Analysis verbal sensory methods in the evaluation of organic coffee with different roasting intensities

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ABSTRACT
A sensory diagnostic of organic coffee from Otomi-Tepehua zone of Hidalgo state was carried out, which were subjected to 4 types of roasting: Medium roasting, Intense roasting, Very Intense roasting, and Artisanal roasting using a mud “comal.” Also, a Blend was made (Medium, Intense, and Very Intense toasted coffee in 1:1:1 ratio). Sensory analysis was made using the verbal methods Check-All-That-Apply (ATA) and Flash profile. It was used 44 sensory attributes in CATA method, from which 10 had significant differences (p > .05). Flash profile method grouped the coffee samples according to their descriptor similarity mentioned by the consumers, and a nine-point hedonic test was also carried out. Both methods described all the coffee samples with similar sensory profiles, the results suggested that the Blend made a sensory profile similar to Artisanal roasting coffee. Nevertheless, the consumers differed in preference due to the intensity of the attributes was different of coffee roasting.

Introduction
The first organic coffee exported to Europe was produced by farmer union UCIRI from Oaxaca, México in 1985.[1] Nowadays, Mexico ranks fifth in the area of coffee culture in the world, with which it was obtained 159.9 million dollars derived from foreign trade with the USA, being the second organic agricultural product in Mexico.[2]

Hidalgo State is the sixth coffee producer in Mexico[2] and the Otomi-Tepehua zone has made many efforts in order to maintain the organic production. The roasting process is carried out by the producers themselves, using a mud “comal,” firewood and charcoal, which confers different sensory characteristics compared to other products. It was proposed to carry out the coffee sensory analysis to provide added value, thus benefit the producers, salesmen, and consumers.

Many classical sensory methods have been widely used in alimentary research, such as Flavor Profile Method, Texture Profile Method, Quantitative Descriptive Analysis, Quantitative Flavor Profile and Spectrum method.[3–10] Those methods are according to “ISO 8586: 2014 Sensory analysis –
General guidelines for the selection, training and monitoring of selected assessors and expert sensory assessors,” in which it is mentioned that it must be carry out a pre-selection and a specific selection of sensory judges, followed by an appropriate training for the product (color, taste, smell, texture, detection and recognition of special flavors and odors, use of scales and descriptors), providing sensory attributes and profiles with high accuracy, resulting in large and expensive tests, which make them unavailable to little producers from Otomí-Tepehua zone of Hidalgo state.

Different methods have been created in the last 10 years due to economic aspects and time required for judge training, which are carried out using consumers or semi-trained judges at low cost. Besides, such methods provide similar sensory maps. Among those novel methods are verbal methods such as CATA and Flash profile,[11] based on evaluation of individual attributes (intensity scale, verification questions and descriptor generation).[12] The aim of the study was to use sensory evaluation to describe four different roasting treatments of organic and Artisanal coffee produced in the region of Hidalgo, Mexico.

Materials and methods

Coffee samples

Coffee samples were obtained from San Bartolo Tutotepec municipality, owned to Otomí-Tepehua zone in Hidalgo State, the property has 15 ha at 1600 m above sea level, arabica variety and was harvested in 2019. The coffee trees were 2-meter-high, in their third year of production and cultivated organically and agrochemical free, with a yield of 3 kg per plant. Cherries were manually collected in order to select only the red ones. Then, they were fermented during 12 h, and subsequently depulped and washed to remove parchment coffee.

Coffee samples were subjected to 4 types of roasting: 1) “Medium roasting” (180°C, 7 min), 2) “Intense roasting” (200°C, 7 min), 3) “Very Intense roasting” (220°C, 7 min) and 4) “Artisanal roasting” (Coffee beans were placed in a mud “comal,” over a fire produced by firewood for 7 min), the degree of roasting was checked visually. Additionally, it was carried out a fifth treatment, consisting in an “Blend” with treatments 1, 2 and 3 in 1:1:1 ratio (data provided by coffee producers).

Espresso coffee processing

For each coffee treatment were used, 5 g of ground coffee of each treatment and sodium-free purified water (Member’s Mark®) and placed in a pump coffee machine set at 15 bar (KRUPS®, Gusto Vivo F880), according to manufacturer’s instructions. The final volume of espresso coffee was 20 mL and the service temperature was 90–92°C.

Sensory analysis

The analyzes were carried out with 50 consumers (between 18 and 50 years old), being 50% men and 50% women, all of them regular coffee consumers and they were part of the university community (Universidad Autónoma del Estado de Hidalgo, Instituto de Ciencias Agropecuarias), all were volunteers. The study was carried out in a sensory analysis laboratory, which has individual panels for the consumers and white lighting, as well as a room for sample preparation. Water was provided to clean the palate. Each session was independent and lasted approximately 10 min. Samples were presented monadically in standard random fashion, and all samples were presented at the same time.

