coffee taste with medium intensity.
Intense	Characteristic conilon coffee taste with intense intensity.
Strange tastes	Other tastes from several origins predominating over the conilon coffee characteristic taste.

Source: Cortez (2004).

3.4.2.3 Sensory classification proposed by the CQI/UCDA

In general, the conilon coffee tasters traditionally seek to distinguish, in sensory evaluations, the presence of characteristics that compromise the product quality assigning, afterwards, a general score, which is usually greater the more neutral the beverage is. This classification is based on the need of taking into account, in addition to attributes that compromise quality, the presence of those that contribute effectively to the final quality of coffee, such as, in the most pronounced body and the balance of acidity in *blends* and in the higher cream density in an *espresso* or even in the greater extractability, in the soluble coffees industrialization.

In order to be well conducted for the sensory evaluation (also called "coffee cupping") and to precisely identify the attributes that qualify the coffee, the taster must have adequate olfactory and gustatory sensibility so it is possible to distinguish the several aroma and flavor nuances that are formed in the beverage (ILLY, 2002).

Among the methodologies used, the one recommended by SCAA has become almost unanimous in relation to the quality evaluation for arabica coffee. From this protocol, used until very recently, almost exclusively for the arabica coffee, it was adapted the sensory classification for the robusta/conilon, proposed by the CQI, called *Fine Robusta Coffee Standards and Protocols: technical standards, evaluation procedures and reference materials for quality-differentiated Robusta coffee* (Standards and Protocols to the classification of quality robusta coffee: technical regulations, evaluation procedures and reference materials for Robusta coffee, distinguished by quality. (CQI/USDA, 2015).

According to this protocol, the sensory tests aim to define the sensory differences between the samples, describe their taste and, finally, determine the taster preference for the samples. But no test is able to effectively address all the related issues. It is important that the taster knows the objectives of the evaluation that he will carry out. The specific quality attributes are analyzed based on the professional experience, each *flavor* attribute is classified on a numerical scale and thus scores between samples can be compared.

According to Teixeira (2011), the method recommended by the tasting CQI Protocol for the robusta/conilon coffee, provides a systematic way for the characterization of ten quality attributes in the conilon flavor as: Fragrance/aroma flavor, aftertaste, acidity and salinity ratio, bitterness and sweetness ratio, mouthfeel, balance, body, uniformity, cleanliness and general impression. The description of these characteristics, as well as all the methodology recommended in the CQI Protocol (CQI/UCDA, 2015), is transcribed in the following items Defects and impurities can be identified and recorded.

3.4.2.3.1 Sample preparation for coffee cupping

The CQI Protocol establishes several needs to be considered for conducting sensory evaluations, including the moisture level permitted in the beans, water quality (purity, pH and temperature), correct roasting time, roasting moment in relation to the test itself and the storage of roasted samples. It also guides the milling (timing and granulometry), volume and containers material, the amount of powder used (0.058g per ml), the rest time of the samples after the container volume has been completed with water, the spoons capacity, environmental conditions and the dynamics of operationalization (CQI / UCDA, 2015).

Robusta/conilon coffee beans, unlike arabicas, do not snap so loudly when they reach the appropriate roasting point. According to Lingle (2011), their beans are, in general, much denser than most of the arabicas, besides being more resistant to heat. That's why its surface should reflect a much darker toast than the arabica beans to achieve a similar development in taste and color after milling.

3.4.2.3.2 The quality scale (CQI/UCDA)

The specific attributes to *flavor* result in positive quality scores, reflecting a relevant classification to the taster judgment, while the defects result in negative scores, denoting the unpleasant taste sensations. The general score is based on the tater's sensory experience and therefore constitutes a personal evaluation. Table 6 presents the sensory attributes classified in a scale of 16 points that represent the levels of quality. Theoretically the scale varies from a minimum value of 0 and a maximum value of 10 points. The inferior end of the scale (0.25 to 5.75) is applicable to commercial coffees, which are evaluated mainly by defect types and their intensities (CQI/UCDA, 2015).

Table 6. Coffee quality scale according to CQI Protocol

Good	Very good	Fine	Exceptional
6.00	7.00	8.00	9.00
6.25	7.25	8.25	9.25
6.50	7.50	8.50	9.50
6.75	7.75	8.75	9.75

Source: CQI/UCDA (2015).

In the case of certain positive attributes, there are two scales. Vertical scales are used to assess the intensity of the sensory component listed for the evaluators record. Horizontal scales are used to indicate the evaluators preference for specific components, his perception of the sample and his understanding of quality based on his experience. The attribute score is indicated in the corresponding field in the Tasting Form.

3.4.2.3.3 Sensory attributes of quality

The sensory attributes of quality are valued at CQI (CQI/UCDA, 2015) protocol, as described below, in the form suggested by the entity (Figure 2).

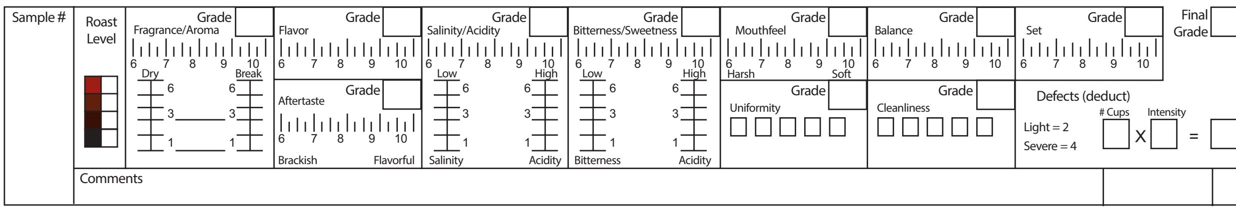

Figure 2. Sample evaluation form.
Source: CQI/UCDA (2015).

a) **Fragrance/Aroma**: The aromatic aspects include Dry Fragrance (defined as the smell of ground coffee when still dry) and Wet Aroma (the smell of coffee after infusion with hot water). These aspects can be evaluated in three different situations: a) by smelling the roasted and ground coffee placed in the cup before pouring the hot water; b) smelling the aromas released during the breaking of the crust; c) smelling the aromas while the coffee rests.

Enzyme notes are commonly found characteristics in fine coffees and include: roses, tea, lemon, coffee flower and honey; and those commonly found in commercials, potatoes and peas. The common caramel notes common in fine coffees resemble vanilla, butter, caramel, cocoa and nuts; while in commercials, they are toasted bread and roasted peanuts. The dry distillation notes usually found in fine coffees refer to malt; and in the commercials, pepper, cedar and pipe tobacco. Light aromatic defects are commonly found in fine coffees and include coffee pulp; and those commonly found in commercials, land, medicines, smoke, rubber and straw.

b) ***Flavor***: The term *Flavor*, English word, is mistakenly translated to Portuguese as taste. However, the expression refers to the set of physiological sensations perceived through the interaction of the taste and smell when ingesting a food or drink.

