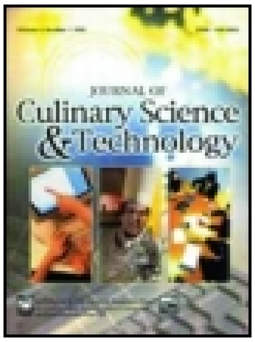

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Targeted Chemical and Sensory Profiling to Guide Consumption of Blood Orange

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ABSTRACT

The objective of this study was to identify the perception of consumers regarding the consumption of blood oranges as well as to generate information that helps in their greater consumption. The physical-chemical characterization of the blood orange, cultivar Cara Cara, and the yellow-pulp orange, cultivar Bahia, was carried out, drawing a parallel between them that indicated their potential nutritional benefits. Both samples showed desirable characteristics, Cara Cara has higher levels of carotenoids, flavonoids and total phenols. The sensorial analysis revealed important descriptors of differences between oranges and was possible to identify factors that characterized the marketing and consumption of blood oranges, which were related to the consumption, quality, health and, perception of this type of fruit. It was concluded that these evaluations were able to indicate important characteristics to be used in marketing strategies in order to promote the greater consumption of oranges with red pulp, exploring their bioactive benefits.

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KEYWORDS
Antioxidants; Cara Cara; temporal dominance of sensations; consumer; word association

Introduction

Globalization and modern life have changed different aspects of society in the last two decades, including people's eating habits. The result is an increase in food availability and diversity, not necessarily making access to food universal. In developing countries, obesity has been considered the result of a series of changes in diet, physical activity, health, and nutrition of individuals, known as nutritional transition. Malnutrition, including undernutrition, obesity and other dietary risks, is the leading cause of global ill health. Low consumption of fruits and, vegetables is a major contributor to this nutritional deficiency (Swinburn et al., 2019).

Promote increased consumption of fruit and vegetables implies a great challenge. The intake of these important foods is dependent on a series of

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Supplemental data for this article can be accessed on the publisher's website

variables of the complex process that involves the choice and consumption of food and drinks, such as lifestyle, product value, quality, and, nutritional or affective value (Kaya, 2016). Thus, the recognition of these different consumer segments and the quantification of such choices are essential to estimate the potential of the food market.

The orange fruits (*Citrus sinensis* [L.] Osbeck) presents a high social, and economic contribution to the world. Orange fruits have important phytonutrients, such as minerals, carotenoids, vitamins, flavonoids, phenols and fatty acids, which have been reported in the literature because they have a strong antioxidant capacity (Filla, Garcia, & Prudencio, 2017; Roussos, 2016). Dietary choices which lower inflammatory would be a strategy to reduce the risk for cardiovascular diseases. The current studies suggest that orange juice could be a dietary feature for the prevention and treatment of chronic diseases (Russo et al., 2019; Silveira, Dourado, & Cesar, 2015).

Oranges can be divided into two large groups, depending on the color of the pulp: white or light-colored oranges and blood oranges. Blood oranges are quite popular in Europe where it is used in juices and salads. The color variations of the fruit pulp are due to variations in the concentration and distribution of carotenoids or anthocyanins present (Adeloye & Agboola, 2020).

According to Russo et al. (2019) the main criteria in the selection of a cultivar, besides the characteristics of the plant itself, are mainly the size of the fruit, its flavor, the ease of peeling and the juice content. Currently, new criteria are being added, especially in relation to the functionality of the fruit consumed and the content of its bioactive compounds. The antioxidant properties of citrus fruits are becoming an important factor in the determination of consumer purchasing (Loizzo et al., 2018).

The 'Bahia' orange (Yellow Navel Orange) arose from a natural mutation among citrus trees planted in the state of Bahia in Brazil. It was later introduced in California, USA. This cultivar has no seeds, is easy to peel, has sweet, juicy, acidic and yellow pulp, appreciated for *in natura* consumption. It is considered an important citrus cultivar, being highly appreciated by consumers in general (Oliveira, De, Scivittaro, Schroder, & Esswein, 2010).

The 'Cara Cara' cultivar orange appeared by spontaneous mutation of the Washington Navel cultivar; it is characterized as blood orange, with the intense and uniform red coloration of the pulp and juice. This cultivar represents a novelty on the Brazilian market, which does not have the habit of consuming citrus fruits with red pulp (Oliveira et al., 2015).