CATA method[8] was carried out with 50 consumers randomly selected in unique session. The samples were codified using random 3-digit numbering and described with the attributes recommended by “Le Nez Du Café™es” (Table 1), and an additional column was added entitled as “Other” in order to the consumers could include additional attributes.
Flash profile method[4] was carried out in unique session with 50 consumers which tested the codified coffee samples in a comparative way in order to mention all the attributes that they considered appropriate to discriminate samples. Later, samples were classified according to the attributes intensity generated from each consumer. A nine-points hedonic test was also carried out to evaluate the level of liking of the samples.[13]

**Statistical Analysis**

Cochran’s Q test was carried out to evaluate any significant difference among the samples analyzed with CATA method, such non-parametric test is used in bidirectional randomized blocks designs analysis where the response variable is binary (0 = no descriptor presence, 1 = descriptor presence). Each descriptor (Table 1) could make a data matrix containing samples (columns) and consumers (rows). Subsequently, a Multiple Correspondence Analysis (MCA) (XLSTAT *) was performed in order to obtain a two-dimensional representation of the samples, which provides the sensory map of
the samples allowing determine similitudes and differences and the specific sensory attributes of each sample. An ANOVA was performed (α = 0.05) using the XLSTAT® software, for the hedonic test treatments.

Data analysis with Flash profile method was made by creating individual matrices for each consumer (products in rows and attributes in columns) resulting in tables according to attributes described by each consumer. Data were analyzes by Multiple Factorial Analysis (MFA) (XLSTAT®, α = 0.05) in order to understand the relationship between samples, as well as to identify possible descriptor matches by data mapping. Hedonic test data analysis was carried out by a radial graph using frequencies described by the consumers.

Results

Coffee sensory attributes by CATA method

A Cochran’s Q test was carried out in order to analyze the data obtained with CATA method and determine possible significant differences among samples for each attribute mentioned by the consumers (Table 2). In this sense, only 10 of 44 attributes used were significantly different: woody, tobacco, smoke, bitter, light beige, brown, light brown, little dark brown, very dark brown and black.

Figure 1 shows the MCA, which is the two-dimensional projection of attributes and samples obtained with CATA method. The F1 and F2 explain 86.18% of the total variability of the samples. The scores obtained by each sample indicate the contribution of the attributes. As shown, the “Blend” and “Artisanal roasting” treatments were grouped, described by the attributes floral, nutty, spicy, wine, citrus, fruit, fruity, herbal, cereal, sweet, chocolate, honey, herbal and flora. The “Intense roasting” and “Medium roasting” treatments were grouped and described by the attributes toasted, brown, acid, bitter and carboy. Additionally, the “Very Intense roasting” treatment was not grouped with another treatment, the sensory descriptors for this treatment were black, dark, medicinal, smoky, earthy, sourness, tabacco and woody.

Figure 2 shows the treatments as a two-dimensional projection, which explain 74.26% of the total variability of the samples. The attributes mentioned by the consumers were grouped in Smell, Taste and Sight to facilitate the analysis. Likewise, lines were traced between samples and the points represent the descriptor grouping. The treatment “Intense roasting” was referred by the consumers with 7 attributes which had significant difference (woody, tobacco, smoke, light brown, dark brown, black and bitter). The descriptor bitter is mentioned to treatments “Intense roasting” and “Medium roasting.”

| Aromas     | Flavor  | Color  | Others          |
|------------|---------|--------|-----------------|
| □ Floral   | □ Acid  | Cream  |
| □ Fruit    | □ Bitter| □ Light beige |
| □ Herbal   | □ Sweet | □ Beige |
| □ Rancid   | □ Salty | □ Light brown |
| □ Rubberly (Plastic) | □ Souerss | □ Brown |
| □ Wine     | □ Citrus | □ Dark brown |
| □ Woody    | □ Fruity | □ Infusion |
| □ Earthy   | □ Woody | □ Light brown |
| □ Tobacco  | □ Carboy | □ Dark little brown |
| □ Smoke    | □ Vinegar | □ Dark |
| □ Medicinal| □ Herbal | □ Black |
| □ Honey    | □ Spicy  |        |
| □ Nutty    |         |        |
| □ Caramel  |         |        |
| □ Chocolate|         |        |
| □ Cereal   |         |        |
| □ Toasted  |         |        |
Figure 1. MCA graph obtained from the CATA method. The biplot superimposes the coffee roasting treatments and sensory attributes from organic coffee samples.

Figure 2. Two-dimensional projection obtained with Flash Profile method.
The “Aroma” attributes vector was the longest of the three groups (Figure 2), which means that the consumers described the coffee samples with more “Aroma” attributes than “Color” and “Flavor” attributes. Additionally, “Intense roasting” and “Very Intense roasting” treatments were described with similar attributes by the consumers (Figure 3).