It refers to the main characteristics of the coffee and is equivalent to the "middle phase" notes of the evaluation, going from first impressions, from the first aroma and taste to the final aftertaste. It is a combined impression of all sensations perceived in the flavor buds and all the aromas seized in the retronasal region from the mouth to the nose. The score given to this item should reflect the intensity, quality, and complexity of the taste and aroma combination experienced when coffee is sucked vigorously so as to involve the entire palate in the evaluation.

The *flavor* found in robustas/conilons are distinct to the cafes called fine and the commercial ones:

Fine Robustas: Fruits (cherry, gooseberry, raisins, raspberries, berries, dried figs, lemons and prunes); nuts (chestnut, almond); spices (clove, coriander and black pepper). The set is mentioned as round, complex, complete, mature, deep and delicate.

Commercial Robustas: Vegetals (grass, hay, beans, barley, vegetables, potatoes, peas, silage, jackfruit, popcorn and biscuit); phenol (medicines, metals, rubber, smoke, burnt, wood);

astringents (uric, salty, brine, brackish). The set is mentioned as monotonous, lifeless, tasteless, uneven, neutral, hard, soapy.

c) **Aftertaste**: It is defined as the length of the positive taste qualities (taste and aroma) that emanate from the bottom of the palate and remain after the coffee is expelled from the mouth or swallowed. If the aftertaste lasts a short time or is unpleasant, a lower score should be received. In *C. canephora*, the aftertaste is often induced by the coffee potassium contents. High contents result in brackish aftertaste (salty and very unpleasant aromas) and low levels result in spicy (low salinity and pleasant aromas).

d) **Salinity/Acidity ratio**: It is regarding the pleasant and delicate taste that comes from the acidity and sweetness perceived in the robustas/conilons, resulting from the presence of acids and fruit sugars. The attribute in epigraph is comparable to the categorization of "Strictly Soft" of the Brazilian coffee beverages. The acidity perception is one of the great taste differences between fine and commercial robustas.

e) **Bitter/Sweetness ratio**: Both bitter and sweet taste are present in the robustas/conilons. The bitterness comes mainly from caffeine and potassium contents in coffee; the sweetness, fruit and chlorogenic acids contents and coffee sugars. In the taste of fine robustas/conilons, the bitter aspect is little pronounced and the sweet is more noticeable; and in the taste of the commercial robustas, the bitter aspect is more prominent unlike the sweet. In determining the Bitterness/Sweetness ratio, the taster evaluates the relative bitterness on a scale of 1 to 6, assigning the highest number of points to the lowest bitterness perceived; and evaluates the relative sweetness on a scale of 1 to 6, giving the highest number of points to the highest sweetness perceived. The both scores are then summed to determine the result of the Bitterness/Sweetness Ratio.

f) **Mouthfeel**: The aftertaste quality is based on tactile sensation of the liquid in the mouth, especially as it is perceived between the tongue and the palate. Most samples that weigh in the mouth can also receive a high score in terms of quality due to the presence of colloids in the beverage. Colloids are formed when the oils extracted from the ground coffee coagulate around the microfine fibers of the beans suspended in the beverage. The mouthfeel has two distinct aspects: weight and texture.

g) **Balance**: This is how the various sample aspects (taste, aftertaste, salinity/acidity ratio, bitterness/sweetness ratio and mouthfeel) combine and complement or contrast with each other. As the intensity of each of these attributes increases, the balance among all of them becomes more difficult. When all of them increase with the same intensity, the balance score is high. When the sample does not have one or more attributes, or when some attributes excessively come out, the Balance score decreases.

h) **Uniformity**: Refers to the consistency of flavor in the different cups of the sample tested. If in a single acid, fermented, phenolic bean or other taste defects are present in any of the cups, a different taste may arise in one or more of them. The inconsistency in the coffee taste is a very negative attribute, which must be different to the point where the taster can easily identify the defective cup in a triangulation with the others of the same group. The this attribute evaluation is done cup by cup. Two points are assigned to each uniform cup (which has the same taste as the others), with a maximum of 10 points if the five cups are uniform.

i) **Cleanliness**: Refers to the lack of negative impressions from the first ingestion to the aftertaste, that is, a “beverage transparency”. In assessing this attribute, it is necessary to note the entire taste experience from the time of the initial ingestion until the coffee is expelled at the end of the evaluation. If a single moldy, dirty, contaminated by the bags or other defect is present, strange tastes may be detected in one or more cups. Any taste or aroma other than coffee disqualifies a particular cup. Two points are assigned to each cup that is free from a taste or aroma other than coffee.

j) **Set**: It should reflect a holistically integrated evaluation of the sample, according to the taster’s perception. A sample with many highly agreeable pleasant attributes, but not quite up to the taster’s expectations would receive a lower score. A coffee, whose characteristics would meet their expectations and reflects taste qualities specific to the origin, would receive a high score. A remarkable example of preferred characteristics not fully reflected in the individual score of specific attributes could even receive a higher score. This is the time when tasters make their own personal coffee evaluation. The good professionals do not leave their personal preference for a coffee to interfere in the evaluation of the other taste attributes of the sample.

k) **Defects**: They are negative or undesirable tastes, whose perception depreciates the coffee quality. They are classified in two categories: a) A slight defect can be noticed, but it does not predominate over the others and is usually between the aromatic aspects, receiving the grade 2 by its intensity; b) A severe defect is generally found in the aspects of taste that prevails over the others or gives the sample a very unpleasant taste and receives the grade 4 by its intensity. The defect must first be classified (light or severe), then described (sour, rubbery, fermented, phenolic, for example), and the description registered. The number of cups in which the defect was found should then be registered, and the defect intensity recorded as 2 or 4. The defect score is multiplied by the number of cups in which it is found and subtracted from the total score in the final result calculation, according to the instructions in the tasting form.

3.4.2.3.4 Final result of sensory evaluation by CQI/UCDA protocol

The final result of sensory evaluation by CQI protocol (CQI/UCDAO, 2015) is firstly calculated by adding the scores of each primary attribute in the “Total Points” field. The value corresponding to the defects is then subtracted from the total points to obtain a final result. Based on the final score, it ca be defined the key of the quality description and its classification, according to the CQI criteria (Table 7).

Table 7. Equivalence between the total score achieved, quality description and CQI classification

(to be continued)

Total score	Quality Description	Classification
90-100	Exceptional	Very fine
80-90	Fine	Fine
70-80	Very good	Premium

(conclusion)

Total score	Quality Description	Classification
60-70	Medium	Usual Good Quality
50-60	Regular	Usual Good Quality
40-50	Regular	Commercial
< 40		Commercial classification
< 30		Below the classification
< 20		Not classifiable
< 10		Choice

Source: CQI/UCDA (2015).

