

Sensory perception of coffee consumers as a function of different genotypes and extraction methods

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ABSTRACT: Coffee is one of the most consumed beverages in the world, with unique organoleptic characteristics of aroma and flavor, also varying according to the several extraction methods. Therefore, the objective of this study was to investigate whether the different Arabic coffee genotypes prepared by various extraction methods would influence amateur consumers' perception of sensory and hedonic judgments of specialty coffee. A large-sample experiment (n = 270) was conducted in a coffee shop at the Universidade Federal de Lavras and participants were divided into three groups according to the evaluated genotypes (Bourbon Amarelo, Pacamara and Híbrido de Timor), who tasted four samples, varying to the extraction methods ('Conventional Brewed', Hario V60, French Press and Espresso). From the results obtained, it is possible to conclude that there is a change in the sensory perception of aromas and flavors of coffees in all genotypes studied in the four extraction methods, as well as in the acceptance and purchase intention by consumers.

Key words: acceptance; beverage; consumption; sensory profile; specialty

Percepção sensorial de consumidores de café em função de diferentes genótipos e métodos de extração

RESUMO: O café é uma das bebidas mais consumidas no mundo, com características organolépticas únicas de aroma e sabor, variando, também, pelos diversos métodos de extração. Portanto, o objetivo deste trabalho foi investigar se diferentes genótipos de café arábica preparados por vários métodos de extração influenciariam a percepção sensorial e os julgamentos hedônicos de consumidores amadores de café especial. Um experimento de grande amostra (n = 270) foi conduzido em uma cafeteria da Universidade Federal de Lavras e os participantes foram divididos em três grupos de acordo com os genótipos avaliados (Bourbon Amarelo, Pacamara e Híbrido de Timor), que degustaram quatro amostras, variando quanto aos métodos de extração (Filtrado Convencional, Hario V60, Prensa Francesa e Espresso). Para tanto, foram utilizadas técnicas de análise multivariada e variância. A partir dos resultados obtidos é possível concluir que há alteração na percepção sensorial de aromas e sabores dos cafés em todos os genótipos estudados nos quatro métodos de extração, bem como na aceitação e intenção de compra pelos consumidores.

Palavras-chave: aceitação; bebida; consumo; perfil sensorial; especial



Introduction

Coffee is one of the most popular and appreciated beverages in the world, and over the decades, the production, process, trade, and consumption has undergone a transformation from a pure commodity to a specialty product (Samoggia & Riedel, 2018; Guimarães et al., 2019; Samoggia et al., 2020). According to the Specialty Coffee Association (SCA, 2021) and the international Q.Coffee System Protocols (Lingle & Menon, 2017), specialty coffee is a term used to refer to coffee or coffee experience recognized for its distinctive attributes, both intrinsic (flavor attributes, roast color, descriptive profile, etc.) and extrinsic (origin, producer, certification, and others) that can be distinguished on the basis of quality and uniqueness, and so having a significant extra value in the marketplace. This definition points out that coffee is now considered a high-quality standard product, focusing not only on the quality but also on the experience of consumption (Samoggia et al., 2020).

The coffee consumers are increasingly demanding in terms of quality, due to greater knowledge and access to differentiated products and, consequently, willing to pay higher prices for them (Guimarães et al., 2019; Santos et al., 2021). This appreciation and growing demand for these coffees make it essential to knowing the bottlenecks pertinent to production, as well as to the countless peculiarities involved in the commercialization and consumption of this beverage. Thereby, stands out the need for approximation between all the links chain, since the producers until consumers, in order to know their preferences (Boaventura et al., 2018). It is noteworthy that, in recent decades, numerous coffee beverages, obtained using different extraction techniques have entered the market (Angeloni et al., 2019). However, still difficulty in determining the factors that interfere in consumers preferences and extraction methods in relation to coffee, given the cultural, tradition and, of course, personal issues that are linked to the consumption habits (Samoggia & Riedel, 2018).

