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Sensory characterization of conventional and organic extra virgin olive oil by Check-all-that-apply and emotional responses methods

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Abstract

This study aimed to investigate the sensory characterization of commercial and organic extra virgin olive oils by the Check-all-that-apply (CATA) and emotional responses methodologies. The samples were evaluated for viscosity and yellow color by 120 consumers using CATA, acceptance test, purchase intention test, emotional responses, and ideal scaling, allowing the construction of two External Preference Maps aimed to associate the results from the overall impression with the terms from CATA and the emotional responses. The samples Conventional 2 and Organic 2 presented greater proximity with positive descriptors and emotions, while the samples Conventional 4 and Organic 4 were correlated with negative descriptors and emotions, which was also observed in the acceptance and purchase intention tests, showing the consumers' preference for softer products.

Practical application: The results of this study showed that most consumers do not like the bitterness and piquancy present in olive oils. For them, the oil should be sensorially smooth. In return, they want to buy olive oils of the highest nutritional quality. This demonstrates that, most consumers are laymen and do not know that the greater the bitterness and spiciness the greater the presence of bi-active compounds present in the products. This study makes it evident that we must inform consumers about how the sensory part is related to physical–chemical aspects of products. With the end of the study, it would be interesting for future studies, to identify the bioactive compounds present in the studied samples and to interrelate with the available sensory results.

1 | INTRODUCTION

Globalization and the growing popularity of healthier foods have led to an increase in the consumption of extra virgin olive oil due to its health benefits (Chousou, Tsakiridou, & Mattas, 2017). The chemical and bioactive compounds present in extra virgin olive oil can protect lipoproteins and cell membranes from oxidative damage (Romero, 2011), with positive effects on high-density lipoproteins and removal of excess low-density lipoproteins, thus reducing the incidence of coronary disease (Hernáez, Farràs, & Fitó, 2016), diabetes mellitus, metabolic syndrome, and cancers (Schwingshackl et al., 2017), (Grosso et al., 2017) & (Daniele et al., 2017).

The olive varieties most suitable for olive oil extraction have up to 80% oleic acid (C: 18:1; ω9), and smaller quantities of essential fatty acids, such as linoleic (C: 18:2; ω6) and linolenic acids. (C: 18:3; ω3) (Bobbio & Bobbio, 2003). The beneficial effects of omega-3 fatty acids are mainly seen with fatal cardiovascular disease (Tehrany, Gaiani, Jacquot, & Imran, 2012); (Glick & Fischer, 2013).

In the world economic scenario, the EU is the largest producer of olive oil, producing 69% of the world's production. There are nine producing States: Spain, Italy, Greece, Portugal, France, Slovenia, Croatia, Cyprus, and Malta. The Spain is the biggest producer of olive oil, representing more than half of the total EU are under olive groves, with an average of 63% of all EU production from 2015 to 2018 (European Commission, 2020). Brazil is considered the second largest importer of extra virgin olive oil, with an increase in the rate of variation from 2014 to 2019 of 12%, second only to the United States. In the 2018/2019 harvest, Brazil imported and consumed 86,000 T of olive oil (International Olive Council, 2020).

The expansion of the food market and the easier access to information have led to more aware and demanding consumers in choosing food products, giving rise to the "organic consumer." The choose this food because they believe it is a viable solution to reduce the environmental impact caused by conventional agriculture, residing in the fact that organic foods are understood as more sustainable than conventional ones, providing economic balance, food security, production cleaner agricultural environment, and preservation of the global ecosystem (Schutter, 2011; Gustavsen & Hegnes, 2020), aim to sustain the health of soils and minimize environmental pollution with the use of natural fertilizers (Altieri, 2018).