3.4.2.3.5 Step by step of the tasting and sensory classification process

According to the CQI (CQI/UCDA, 2015) protocol, the coffee tasting process and sensory classification is developed by following the steps described below. Samples should first be visually inspected for checking the roasting color. This is marked on the left side of the form and can be used as a reference during the verification of a specific taste attribute, particularly if the sample roasting is too light or too dark. The evaluation sequence of each attribute is based on changes in taste perception caused by the reduction of coffee temperature as it cools down.

Step 1: Fragrance/Aroma evaluation After 15 minutes of milling the samples, the Dry Fragrance should be evaluated by lifting the lid and smelling the ground coffee. The Dry Fragrance type and intensity are scored on a scale of 1 to 6 and then indicated on the corresponding vertical scale field. The taster should also write down the Dried Fragrance type on the small horizontal line. After the infusion with water, the crust should be kept, without breaking it, for at least three minutes and five at the most. The breaking of the crust is done by stirring three times, then letting the foam run down the back of the spoon and gently smelling the coffee. Both the type and the intensity of the wet aroma are scored on a scale of 1 to 6, later indicated in the corresponding field of the vertical scale. The taster should also write down the Wet Aroma type on the small horizontal line.

The total score for the Dry Fragrance and the Wet Aroma is calculated and the result of the Fragrance/Aroma set, with a maximum score of 10, is indicated on the form.

Step 2: *Flavor*, Aftertaste, Salinity/Acidity, Bitterness/Sweetness and Mouthfeel evaluation. When the sample cools to 70 °C, 8-10 minutes after infusion, the beverage evaluation may begin. The beverage is sucked into the mouth in order to cover most of the region, especially the tongue and the palate. As the vapor converge in the retro nasal region in its maximum intensity under these high temperatures, Flavor and aftertaste are evaluated at this point.

As coffee continues to cool (between 70 °C and 60 °C), the items Salinity/Acidity Ratio, Bitterness/Sweetness Ratio and Mouthfeel should be evaluated:

a) **Salinity/Acidity ratio** is the relative balance between the sensations created by salt, mainly due to higher contents of potassium in Robustas, in contrast to the normally lower levels of organic acids, particularly citric acid. "Fine" Robustas are characterized by lower salt levels, which produce a "Hard" taste in the cup, and by higher levels of organic acids, which produce a "Soft" taste in the cup. Low salinity indicated on the vertical scale is 1 to 6, where the higher number represents a perception of a low level of salinity. High acidity is indicated on the vertical scale from 1 to 6, where the highest number represents the perception of a high level of acidity. The two scores are summed to obtain the total Salinity/Acidity Ratio, with a maximum score of 10.

b) **Mouthfeel** is a combination of weight and texture. The weight comes from the microfine fibrous particles that beans absorb from the soil, and the texture comes from the oils extracted from the coffee particles suspended in the beverage. The evaluation of both weight (tongue weight compared to pure water) and texture (viscosity compared to pure water) is indicated on vertical scales from 1 to 6. The two scores are summed to obtain the evaluation of Mouthfeel, with a maximum score of 10.

The Bitterness/Sweetness Ratio is the relative balance between bitter and sweet taste sensations, in which the ideal result corresponds to a combination of low bitterness and high sweetness. The low bitterness evaluation is indicated on the vertical scale from 1 to 6, where the highest number represents the perception of a low bitterness level. The high sweetness is indicated on the scale from 1 to 6, where the highest number represents a perception of a high sweetness level. The two scores are summed to obtain the total evaluation of the Bitterness/ Sweetness Ratio, with a maximum score of 10. The taster preference for each attribute is evaluated at several temperatures (2 or 3 times) as the sample cools down. To register the sample evaluation on the 16-point scale, the taster must make a circle in the appropriate field on the tasting form. If a change needs to be made (if the perception indicates an increase or decrease in the quality of a sample due to changes in temperature), make a new mark on the horizontal scale and draw an arrow indicating the direction of the final score.

Step 3: Balance, uniformity and cleanliness evaluation. As the beverage approaches the room temperature (less than 38 °C), the attributes Balance, Uniformity and Cleanliness are evaluated:

a) **Balance** is the taster's evaluation of how well the attributes *Flavor*, Aftertaste, Mouthfeel and Bitterness/Sweetness Ratio fit into a synergistic combination. The four attributes must be present at equal intensities so that there is "balance" in the cup. The higher the intensity, without dispensing the beverage drink, the higher the score should be.

b) **Uniformity and Cleanliness** are judged cup by cup. Regarding these attributes, the taster judges each cup, giving 2 points for the Uniformity and 2 for the Cleanliness of the Beverage (maximum score of 10).

Step 4: Set evaluation and Total Score. The beverage evaluation should end when the sample reaches 21 °C, and The set is determined by the taster, which attributes "Taster Points" to the sample based on the all combined attributes. The points assigned to each of the ten attributes are then summed and indicated in the field on the right side of the form, where it reads "Total Score".

Step 5: Final quality and classification evaluation. After calculating the Total Score, deduct the points referring to light and serious defects, that are in any of the five cups, and indicated in the field where it reads "Final Score".

3.4.3 Considerations on other sensory attributes characteristic of conilon coffee

The robusta/conilon has demonstrated an infinity of aromas and fragrances. This is due to the genetic peculiarities, edaphic conditions of cultivation, culture, crop and post-harvesting management. Clonal cultivar plantations have made it possible to evaluate and isolate a range of flavors, which may be the target of highly promising market niches.

Most test rooms have been using several terms to sensory classify the conilon beverage. Among them, some refer to nuances as beverage positive attributes and to defects, such as negative attributes whose characteristics are described below.

The most cited conilon coffee nuances are fruity and woody. The both terms have been used to characterize, in a way, the degree of sweetness or roughness of the beverage. The fruity flavor often appears in samples with a higher level of sweetness, a light fermentation accentuating flavors similar to those of fruits. The woody nuance comes from a rougher perception of the beverage, more astringent, with woody or herbal notes. In evaluating beverage quality in experiments with shaded or non shaded cultivation, distinctions were observed regarding these nuances, where fruity is most observed in plants managed in full sun and woody in plants grown under shade trees (CQI/USDA, 2015).

The body is an attribute that has been widely used and is chemically related to soluble solids contents. This attribute refers to the beverage "weight" on the palate, the sensation of filling and the permanence in the oral cavity. It is the tactile perception of oiliness, viscosity and volume in the mouth, which can vary from full-bodied to medium (PAIVA, 2005).