Considering the importance of citrus production in the world, the aim of study was to evaluate bioactive compounds and sensory parameters of blood orange in order to overcome the obstacles and prejudices related to its consumption in Brazil and thus generate information that helps in trade and marketing strategies, exposing its functional benefits.

Materials and methods

Samples

The oranges considered in the study were: (*C. sinensis* (L.) cv Cara Cara) and (*C. sinensis* (L.) cv. Bahia). In Brazil, the cultivation was carried out between May and July, harvested in the year 2018. The experiment was carried at the Embrapa Clima Temperado in Pelotas, RS, Brazil (31°40′47″ S and 52°26′24″ W; at 57 m of altitude). Three different lots were harvested, providing a representative sample of fruits offered to consumers in commercial consumption phase.

Chemical characterization

Physical-chemical parameters

The following physical-chemical parameters – pH, titratable acidity and total soluble solids (Horwitz & Latimer, 2005) from the homogenization of fresh orange pulp.

Content of organic acids, vitamin C and sugars

Samples were analyzed using high-performance liquid chromatography (HPLC) (Sánchez-Mata et al., 2012). The results of glucose, fructose, sucrose, oxalic acid, tartaric, citric, malic and vitamin C were expressed as fresh weight g.100 g^{-1}.

Carotenoid content

The determination of carotenoids (Lee, 2001) in oranges was performed after solvent extraction with hexane: acetone: methanol (50:25:25 v/v/v) The total carotenoid content was expressed as β-carotene equivalent. A standard Sigma-Aldrich-Fluka (St. Louis, MO) was used for identification and quantification.

Total flavonoids

Flavonoids were quantified (Wang, Chuang, & Hsu, 2008) through the extract dissolved in methanol with the addition of 0.3 ml of $Al(NO_3)_3$ (10%). The routine calibration curve was prepared in ethanolic solutions. Total flavonoids were expressed as routine equivalents.

Total phenols

The method was performed according to the methodology (Xu et al., 2008). The samples (100 µl extract) were reacted with 500 µl of Folin-Ciocalteu reagent, 1.5 ml of 20% (w/v) Na_2CO_3 and H_2O. After 2 h of incubation at 25 C, the absorbance was measured at 760 nm and expressed as mg of gallic acid equivalents.

Sensory analysis

All the experiments carried out in this study were approved by the Research Ethics Committee of the Federal University of Pelotas, Brazil under the number CAAE 76628617.0.0000.5317.

Acceptance test (Hedonic scale)

Sensory analysis using the acceptance test (O'Sullivan, 2017) was performed at the Sensory Analysis Laboratory of the Federal University of Pelotas and involved 100 volunteers. The samples were coded with three random digits and served in white porcelain dishes, whole and cut into 10 g pieces. The sensory data sheet contained the following attributes: overall impression, orange's outward appearance, peel color, internal color, internal appearance, size, characteristic taste, aroma, juiciness, sweetness and acidity, which were analyzed using a 7-point hedonic scale (7 – I liked it very much, 1 – I really disliked it).

Temporal dominance of sensations

The temporal dominance of sensations (TDS) was performed according to Pineau (2009), with a team of selected evaluators, based on their sensory aptitude. To this end, 15 citrus consumers were recruited. In the analysis, the evaluators were asked to choose the dominant sensation during the time of ingestion, considering as dominant the knowledge perceived with greatest clarity and intensity among others in a predefined list. The duration of 30 seconds was determined as a time to analyze each sample; the attributes available during the sessions were: acid, sweet, wild fruits, succulence, bitterness, soft, citrus aroma, refreshing.

Word association and questionnaire

The number of participants chosen and their actual selection was carried out by focusing potential consumers and/or their perceptions in relation to the consumption of oranges. Participants were recruited via a social network, a total of 1800 consumers participated (61% female and 39% male, aged between 16 and 61 years). Sensory analysis by word association was conducted through the Google Docs web interface in which participants were asked to write, spontaneously, the first four words, that came to mind when viewing photos of the blood oranges conducted in that study. Besides the word association, the participants were invited to answer questions related to the consumption and trade of oranges. As data collection instruments, a closed structured questionnaire containing 12 questions was used (**Supplementary material 1**). Data were collected between August and September 2019.

