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The impact of sensory attributes of mandarins on consumer perception and preferences

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ABSTRACT

Although the sensory characterization of mandarins has usually been performed by trained assessors, in recent years, the methodologies that depict sensory descriptions from the perception of consumers, such as the check-all-that-apply (CATA) questionnaires have become very popular. In this work, an exploratory study was first carried out using a focus group (FG) technique to determine attributes and aspects that influence the decision to purchase mandarins. Secondly, the consumer panel recruited 100 regular mandarin consumers that were randomly divided into two groups. Group "A" received segments of 15 mandarins. Group "B", instead of receiving the same mandarins in segments, they received them as a whole fruit having to peel them by themselves. Both groups evaluated the total acceptability with a 9-point hedonic scale and answered a CATA questionnaire composed of 38 terms for Group "A" and 52 terms for Group "B". Although the consumers in the FG described an "ideal" mandarin as easy-to-peel, no significant difference ($p > 0.05$) was found in the acceptability between groups "A" and "B". Characteristics such as sweet, very sweet, fresh smell, sweet smell, bright, fruity taste, fresh flavor, typical flavor, balanced taste and nice flavor were strongly and positively correlated with overall consumers' acceptance.

These descriptors could be considered the sensory drivers of the liking of mandarins.

1. Introduction

Mandarins are generally considered a sweeter and less bitter fruit than oranges [1]. The perceived flavor of mandarins is composed by aroma, tactile sensations and taste, among which sweetness, acidity and the relationship between these two parameters, are the so-called "fruit ripening ratio" [2]. In addition, bitterness can also be perceived, resulting from the presence of compounds such as limonin, naringin and neohesperidin [3]. The aroma of a mandarin results from a mixture of various aromatic compounds, including alcohols, aldehydes, ketones, terpenes, and esters [4,5]. Limonene is one of these characteristic compounds, being part of the group of monoterpenes together with linalool and 4-terpineol [6]. Each citrus cultivar presents a different combination of volatiles in the peel, usually named as essential oils [7]. These compounds are present in oil glands in the skin and are rapidly released during fruit peeling, infusing consumer's hand with the typical flavors of mandarins. According to researchers, the mouthfeel perception during consumption is due to the chewiness / gumminess of the mandarin segments and their juiciness [2].

The sensory characterization of mandarins has usually been obtained by performing descriptive analysis with panels of trained judges in order to measure specific variables concerning fruit quality [8,9] or to study the effects of storage conditions [10–16]. In particular, Carbonell et al. [17], developed a list of 21 descriptors for fresh juice and 29 descriptors for processed juice of Spanish mandarins with a panel of 20 trained assessors. Besides, other authors have studied the relationship between physico-chemical analytical data and sensory data obtained by trained panels [18,19].

For many years, consumers have been considered only capable of making hedonic judgments. Thus, to identify the critical flavor attributes and the key factors determining the acceptability of a product, the descriptive sensory analysis data obtained with trained assessors was

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related to the preferences of consumers [20]. For example, Goldenberg et al., [21], conducted a sensory quality study with 42 different mandarin varieties from Israel where a trained panel measured the intensity of sweetness, acidity, bitterness, fruitiness, mandarin flavor, juiciness and gumminess of mandarin samples and explored their correlation with consumers acceptance. Simons et al. [22], performed a generic descriptive analysis of 8 commercially available California mandarins and a tangelo (hybrids between tangerines and grapefruit) with a panel of trained assessors. The same samples were evaluated by adults as well as children consumers. They all showed liking for its appearance, internal color, flavor, texture and general liking with hedonic scales. Also, the adequacy of sweetness, acidity, firmness and juiciness with JAR (just-about-right) scales. Adults as well as children also scored the difficulty to peel the fruit. Consumer preferences were modeled with the descriptive analysis measurements using a PLS2 regression model.

Other authors have only used the consumers in order to explain the preferences for varieties of mandarins. House et al. [23] performed sensory studies in 3 cities of USA in order to research the preferences of adults and children for new and existing varieties of mandarins and tangelos. From four to six different mandarins and tangelos were presented to the participants (a whole fruit as well as a segment without peeling).They were asked to score the color of the whole mandarin, the color of the fruit pulp, the sweetness, acidity, juiciness, the ease of peeling, the amount of seeds, size and shape, using scales of adequacy JAR (just-about-right). The appearance and flavor were evaluated with 9 score hedonic scales. Bi et al., [24], explored the preferences of Atlanta (USA) consumers for internal sensory factors (ease of peeling, number of seeds and taste) and external factors (appearance).

Existing literature suggests that all the available sensory studies reported to have been done on mandarin segments or juice. However, there is little information about the real influence of fruit external appearance (peel color and texture) and the ease of peeling in reference to the acceptability of consumers and the perception of other sensory aspects such as smell, texture and flavor. For instance Ref. [25], performed experimental auctions in which participants were asked to present offers for five different mandarins in three stages: after looking at the fruit, after peeling the fruit and after tasting the fruit.

In the last decade, the methodology ''Check all that apply'' (CATA) has been proposed as a method to obtain accurate information of sensory characteristics of various products, being the results reliable and stable [26]. The CATA questionnaire provides the evaluators with a list of terms to select those that are considered appropriate to describe the evaluated product. Considering both qualitative and quantitative aspects, a measure of the consumers' sensory reaction to a product is obtained. Therefore, there is an identification of indirect associations made by consumers [27].