The sensory evaluation is a 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 (ABNT, 2000). Consumer acceptance or preference can be assessed by affective methods, which aim to determine the most appreciated product and the sensory characteristics that guide an audience, being a scalar measure of preferences (Stone & Sidel, 2004). To study the sensory perception of consumers toward products, quantitative descriptive analysis has been applied through word association methods, using the open-ended method and consequently the Check-all-that-apply (CATA) (Ares, Giménez, Barreiro, & Gámbaro, 2010).

Studies on the consumers' emotions have been a trend in Sensory Science, once foods have an impact on the consumers' feelings, which is little explored (King & Meiselman, 2010). The growing interest in this area is due to the potential of emotional responses to prov ide important information about the products that go beyond the traditional sensory and preference variables (Jiang, King, & Prinyawiwatkul, 2014).

As reported by Macfie and Thomson (1988), the relationship between the acceptability and the descriptive profile of a product can be accessed through external preference maps, which is essentially a multidimensional graphical representation of the acceptance differences between samples, allowing us to identify individual preferences (Rodrigues et al., 2013). Thus, the present study evaluated the sensory characterization of commercial conventional and organic extra virgin olive oils using CATA, emotional responses methodologies, beyond open-ended, emotional descriptors, acceptance test, ideal for viscosity and yellow color and purchase Intention.

2 | MATERIALS AND METHODS

2.1 | Samples

Eight commercial samples labeled as extra virgin olive oil were selected, four organic and four conventional, from Spain, Italy, Portugal, and Chile, marketed in Ouro Fino—MG and São Paulo—SP, Brazil. All samples were stored in amber glass bottles (500 ml) under appropriate storage conditions, without incidence of light and humidity, at room temperature (25°C) covered with aluminum foil, within the shelf-life period, in a styrofoam box.

2.2 | Sensory evaluation

2.2.1 | Presentation of samples to consumers

Three sensory analysis sessions were performed, and the samples were presented in complete balanced blocks (Stone & Sidel, 2010) in three-digit random-coded white cups containing 5 ml of sample, at room temperature (25°C), which was evaluated in individual booths with natural daylight. During the analysis, the olive oils samples were stored in the amber glass packaging. The assessor was advised to consume water and unsalted biscuits between each sample for 30 s to clean the palate. Bread pieces cut into $3.0 \times 3.5 \times 1.2$ cm were used as a support to evaluate the attributes flavor and texture, which was immersed into olive oil to perform the analysis. To separate and characterize the eight samples referring to their trademark during the study, the conventional samples were represented by the letter C, and the organic samples were identified with the letter O, as they are the initials of the words.

2.3 | First section of sensory evaluation

2.3.1 | Open-ended method

Open-ended questions were used to evoke responses from 80 consumers, 55 female and 34 male, aged 15–30 years. The consumers voluntarily informed three to five words or expressions to describe the sensory characteristics of two conventional and two organic samples (Ares, Barreiro, Deliza, Giménez, & Gámbaro, 2010). Then, a frequency analysis of the responses was performed, and the most frequently cited descriptors were selected for use in the CATA method.

2.4 | Second section of sensory evaluation

2.4.1 | Emotional descriptors

The analysis was performed with 80 consumers, 51 female and 34 male, aged 15–30 years to obtain the emotional descriptors. The

consumers voluntarily described three to five emotions aroused while consuming two conventional and two organic extra virgin olive oil samples, using words or phrases related to the samples (Jiang et al., 2014).

2.5 | Third section of sensory evaluation

From the acceptance test, all sensory evaluation was performed in the third sensory session, using four organic and four conventional samples, with the participation of 120 consumers, 77 female and 43 male, aged from 15 to 60 years.

2.5.1 | Acceptance test

The following attributes were evaluated in the acceptance test: appearance, aroma, flavor, texture, and overall impression of the samples, using a nine-point structured hedonic scale anchored at the extremes by "disliked very much" and "liked very much" (Stone & Sidel, 2010).

2.5.2 | Check-all-that-apply method

After the frequency analysis of the open-ended responses, the terms most frequently used were considered as CATA descriptors. The eight samples of extra virgin olive oil were served to consumers, who had to indicate in the sheet all the descriptors that characterized each sample (Dooley, Lee, & Meullenet, 2010).