Statistical analysis

In the physicochemical analyses, the results were expressed through triplicate means ($n = 3$) with analysis of variance (ANOVA) at the 95% confidence level. The acceptance test of the sensory analysis was analyzed through analysis of variance (ANOVA) at the 95% confidence level, through the average of the evaluators' observations ($n = 100$). For the evaluation of the results obtained in the Temporal Dominance of Sensations test, the TDS curves were constructed, as proposed by Pineau et al. (2009), using the software SensoMaker, and in the word association analysis the Cluster method was used.

The questionnaire was analyzed by exploratory factorial analysis (EFA) with preliminary Kaizer-Meyer-Olkin test (KMO) and Bartlett's Test of Sphericity (BTS) test with significance ($p < .05$). In order to analyze the internal reliability of the factorial model, Cronbach's alpha coefficient was determined.

Results and discussion

Physical-chemical parameters

The physical-chemical parameters of oranges can be observed in Table 1. The samples of oranges studied presented significant differences in pH values. In addition, the Bahia variety presented lower values (4.31) than those found by Wang et al. (2019) who also studied varieties of yellow coloration.

With respect to titratable acidity, the blood orange variety is within the values found by Continellaa et al. (2018) and Cebadera-Miranda et al. (2019). Among the physicochemical properties, the content of total soluble solids

Table 1. Physical-chemical parameters of oranges Cara Cara and Bahia.

	Cultivar	
	Cara Cara	Bahia
Physical-chemical parameters		
pH	3.85 ± 0.06	3.09 ± 0.05
Total titratable acidity ($g.L^{-1}$)	11.34 ± 0.23	14.30 ± 0.06
Total soluble solids (°Brix)	16.39 ± 0.15	14.51 ± 0.12
Sugars ($g.L^{-1}$)		
Fructose	32.14 ± 0.23	26.71 ± 0.16
Sucrose	37.11 ± 0.12	27.58 ± 0.08
Glucose	25.15 ± 2.19 ^{ns}	23.21 ± 1.15
Organic acids ($mg.100\ g^{-1}$)		
Tartaric acid	69.71 ± 3.45 ^{ns}	64.92 ± 4.89
Malic acid	158.39 ± 1.25	137.45 ± 1.02
Oxalic acid	11.34 ± 0.08	7.92 ± 0.05
Citric acid	1023.58 ± 10.15	1238.14 ± 11.25
Vitamin C	68.93 ± 0.91	53.09 ± 0.59
Bioactive compounds		
Total Carotenoid ($mg.g^{-1}$ db)	0.58 ± 0.02	0.31 ± 0.04
Total Flavonoids ($mg.L^{-1}$)	242.81 ± 1.72	125.42 ± 1.18
Total Phenols (mg $GAE.L^{-1}$)	540.89 ± 0.6	470.12 ± 0.7

means±standard deviation ($n = 3$). ^{ns} The variable has no significant effect at a 5% significance level by *t*-test.

(TSS) is an important parameter in the fruit industry. The TSS content of the Cara Cara variety (16.39 °Brix) was higher than that of the Bahia cultivar. These changes in total soluble solids, pH and acidity are characteristic, as are fruit size and shape, due to their influence on rootstocks (El-Sayed, Somaia, El-Saiada, & Ennab, 2007)

Profile of sugars, content of organic acids and vitamin C

The levels of these sugars (Table 1) were higher in Cara Cara, Kafkas, Ercisli, Kemal, Baydar, and Yilmaz (2009) pointed out similar values when studying three varieties of blood oranges. According to these authors, the composition and concentration of these sugars are important indicators of fruit quality, since they influence the sensory and consumption properties.

Citric acid is the acid found in largest quantities in citrus fruits, as was observed in cv. Cara Cara and in cv. Bahia, with a significant difference ($p \leq 0.05$) between oranges. With regard to blood oranges (Cebadera-Miranda et al., 2019; Kafkas et al., 2009) also found high values of citric acid, 854–1592 mg.100 g^{-1} and 4.21–6.36 g.L^{-1}, respectively. Ascorbic acid is usually the vitamin the consumer most associates with healthiness, which is why juice labels always emphasize vitamin C content. In this study, higher levels were observed in the blood orange Cara Cara (68.93 mg. 100 g^{-1}), and the yellow Bahia orange differed significantly ($p \leq 0.05$), however, although the value was lower (Plaza et al., 2011). According to the Brazilian Health Surveillance Agency (Brasil, 2005) and European Regulation No. 1169 of 2011 (EU Regulation, 2011) the daily recommendation of vitamin C for adults is 45–80 mg/day, indicating that both cultivars would supply the daily need.