Compared with the data obtained with the descriptive sensory analysis from panels of trained judges [28,29], several authors have reported that CATA is an easy and fast methodology, due to have a similar characterization of products from consumers. There are precedents about the use of CATA questionnaires to determine how consumers perceive the sensory characteristics of fruits, in particular strawberries [26,30], kiwis and black currant juice [28].

The objectives of the present work was: (a) to obtain the sensory profile of mandarins generated by consumers using CATA questions and (b) to investigate the relative importance of different sensory attributes in the acceptability and selection of the terms of the CATA questionnaire to describe samples.

To achieve this objective, the study was organized in two stages: a qualitative exploratory study using the Focus Group technique and a quantitative investigation with mandarin samples evaluated by regular consumers.

2. Materials and methods

2.1. Focus Groups: exploratory study

Focus Groups (FGs) are one of the most used qualitative research tools in the study of food sciences [31] and have been defined by Ref. [32] as "a carefully planned discussion designed to obtain perceptions on a defined area of interest in a permissive, nonthreatening environment". In the present study, FGs were used in order to explore the most important attributes for consumers when choosing and purchasing mandarins.

Three FGs were held in March 2019 in Montevideo city (Uruguay). The number of participants in each FG varied between 7 and 8 (N = 24), and groups were carried out in a space which was suitable for that purpose at the Chemistry Faculty. The participants were recruited taking into account their age (between 20 and 50 years old), their gender (50% men and 50% women) and their consumption of mandarins (once a week or more). The FGs were supervised by the same trained moderator and an observer was also present in each session. The sessions were audio recorded to facilitate qualitative analysis.

FG sessions lasted approximately 1 h and were divided into three stages (a) generic discussion on fruit consumption (frequency, habits) (b) drawing of an ideal mandarin with a description of it and (c) discussion on the consumption of mandarins (relevant aspects at the time of purchase, advantages / disadvantages of mandarin consumption). The attributes and the most important aspects that determine the consumption of mandarins were identified and formed the basis for the design of the evaluation report of the quantitative study.

3. Consumer study

3.1. Data collection

Fifteen 2019 harvest samples of mandarins were evaluated, corresponding to different hybrid developed by the Citrus Genetic Improvement Program of the National Institute of Agricultural Research (INIA) and the Faculty of Agronomy of Universidad de la República (Udelar), Uruguay. The hybrids were generated from crossbreeding between the varieties Ellendale (*Citrus reticulata* Blanco), Satsuma cv 'Owari' (*Citrus unshiu*), Willowleaf mandarin (*Citrus deliciosa* Tenore) and the 'Page' (*Citrus clementina* x [*Citrus mandarin* x *Citrus paradise*]). All cultivars were grown under the same environmental and agronomical conditions. Fruits were harvested at full commercial maturity stage (Citric Acid <1.2% and >0.7%; TSS >9) between May and September, depending on the cultivar. The sensory tests were carried out between one and five days after harvest, storing the fruits at 5–6 °C and allowing them to reach room temperature before carrying out the study.

It should be noted, that the main objective of this study was to investigate the relative importance of different sensory attributes in the acceptability of mandarins instead of characterizing the flavor of different varieties, due to the quality and flavor of the fruit can be highly influenced by climatic conditions, horticultural practices, etc., as several authors have shown [4,33,34].

The study was conducted in Montevideo (Uruguay). A total of 100 regular mandarin consumers (once a week or more), aged between 20 and 64 years (46% men and 54% women, 61% professionals or university students) evaluated the samples over 6 sessions, between March and September 2019. This number of consumers is suggested for sensory acceptance according to Hough et al. [35]. Participants were recruited from a consumer database for their interest in tasting mandarins and for their availability for the study. In each session, 2 to 3 samples were studied, according to the optimum commercial harvest for each variety.

Consumers were randomly divided into two groups of 50 consumers each (Group "A" and Group "B") without significant differences ($p > 0.05$) in sociodemographic data (age, gender, education) according to the chi-square test. One mandarin sample was presented to each

consumer. Group "A" evaluated peeled mandarin segments while group "B" evaluated mandarins with skin and they had to peel the fruit before tasting. All samples were presented in odor-free plastic containers labeled with 3-digit random codes. Presentation order was monadic in accordance with designs that were balanced for presentation order and carry-over effects (Williams design). Still mineral water was available for rinsing. Testing took place in a sensory laboratory in standard sensory booths that were designed in accordance with ISO 8589 [36], under artificial daylight and temperature control (22 °C).

Respondents scored their overall liking for each of the samples on a nine-point hedonic scale bearing the Spanish legends reported by Curia et al. [37]. The description of the samples was also requested by means of a check-all-that-apply (CATA) questionnaire, composed for group "A" with 38 terms: 7 of texture (*soft, fibrous, firm, dry, with little juice, juicy, with little pulp), 8 of odor (with a lot of smell, with little smell, sweet smell, strange smell, fresh smell, natural smell, green smell, no smell*), 18 of flavor (*acidic, very acidic, bitter, very bitter, a little sweet, sweet, very sweet, balanced flavor, strange taste, fermented taste, fresh flavor, fruity taste, intense flavor, without flavor, typical flavor, bad taste, nice flavor*) and 5 referred to seeds (*with many seeds, with few seeds, without seeds, with small seeds, with large seeds*). For group "B", 14 terms related to the peel characteristics were added (*bright peel, brightly colored peel, peel with wrinkles, peel with spots, peel with reliefs, thin peel, thick peel, smooth peel, very sticky peel, easy to peel, orange peel, porous peel, uniform peel, green peel*).