It is important to consider the specialty coffee consumer is interested, each more day, on quality and unique characteristics, obtained by different coffee flavor profiles, sensory attributes, origin, types of coffee - e.g., espresso, filter, instant, with milk, iced, and others (Sepúlveda et al., 2016; Samoggia & Riedel, 2018). Over the last decades, the preparation of the coffee beverage for consumption follows different standards, generally defined and/or chosen according to the method of extraction, which can directly influence consumer acceptance, due to the sensory profile obtained by each method used, differing in terms of the process, utensils, grinding, ratio of water and coffee. There is no best extraction method, but that each technique has its own characteristics (Bezzan & Dulgheroff, 2016; Angeloni et al., 2019).

So, it is essential to understand the consumer's ability to perceive the peculiar characteristics of coffee samples, since it is an essential factor for product acquisition (Guimarães

et al., 2019). Nonetheless, the results still remain scarce, especially when the coffee genotype is changed, since this is one of the crucial pillars in the construction of the characteristic aroma and flavor (Sobreira et al., 2015; Nadaleti et al., 2018; Fassio et al., 2019). In this sense, the present study aimed to investigate whether the different Arabic coffee genotypes prepared by various methods of extraction would influence amateur consumers' perception sensory and hedonic judgments of specialty coffee.

Materials and Methods

The experiment was conducted at Universidade Federal de Lavras - UFLA (Lavras, MG, Brazil), in partnership with coffee shop 'Cafeteria Escola - CafEsal'.

Evaluated genotypes

Arabica coffee genotypes (*Coffea* spp.) were used from Active Germplasm Bank (AGB) of the Experimental Field of Patrocínio (CEPC), Minas Gerais, Brazil, which was set in 2005, belongings at Empresa de Pesquisa Agropecuária de Minas Gerais - EPAMIG, located in Alto Paranaíba region, in the Cerrado Mineiro (at 18° 59' 26" S and 48° 58' 9.5" W, with altitude of approximately 1,000 m above sea level), which has the 1st Coffee Designation Origin in Brazil.

Three genotypes were selected for evaluation, namely: Bourbon Amarelo (MG0128), for being a world reference in the production of specialty coffees (Borém et al., 2016), Pacamara (MG0224), for presenting an exotic sensory profile (López-García et al., 2016) and Híbrido de Timor (MG0364), which is a valuable Germplasm widely used in coffee breeding programs, as it has rust resistance and genetic variability for sensory quality (Sobreira et al., 2015).

Obtention of coffee

After the 2018/2019 crop, in May 2019, the coffees were harvested and, immediately, directed to the CEPC post-harvest sector. Subsequently, they were washed to separate and remove impurities and/or less dense fruits, such as floaters, poorly grained and dry. Then, 50 L of ripe fruits were selected for each one of the genotypes.

The coffee fruits were directed to drying, with constant revolving in full sun, in sieves suspended 1 m above the ground to favor the circulation of air through the fruit mass until the beans reached a water content of 11%. After drying, the samples were packed in double-layer Kraft paper bags, covered by a plastic bag, and stored for a period of 30 days in a cold chamber with a constant temperature of 16 °C to standardize the water content in the beans. After this period, the samples were processed and packed in impermeable plastic bags until roasting.

For the sensory analysis, the samples were standardized on a 16/64 sieve and above (beans retained in sieves 16, 17, 18, and 19 combined), absent of intrinsic and extrinsic defects. Then, the next step was the roasting process according to the protocol proposed by the Specialty Coffee Association -

SCA ([Lingle & Menon, 2017](#)), which recommends color 55# to 65# on the Agrtron scale (medium roast) for whole beans, with roasting time between 8-12 minutes.