Bioactive compounds

The results of the present study confirm (Table 1) the higher carotenoid content in blood orange compared to the cultivar Bahia. Studied the carotenoid profile of blood oranges (Lu, Huang, Lv, & Pan, 2017) from five regions of China and concluded that the contents and composition of carotenoids are influenced by local temperature and environmental conditions. Regarding the total content of flavonoids and total phenols, Cara Cara showed higher values ($p \leq 0.05$) in relation to Bahia. The knowledge of compounds with antioxidant capacity is an important indicator of the nutritional quality of food, due to its effectiveness in preventing chronic diseases (Al-Jabri & Hossain, 2018; Nakajima, Macedo, & Macedo, 2014).

The content of total flavonoids and total phenols of the Cara Cara cultivar was higher than that found by Kafkas et al. (2009) these authors analyzed two other blood orange strains, finding variations of 121–239 mg.L^{-1} in flavonoids and 441–527 mg.L^{-1} in total phenols. The content and profile of flavonoids can also vary among cultivars, since the activity of enzymes and transcription activators of their synthesis are influenced by relative humidity (Ithal & Reddy, 2004). Hesperidin and naringin are flavonoids predominantly found in oranges and grapefruit, and their antioxidant activity and transport of blood cells (Cao, Chen, & Xiao, 2011).

Sensory analysis

Acceptance testing (hedonic scale)

The analysis of variance of the results of the sensory attributes of oranges showed that there was a significant difference ($p \leq 0.05$) in most attributes, except for overall impression and size, according to Table 2.

In the overall impression, both oranges were well accepted sensorially. The external appearance and color of the peel were considered close to the term 'moderately liked', with the cultivar Cara Cara attributed a higher value. There is not always a direct relation between external and internal color in blood oranges (Meléndez-Martínez, Gómez-Robledo, Melgosa, Vicario, & Heredia, 2011) a fact that we observed with the sensorial analysis, in which the consumers gave higher grades on the external color (peel) for Cara Cara and lower grades for the internal color (pulp). This demonstrated that the orange/yellow pulp color is more accepted in the consumer's view than the red color, as well as in the attribute 'internal appearance'. In the attribute 'characteristic flavor' it was verified that the cultivar Bahia had a greater acceptance. Observations by consumers on the sensory data indicated that the blood orange did not have an intense taste, as expected, similar to the 'aroma' attribute. The combination of these two attributes, known as 'flavor', has a great influence on the acceptance of citrus, and they are also related to content of total solids, acidity and volatile compounds (Obenland, Campisi-Pinto, & Arpaia, 2018).

Table 2. Means of acceptance (hedonic scale of 7 points) of consumers for Cara Cara and Bahia oranges.

	Cultivars	
Attributes	Cara Cara	Bahia
Overall impression	6.40 ± 1.00 ^{ns}	6.00 ± 0.80
External appearance	6.74 ± 0.56	6.40 ± 0.69
Peel color	6.85 ± 0.35	6.57 ± 0.60
Internal color	5.80 ± 1.34	6.45 ± 0.65
Internal appearance	5.88 ± 1.33	6.48 ± 0.64
Size	6.65 ± 0.76 ^{ns}	6.34 ± 0.63
Characteristic flavor	5.91 ± 0.90	6.54 ± 0.71
Aroma	5.60 ± 1.32	6.65 ± 0.53
Succulence	6.57 ± 0.69	5.40 ± 0.88
Sweetness	6.62 ± 1.04	5.97 ± 0.59
Acidity	4.65 ± 1.98	6.51 ± 0.74

^{ns}The variable has no significant effect at a 5% significance level by *t*-test. (n = 100).