The terms were selected from the results of the qualitative exploratory study. Terms were presented in a different order for each participant according to recommendations [38], following a design balanced for presentation order (Williams Latin Square). The test was carried out in a sensory laboratory compliant with ISO 8589 [36].

3.2. Data analysis

Analysis of variance (ANOVA) was conducted on the overall liking data considering sample, consumer group and the double interaction as variation sources. Tukey's test was used to determine statistically significant ($p \leq 0.05$) differences between samples.

Data analysis of frequency of use of CATA terms was performed according to Cadena et al. [39] using Cochran's Q test and correspondence analysis (CA).

For the internal preference maps, a Multiple Factor Analysis (MFA) was performed on the liking scores table and the frequency table of CATA terms according to Bécue-Bertaut & Pagès [40]; considering liking scores as active variables and CATA counts as supplementary variables [41]. Statistical analyses were performed using XLStat 2016 (Addinsoft, NY).

4. Results

4.1. Focus Groups: exploratory study

The textual transcriptions of what was expressed by consumers are presented between quotation marks in italics. Consumers stated that citrus fruits, especially mandarins, are seasonal fruits, and thus, this is the perception during their consumption.

> "There were good mandarins a couple of weeks ago." "It is time for beautiful mandarins." "At this moment, I consume citrus."

Fruits, in general, including mandarins, are preferably purchased in places where the participants are allowed to touch and smell the fruit. Therefore, the places to purchase fruits are the supermarket or neighborhood markets. *"I use to touch a lot, much more than look." "I buy in places where they let me touch; if they do not let me get my hands on the fruit, I do not buy."* In addition, there are other requirements when choosing the fruit in the place of purchase that are summarized in the following sentences. *"The fruit can be touched. What I strongly notice is the smell of the fruit; I put it close to my nose, and I associate the smell with whether it is ripe or not. If it has no smell, it has no flavor for me "*.

Most of the participants refer to the smell as a characteristic of the ideal mandarin; it is an attribute that must be present, i.e., *"It should have a good aroma."* Consumers think that they can predict taste through smell: *"You can perceive its sweetness by its aroma."*

All participants agreed that mandarins should be *"juicy"*, with a balanced flavor between sweetness and sourness. It must have *"an exquisite balance between sourness and sweetness"*. Some participants prefer a sweet taste: *"Balance between sweet and sour but inclined to sweet"*. All participants said they prefer brightly colored mandarins. As for the tone, half of them prefer orange peel, and the other half, orange and green peel. Regarding peeling, there was consensus that an ideal mandarin should be *"easy to peel"*.

As for seeds, their presence or absence is not an attribute that participants considered, although they did point out *"sometimes when they have a lot of bothersome seeds, especially if they are very small, your mouth is full of seeds"*. No participant indicated any variety of their preference; they simply did not remember specific cultivar names. Either shape, size or price was mentioned.

Mandarins can be consumed in various ways, as a juice, smoothie or as a fresh whole fruit. Participants agreed that they are *"easy to eat", "they are practical to eat and, despite the smell, you can eat it on the bus"*. It is a *"fruit to share"*.

5. Consumer study

Table 1 shows the mean of overall liking scores based on sample and group. Among the variables considered, the sample factor was found to have a significant influence on overall liking scores ($p<0.0001$), unlike the group ($p = 0.6130$) and the sample*group interaction ($p = 0.6261$).

Significantly different acceptability scores were observed among the samples, indicating that evaluated mandarins showed differences in their sensory characteristics that affected consumers' preferences (see Table 1).

Average values within a column with different letters were significantly different according to Tukey's test ($p \leq 0.05$). No significant differences were found ($p > 0.05$) between the acceptability of the samples evaluated without and with skin (Group "A" vs Group "B").

The 15 samples were clearly different from the sensory terms selected by consumers to describe the samples using CATA questionnaire. The most used descriptors by consumers of the Group "A" were: juicy, sweet and with a little odor, with 532, 324 and 313 total mentions, respectively. The most used descriptors by consumers of Group "B" were: juicy, orange peel, thin peel and sweet (with 506, 459, 319 and

Table 1
Average overall liking scores (evaluated in a 9-point structured scale) for consumers who evaluated mandarin samples.

Sample	Group "A"	Group "B"	P
M1	$6.4^{a,b,c}$	$6.3^{a,b,c,d}$	0.7934
M2	$5.9^{b,c,d}$	$6.4^{a,b,c,d}$	0.2809
M3	7.4^{a}	$7.2^{a,b}$	0.5277
M4	$6.1^{a,b,c}$	$5.6^{c,d,e}$	0.1928
M5	$6.1^{a,b,c}$	$6.3^{a,b,c,d}$	0.5494
M6	$5.8^{c,d}$	$6.1^{b,c,d,e}$	0.4340
M7	$4.7^{d,e}$	$4.9^{e,f}$	0.5491
M8	$5.7^{c,d}$	$5.3^{d,e}$	0.2575
M9	$6.1^{a,b,c}$	$6.5^{a,b,c,d}$	0.4066
M10	$5.7^{c,d}$	$5.4^{d,e}$	0.4688
M11	$7.2^{a,b}$	7.5^{a}	0.3197
M12	$6.3^{a,b,c}$	$6.9^{a,b,c}$	0.1672
M13	3.4^{e}	3.8^{f}	0.3919
M14	$7.0^{a,b,c}$	$6.8^{a,b,c}$	0.5591
M15	$6.9^{a,b,c}$	$6.6^{a,b,c,d}$	0.4881
P	< 0,001	< 0,001	

318 total mentions, respectively).