2.5.3 | Purchase intention test

The purchase intention was assessed using a five-point structured scale ranging from "certainly not buy" to "certainly buy" for the eight samples of extra virgin olive oil (Meilgaard, Civille, & Carr, 1999).

2.5.4 | Ideal intensity of the attribute viscosity

To evaluate the viscosity an ideal test was performed, in which consumers were asked to indicate the alternative they considered to be closer to the ideal viscosity, using a nine-point structured hedonic scale anchored at the extremes "extremely less viscous than ideal" and "extremely more viscous than ideal" (Meilgaard et al., 1999).

2.5.5 | Ideal intensity of the attribute yellow color

To evaluate the yellow an ideal test was performed, in which consumers were asked to indicate the alternative they considered to be closer to the ideal yellow color, using a nine-point structured hedonic scale anchored at the extremes "extremely less yellow than ideal" and "extremely more yellow than ideal" (Meilgaard et al., 1999).

2.5.6 | Emotional responses

To assess the emotions associated with food, the EsSence Profile method was developed, which consists of a list of 39 validated emotional descriptors. Its use is necessary to complement the emotional responses in the foods under study. Different categories of foods require modification of the list of emotions described, according to their specificity. In addition, the intensities of emotions vary and increase more frequently due to the use of the product. Table 1 shows the 39 emotional descriptors provided by the EsSence Profile method. The emotional descriptors with at least 5% frequency of citation were used to describe the emotions aroused by consumers of conventional and organic extra virgin olive oils, along with 39 emotions in EsSence Profile.

2.6 | Statistical analysis

To evaluate the open-ended responses, the descriptors with more than 5% frequency of citation were used in the CATA method, which was also performed for the emotional responses test. The results of the acceptance test and the ideal intensity were analyzed by ANOVA and Tukey's test, at 5% probability, using the Sensomaker software, as described by Pinheiro, Nunes, and Vietoris (2013). Frequency histograms were constructed for the purchase intention test using Microsoft Office Excel 2010, and an external preference map was constructed for the overall impression and the frequency of responses of the CATA descriptors, in which the overall impression was considered as the response variable (*Y*) and the CATA descriptors were the predictive variables (*X*). An external preference map was also constructed for the emotional responses test and the overall impression of the acceptance test.

TABLE 1 Emotional descriptors of the EsSence Profile method

Emotional descriptors of the EsSence Profile method			
Active	Adventurous	Affectionate	Aggressive
Bored	Calm	Audacious	Disgusted
Keen	Energetic	Enthusiastic	Free
Friendly	Glad	Good	Kind
Guilty	Happy	Interested	Joyful
Loving	Fun	Mild	Nostalgic
Peaceful	Satisfied	Pleasant	Polite
Quiet	Satiated	Secure	Steady
Disinterested	Gentle	Understanding	Warm-hearted
Whole	Worried	Wild	

Source: EsSence Profile, 2015.

3 | RESULTS AND DISCUSSION

3.1 | First section of sensory evaluation

3.1.1 | Open-ended method

The open-ended method allowed consumers to describe three to five words or phrases that characterize both the conventional and organic extra virgin olive oil samples. As can be seen in Table 2, it was possible to select 19 descriptors with at least 5% frequency of citation.

3.2 | Second section of sensory evaluation

3.2.1 | Emotional descriptors

The sensory evaluation using emotional descriptors allowed consumers to describe three to five emotions that characterize both the conventional and organic extra virgin olive oil samples. Table 3 shows the emotional descriptors with at least 5% frequency of citation. The descriptors: sad, unsatisfied, healthy, angry, full, bitter, and indifferent, that were not in the EsSence Profile, and for the reasons were included in the study, to increase the emotions present in the EsSence Profile, in order to characterize the emotions aroused during consumption of conventional and organic extra virgin olive oils.