For conilon coffee, its use was not very acceptable, since it was considered that, in relation to arabica, all the "conilons" would be considered full-bodied. However, in recent years, within a universe of evaluated conilon coffee samples, sensitive variations have been observed in this characteristic, to which grades can be attributed. This variation has been observed as a function of the post-harvesting processing (hulling, demucilaging, etc.).

The Characteristic Green is an attribute conferred to the coffee that, even with low score of this defect in the classification by types, nevertheless, it presents certain astringency in the "coffee cupping". There are several factors that make it difficult to separate effectively green beans and the ones close to adequate maturation, which present a color very similar to normal and, finally, a mixture of colors from the fast drying at high temperatures (direct fire), the hinder the visualization of the beans natural color.

The Smoky defect is attributed to the presence of strong characteristic odor that comes from drying using wet wood from the combustion of not indicated species, use of wet coffee skin and drying using direct fire. The coffee with this defect has been rejected by more demanding buyers.

The Rubbery defect is a characteristic presented in coffees processed in direct fire furnaces in fast drying and at high temperatures. It is associated with the presence of many green beans. It is also a cup feature that greatly devalues the coffee from the market. There is also a certain persistent rancid background associated with this attribute.

The chemical defect found in the cup is attributed, in fact, to a sum of various defects and its persistent characteristic. It occurs in samples of coffee that usually extrapolate the type table with high score of defect points.

The Rancid defect is related to a butyric fermentation, also associated with a drying at high temperatures, where the natural lipids of the coffee pass through the membranes and are decomposed through oxidation reactions by the oxygen of the air. It resembles what happens to the melted butter and described as a persistent "tallow taste" in the tongue.

The Earthy defect arises from the harvesting performed by throwing the coffee on the ground or when there is drying in earth farmyards. This imperfection is associated with a wet earth odor. It is not a serious defect when it happens at light levels.

As for Ferment, it comes from several factors mentioned above. It is worth adding care in the perception of this defect, because there are levels and types of fermentation that are acceptable or even desirable in the coffee, conferring attributes of ripe fruits or wines, lactic acidity, exotic and complex flavors.

4 ABIC COFFEE QUALITY PROGRAMS

The Associação Brasileira da Industria de Café - ABIC (Brazilian Association of the Coffee Industry), through its Permanent Program for the Coffee Purity Control, created in 1989 and keeps, since then, the Coffee Purity Seal. This seal has greatly contributed to the significant recovery and expansion of domestic coffee consumption in Brazil, from 2.85 to 6.12 kg of green coffee per inhabitant/year, in the period between 1985 and 2014, equivalent to approximately 81 L of the beverage per inhabitant/year (ABIC, 2015). It aims to certify that in the package of industrialized coffee, it contains no other product but coffee. It does not certify the product quality, but its purity. The label in question may be obtained by any company that commercializes roasted coffee in the domestic market.

In 2004, as an evolution of the Purity Seal, ABIC launched the PQC, which generated the Coffee Quality Seal, a new and different proposal that distinguishes three categories of coffee for consumption. This seal certifies both everyday coffee taste, designated as the 'Traditional' as the highest quality coffee, the 'Premium" and the 'Gourmet' (ABIC, 2004). This program rules, applicable to roasted beans and roasted and ground beans, have undergone successive reviews, adjusting according to contemporary needs and since its launch, being continuously improved, when the last adjustment was registered on 08/28/2013 (ABIC, 2013).

According to the PQC, in order to define the beverage quality of a particular roasted coffee or roasted and ground coffee, the first factor to consider is its species, since there are substantial differences between the arabica and robusta/conilon coffees produced and marketed in the world.

The robusta/conilon stands out for presenting, compared to arabica, higher content of soluble solids, a characteristic of great interest in the soluble coffees industrialization and for contributing to the *blends* with arabicas, giving more body to the beverage by reducing its acidity and making it more balanced. There is also a need to adjust the beverage to the preference to the habits of certain consumer segments and to reduce the final product price having in mind its lower production cost and prices adopted in the market compared to the arabicas.

The second factor considered in the PQC as a coffee quality determinant is the environment in which it is being cultivated, since the climatic diversity provides variations as to its acidity, body, sweetness and aroma.

Considering the issues previously discussed, as well as the guidelines contained in Chapter 20, "Conilon Coffee Harvesting and Post-harvesting", related to the proper procedures for coffee harvesting, post-harvesting and storage, all of great relevance for the product final quality, it is processed as soon as its marketing is defined.

In industry, still due to the quality of the product, it is also fundamental to consider the roasting and the milling degree as they are also fundamental for the final definition of the beverage. The ideal roasting point, which reveals all the flavor and aroma, has, according to ABIC, the chocolate color. The milling process defines the coffee preparation process. The fine is used for the Turkish coffee preparation, and the rough for Italian coffee makers (ABIC, 2004).

Thus, the methodology in question, for the classification between these different categories, simultaneously considers the presence of defects and qualitative characteristics as well as others related to legal aspects and to the so-called good practices, from the production to the industrialization.

The product characteristics currently considered by PQC are: a) aspect (coffee type (COB) and the maximum percentage by weight of green, black, black-green, burnt and fermented beans in the sample); b) physical characteristics of the roasting; c) chemical and sensory characteristics and the whole quality of the beverage; d) biological characteristics; e) current legislation; (f) packaging and labeling; eg) macro and microscopic characteristics (ABIC, 2013).

Additionally, PQC, besides the coffee macro classification in the category that it best fits in, recommends the introduction to other information relevant to the product specification, the taste profile, which identifies seven characteristics of the product. This information is printed next to the category. The profile of each coffee is defined regarding the beverage, roasting, milling, taste, body, aroma and coffee type. It is also explained when dealing with pure arabica, pure robusta/conilon or a blend between both, specifying the predominant one.

The rules of the program in question, as well as all the updates made, are available on the ABIC website, under the 'Programa de Qualidade de Café – PQC' (Quality of Coffee Program - PQC), on the 'Norma de Qualidade' (Quality Regulation) tab (ABIC, 2004, 2013).

5 COFFEE CHEMICAL CHARACTERISTICS

Coffee is recognized as one of the commodities with more complex chemical composition. The different chemical compounds that constitute the beans react and interact at all stages of coffee processing, resulting in a final product with great complexity and diversity (ILLY; VIANI, 2005; ALESSANDRINI et al., 2008).

According to Clifford (1975), the main chemical compound present in coffee have been known for a long time. Among them, caffeine is one of those that deserve special attention because it has a stimulating effect due to its antagonism with adenosine receptors in the brain (FREDHOLM et al., 1999)

According to Lima Filho et al. (2013a), the physical-chemical composition of the coffee is related to the sensory characteristics of the final product and define the beverage final quality. However, the coffee sensory and physical-chemical characterization are very complex, since they are influenced by several factors, which requires numerous studies in order to elucidate those that guarantee better quality coffees.