Temporal dominance of sensations

Figure 1 shows the dominance profile of the sensations (TDS) of the oranges studied. Through the TDS analysis, the 'soft', 'acid', 'succulence' and 'bitterness' sensation for the Bahia orange was observed, with maximum dominance rates of 0.68, 0.50, 0.50 and 0.50 respectively. For the Bahia cultivar, 68% of the evaluators considered that the sensation of softness was the most dominant. The sweet taste also had a high dominance rate, from 0.43 to 10 seconds. We can that the acidity was the dominant sensation perceived at the beginning of the test, with the observed maximum time of 4.5 seconds and the bitterness

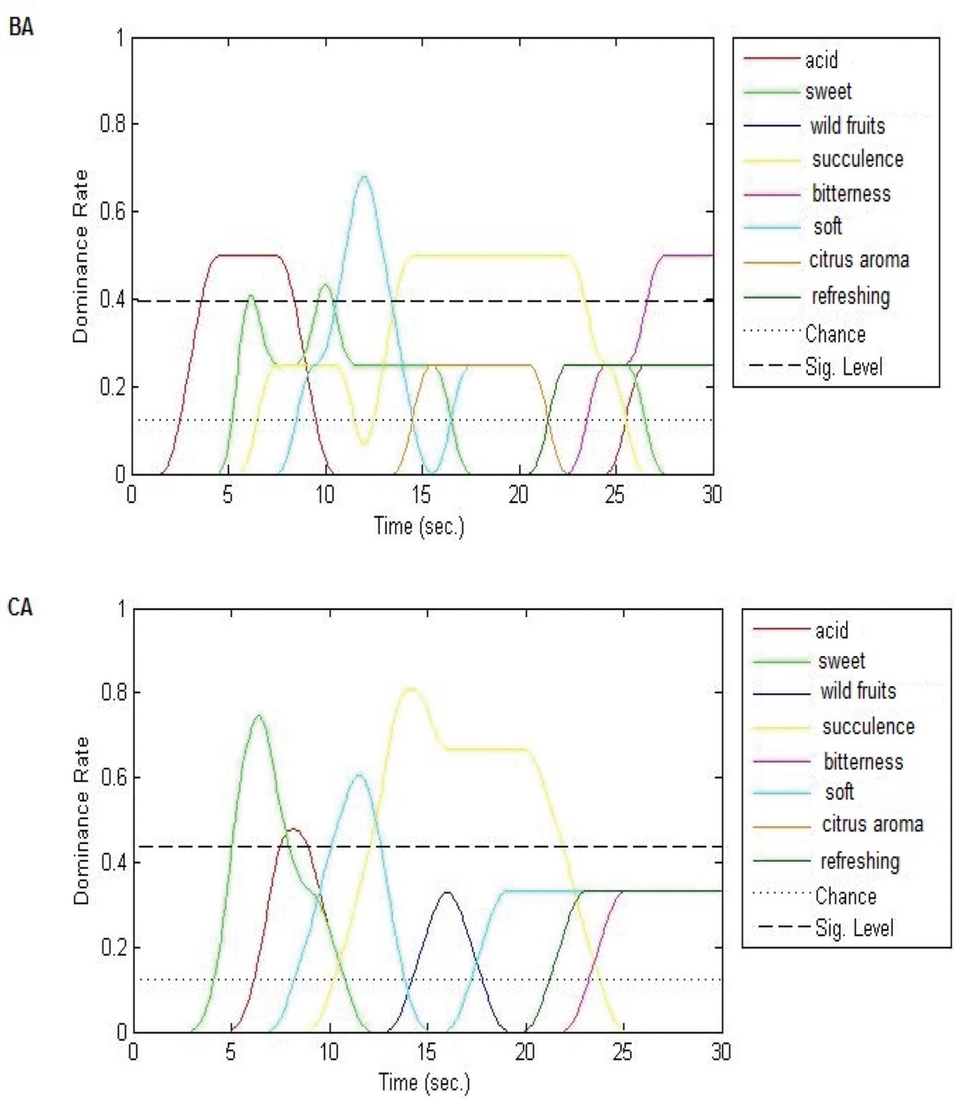

Figure 1. TDS graphical representation of the oranges BA (cultivar Bahia) and CA (cultivar Cara Cara).

with the maximum time of 27.5 seconds. Navel type oranges have a sweet and pleasant taste; however, a slow bitterness is detected due to the release of limonin (Saunt, 2000). In the dominance profile of sensations, the Cara Cara cultivar showed that during the proposed period of time, succulence was the dominant sensation, followed by the 'sweet' attribute. Although the perception of these attributes was superior to that of the Bahia orange, the citrus aroma was not detected by any evaluator in the blood orange. Blood oranges are the ones that generate the highest percentage of juice, besides having a higher concentration of sugars; nevertheless, in relation to the compound limonene (which is the most important compound regarding aroma), the content is lower (Moufida & Marzouk, 2003).