3.3 | Third section of sensory evaluation

3.3.1 | Acceptance test

As can be seen in Table 4 for the results of the acceptance test, the conventional sample C1 obtained a lower hedonic average of acceptance for the appearance attribute, differing significantly ($p < .05$) from the other samples. For the attribute aroma, the conventional olive oils C2 and C4 showed higher acceptability, with no differences between them ($p > .05$), which was different ($p < .05$) from the C1.

For the attribute flavor, the organic extra virgin olive oil O1 presented the highest scores, differing ($p < .05$) from the samples C4 and O4, which exhibited lower acceptance. For the attribute texture, the samples O1 and C2 presented higher scores, differing significantly ($p < .05$) from sample C1, which obtained lower acceptability. No significant differences were observed ($p > .05$) for the overall impression between all samples.

Rodrigues (2015) conducted a sensory study to characterize the quality of olive oils from Serra da Mantiqueira varieties, using the temporal dominance of sensations and the acceptance tests. The positive attributes such as bitter, olive, fruity, green, and oil-flavored were significantly dominant in the different oils, while the descriptors green flavor and more intense bitter taste were less accepted by consumers.

3.3.2 | Ideal intensity of the attributes viscosity and yellow color

The ideal intensity testing assumes that the ideal sample will have a score close to zero, thus representing the consumers' perception of the product. According to Table 5, the sample C3 was closer to the ideal for the yellow color, differing significantly ($p < .05$) from the sample O2, which has a slightly lower than the ideal. Mendes and Yilmaz (2008) studied the sensory and physicochemical characterization of virgin olive oil by Quantitative Descriptive Analysis, and observed that the color of olive oil is not a strong quality indicator, as the samples ranged from a stronger to a lighter yellow shade, besides exhibiting a lighter green color.

The viscosity of oils increases with triacylglycerol chain length and decreases with unsaturation (Santos, Santos, & Souza, 2005), which is characteristic of extra virgin olive oils. Thus, the viscosity of the sample O1 was closer to the ideal, with no significant differences ($p > 0.05$) from all samples, which can be associated to the texture attribute in the acceptance test.

3.3.3 | Purchase intention test

The samples O2 and C2 show higher frequencies of positive purchase intention, represented by the sum of the responses "certainly would buy" and "probably would buy" with 54% and 52%, respectively. The indecision of purchase, represented by the response "maybe would buy", presented higher frequency of responses for the samples C3 and O2, both with 36%. For the negative purchase intention represented by the sum of the responses "certainly would not buy" and "probably would not buy", the samples O4 and C4 obtained higher frequencies with 57 and 50%, respectively, as shown in Figure 1.

Valli, Bendini, Popp, and Bongartz (2013) evaluated the acceptance of 140 samples of high-quality extra virgin olive oils through sensory descriptive analysis. That the descriptors with high intensity in olive oils such as bitterness and pungency, for example, were not

TABLE 2 Words with at least 5% frequency of citation in open-ended method

Descriptors with 5% frequency in open-ended method							
1	Bitter taste	6	Light color	11	Pleasant flavor	16	Strong flavor of olive oil
2	Pleasant aroma	7	Very viscous	12	Pleasant texture	17	Ideal flavor of olive oil
3	Pleasant color	8	Dark color	13	Little viscous	18	Characteristic aroma
4	Unpleasant flavor	9	Ideal viscosity	14	Soft flavor	19	Unpleasant aroma
5	Strong aroma of olive oil	10	Mild aroma	15	Ideal color		

Source: The author, 2019.

TABLE 3 Descriptors with at least 5% of the frequency of citation in the emotional responses

Emotions with at least 5% frequency of citation in the emotional responses			
1	Satisfied	7	Happy
2	Joyful	8	Glad
3	Sad	9	Healthy
4	Unsatisfied	10	Indifferent
5	Full	11	Angry
6	Bitter		

Source: The author, 2019.