Of the 38 terms evaluated by both groups, 5 were eliminated (with little pulp, very bitter, fermented taste, dry and without taste) because they did not reach a minimum of 10% in the number of mentions in at least one sample. Of the 14 terms evaluated only by Group "B", the term peel with wrinkles was eliminated for the same reason.

In Group "A", significant differences were found in 28 of the 33 terms of the CATA questionnaire, according to the Cochran Q test. No significant differences were found ($p > 0.05$) in the number of mentions of the terms fresh smell, natural smell, little taste, fresh taste and no smell. In Group "B", a significant difference was found in 41 of the 46 terms used, according to the Cochran Q test. No significant difference was found ($p > 0.05$) in the number of mentions of the terms very sweet, green smell, strange taste, fresh taste and no smell.

To analyze the influence of the peeling process on the perception of these terms, a Chi-square test was performed between the number of total terms used to describe the samples with and without peel. When mandarins without peel were evaluated, the total number of the following attributes increased significantly ($p \leq 0.05$) according to the Chi-square test: with little smell, and no smell, while decrease significantly ($p \leq 0.05$) the number of the following attributes: with much smell, sweet smell, strange smell, fresh smell, natural smell and green smell (see Table 2).

For a better visualization of the relationship between the terms of the CATA questionnaire and the mandarin samples, a correspondence analysis was made with common terms to both groups of consumers (not linked to peel) and for identifying the samples that were evaluated with and without peel (Fig. 1). The first two factors explained almost 47% of the variability of the experimental data obtained. Fig. 1 shows that the samples evaluated with and without peel are in very close zones in the space. This means that the description of the samples through terms of texture, odor, taste and seeds were not affected for most of the samples by peel presence.

In Fig. 1, it is also observed that the samples with higher acceptability (M3, M11 and M14) are found in the upper left quadrant, associated with odor terms (natural, fresh, sweet, with much smell) and flavor (rich taste, intense, typical, fruity, fresh, balanced, sweet and very sweet). The sample with lower acceptability (M13) is to the right of the F1 associated with the terms very acidic, strange smell and ugly taste.

In parallel, another AC was made only with terms related to peel and evaluated by Group "B". The results are presented in Fig. 2. In this case, the first two factors explained almost 60% of the variability of the experimental data obtained. It is worth to note that one of the samples which showed high acceptability (M3) was associated with the term very sticky peel.

The results of the internal preference analysis of the mandarin study (generated from the global individual liking scores) are shown in Fig. 3. For each individual, the end point of a linear vector is shown, which represents the highest acceptance. The first two dimensions of preference explained 39.9% of the variability, representing 27.0% and 12.9% of the total variance, respectively. Third and fourth dimensions did not add useful information to understand the consumers' perception of the mandarins evaluated. For this reason, a two component solution was selected.

According to the space of preference defined by the first two dimensions (Fig. 3 a, b), mandarin cultivars were distributed in the four sectors of the space, Most of the consumers liking scores were located in the right sector. In order to understand which attributes determine acceptance, the correlation between the preferred directions and the characteristics of the products must be studied by combining Fig. 3 a, b with Fig. 4.

Characteristics such as acidic, no smell, strange taste, little taste, bitter, green smell, strange smell, ugly taste, green peel, with little juice, very sticky peel, very acidic, not very sweet, with large seeds, soft, with many seeds, peel with spots and porous peel were negatively correlated with the overall liking direction.

Characteristics such as sweet, very sweet, fresh smell, sweet smell, bright, fruity taste, fresh flavor, typical flavor, balanced taste and rich flavor were the ones that positively correlated with the overall liking direction, being able to induce feelings of liking.

Table 2
Total number of mentions of CATA terms questionnaire. Only the terms with significant difference is shown according to Chi-square test between the number of mentions of both groups of consumers.

CATA questionnaire	Group A	Group B	P (Chi-square)
With a lot of smell	220	356	<0.0001
With little smell	628	350	<0.0001
Sweet smell	176	236	0.036
Strange smell	40	78	0.012
Fresh smell	278	374	0.008
Natural smell	304	454	<0.0001
Green smell	72	162	<0.0001
No smell	164	74	<0.0001

6. Discussion

The FG sessions provided valuable information on consumer perceptions of mandarins and their consumption patterns. Unlike other citrus fruits that are consumed throughout the year, the fact that consumers consider mandarins as a seasonal fruit, could give more relevance to its "hedonist" properties such as: size, color and flavor [42].

