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The typicity of coffees from different terroirs determined by groups of physico-chemical and sensory variables and multiple factor analysis

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A R T I C L E I N F O

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A B S T R A C T

Coffee production is the result of the relationship between local environmental conditions and coffee cultivars that grow in this place. Coffee plants develop original physico-chemical and sensory characteristics that together with the agricultural techniques practiced by growers define the terroir. The objective of this study was to describe the typicity of coffee prepared by coffee growers from seven coffee terroirs in Paraná, Brazil. The terroir categorization was based on the local latitude, longitude, altitude and annual average temperature. Coffee samples were prepared by the coffee growers according to their agricultural techniques. A multiple factor analysis (MFA) was applied to the groups of variables of the green and roasted coffee bean physico-chemical and sensory attributes. The variability in environmental conditions was sufficient to modify the green and roasted coffee bean characteristics and sensory attributes. The terroir description obtained with MFA description compared to that obtained with individual groups of variables was different among terroirs. Roasted coffee variables and sensory attributes caused the greatest differences. The individual use of these groups of variables may result in non-representative descriptions of coffee from different terroirs. Mandaguari and Ivaiporã terroirs were associated with high nitrogenous compounds content, high expansion volume and low density of roasted coffees, and the beverages showed a high turbidity and intense body. Apucarana, São Jerônimo da Serra and Ribeirão do Pinhal terroirs were associated with low lipids content, high density and low volume expansion roasted coffee, and the beverage showed intense coffee and sweet aromas and a low turbidity and body texture. In coffee from the Londrina terroir, medium nitrogenous compounds content and high sucrose and lipids contents were found. Their beverage showed a high turbidity and intense body as well as a grassy green taste and astringency. Coffee from Ribeirão Claro terroir presented high lipids and sucrose contents and low caffeine and phenolic compounds contents, and the main sensory attributes were a coffee aroma and sweet and sour tastes. In conclusion, a terroir formed by environmental conditions and agricultural techniques can produce coffee with a set of physico-chemical and sensory characteristics that define its typicity.

1. Introduction

Coffee is a globally consumed beverage due to its stimulating effects (Glade, 2010), appealing beneficial healthy effects (Vignoli, Viegas, Bassoli, & Benassi, 2014) and sensory attributes (Figueiredo et al., 2015; Kitzberger, Scholz, & Benassi, 2014). Therefore, the quality of coffee beans for beverage processing plays a fundamental role when the goal is to satisfy the consumers of this enormous production chain.

The coffee plant (*Coffea arabica*) is native to regions of Ethiopia and has been cultivated in places where environmental conditions exist for the complete development of coffee beans (Bertrand et al., 2006; Bertrand et al., 2012). In favorable environments, the plant can show its potential to produce high-quality sensory beverages, generating important income for coffee growers (Figueiredo et al., 2015; Scholz et al., 2016).

Environmental factors such as altitude, latitude (Bertrand et al., 2012; Figueiredo et al., 2013), temperature and rainfall (Joët et al., 2010) have a decisive impact on the chemical composition (Figueiredo et al., 2015; Villarreal et al., 2009) and sensory attributes of coffee beverages (Barbosa et al., 2012; Figueiredo et al., 2015).

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The implantation of coffee in a region is favored by the local environmental conditions (Caramori et al., 2001; Silva et al., 2005). The interactions between the coffee cultivars and the local growth produce coffees with specific physico-chemical compositions, and consequently, typical sensory characteristics are perceived in the beverage. Therefore, a system of complex interactions between the techniques practiced by growers and the environmental conditions of production results in products with typical characteristics that can be economically exploited, and this area is called a terroir (Salette, Asselin, & Morlat, 1998).

In global coffee-producing regions, several terroirs have been identified, and their typicity was recognized (Bertrand et al., 2008; Figueiredo et al., 2015; Villarreal et al., 2009). However, the identification of coffee typicity is a complex and expensive task. Numerous variables in the chemical composition, the presence of volatile compounds and numerous sensory attributes must be used to obtain a correct characterization (Decazy et al., 2003; Pagès, 2005; Rason, Martin, Dufour, & Lebecque, 2007).

The description of coffee from a specific microregion using one or more groups of variables individually can lead to inaccurate or distorted results (Pagès, 2005; Perrin & Pagès, 2009). Often, these groups may have different relationships with the quality characteristic of the coffee from each microregion.

Therefore, the use of multivariate techniques is crucial to evaluate both the effect of a large number of variables and the contribution of each group to obtain an adequate description of the coffee in this region (Perrin & Pagès, 2009).

In this context, multiple factor analysis (MFA) is used to simultaneously evaluate a sample with several groups of quantitative and qualitative variables (Perrin & Pagès, 2009). After balancing the influence of the groups, MFA allows the contribution of each group of variables to the sample description to be evaluated. This technique has been applied to describe the influence of local wine origin (Pagès, 2005; Perrin & Pagès, 2009), coffee quality (Decazy et al., 2003) and sausage origin (Rason et al., 2007).