TABLE 4 Mean value * and *SD* ** of the acceptance attributes for the conventional and organic extra virgin olive oil samples

Samples	Appearance	Aroma	Flavor	Texture	Overall impression
C1	6.12 ± 1.89 ^{b}	5.89 ± 1.93 ^{b}	6.04 ± 1.93 ^{ab}	5.91 ± 1.94 ^{b}	6.17 ± 1.78 ^{a}
C2	6.99 ± 1.55 ^{a}	6.75 ± 1.75 ^{a}	6.02 ± 2.05 ^{ab}	6.66 ± 1.60 ^{a}	6.51 ± 1.86 ^{a}
C3	6.85 ± 1.58 ^{a}	6.48 ± 1.77 ^{ab}	5.70 ± 2.14 ^{ab}	6.33 ± 1.57 ^{ab}	5.97 ± 1.90 ^{a}
C4	6.85 ± 1.69 ^{a}	6.65 ± 1.79 ^{a}	5.35 ± 2.31 ^{b}	6.17 ± 1.78 ^{ab}	5.87 ± 2.06 ^{a}
O1	7.23 ± 1.44 ^{a}	6.33 ± 1.74 ^{ab}	6.32 ± 1.83 ^{a}	6.74 ± 1.49 ^{a}	6.56 ± 1.53 ^{a}
O2	6.92 ± 1.60 ^{a}	6.46 ± 1.81^{ab}	6.11 ± 1.99 ^{ab}	6.20 ± 1.88 ^{ab}	6.35 ± 1.86 ^{a}
O3	6.81 ± 1.71 ^{a}	6.51 ± 1.91^{ab}	5.56 ± 2.26 ^{ab}	6.40 ± 1.61 ^{ab}	6.13 ± 1.78 ^{a}
O4	7.03 ± 1.63 ^{a}	6.40 ± 1.86 ^{ab}	5.30 ± 2.26 ^{b}	6.17 ± 1.91 ^{ab}	5.91 ± 2.09^{a}

Note: *Means followed by the same letter in the same column do not differ from each other at $p \leq .05$ by the Tukey's test. ** Estimated *SD* from 120 consumer data.
Source: The author, 2019.

TABLE 5 Mean value * and *SD* ** of yellow color and viscosity for the conventional and organic extra virgin olive oil samples

Samples	Yellow color	Viscosity
C1	0.55 ± 1.75 ^{a}	−0.20 ± 1.58 ^{ab}
C2	0.52 ± 1.37 ^{a}	0.24 ± 1.29 ^{a}
C3	0.28 ± 1.37 ^{a}	0.24 ± 1.28 ^{a}
C4	0.42 ± 1.51 ^{a}	0.02 ± 1.20 ^{ab}
O1	0.52 ± 1.31 ^{a}	0.01 ± 1.02 ^{ab}
O2	−0.42 ± 1.21 ^{b}	−0.34 ± 1.33 ^{b}
O3	0.43 ± 1.45 ^{a}	0.04 ± 1.30 ^{ab}
O4	0.79 ± 1.52 ^{a}	0.19 ± 1.45 ^{a}

Note: *Means followed by the same letter in the same column do not differ from each other at $p \leq .05$ by the Tukey's test. ** Estimated *SD* from 120 consumer data.
Source: The author, 2019.

well accepted by consumers, thus leading to a negative purchase intention. Those results corroborate the present study.

3.3.4 | External preference map of CATA

The external preference map allows identifying the acceptance level of a sample as a function of the descriptors. According to Figure 2, the sample C2 was characterized by the descriptors pleasant color and ideal viscosity, which is also demonstrated by a higher acceptance of the attribute texture and a higher positive purchase intention. The sample O2 was close to the descriptors pleasant flavor and mild aroma, while the sample O1 was close to pleasant flavor, which is associated with the greater acceptability of the attributes flavor, appearance, and texture in the acceptance test.