According to Clarke (2003), the chemical composition (Table 8) varies according to the species and this difference contributes to the fact that raw beans, when submitted to thermal treatments, provide beverages with different sensory characteristics.

It is quite frequent that results found in works carried out with the most diverse objectives present small variations in the chemical composition of arabica and robusta/conilon coffees. However, it is necessary to analyze these variations as influence possibilities of the genetic and environmental factors and conditions which are produced and processed, in order to avoid misinterpretations.

Table 8. Content of some raw and roasted arabica coffee and conilon compounds

Compounds	Average Composition (%)			
	Raw Arabica	Roasted Arabica	Raw Conilon	Roasted Conilon
Caffeine	0.9-1.2	1.0-1.3	1.6-2.0	1.7-2.4
Trigonelline	1.0-1.2	0.5-1.0	0.7-1.0	0.3-0.7
Ashes	3.0-4.2	3.0-4.5	4.0-4.4	4.0-6.0
Chlorogenic Acids	5.5-8.0	2.5-4.5	7.0-10.0	3.8-4.6
Other Acids	1.5-2.0	1.0-2.4	1.5-2.0	1.0-2.6
Sucrose	6.0-8.0	0.0	5.0-7.0	0.0
Reducing sugars	0.1-1.0	0.2-0.3	0.4-1.0	0.2-0.3
Polysaccharides	44.0-55.0	24.0-39.0	37.0-47.0	25.0-37.0
Proteins	11.0-13.0	7.8-10.4	11.0-13.0	7.8-10.4
Amino acids	0.5	0.0	0.8	0.0
Lipids	14.0-16.0	14.0-20.0	9.0-13.0	11.0-16.0
Solids Soluble	23.8-27.3	26.8-30.1	26.0-30.0	28.0-32.0

Source: Clarke (2003).

Santos et al. (2013b), aiming to study the caffeine and chlorogenic acids effect on neurological diseases, it was verified the content of some important compounds found in raw beans (Table 9) and roasting (Table 10) of both species, respectively.

Table 9. Chemical compound of arabica and robusta/conilon raw coffee beans

Compounds	Percentage content	
	Arabica	Robusta
Caffeine	1.2	2.2
Trigonelline	1.0	0.7
Minerals (42% = K)	4.2	4.4
Chlorogenic Acids	6.5	10.0
Aliphatic Acids	1.0	1.0
Chemical Acids	0.4	0.4
Sucrose	8.0	4.0
Reducing sugars	0.1	0.4
Polysaccharides	44.0	48.0
Lignin	3.0	3.0
Pectin	2.0	2.0
Proteins	11.0	11.0
Free amino acids	0.5	0.8
Lipids	16.0	1.0

Source: Santos et al. (2013b).

Table 10. Chemical composition of arabica and robusta/conilon coffee roasted beans (medium roast)

Compounds	Content (% on dry base)	
	Arabica	Robusta
Caffeine	1.3	2.4
Lipids	17.0	11.0
Proteins	10.0	10.0
Carbohydrates	38.0	41.5
Trigonelline, Niacin	1.0	0.7
Aliphatic Acids	2.4	2.5
Chlorogenic Acids	2.7	3.1
Volatile compounds	0.1	0.1
Minerals	4.5	4.7
Melanoidin	23.0	23.0

Source: Santos et al. (2013b).

Fonseca et al. (2011), studying the chemical composition of a group of 49 *C. canephora* clones selected by the genetic breeding program conducted at Incaper, evaluated the caffeine content, trigonelline, chlorogenic acids and total soluble solids. They found significant variation between the different clones analyzed, with extreme values of 1.51% to 2.64% for caffeine; from 0.64% to 1.30% for trigonelline; from 3.61% to 5.64% for chlorogenic acids and from 29.36% to

36.36% for soluble solids. The results obtained characterize the existence of significant genetic variability for the studied characteristics, as well as the possibility of selecting plants that have more specific qualitative characteristics and of greater commercial interest.

During the roasting process, specific sensory attributes such as taste, aroma and color are developed and are fundamental for good beverage quality (HERNÁNDEZ; HEYD; TRYSTRAM, 2008). The hundreds of chemical compounds formed during the roasting process confer on coffee sensory characteristics that may or may not be desirable (EUGÊNIO, 2011).

Among the various parameters, the color is the most used to describe the roasting levels of the coffee, which according to the brightness of the color is classified as light, medium and dark (ILLY; VIANI, 1998; EGGERS; PIETSH, 2001; SACCHETTI et al. al., 2009). The reactions of Maillard[2], Strecker degradation, sugars caramelization and the chlorogenic acids degradation, proteins and polysaccharides stand out among several reactions that occur during the roasting process (ILLY; VIANI, 1998).

The polysaccharides are part of more than half of all constituents of the coffee bean, ranging from 37% to 47% in conilon coffee and 44% to 55% in arabica coffee (ILLY; VIANI, 1998). During roasting, the polysaccharides are partially lost, forming complexes with other polysaccharides, proteins, protein fragments and chlorogenic acids. They, in turn, do not directly contribute to the formation of the coffee taste during roasting, however, they are important for the retention of the beverage aroma, besides interfering in the viscosity of *espresso* coffee. Other known carbohydrates, as lower mass sugars, unlike polysaccharides, already have greater interference in the formation of the beverage taste (FLAMENT, 2002; RODARTE, 2008).

According to these same authors, the non-reducing sugars degradation, particularly sucrose, during the roasting process can increase the reducing sugars levels that are found in small amounts in raw coffee. During roasting, the reducing sugars react with amino acids (Maillard reaction), giving rise to the characteristic color of roasted beans, as well as the formation of compounds responsible for the beverage aroma and taste (FLAMENT, 2002; RODARTE, 2008). The average total sugars content observed in raw *C. arabica* and *C. canephora* beans have been generally close (FERNANDES, et al., 2003; AGNOLETTI, 2015).

During the roasting process, reactions occur to decompose the proteins present in the beans, which contribute to form the coffee taste. Amino groups react with reducing sugars, giving rise to compounds responsible for the roasted coffee brown color, in addition to promoting the formation of several volatile compounds important for the beverage aroma and flavor (CARVALHO; CHAGAS; SOUZA, 1997; FLAMENT, 2002; RODARTE, 2008; EUGÊNIO, 2011).

Moura et al. (2007) observed that with the increase of conilon coffee percentage in the *blends* composition with arabica coffee, there is a proportional reduction of the non-reducing sugars amount of in the final product, regardless of the total sugars values, that remain unchanged with the different compositions.

[2]Maillard reaction during roasting occurs when the reducing sugars react with amino acids to give the characteristic color of the roasted beans and the formation of compounds related to the beverage aroma and taste (FLAMENT, 2002; RODARTE, 2008).