The consumers had similar likeliness level with the treatments “Medium roasting,” “Intense roasting” and “Artisanal roasting,” with score of 5.5 (Figure 3). The treatment “Very Intense roasting” produced a higher level of likeliness (score of 5). On the other hand, the treatment that had the lowest level of likeliness (score of 3) was “Blend,” possibly due to the consumers described it as the treatment with the lowest aroma profile and reduced presence of Aroma attributes (Fig. 1 and 2), giving more importance to those treatments with higher descriptor diversity and intensity.$^{16,17}$

**Discussion**

The classic sensory evaluation methodologies used to carry out descriptive profiles are long-lasting, expensive, and complex. Nowadays, for industry and research, sensory results are required in a short time and ideally it is desired that these studies are cheap, characteristics that the generation of Flash methodologies. Within these methodologies, the verbal methods stand out because the results provided indicate a description of the sensory profile of the product, as well as the preference for it, these methodologies also stand out for the use of consumers, that is, who do not require a previous training for the analysis. The use of untrained consumers has been shown to generate sensory characteristics that describe products with assertiveness similar to that provided by trained judges.$^{18}$

This study shows that the level of consumer liking for Artisanal roasted coffee is similar to that obtained by samples of coffee roasted in a standardized way regardless of the level of roasting (Figure 3) with the CATA method. Time variations in the type of coffee roasting can change the sensory profile, since there are differences in the production of compounds associated with these variations, which allows roast masters to obtain special aroma profiles through small changes in the time or degree of roasting.$^{19}$ In recent studies, it is mentioned that coffee roasting level is a consequence of temperature and time, which influence in the intensity of coffee compounds and final sensory profile.$^{19–23}$ According to Table 2 and Figure 1, the “Intense roasting” treatment shown a sensory profile with the higher intensity in flavor, color and aroma. When performing the ANOVA, no significant differences were found between the treatments of medium roast, intense roast, very intense roast and artisanal roast, only the Blend treatment showed a lower preference among consumers, which was significantly different (data not shown), this agrees with the results shown in Figure 3.
The CATA method allowed to describe many samples submitted to different roasting treatments (Figure 1). The Artisanal roasting treatment shows a similar sensory profile to the Blend, however consumers preferred the Very Intense roasting, Intense roasting and Medium roasting samples. Figure 1 shows that the coffee with Artisanal roasting had few defects. However, the preference was similar to the samples “Medium Roasting,” “Intense Roasting” and “Very Intense Roasting,” as shown in Figure 3. The main advantage of the hedonic test is that it provides information on consumer acceptance and preference.

Flash profile method is characterized by quickly generating a sensory map of a set of products, since it can be easily understood by the consumers. When all the samples are compared at the same time, it is easier to differentiate between products with a conventional Profile, and provides descriptors generated by consumers. Due to these characteristics, a semantic terminology is obtained, this methodology is presented as a communication tool between research, development and marketing.\(^{[18]}\)

In Figure 2 it is shown that the Blend treatment is the most similar to the Artisanal Roasting treatment, using the Flash profile method, which coincides with that obtained with the CATA method (Figure 1), analyzing the size of the vectors presented in the Figure 2 it can be seen how the consumers describe with greater intensity the Artisanal roasting treatment. On the other hand, probably the lower intensity in the Blend treatment descriptors was related to the lower preference for the sample, with respect to the rest of the treatments (Figure 3).

The conditions for the treatment of coffee with Artisanal roasting can be considered optimal\(^{[20]}\) since they generate sensory descriptors with a preference similar to the treatments of Medium toast, Intense toast and very Intense toast (Figure 3). There are sensory studies about Blend coffee samples, which are made up of different percentages, types of coffee and roasting. These analyzes were carried out under classic methodologies such as QDA,\(^{[3–10]}\) the studies reveal the sensory profiles of the samples, as well as the consumption preference. This information is used by producers to generate Blends with specific sensory profiles and preferences for consumers.\(^{[24–26]}\) Our study revealed that using sensory methodologies such as CATA and Flash profile, the sensory profile and consumer preference of a Blend sample can be known in shorter time and lower cost.

**Conclusion**

Verbal sensory methods allowed to describe the coffee samples comparing their similitudes and differences. CATA method showed the significant differences between samples, whereas Flash profile method showed their similitudes. It is important to mention that both methods are considered fast, allowing participation of consumers in a unique session, unlike classical methods such as QDA. CATA and Flash profile methods separated “Artisanal roasting” samples from the rest of treatments. Furthermore, the results suggested that the “Blend” produced a sensory profile similar to the “Artisanal roasting” one. Despite this, the consumers had different preferences between these samples due to the intensity of their attributes.

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