Beverage preparation methods

After roasting, the coffee of each genotype was subjected to four different extraction methods of the beverage: one espresso system and three filter methods (Conventional Brewed, Hario V60, French Press), that uses different pressures and filter techniques. These methods were selected for this study because they are more common coffee extraction methods chosen by Brazilian consumers ([Guimarães et al., 2019](#); [ABIC, 2021a](#)). It is worth mentioning, that drinks were prepared without added sugar, by a professional barista, using the mineral water from the same source, the beans were ground using a professional grinder (EK43 Mahlkönig AG, Switzerland), and in accordance with the recommendations suggested by Brazilian Coffee Industry Association ([ABIC, 2021b](#)). So, a specific recipe was followed for each of the four methods. The procedures of extraction parameters were prepared following a pre-established standard, that differed in terms of the grind, the amount of coffee used and, water temperature. And all the filter methods involved scalding for pre-cleaning and preheating of the equipment, 30 seconds of pre-infusion of the powder in about 10% of the total water, and a filtration time greater than 2 minutes were used.

One of traditional largely method to prepare coffee used at houses in Brazil is with paper filter, in this study named 'Conventional Brewed'. The preparation was carried out following the ratio of 50 g of roasted and ground coffee (medium/fine grind) were evenly spread on a Melitta® paper filter (103) to 0.5 L of hot mineral water (92 °C) was poured over the powder, as described in the ABIC PQC quality method ([ABIC, 2021b](#)). The other filtered (pour-over) coffee beverage served to the participants was prepared with the Hario V60 Kit (filter No. 03) at a concentration of 100 g L⁻¹ obtained by pouring hot mineral water (92 °C) over the roasted and ground coffee (medium grind). As for the French Press, 10 g of roasted and coarse-ground coffee were added to the coffee maker, and 100 mL of hot mineral water were then added (93.5 °C). The mixture was brewed for 4 minutes in infusion, then the plunger was pressed to trap coffee grounds at the bottom of the container, following the SCA standard procedure ([SCA, 2016](#)). And, for the preparation of Espresso, a manual machine was used, where eleven grams of powdered coffee (fine grind) were pressed into the filter and 100 mL of water heated at 90 °C passed through, at a pressure of 9 atm for 30 seconds, according to the manufacturer's instructions (Tramontina by Breville Express Pro®).

Sensory analysis

This study was approved by the Human Research Ethics Committee of Universidade Federal de Lavras (Lavras, MG, Brazil), according to protocol CAAE 29529220.1.0000.5148.

The sensory analysis of the experiment was conducted at CafEsal, a coffee shop school at the Universidade Federal de Lavras. At the start of each session, the participants were informed that they would taste and evaluate four samples of specialty coffees and, then, received a 2 minutes briefing to ensure that they were all given the same instructions prior to the experiment and the supervisor was present during the testing sessions in order to provide that the participants evaluated samples individually, without any exchange of information with another evaluator.

For this, 270 coffee consumers were randomly recruited (52% female and 48% male; mean age 26, 18-65 years). Three sessions of sensory analysis were carried out, in randomized blocks, with one genotype per block (i.e., Bourbon Amarelo, Pacamara or Híbrido do Timor). Each block was evaluated by 90 coffee consumers, who tasted four samples, referring to the extraction methods.

The samples were presented to consumers in a monadic way, that is, one at a time, and in a balanced order, in disposable paper cups with a capacity of 50 mL (containing 25 mL of sample), duly coded by three-digit numbers randomized. All samples were served with a temperature between 62 and 65 °C. Consumers were instructed to taste one sample at a time, according to the predetermined sequence offered, and rinse the mouth with mineral water between the coffee samples.

The Check-All-That-Apply (CATA) technique and the acceptance tests were used according to [Lara et al. \(2018\)](#), with some modifications. The survey of the CATA consists of a list of words or phrases, from which the panelist selects which ones apply to the sample, being able to choose all the possible attributes to describe the product. In this study, the attributes were defined by SCA-certified sensory analysts (Q-graders), resulting in a list with seven words (chocolate, caramel, fruity, citrus, nuts, honey and sweet), besides the option 'others'. In order to carry out the CATA analysis, the consumers were instructed to read the list of attributes present on the sensory analysis form and, then, after tasting the samples, indicate that were best adequate to describe in terms of aroma and flavor of each one, being free to express their perception of the attributes to be chosen, according to their opinion ([Varela & Ares, 2012](#)).