Caffeine is one of the most known coffee components. Among the most widely disseminated attributes of the substance, it is its scientifically proven stimulating effect on the central nervous system and heart muscle and sleep reduction (MONTEIRO; TRUGO, 2005). It has a bitter taste, is odorless and resistant to roasting, not being reduced by the process, even though it is more intense (FARAH et al., 2005).

In commercial, roasted and ground coffee, the different caffeine contents found have been attributed by different authors to the use of greater or lesser percentage of conilon coffee in the respective *blends* (MONTEIRO; TRUGO, 2005; SOUZA et al., 2010), since Moura et al. (2007), in addition to many others, comparing samples of both species, conclude that this alkaloid presence is substantially higher in *C. canephora*, and that, due to its high thermal stability, even roasted or roasted and ground coffees reflect this component original content in the beans (SOUZA et al., 2010).

During storage, coffee is subject to a number of changes in its quality which, in order to avoid them, it requires much care. The deterioration of the coffee beverage quality is influenced by several chemical reactions, among them the lipids oxidation that normally take place during the storage process and may favor important changes in the product quality, especially with regard to its flavor and aroma (PÁDUA et al., 2002).

On the other hand, lipids are able to play an important role in improving the coffee quality, since they can accumulate during the roasting in the outermost parts of the beans, acting as protectors against losses of important substances involved in the aroma formation, being almost always present in these areas, in better quality coffee, presenting themselves with well defined lipid bodies inside the protoplasts (PÁDUA et al., 2002). The lipids distribution in the tissues of roasted beans, in a dispersed and irregular way, inside the cells and in the intercellular spaces is almost always associated with inferior quality coffees (GOULART et al., 2007; RODARTE, 2008).

Similar results were found by Ribeiro et al. (2014), who conclude that there are significant changes of the sensory attributes regarding the composition of *C. arabica* and *C. canephora* species in the different *blends*. According to these authors, as it increases the proportion of *canephora* in *blends*, it is observed the reduction in scores for the attributes Fragrance, Aroma and Acidity, ether extract and the Total and Non-reducing sugar and increase to the attributes Bitterness and Body, while it recognizes greater contents of caffeine, soluble solids and polyphenols.

Trigonelline is an N-methyl betaine, important for the coffee taste and aroma. It contributes to the aroma through the degradation products formation during roasting and, among these products, are pyridines and N-methylpyrrole (MONTEIRO; TRUGO, 2005). Coffee is one of the only products that, through a process as drastic as roasting, produces an important vitamin for the human metabolism, the niacin. During the roasting, trigonelline undergoes demethylation to form niacin in amounts close to 20 mg 100 g-1 of roasted coffee (MONTEIRO; TRUGO, 2005).

Many authors report that the variation of the trigonelline content relates with the bean species, being the arabica the one that shows the highest values (CLARKE; MACRAE, 1989; DAGLIA et al., 2004; SOUZA et al., 2010). The roasting process will also influence the component content in the beans. However, those submitted to a more drastic roasting process will present lower content of this compound (MONTEIRO; TRUGO, 2005).

Farah et al. (2005) concluded that higher quality beverages present higher levels of trigonelline than those of lower quality, and the arabica coffee has higher levels of trigonelline than robusta coffee, both for raw and roasted coffee, for the different qualities of beverages studied. It was also observed that the more intense roastings decrease this component content.

Phenolic compounds are known for their antioxidant characteristics *in vitro* and *in vivo*. Among them are the chlorogenic acids (CGA), which are considered to be the most important and those with the greatest concentration in coffee.

Chlorogenic acids are composed of five major groups of phenolic compounds and their isomers consisting mainly of the quinic acid esterification with one of the following acids derived from cinnamic acid: caffeic, ferulic or p-coumaric acid. These groups are the caffeine-linoleic acids, with three major isomers (3, 4, 5); dicaffeoylquinic acids, whose main isomers are 3,4; 3.5; 4,5; feruloylquinic acids (3,4,5); p-coumaroylquinic acids and caffeo feruloylquinic acids (CLIFFORD, 1985b; MONTEIRO; TRUGO, 2005). For being important precursors of free phenolic acids and therefore of volatile phenolic compounds, which participate in the aroma formation of roasted coffee, chlorogenic acids are important for the coffee beverage sensory evaluation (MOREIRA; TRUGO; DE MARIA, 2000; ABRAHÃO et al., 2008).

In a study on bioactive compounds in whole and decaffeinated coffee, and the beverage sensory quality, Abrahão et al. (2008) found that the roasting process induced a significant reduction in the 5-caffeoylquinic acid concentration. And, in a similar work, Lima Filho et al. (2010) conclude that decaffeination reduces the *in vitro* antioxidant activity of the coffee beverage, while the roasting process potentiates the free radicals scavenging activity and its reducing power, but that, regardless of the roasting or decaffeination process, the beverages resulting present antioxidant activity, and may contribute to the development prevention or reduction of pathologies associated with oxidative stress.

Morais et al. (2009) verified the decrease of 5-ACQ contents in the samples in a study on the characterization of the bioactive compounds and antioxidant activity of the conilon coffee submitted to different degrees of roasting. The 5-ACQ contents found in conilon coffee were higher than that of arabica coffee in light and medium roastings but lower in the dark. The authors conclude that the chemical composition of the conilon coffee beverage is dependent on the roasting and that the yield of essential oil in the medium roasting was higher than in the others, making it more aromatic.

Working with arabica coffee samples classified as “soft”, “hard” and “Rio”, in raw coffee and with light, medium and dark roastings, Rodarte et al. (2009) found that the more pronounced roastings promoted a greater degradation of trigonelline and 5-caffeoylquinic acid of the beans, whereas the light roasting favored only the degradation of the chlorogenic acid, not interfering in the concentrations of trigonelline, and the caffeine content was not altered in any of the situations studied.

Farah and Donangelo (2006), through analyzes of several results published by other authors, concluded that *C. canephora* is associated with higher levels of chlorogenic acids, the main component of the raw coffee beans phenolic fraction. However, chlorogenic acids contribute to the final acidity (Table 11) and confer astringency and bitterness according to several authors related to this review (CARELLI et al., 1974; CLIFFORD; WIGHT, 1976; TRUGO; MACRAE, 1984; VARIYAR et al., 2003; citados por FARAH; DONANGELO, 2006). Variyear et al. (2003) explain that, as a result of Maillard and Streckerm reactions, coffee bitterness increases due to the phenolic compounds degradation with the release of caffeic acid, formation of lactones and various phenolic derivatives responsible for aroma and flavor. So, when it is assigned to *C. canephora* species the higher contents of these acids, they justify the most preponderant characteristics of its beverage, such as sharp bitterness and characteristic astringency.