The sample C4 was characterized by the descriptor unpleasant flavor and is related to slower acceptability of the attribute flavor in the acceptance test. The samples C3 and O4 were closely related to the descriptors strong aroma of olive oil, very viscous, strong flavor of olive oil, and bitter taste, which is associated with the lower flavor acceptance in the acceptance test. Thus, the sensory quality of extra virgin olive oil is influenced by the ripening stage and type of cultivation of the olives, (Rivas, Ortiz, Jimenez, Moyano, & Lorenzo, 2013), once ripe fruits produce softer and sweeter aromas, while green fruits produce more pronounced aromas (Jorge, 2013). Ares, Varela, Rado, and Giménez (2011) studied sensory methods to evaluate orange powdered soft drinks and concluded that the CATA method was able to significantly discriminate the samples.

Barbieri, Bendini, Valli, and Toschi (2015) studied the positive sensory attributes of eight samples of conventional and organic olive oils. The acceptance test and the external preference map showed that consumers did not recognize the attribute bitterness as a positive factor, probably due to the common rejection of the bitter compounds in eating habits.

3.3.5 | External preference map of the emotional responses

Whereas food impacts the consumer behavior, researchers have included emotional responses as a determining variable in food

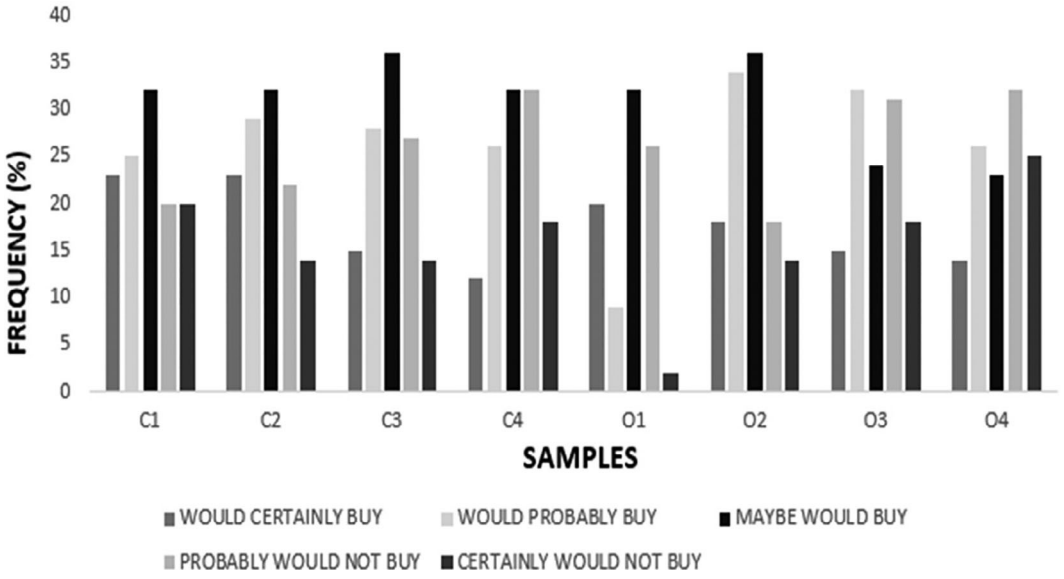

FIGURE 1 Frequency of purchase intention of conventional and organic extra virgin olive oil samples
Source: The author, 2019