Along with the CATA test, they were also asked to assess the acceptance of aroma, flavor, and overall impression, in addition to their intention to purchase the coffees. For the acceptance analysis, a 9-point structured hedonic scale was used, ranging from 'dislike extremely' (1), 'indifferent' (5) to 'like extremely' (9), in relation to aroma, flavor, and overall impression of the samples. And the purchase intention was evaluated using a 5-point attitude scale, ranging from 'certainly would not buy' (1), 'have doubts if I would buy' (3) to 'would certainly buy' (5) ([Meilgaard et al., 2007](#)).

Statistical analysis

A contingency matrix was designed, taking into account the frequency of each attribute mentioned in CATA for each

of the evaluated samples. These contingency matrices were performed as an input in a Correspondence Analysis (CA), using the software R, version 3.6.2 (R Core Team, 2019) and the packages FactoMinerR (Lê et al., 2008) and factoextra (Kassambara & Mundt, 2019).

An Analysis of Variance (ANOVA) was used to verify if there was a difference among the samples, and the results of the sensory attributes aroma, flavor and overall impression obtained in the acceptance and purchase intention tests. Then, the Tukey test was performed to verify which samples were different from each other. Three Way Preference Maps (PARAFAC) were designed, using the SensoMaker software (Pinheiro et al., 2013).

Results and Discussion

According to the CATA analysis, Figures 1A, 1B, and 1C are able to demonstrate that the extraction methods were characterized differently in relation to aroma and flavor attributes, and also as a function of genetic material. For the Bourbon Amarelo genotype (Figure 1A), it is observed that the first and second dimensions represented, respectively, 71.9 and 21% of the variability of the experimental data (92.9% in total). The attributes that characterized the Hario V60 method were fruity aroma and flavor, besides caramel flavor. On the other hand, the beverage by 'Conventional Brewed' extraction was recognized for its sweet and citrus aroma and flavor. The French Press was characterized by nuts and honey aroma and flavor. And with the Espresso coffee, there was a predominance of chocolate aroma and flavor, in addition to bitterness in the beverage.

Regarding Pacamara (Figure 1B), there was 94.2% in total data variance, 73.5 and 20.7%, respectively, for the first and second dimensions. In this genotype, the beverage of Espresso coffee was characterized by chocolate aroma and flavor, besides a bitter taste, similar with the sensory profile observed in Bourbon Amarelo for this method. The extraction of French Press was identified by the sweet aroma and flavor, besides the caramel flavor. And, for the most traditional methods, 'Conventional Brewed' and Hario V60 it were observed an evident complexity of aromas and flavors, identified by the tasters. This result is in line with the greater acceptance and purchase intention for these preparation methods by consumers, since the flavor is one of the most important factors positively associated with consumer acceptance of coffee (Sunarharum et al., 2014). The coffee by method Hario V60 was distinguished from the others by the aromas of nutty, honey, citrus, and fruity, as well as the flavor of honey and nuts. The 'Conventional Brewed' coffee was highlighted with aromas of nuts, citrus, and caramel, in addition to flavors caramel, fruity, and citrus.

As for Híbrido de Timor genotype (Figure 1C), the first and second dimensions represented, respectively, 80.2 and 13.7%, of the variation of data (93.9% in total). The Hario V60 samples of coffee were characterized by a sweet aroma and flavors of chocolate, honey, and caramel. The beverage