Word association and questionnaire

In the word association, 258 different words or terms were counted. We classified nine dimensions with categories related to the words of the greatest impact cited. Table 3 shows the frequency of mention of the dimensions, categories and examples of words that were cited.

The dimension related to sensory characteristics was the one most mentioned by the participants when referring to the image of blood orange. It was possible to observe that the categories related to color, texture, aroma and flavor were well cited. The second most cited dimension was different/unknown, clearly showing the ignorance of people regarding the consumption of blood oranges. The Mediterranean region dominates export market for fruit *in natura*; however, Brazil is the largest producer of oranges in the world, concentrating its production in the form of juice for export.

Table 3. Frequency of dimensions, categories and examples of words mentioned by participants in the word association analysis of the consumption of blood orange.

Dimensions	Categories	Percentage of mention (%)
Sensory feature	Color (strong, bright, red, uniform) Texture (astringent, dry, juicy) Aroma (citrus, wild, fruit salad) Flavor (sweet, bitter, sour, less acidic)	90.0
Different/Unknown	Different (different, strange, curious) Exotic (exotic, not uncommon, unknown)	67.92
Positive Hedonic Attitudes	Hedonic (tasty, very tasty, delicious, appetizing)	52.83
Negative Hedonic Attitudes	Negative (bad smell, no taste, spoiled, does not look appetizing, ugly color)	41.50
Health/Nutrition	Health (healthiness, healthy, important for health, disease free) Nutrition (vitamin C, antioxidant, fiber, iron, anthocyanins)	37.73
Consumption	Price (very expensive, inaccessible) Gourmet (gourmet, differentiated product, dessert, juice)	33.96
Non-sensory	Miscellaneous (beautiful, ugly, refreshing, porous, innovative, large)	30.18
Altered/Genetics	Genetic modification (transgenic) Alteration (modified, artificial, strange color, organic)	30.10
Association with other fruits	Diverse fruits (dragon fruit, tangerine, strawberry guava, pomegranate, grapefruit, does not look orange)	24.52

The third dimension, with a high percentage of words cited, was that of positive hedonic attitudes that expressed favorable feelings toward consumption. The blood orange was considered tasty and appetizing by those who had probably already consumed it. Negative hedonic attitudes, corresponding to the fourth dimension, reflected negative feelings. With this, we can suggest that marketing should be carried out in a more practical way, through tastings in fairs, supermarkets and schools, because only seeing the image of a blood orange can raise uncertainty among consumers who do not know it. A number of participants in the questionnaire suggested words related to health and nutrition, as shown in the fifth dimension. The use of terms like vitamin C, fiber, antioxidants and health demonstrates a niche to be explored, as suggested by this study.

In the sixth dimension, corresponding to consumption, 33.96% of the words were associated with the high price of red oranges. Besides the price, they also consider it inaccessible, that is, they are not easily found in fruit stores and markets. According to Kotler (2000), it is necessary to have specific instruments of information gathering among various types of consumers, thus identifying the most frequent stimuli that raise interest in a category of products.

The non-sensory dimension was categorized with several words that emerged in the analysis, such as beautiful, large, refreshing and innovative. The eighth dimension was related to altered/genetic, which demonstrates the consumer's concern regarding pesticides or genetic modification. The characteristic of great nutritional value, suggested by the red coloration, corresponding to high levels of carotenoids or anthocyanins, generates erroneous thoughts and of mistrust in the consumers, which clearly demonstrates the lack of information among potential customers. This question points to a concern among consumers about risks of food they buy being contaminated by chemical or biological agents (Wunderlich & Gatto, 2015). From the obtained dendrogram, it is possible to identify information about the relationship of dimensions and categories in the perception of consumers. It was possible to identify four segments, according to the contribution of each factor (Figure 2).

Segment 1 was isolated, related to the 'sensory characteristics' of blood orange. Segment 2 grouped the terms 'positive hedonic attitudes' and 'different/unknown', reflecting the fact that consumers do not consider that something different is limiting, and there is a sense of curiosity that can be exploited through the increased availability of red pulp fruits in commercial outlets. The elaboration of the questionnaire was aimed at better evaluating consumers' perceptions regarding the trade and consumption of oranges and also verifying the knowledge about oranges with red pulp.