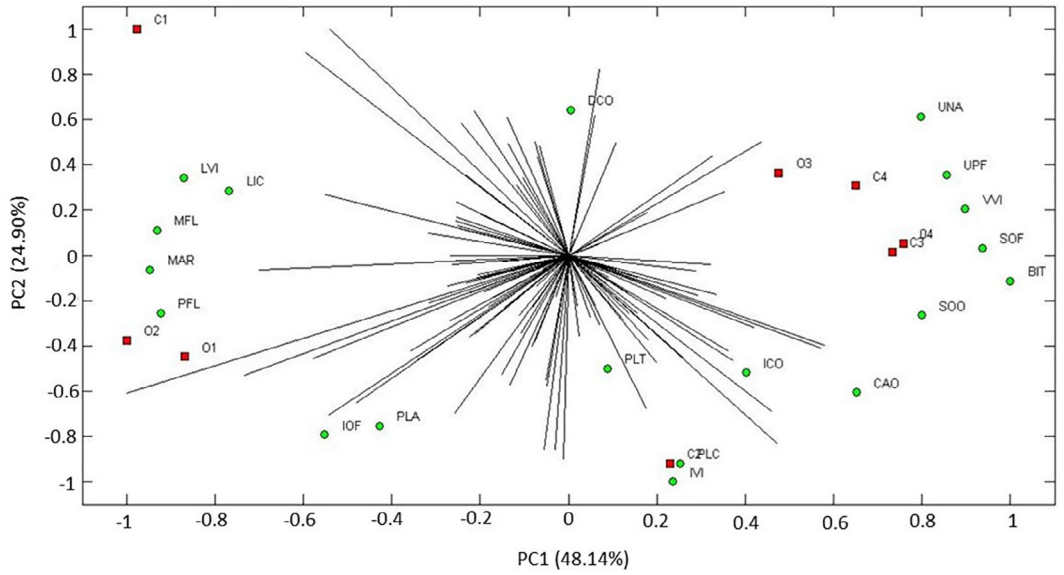

FIGURE 2 External preference map of CATA and overall impression of conventional and organic extra virgin olive oil. BIT, bitter taste; CAO, characteristic aroma of olive oil; DCO, dark color; ICO, ideal color; IOF, ideal olive oil flavor; IVI, ideal viscosity; LIC, light color; LVI, little viscous; MAR, mild aroma; MFL, mild flavor; PLA, pleasant aroma; PLC, pleasant color; PFL, pleasant flavor; PLT, pleasant texture; SOF, strong olive oil flavor; SOO, strong olive oil aroma; UPF, unpleasant flavor; UNA, unpleasant aroma; VVI, very viscous. ** PC1 + PC2 represent 73.04% of the variability between samples
Source: The author, 2019

choices, thus allowing understanding their eating experience, besides assisting in sensory science, marketing, and development of new products (King & Meiselman, 2010). Figure 3 presents the results of the emotional response test and their correlation with the overall impression of conventional and organic extra virgin olive oil samples.

The sample C1 was represented by the descriptor friendly once it is close to the map. The conventional sample C2 was related to positive emotional descriptors, including happy, interested, healthful, polite, and kind, which is correlated with the results of the purchase intention, with higher scores for the attributes aroma and texture, and the external preference map of CATA, due to the association with the descriptors pleasant and ideal viscosity. The sample C3 is close to the descriptor warm-hearted, while the sample C4 is close to the descriptor angry, which is associated with the external preference map of CATA due to the unpleasant flavor and the higher negative purchase intention and lower flavor acceptance of this sample.