Although many participants would prefer to purchase mandarins at places where they can touch and look at them, the sensory attributes assessed during consumption such as: smell, juiciness, balance between sweet and acidity and the ease of peeling, emerge as key descriptors of an "ideal mandarin". Di Vita et al., [42]; performed surveys to determine which are the citruses' attributes that Italian consumers considering the most important and which are the main boosters for purchasing different citruses, mandarins among them. The results of our study coincide with the results of these authors, who reported that sweetness, flavor and smell were important attributes as well as predictors of the frequency of mandarin purchases. Also, Gao et al. [43], through surveys performed in USA, reported that more than 60% of the surveyed considered: freshness, flavor, appearance, juiciness of citruses as extremely essential attributes. These results are slightly different from Poole and Baron (1996) studies who studied the importance of ten attributes of citruses and found that more than the 50% of the surveyed scored: juiciness, peel quality, sweetness and texture as the most important attributes.

Regarding peeling, there was consensus that an ideal mandarin should be *"easy to peel"*. This result is consistent with the statement by Goldenberg et al. [44]. These authors stated that the easy-to-peel mandarin market has increased steadily against other hard-to-peel citrus fruits. However, other authors such as Poole and Baron (1996) and Gao et al. [43]; found that the easy-to-peel was a little important factor in the decision of purchase citruses.

The presence or absence of seeds was not an attribute that participants considered. Gao et al. [43], also showed that seeds were less important attributes in consumer preferences for fresh citruses. These results do not coincide with those of Campbell et al., [45]. These authors, through surveys together with the analysis methodology, evaluated the preferences of consumers in 9 cities of USA for seven external attributes of Satsuma mandarins, finding a segment of consumers which was named "no-seed" (41% of the sample) and whose preference for these mandarins was linked to the absence of seeds in the fruit. This group of consumers considered the absence of seeds from two to three times more important in their purchase decision than the color, size, price or mandarins' imperfections. This study showed that the preferences of consumers are heterogeneous, thus, it is essential the identification of groups of specific consumers who have similar attitudes towards the product attributes.

Although in other countries, the main concern of consumers is the

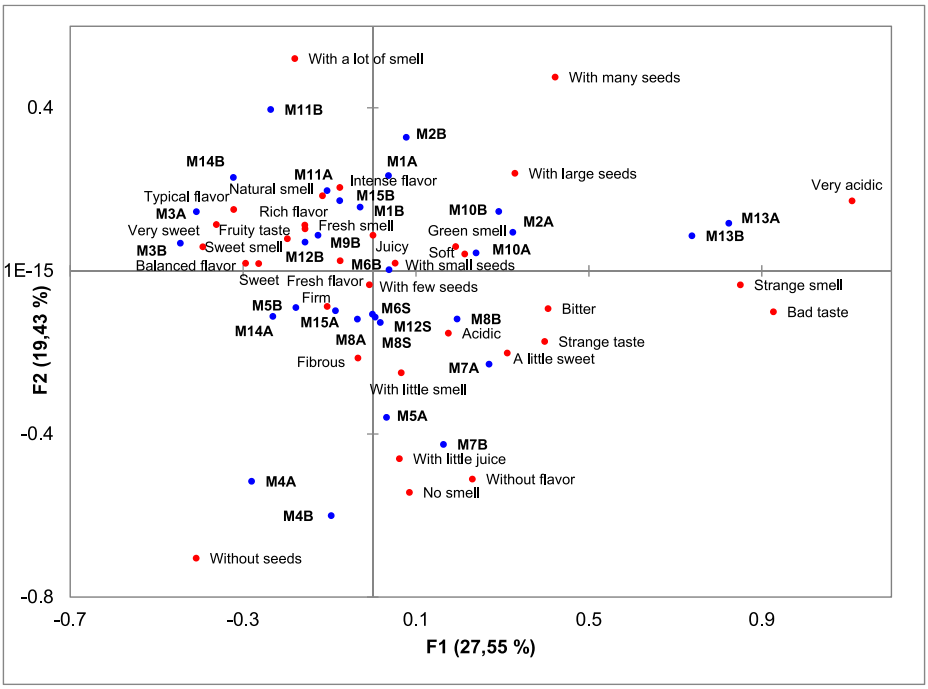

Fig. 1. Representation of the samples and attributes in the first two factors of the. correspondence analysis of sensory data obtained using common terms used by both groups of consumers. The letter "A" indicates that the sample that was evaluated by Group A, and the letter "B" indicates that the sample was evaluated by Group B.