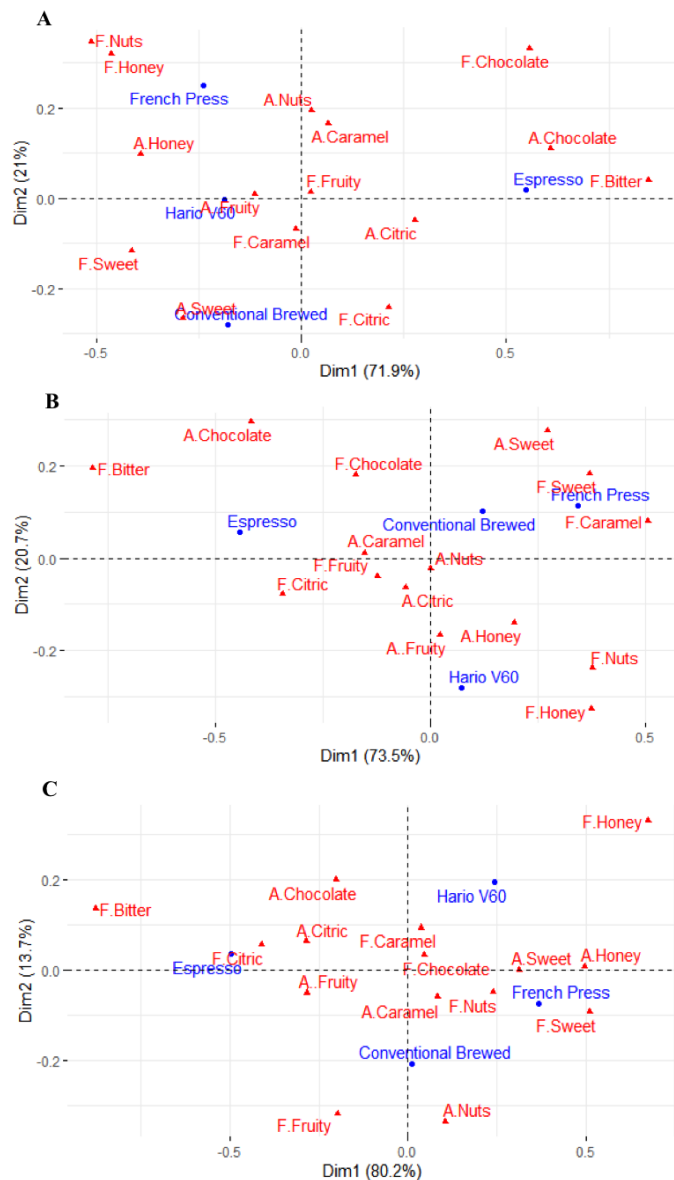


Figure 1. A, B and C - Representation of terms and samples of beverage extraction methods of the first and second dimension of correspondence analysis, held in the contingency table CATA for Bourbon Amarelo, Pacamara and Híbrido do Timor, respectively (A - aroma; F - flavor).

of 'Conventional Brewed' coffee was characterized as having nutty and caramel aromas, as well as fruity and nutty flavors. Regarding the Espresso extraction method, as in the other genotypes, the bitter flavor and chocolate aroma were predominant, according to participants. However, it is important to highlight the perception of citric aroma and flavor, which may be linked to the greater purchase intention of this method for genotype Híbrido de Timor, when compared to the others, Bourbon Amarelo and Pacamara (Figure 3).

Consumers were able to detect sensory differences between coffees and this wide variation of perceived nuances in the samples of this study is in agreement with Sunarharum et al. (2014), who state that the complexity of the coffee flavor stems from innumerable influences from

cultivation, processing, and preparation, all of them capable of altering the construction of the coffee aroma and flavor raw, roasted and even in the beverage, linked to volatile and non-volatile compounds, influencing the perception of taste, acceptance, and pleasure of the coffee consumer. That is why it is essential that the knowledge of the complexity involved in the beverage coming from different coffee genotypes prepared by various extraction methods reaches from producers to coffee shop owners, as well as consumers, in order to favor a more profitable commercialization of this beverage and that is more attractive and pleasing to specialty coffee consumers, because, each more, they increase their consumption of these type of coffee, searching to have different experiences with distinct extraction methods and, consequently, they are willing to pay more for the product (Guimarães et al., 2016).