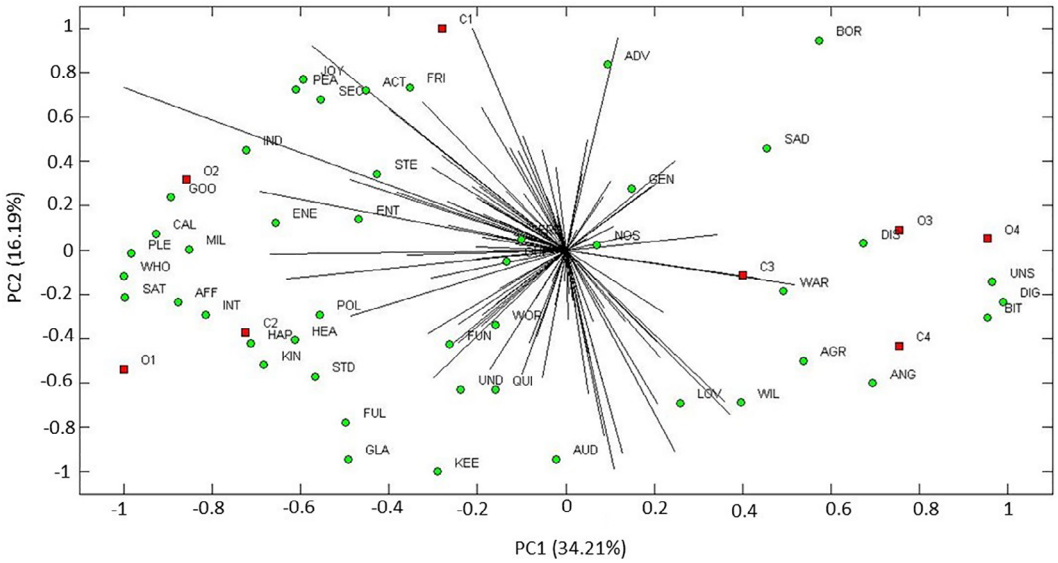

FIGURE 3 External preference map of the overall impression and the emotional responses of conventional and organic extra virgin olive oil. ACT, active; ADV, adventurous; AFF, affectionate; AGR, aggressive; ANG, Angry; AUD, audacious; BIT, bitter; BOR, bored; CAL, calm; DIG, disgusted; DIS, disinterested; ENE, energetic; ENT, enthusiastic; FRE, free; FUL, full; FRI, friendly; FUN, fun; GEN, gentle; GLA, glad; GOO, good; GUI, guilty; HAP, happy; HEA, healthy; IND, indifferent; INT, interested; JOY, joyful; KIN, kind; KEE, keen; LOV, loving; MIL, mild; NOS, nostalgic; PEA, peaceful; PLE, pleasant; POL, polite; QUI, quiet; SAD, sad; SAT, satisfied; STD, satiated; SEC, secure; STE, steady; UNS, unsatisfied; UND, understanding; WAR, warm; WIL, wild; WOR, worried; WHO, whole. ** PC1 + PC2 represent 50.40% of the variability between samples
Source: The author, 2019

Concerning the organic extra virgin oil samples, the sample O2 was represented by the descriptors well and indifferent, and the sample O3 was close to the descriptor disinterested. The sample O4 was close to the negative emotional descriptors unsatisfied, disgusted, and bitter, exhibiting a higher negative purchase intention, lower flavor acceptance, more distant from the ideal yellow color, and characterized by the descriptors very viscous, strong flavor of olive oil, strong aroma of olive oil, and bitter taste, which was demonstrated by the external preference map and CATA test. Such inferences are possible due to the proximity and distance of the vectors.

Ares et al. (2015) studied the coffee consumption through word association analysis and emotional responses and concluded that 26 descriptors were able to elicit consumer emotions, including awake, relieved, excited, well, willing, smart, quiet, sociable, and happy, among others. Emotion-raising and food consumption studies have shown that a small fraction of the emotional descriptors is strongly related to the product acceptability, and most complement the sensory evaluation of the products (Gutjar et al., 2015).

4 | CONCLUSIONS

The external preference map of the CATA and emotional responses tests showed that the samples C2 and O2 exhibited greater proximity with positive emotional descriptors, while the samples C4 and O4 showed greater correlations with negative emotional descriptors. These results are in accordance with the acceptance and purchase intention tests, as the samples C2 and O2 presented higher frequencies of positive purchase intention, and the sample C2 exhibited higher acceptance for the attributes aroma and texture. In contrast, the samples C4 and O4 presented higher frequencies of negative purchase intention and lower flavor acceptance. For suggestions for future studies, it would be interesting to study with physical–chemical analysis, how the chemical compounds present in extra virgin olive oil interfere with consumers' sensory perception.

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