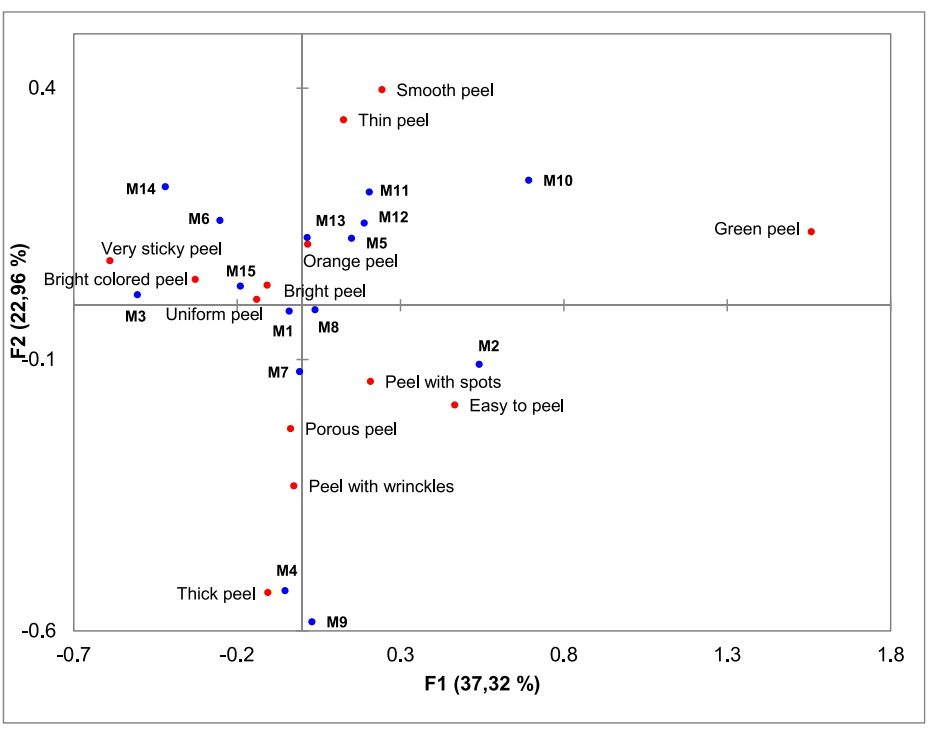

Fig. 2. Representation of the samples and attributes in the first two factors of the. correspondence analysis of sensory data obtained using only the terms associated with peel (evaluated by Group B).

absence of seeds, at the same time as the consumption of varieties of mandarins with fewer seeds increases, the number of seeds of a mandarin at the time of purchase cannot be observed (Huose et al., 2011). The participants in our study could not name varieties of mandarins, so identifying a fruit by its variety would imply a consumer learning about varieties with fewer seeds, although variations can occur from one fruit to another.

Neither our participants mentioned about the fruit size nor shape, being the result different from that stated by Goldenberg et al., [44]. However, our results coincide with what Gao et al. [43], and House et al. [23] who reported that the size was a less important factor in the disposal to purchase citruses.

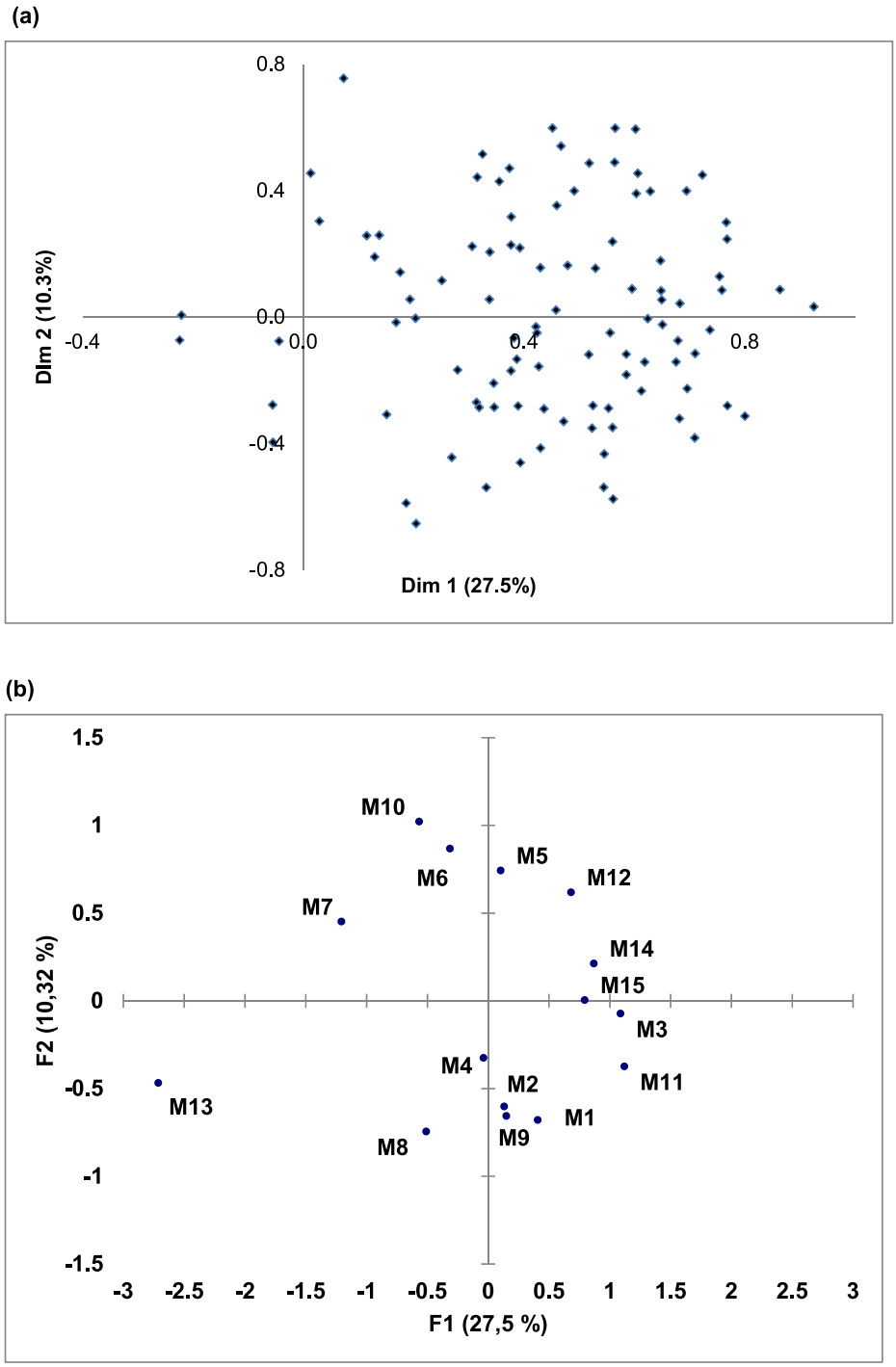

Fig. 3. Internal Preference Mapping on the first two dimensions of the Multiple. Factor Analysis. (a) Liking vectors and (b) samples' representation.