According to Table 1, it is possible to observe the significant effect ($p < 0.05$) of the different beverage extraction methods for the variables aroma, flavor, and overall impression in all the three arabica coffee genotypes studied. Several studies confirm that the main motive for drinking coffee by consumers is its flavor and aroma (Sousa et al., 2016; Czarniecka-Skubina et al., 2021). In general, the methods 'Conventional Brewed' and Hario V60 consisted of higher acceptance averages for flavor and overall impression, with scores between 6 and 7, with the terms varying between "like slightly" and "like moderately", with small oscillations among genotypes. For the attribute aroma, these methods are similarly with Espresso and all of them are superior to the French Press.

It is observed that, in all genotypes, the Espresso method remained in groups with higher values for aroma, and lower for flavor and overall impression. This can be explained by the fact that this kind of method, demands a very fine grind, having the capacity to potentiate the characteristics of aroma, due to crema formation (Labbe et al., 2016), and also more intense extraction, which can cause confusion in the beverage profile with the bitter taste, being negatively related to consumer acceptance, especially those used to consuming filtered coffee. Corroborating these data, the term bitterness can be observed in Figures 1A, 1B, and 1C, being decisive in the characterization of the samples of the Espresso preparation method, by CATA test.

In contrast, the coffee of French Press showed low acceptance averages for all variables in the three genotypes. These results are in agreement with Pereira et al. (2023),

who also observed less acceptance of the French Press in relation to other methods (Chemex, Hario V60, and Espresso), for all the evaluated attributes. This kind of method requires a coarse grind, thus, the extraction is less intense, yielding a smoother beverage, which may not have accentuated the desired aroma and flavor nuances. Another point to be highlighted regarding the low appreciation and acceptance of this method is a possible interference from other variables, such as color, texture, body, and fat content (Jervis et al., 2012; Varela et al., 2014; Nguyen et al., 2016). The coffee prepared by the French Press results in a beverage with no crema formation, medium color, and turbid, due to the mixture of water and coffee that passes through the mesh filter (Espitia-López et al., 2019), which may have led to the rejection by amateur consumers. Furthermore, the visual characteristics of the product are, for consumers, an indicator of quality, placing their mind in an anticipatory or predictive model that can be powerful enough to modify the activation pattern observed in the primary sensory regions (Carvalho & Spence, 2018).

Figure 2A shows the Three Way Preference Maps - PARAFAC for Bourbon Amarelo genotype, which accounted for 84.75% data variance (30.46% from factor 1 and 54.29% from factor 2). There is a greater vector concentration and, consequently, higher acceptance by consumers for the 'Conventional Brewed' method, followed by Hario V60, when compared to the others (Espresso and French Press). The variables of aroma, flavor, and overall impression were significant for this excellent acceptance. For the genotype Pacamara (Figure 2B), factors 1 and 2 represented 88.70% total of data variance, i.e., 30.82 and 57.89, respectively. It can be observed that there was a greater similarity in the acceptance between the methods 'Conventional Brewed' and Hario V60, being superior to the others. Like the Bourbon Amarelo genotype, for Híbrido de Timor (Figure 2C), which accounted for 88.36% data variance (31.14% factor 1 and 57.22% factor 2), the predominance of acceptance was for the coffee obtained by 'Conventional Brewed', followed by methods Hario V60, Espresso, and French Press.

In general, the acceptance of all variables in this study showed similar behavior for all genotypes, with the highlight on the 'Conventional Brewed' method. These results are in line with the consumer habit of most Brazilians, since the consumption of filtered coffee is predominant in the country because it is a classic method, cheap and easy to prepare (Guimarães et al., 2016).

Table 1. Averages for acceptance of aroma (A), flavor (F), overall impression (OI) and purchase intention (PI), of the four beverage extraction methods in each genotype of Arabica coffee.