Table 11. Chlorogenic acids content in *Coffea arabica* and *Coffea canephora* samples expressed as a percentage, in dry matter grams, found by several authors

Amostras	CQA	FQA	diCQA	CGA Total	References
C. arabica	5,76	0,25	0,87	6,88	Trugo and Macrae (1984)
C. arabica var. Caturra	4,63	0,33	0,66	5,62	Clifford and Ramirez-Martinez (1991)
C. arabica var. Bourbon	4,77	0,34	0,56	5,67	
Wild *C. arabica* (average)	3,26	0,19	0,60	4,10	Ky et al. (2001)
C. arabica (Angola)	4,30	0,57	1,23	6,10	Correia et al. (1995)
C. arabica (Angola)	4,84	0,28	0,53	5,65	
C. arabica (Angola)	5,67	0,79	1,39	7,85	
C. arabica var. Boubon (Brazil)	4,20	0,28	0,77	5,25	Farah et al. (2005a)
C. arabica cv. Longberry (Ethiopia)	4,60	0,29	0,84	5,73	
C. canephora cv. Robusta	6,82	0,60	1,37	8,80	Trugo and Macrae (1984)
C. canephora cv. Robusta (Angola)	3,43	0,54	1,20	6,08	Correia et al. (1995)
C. canephora cv. Robusta (Angola)	4,97	0,75	1,46	7,18	
C. canephora cv. Conillon (Brazil)	7,42	0,95	1,09	9,47	Farah et al. (2001)
Wild *C. canephora* (average)	7,66	1,43	2,31	11,3	Ky et al. (2001)
C. canephora var. Robusta (Uganda)	5,77	0,47	1,34	7,58	Farah et al. (2005a)
C. canephora cv. Robusta	5,33	0,79	1,05	7,17	Clifford and Ramirez-Martinez (1991)
Timor hybrid (*C. arabica* x *C. canephora*)	4,71	0,33	0,58	5,62	
Catimor (Timor hybrid x *C. arabica*)	5,51	0,35	0,45	6,31	
C. liberica cv. Dewevrei	5,39	0,48	1,10	6,97	Ky et al. (1977)

Source: Adapted from Farah; Donangelo (2006).

CQA - caffeoylquinic acid; FQA - feruloylquinic acids; diCQA dicaffeoylquinic acids. Total CGA - total chlorogenic acids. Units may have changed for consistency in comparison.

On the other hand, the authors list the beneficial properties to health due to their antioxidant characteristics and also as hepatoprotective, hypoglycemic and antiviral agents (FARAH; DONANGELO, 2006).

In their study, Farah and Donangelo (2006) also add that the main groups of chlorogenic acids found in green coffee beans are the caffeoylquinic, dicaffeoylquinic, feruloylquinic, p-coumaroylquinic and mixed esters of caffeic and ferulic acids with quinic acid , with at least three isomers per group. And they add the effects they may experience during coffee processing, for example, the partial isomerization, hydrolysis or degradation to low molecular weight compounds. Another important issue that Farah et al. (2005) and Monteiro and Trugo (2005) discuss on the chlorogenic acids is their interference in the beverage quality, since there is an expressive increase in their contents in beans that present defects, such as immature, black, green and burnt.

According to Halsted, cited by Lima et al. (2010), coffee is considered a unique food, because despite the partial degradation of phenolic compounds during roasting, it has antioxidant activity due to the high free radicals scavenging capacity (DPPH), that is, to inhibit oxidative degradation and also by the development of other bioactive compounds. Daglia et al. (2008), studying the isolation of high molecular weight components and the contribution of coffee protective activity against lipid peroxidation in the system of microsomes in rat liver, observed that the compounds of high molecular weight (> 3500dA) were able to inhibit the antioxidant activity completely (100%), while the low molecular weight compounds (<3500dA) inhibited the antioxidant activity by 52%.

6 DEFECTS DESCRIPTION, CAUSES AND RELATION TO QUALITY

The characterization of defects found in coffee, its causes and influence on the product quality, presented below in a summarized way, were adapted from CQI / USDA (2015).

Black beans

They are caused by oxidation of green beans, excessive and uncontrolled fermentation, insect damage and frost. They originate from fruits harvested excessively ripe, raisins or dried, fallen on the ground and may be associated with microorganisms activities (aerobic and anaerobic fermentation). They are distinguished by opaque black color. However, immature conilon/robusta beans tend to oxidize and grow in a turbid manner, with the color evolving from light green to a grayish green, brown, dark brown, and finally black. In this case it is necessary to observe the beans innermost layers so that the coloring can be verified in addition to the outermost films, that in this case must also be black.

They are generally less dense and can be removed on tables of density. They influence the beverage quality by imparting musty, earthy, smelly fish, and phenolic tastes. They may lead to a risk of contamination with ochratoxin (OTA).

Manual removal or by electronic sorting machines is the best way to eliminate them. This defect occurrence can be prevented by a process of balanced nutrition and selective harvesting and avoiding the contact of the fruits with the ground.

Fully/partially burnt beans

The fermented bean is characterized by the embryo's death in its interior. This is caused by excessive fermentation (extensive microbiological activity) and elevated temperatures in several steps during harvesting and processing. Specific causes include: harvesting of very ripe cherries, harvesting the coffee on the ground, contaminated water during the depulping process, excess fermentation in the fruit when the moisture is high and drying at high temperatures (> 45 °C). Crops implanted in low areas and close to lakes, dams or rivers are more prone to this type of defect.

The influence on the beverage quality depends on the fermentation and its intensity. It can be positive in using specific yeasts and under controlled conditions. But, if not properly planned, it can affect the he green bean aroma and physical aspect. When the beans is partially fermented, it can bring out pulp, fermented or sweet flavors. When the bean is very fermented, it produces a characteristic pungent odor resembling yeast, rotten fruit, onion, sweat and rancid.

Beans with fungi/mold

The fungi that are harmful to coffee quality are usually of the genus *Aspergillus, Penicillium and Fusarium*. Coffee can be infected at any stage of cropping, harvesting, processing and storage, particularly in environments with high temperature and high relative humidity of the air. The presence of fungi in beans can cause the perception of mold, earth, dirt, excessively fermented and phenolic flavors taste, besides offering a risk of ochratoxin (OTA) occurrence. The fungi and bacteria action tends to occur until the beans, in the drying process, reach 11%/12% moisture, and even in storage.

The fungi identification can be easily accomplished by the presence of a dark powder on the beans or parchment and for they present purple spots on their surface. The fungi presence can be prevented with attention to the use of good practices in the processing sites, avoiding that the beans suffer physical damages in this stage, uncontrolled fermentation, beans remaining in the pulpers, drying process interruption, perforated beans, storage in conditions of high temperature and high relative humidity of the air.