For most of consumers the price of the product is usually important. Previous studies of food products, showed that the importance of the price in the decision of purchase is of relative and variable importance. Campbell et al. [45], found a segment of consumers sensitive to the price of mandarins that represented the 23% of the sample. Di Vita et al. [46], applied a conjoint analysis to estimate the mean relative importance of different clementine attributes. Results reveled that price was the most important attribute. In spite of the background, the price was not mentioned by the participants of the Focus Group, maybe due to mandarins are an economic seasonal product in Uruguay.

7. Consumer study

The acceptability of the samples evaluated with or without peel (Group "A" vs. Group "B") was similar. This might suggest that when a consumer is asked to describe an "ideal" mandarin, although it refers to external aspects such as peel color, peel brightness and the ease of peeling, these attributes do not weigh on the total acceptability of mandarins compared to other sensory attributes such as taste and texture. Therefore, taste and texture are determinant attributes in mandarin perception and acceptance by consumer, according to Goldenberg et al., [44].

The CATA questionnaire was able to detect differences in consumer

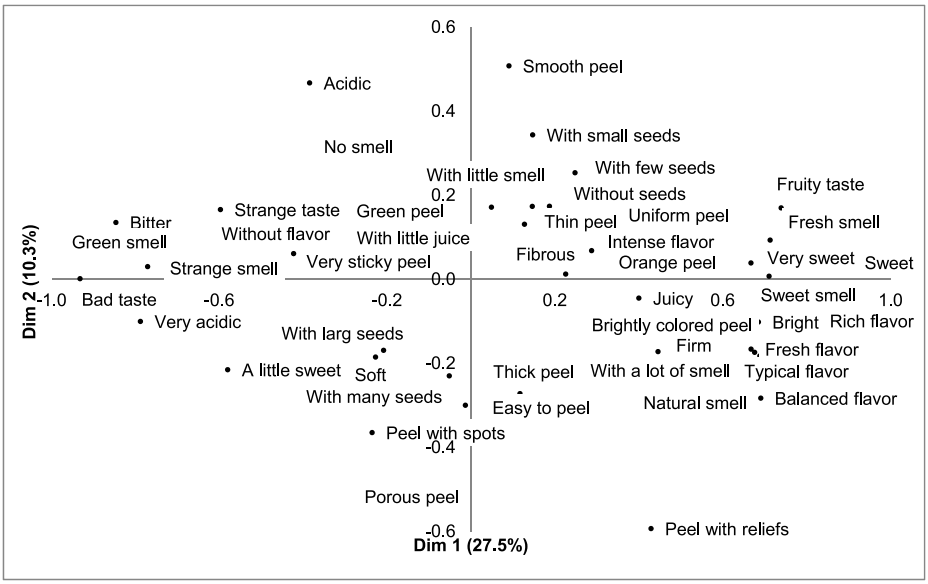

Fig. 4. Representation of the CATA questionnaire on the first two dimensions of the multiple factor analysis considering overall liking scores as active data and product characteristics as supplementary variables.

perception of the sensory characteristics of the varieties of mandarins evaluated, which could explain the wide range in consumers' scores. The act of peeling a mandarin, as Group "B" had to do, influenced the odor perception, since this group of consumers used a significantly greater number of odor-related terms to describe the sample. However, the greatest perception of odors by peeling process did not influence the acceptability scores of the samples, being very similar to those assigned by group "A".

Characteristics such as sweet, very sweet, fresh smell, sweet smell, bright, fruity taste, fresh flavor, typical flavor, balanced taste and rich flavor were the ones that positively correlated with the overall liking direction, being able to induce feelings of liking. These results coincide with that reported by other authors in mandarin studies [21,34,44] and for other fruits, such as strawberries [30] and pomegranates [47].

The samples with higher acceptability were associated with odor terms (natural, fresh, sweet, with much smell) and flavor (rich taste, intense, typical, fruity, fresh, balanced, sweet and very sweet). These results coincide with what other authors reported on the potential impact of aromatic volatile compounds in navel oranges 'flavor [48], Kinokuni and Satsuma mandarin [4], tangerine [5] and mandarin [9]. Obenland et al. [49], who postulated that it is very likely that aroma plays an important role in determining the liking of grapefruit, which was corroborated in our mandarin study.

The relationship found between sweetness and acceptability also coincides with what other authors reported for other citrus fruits. Obenland et al. [49], reported that for grapefruit, as the sweetness perceived in a sample increased, the hedonic score linearly increased. According to House et al., [23]; the sensory attribute with the strongest effect in acceptability of adult mandarins 'consumers was the sweetness thus, increasing the likelihood to show that it was very likely or extremely likely to purchase the fruit. Other sensory variables which significantly increased the likelihood that can make adults indicate why they are very likely and extremely likely to purchase mandarins included: juiciness, acidity, and flavor.