Extraction methods	Bourbon Amarelo				Pacamara				Híbrido de Timor			
	A	F	OI	PI	A	F	OI	PI	A	F	OI	PI
Hario V60	6.62 ab	6.37 ab	6.42 ab	3.53 a	6.42 a	5.96 ab	6.22 ab	3.37 ab	6.59 ab	6.27 a	6.34 a	3.38 a
Conventional Brewed	6.47 ab	6.40 a	6.54 a	3.56 a	6.56 a	6.42 a	6.57 a	3.53 a	6.42 bc	6.12 a	6.18 a	3.33 a
French Press	6.08 b	5.61 bc	5.74 bc	2.98 b	5.88 b	5.48 bc	5.66 b	2.94 bc	5.97 c	5.36 b	5.41 b	2.74 b
Espresso	6.91 a	4.96 c	5.50 c	2.82 b	6.96 a	4.96 c	5.67 b	2.79 c	7.12 a	5.14 b	5.77 ab	2.90 b

Averages followed by the same letter in the column, do not differ significantly by the Tukey test ($p \geq 0.05$).

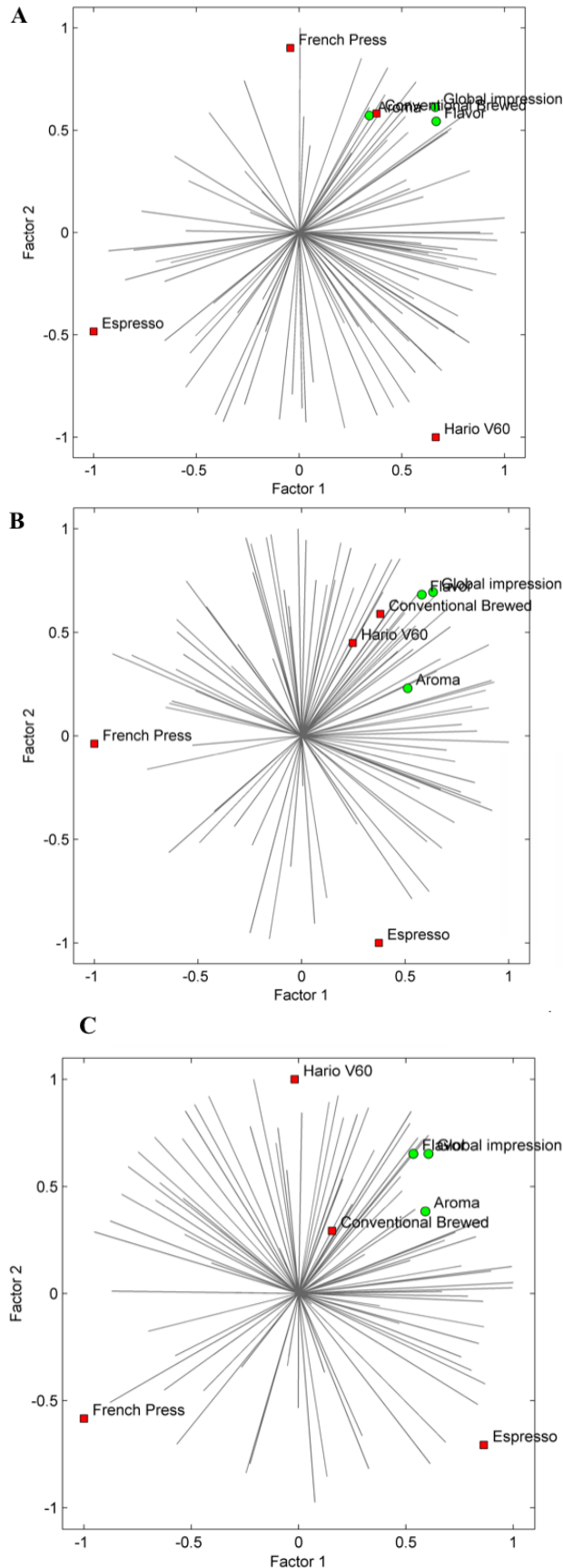


Figure 2. A, B and C - Three Way Preference Maps - PARAFAC for aroma, flavor, and overall impression of different beverage extraction methods for Bourbon Amarelo, Pacamara and Híbrido do Timor, respectively.