When the coffee is cultivated in tropical regions, with higher temperature and relative humidity of the air, some efforts are needed to limit situations that favor the fungi proliferation, such as: collecting the coffee that has fallen on the ground, avoiding perforated beans, removing the excess of perforated beans, as well as the remaining beans and the coffee skins.

Coffee with foreign materials

Foreign materials can accumulate in all stages of coffee processing and represent a threat to health, as well as causing the perception of atypical flavors to the beverage. They affect the green coffee aspect and can damage roasting equipment.

They can be avoided or removed by proper equipment maintenance, selective harvesting, use of flotation tanks for pre-cleaning, constant cleaning of the pulpers and drying yards. In cases of dry or natural processing, equipment such as stone pickers or tables of gravity should be used.

Dry or coconut beans

Caused by lack of water and/or occurrence of pests and diseases that can cause the drying of the fruit still attached to the plant or its detachment and fall on the ground. These factors lead to fermented, moldy beans, earth perception and phenolic substances in the tasting analyzes. The presence of dried or coconut beans is also a result of failures to remove this type of beans in the removers or in the floating tanks.

The presence of coconuts affects the green beans aspect. The skin, once roasted, provides aromas of smoke and charcoal, resulting in bitter and unpleasant flavors. It is prevented from occurring by avoiding the collection of dry beans from the ground or plant, especially those harvested from dry and dead branches. The continuous crop management, with adequate fertilization is recommended to keep it healthy and vigorous.

Perforated beans

The damages caused by the coffee borer can be classified according to the intensity of the damage caused. Little damages, when found between one and two perforations/bean, and severe damages when three or more perforations/bean are detected.

Vega et al. (2009) add that the coffee borer (*Hypothenemus hampei* Ferrari), a small beetle, very adapted in areas that grow coffee, is a pest of greater relevance to the coffee culture around the world. The adult females lay their eggs in a perforation that they make in the fruit, and, after hatching, the larvae feed on the seeds, reducing the yield and compromising the commercial product quality. According to these authors, the pest occurrence impacts in the aspect and weight of green and roasted beans and generates a fermented, dirty, musty beverage. It is all the more compromising the more internally the pest is installed in the bean. May lead to ochratoxin (OTA) risk.

Beans severely damaged by the coffee borer bug can be separated during the coffee washing using floating and fermentation tanks. They can also be removed by densimetric tables. Small damages, on the other hand, are often difficult to remove due to the small weight difference compared to normal beans.

The coffee borer control can be done efficiently by integrating crop management techniques and alternative harvesting to chemical and even biological control. The use of traps can be a good alternative for coffee borer reduction.

Broken/cut/torn beans

They are, as a rule, caused by the processing, mainly, in the fruits depulping or mechanical hulling. When the pulper is unbalanced, it may exert excessive pressure on the beans, leading to its break or crush. They can also originate during the processing by the excessive drying of the beans that break more easily when in friction with the equipment pallets. It causes the perception of earth, dirt and fermented flavors in the beverage and affects the green beans aspect and the roasting uniformity.

The selective harvesting promotes a certain uniformity in the size of the fruits to be processed and can substantially reduce the defect occurrence. It is also necessary to adjust the pulpers and the processing equipment in order to avoid very high pressure and friction during the processing.

Immature/green beans

Immature or green beans are those harvested without being fully developed yet. They did not reach their ideal weight and maximum sugar content. They occur as a consequence of the harvesting precociously performed or due to the strip harvesting of fruits coming from different flowering on a single occasion.

They can be avoided with proper planning of the operations in the field using cultivars that show a greater maturation uniformity. The control of the water application by irrigation can help in concentrating the flowering.

Green beans may be separated from the drier or raisins by the density during the fruits washing procedure, and the ripe or cherries during hulling or depulping. They influence the beverage for causing aromas and flavors of green, grass, bamboo, cereal or bitter, besides impacting in the roasted beans aspect.

Wilted beans

They are caused by lack of sufficient water during the stage of fruits development, vigor and nutrition of the plants. It affects the beans aspects and the roasting uniformity, provoking flavor of green, grass, bamboo, promoting astringent aftertaste,

The shading and irrigation help reduce its occurrence. Shading and proper soil management techniques, as well as good nutrition, reduce the impacts of wilted beans in the product quality. However, since most of the wilted beans are less dense, they can be easily removed in cleaning tanks.

Shell

They come from a natural phenomenon caused by the coffee genetics. Shells do not confer an intrinsic flavor that compromises the beverage, but this type of bean can give rise to an uneven roasting because it is easy to burn during the process operation, resulting in burnt, charcoal and smoke aromas and flavors.

The planting of cultivars known to have a high occurrence rate of this defect should be avoided. During processing, the shells separation can be performed by size or with the aid of a densimetric table.

Whitish beans

The occurrence of whitish beans is not well elucidated, but it is believed that they may originate from genetic issues, high temperature during the drying process, nutritional imbalance, water stress produced by older plants or storage in humid and very clear places, and for a long time.

In processing, the whitish beans presence indicates poor drying. It contributes to wood, cardboard, bamboo, aromas of cereals and high astringency nuances. It affects the beans aspect, which tend to burn when roasted with other normal ones.

Underdeveloped/spongy beans

They originate from malnourished crops, kept with water stress and older plants. Excess moisture, high temperatures, mechanical damage, and microbiological activity can form underdeveloped beans (embryo death, organic matter degradation, weight loss).

In processing, the presence of underdeveloped beans indicates an inappropriate post-harvesting process. Spongy beans are caused by improper drying and storage. Parchment or coconut trapped in dryers or pulping machines retain excessive moisture and may contribute to the development of spongy beans.

This defect affects the beans aspect which tend to burn when roasted with other normal ones. It influences on the beverage quality, bringing woody, cardboard, bush, cereal aroma nuances.

Underdeveloped beans can be prevented by selecting the best cultivars, with the correct plants nutrition, use of pruning, crops renew and suitable soil management. Densimetric tables help in the selection and separation of beans with this defect.

'Parchment' bean

They are those originating from immature or deformed fruits that remain very attached to the parchment. This defects indicates poor processing due to improper calibration of the pulping machine, as well as the use of inappropriate equipment with sieves and densimetric tables. Parchment beans have affected aspect, influence the coffee beverage by burning when roasted along with normal beans causing smokey flavors and aromas.

For the separation of parchment beans and their removal, it is necessary that the processing machines be kept well calibrated. Sieves and density tables help reduce this problem.

Skins

Skins usually appear when using natural processes of drying, very often due to equipment that are kept without proper cleaning and sanitizing care. They also originate from the inadequate processing machines calibration and hamper the green beans aspect and can burn when roasted with normal beans. Depending on the conditions in which the skins are found, they can cause a perception of earth, dirt, mold, fermented and phenolic flavors and aromas.

They can be separated into floating tanks. The use of green separators and well calibrated processing machines contributes to reduce their presence.

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