In our study, the acidity did not have a positive correlation with the acceptability. On the contrary, acceptability was negatively influenced by characteristics such as acidic, no smell, strange taste, little taste, bitter, green smell, strange smell, ugly taste, green peel, with little juice, very sticky peel, very acidic, not very sweet, with large seeds, soft, with many seeds, peel with spots and porous peel were negatively correlated with the overall liking direction. The sample with lower acceptability (M13) was associated with the terms very acidic, strange smell and ugly taste.

Regarding acidity, it was negatively correlated with the direction of the acceptability of the samples, but the acidity had a much lower impact on the hedonic score unless the fruit became extremely sour, as found in this study. In the case of mandarins, consumers seem to prefer low sourness, unlike other citrus fruits such as grapefruit, in which the consumers expect a high degree of acidity and if it is not excessive, it is not unpleasant for many consumers [50]. However, Simons et al. [22], performed a sensory acceptability study of mandarins as well as adequacy of attributes with JAR scales and found a group of consumers (23%) who would clearly prefer the sour samples. This result remarks the importance of studying the preference patterns of different groups of consumers.

Although the term very sticky peel appears to be negatively correlated with the acceptability of the samples, it is not critical, since it was used by 35% of consumers to describe sample M3, which was one of the samples with the highest acceptability. This confirms the previously expressed fact that the ease of peeling of a mandarin, although considered an "ideal" characteristic, does not score higher than other attributes of mandarins, such as flavor and smell, which directly determine the acceptability of this type of product.

The perceived bitterness of mandarin samples was an attribute negatively related to the hedonic score (Fig. 3 and 4), which coincides with what other authors reported in other citrus fruits [49].

Thirty-seven percent of the fruit tested in this study received a hedonic score of less than 6, which indicates that a considerable portion of the evaluated cultivars were not enjoyed by the consumers. The sensory terms used to describe these samples by consumers (acidic, no smell, strange taste, little taste, bitter, green smell, strange smell, ugly taste, green peel, very sticky peel, with little juice, very acidic, slightly sweet, with large seeds, soft, with many seeds, peel with spots and porous peel) are similar in all these samples and could be a good guide for the selection of new cultivars.

As the attitudes of consumers are usually shaped by their past experience and by their experience with the use of products, it is reasonable that the expectations of purchasers pre-consumption can differ from their post-consumption perceptions. In our case, for instance, it is possible that consumers do not think that the absence of seeds are important attributes of pre-consumption of mandarins, due to, Uruguayan consumer regularly expect to find seeds in that fruit. However,

the opinion post-consumption can vary according to the size (very large) or a very high amount of seeds. Therefore, the opinion can change due to the experience the consumer had had with the fruit. In this case, the indication is that the experience of consumption can have had negative information which is important for the next opportunity of purchase.

Additional studies should be done in order to investigate the knowledge consumers have regarding the different varieties of mandarins and how this knowledge affects their preference for the sensory characteristics of these fruits. It is evident that the ignorance of the consumers regarding the product attributes at the time of purchase can lead to a disarrangement between the purchases and consumption preferences. Studies with a greater number of consumers with different demographic and behavioral characteristics are also necessary in order to establish segments with different preferences. Previous studies [45,46,51]; Simons et al., 2008) have shown that consumers 'preferences are heterogeneous. Therefore, the identification of groups of specific consumers with similar attitudes towards the product attributes is essential.

This study has some important limitations, such as its lack of external validity due to the convenience sample adopted. Conducting a survey on a national representative sample is certainly a recommendation for future research. Additionally, sensory test results can be misleading in predicting consumer's purchasing behaviors, as flavor tests can focus the surveyed attention on the characteristics being tested, which can be ignored in a real purchase (particularly when many sensory attributes are not experienced at the time of purchase). However, following the example of today's increased awareness of the health benefits regarding the consumption of fresh fruits, this research has provided additional information upon the preferences of consumers as well as the boosters of mandarins' purchase.

8. Conclusions

This research adds to the previous literature by distinguishing consumer reaction on sensory characteristics of fruit either when it is tasted peeled or when it has to be peeled in order to taste it. Driven by evidence supporting the adoption of citrus fruits to achieve healthier diets and based on a convenience sample of Uruguayan consumers, the study provides new insights into the motivations to purchase mandarins. This study has confirmed that Uruguayan consumers react similarly to consumers of other countries. The results suggest that sweetness and smell are the most important factors to increase the disposal to eat a mandarin. On the other hand, factors such as the presence of seeds or the ease of peeling are less important.

When describing an "ideal mandarin," consumers preferred the fruit to be easy to peel, but the term very sticky peel was used by more than a third of consumers to describe one of the mandarins that received one of the highest scores of acceptability, suggesting that easy to peeling is not the only determinant for consumer liking. Thus, it can be concluded that fruit flavor prevails as a consumer liking factor over peel characteristics in mandarins.

In most of the sensory studies the real consumption is not simulated as the fruits are presented already peeled or in segments. Our study showed that the preferences of consumers were not modified when the fruit had to be peeled.

Hedonistic properties seem to have a significant potential to be used to exploit mandarin consumption and purchases. Determining the importance of product attributes is of particular relevance for producers as they are interested in understanding and perhaps influencing on the consumer's information environment when it comes to purchasing decisions. For the industry, a marketing strategy for mandarins would be to allow consumers to taste a sample when purchasing in grocery stores.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jafr.2021.100196.

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