For purchase intention, significance was also verified by the Tukey test ($p < 0.05$), for all coffee genotypes (Table 1). It is evident that the methods 'Conventional Brewed' and Hario V60 had a higher purchase intention by consumers, with averages between 3.3 and 3.6. This fact shows that consumers liked and would buy coffees from these extraction methods for all genotypes. And the methods French Press and Espresso, on the other hand, presented averages ranging from 2.7 to 3.0, as a function of the evaluated genotype, that is, consumers were not so willing to pay for the beverage served. The graphical representation of these results is shown in Figure 3. In general, Brazilians consume, on average, about 220 mL of infusion coffee per day (Soares et al., 2019) which may explain the less acceptance of other brewing methods.

The preparation methods of coffee consist of different extraction forms and depend on specific equipment, and techniques, resulting in particular and unique sensory profiles (Bezzan & Dulgheroff, 2016), in addition to the oscillation in the nuances and intensities of the sensory attributes that are formed between distinct genotypes (Fassio et al., 2019; Sobreira et al., 2015). These variations need to be considered for beverage marketing, meeting specific consumer requirements, implying variation in the consumers' purchase intention.

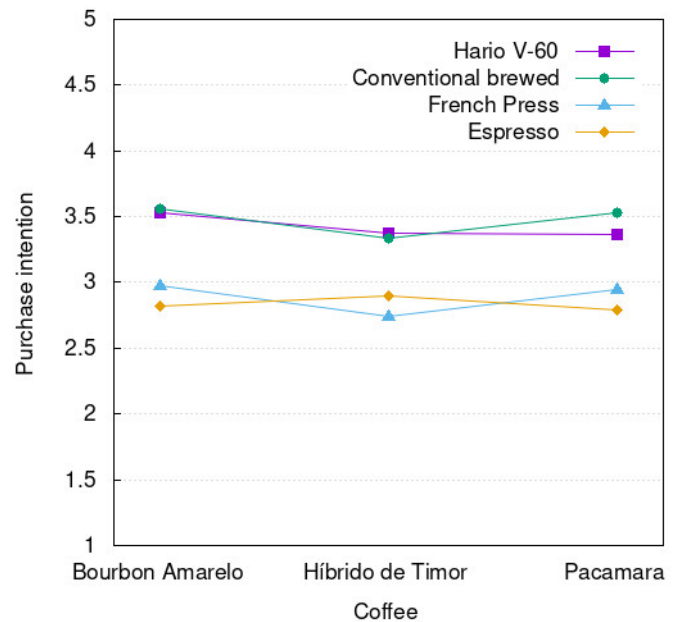


Figure 3. Purchase intention for beverage extraction methods in each arabica coffee genotypes.

Conclusions

The sensory perception of aroma and flavor of coffees by amateur consumers changed according to the genotype and extraction methods of beverages. In the three genotypes, the 'Conventional Brewed' and Hario V60 methods demonstrated more complexity of aromas and flavors, with emphasis on caramel and fruit notes, and also, greater acceptance and purchase intention by consumers. On the

other hand, the Espresso and French Press methods were characterized, in all genotypes, for their sweetie aromas and flavors, although the bitter taste predominated in all Espresso coffees, resulting in lower acceptance and willingness to pay for these kind of coffee beverages.

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Compliance with Ethical Standards

Author contributions: Conceptualization: DHSN; Data curation: DHSN, MNR; Formal analysis: DHSN, MNR; Funding acquisition: GRC; Investigation: DHSN, MMMS, DRP, DJMV; Methodology: DHSN, MNR, MMMS; Project administration: DHSN; Resources: GRC; Supervision: DHSN, GRC; Validation: GRC; Visualization: DHSN, DRP; Writing - original draft: DHSN, MMMS, MNR, DRP, DJMV; Writing - review & editing: DHSN, MMMS.

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