The objective of this study was to describe the typicity of coffee prepared by coffee growers in seven coffee-producing microregions of Paraná, Brazil. MFA was applied to the groups of physico-chemical variables of green and roasted coffee beans and to the group of sensory variables in coffees harvested at these locations.

2. Material and methods

2.1. Formation of terroirs

The coffee-producing region of Paraná (Fig. 1) is located in the southern limit of the regions suitable for coffee planting in Brazil (Caramori et al., 2001). These municipalities have environmental conditions that allow the formation of regions with typical microclimates, and they are organized in different terroirs based on the local latitude, longitude, altitude and annual average temperature (Table 1). This categorization allows the application of an MFA in which the objects under analysis must be organized into a category according to a set of characteristics (Pagès, 2005).

2.2. Coffee samples and coffee analyses

The coffee samples analyzed in the present study were prepared by the coffee growers of each area using the techniques and infrastructures routinely employed. This kind of preparation, which is associated with the environmental conditions, fits perfectly with the aforementioned concept of a terroir.

The coffee samples from each coffee terroir were provided by the Commission for Coffee Quality competition (2004 and 2005). This competition is annually organized by the official coffee entities in the state of Paraná, and coffee growers from different regions participate. The number of samples from each terroir ranged from 16 to 31 coffee samples for a total of 169 samples in these two consecutive competitions (Table 1).

To participate in these competitions, coffee growers must prepare the coffee. Usually, coffee cherries were harvested when they were completely ripe and were prepared by the natural post-harvest process (CN) or peeled cherry process (CD), according to the available infrastructures in the properties.

In the CN process, the harvested coffee cherries are washed in water tanks and spread directly on cement or brick terrace to dry. In the CD process, the coffee cherries are washed and peeled before being spread to dry on the same types of terrace. The drying processes were finished after 12% moisture content was achieved, and the dried coffee cherries were stored in jute bags.

Two kilos of the dried coffee from each process were sent to the organizing committee of the competition, and they were responsible for removing the husk and parchment of the coffee cherries and all defective coffee beans.

2.3. Physico-chemical analysis of green coffee beans

2.3.1. Chemical and equipments

5-O-Caffeoylquinic acid (5CQA), caffeine, glucose, trigonelline and gallic acid were purchased from Sigma-Aldrich (St. Louis, MO, USA).

Potassium sulphate, copper sulphate, sodium hydroxide and petroleum ether were purchased from Quimex (São Paulo, Brazil). Sulfuric acid, zinc sulfate, sodium carbonate, anhydrous disodium phosphate, sodium and potassium tartrate, anhydrous sodium sulfate and sodium arsenate were purchased from Merck (Darmstadt, Germany).

A Fanem oven 315 SE (Fanem, São Paulo, Brazil), a Sorvall centrifuge SS-3 (Ivan Sorvall INC, New York, USA), an ultrasonic bath FS110 (Fischer Scientific, Lafayette, USA), an Evolution 300 UV-Vis spectrophotometer (Thermo Scientific, San Jose, USA), Perten 3600 disc mill (Kungens Kurva, Sweden), a Rod Bel coffee roaster (Rod Bell, São Paulo, Brazil), and Byk Gardner, model PCB-6805 portable colorimeter (Geretsried, Germany) were used.

The green coffee beans were frozen with liquid nitrogen, ground in a disc mill (Perten 3600) and kept in a freezer (−18 °C). Protein, lipids, titratable acidity and phenolic compounds, moisture were determined by the respective methods described in AOAC (1990). The determination of the total chlorogenic acids and density of the green coffee beans followed the respective methods described by Clifford and Wight (1976) and Franca, Oliveira, Mendonça, and Silva (2005).

To determine trigonelline, 5-ACQ and caffeine contents, 0.5 g of ground green coffee beans was added to 30 mL of hot water (80 °C) and held at this temperature for 10 min in a water bath (80 °C). Five milliliters of the filtered sample was diluted in 25 mL of water and passed through a filter membrane (Millipore, 0.45 μm). Chromatographic conditions were described by Alves, Dias, Benassi, and Scholz (2006).

Sugars (reducing and total) were extracted with water for 30 min in a water bath (80 °C). After cooling, the extract was added to 10% zinc sulfate and 0.5 N sodium hydroxide and filtered. Reducing sugars were determined in an aliquot of this filtrate by the method of Somogyi and Nelson (Southgate, 1976). For the total sugar content, an aliquot of the filtered extract was hydrolyzed with concentrated HCl for 16 h at room temperature. After neutralization with NaOH, the reducing sugars were determined by Somogyi and Nelson. The sucrose content was determined by subtracting the reducing sugar content from the total sugar value.

The physico-chemical analyses of green coffee beans were performed with two replicates, and the results are expressed on a dry basis. This variable group was called FQV.

2.4. Physico-chemical analysis of roasted coffee beans

The coffee beans (100 g) were toasted in a Rod Bel coffee roaster,