Table 4 summarizes the eigenvalues, % of the variance and KMO (Kaiser-Meyer-Olkin) of the exploratory factorial analysis, with the extraction of 12

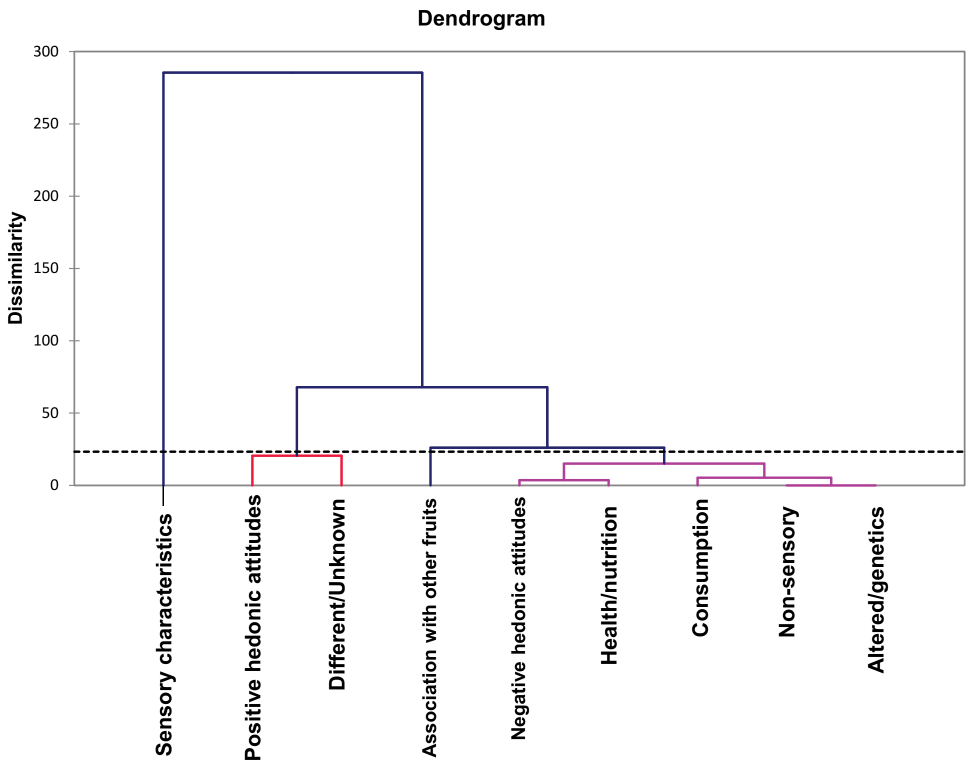

Figure 2. Dendrogram of the dimensions categorized in the word association analysis.

Table 4. Factors retained by the Kaiser method (eigenvalue > 1) from the scores obtained in the questionnaire on trade and consumption of oranges.

Factor	Value	% of Variance
1	6.12	39.71
2	4.57	21.18
3	1.63	11.13
4	1.78	10.09
	Total variance (%)	82.11
	KMO	0.8301
	Cronbach alpha	0.8547

factors, and four were retained (eigenvalues greater than 1), explaining 82.11% of the total variance.

The sample and the model had good fit and consistency according to the KMO test in the factorial analysis (KMO = 0.83) and to Cronbach's alpha test, with a value of 0.8547. Table 5 shows the factor loads after the Varimax rotation. Factor 1 was referred to as "Consumption", factor 2 as "Quality", factor 3 as "Health" and factor 4 as "Perception".

The highest factor loads varied from 0.621 to 0.897. It was verified that the factor "Consumption" included questions such as frequency of consumption, gender, a motive that leads the consumer to buy the fruits, especially oranges

Table 5. Factor loading and communalities (h^2) of the questionnaire items following Varimax rotation.

Item	Factor 1 "Consumption"	Factor 2 "Quality"	Factor 3 "Health"	Factor 4 "Perception"	h^2
1. Gender	0.132	0.111	**0.742**	−0.012	0.732
2. Frequency	**0.775**	0.125	**0.867**	0.337	0.811
3. Reason.	**0.871**	−0.285	**0.896**	0.313	0.754
4. BloodOra.	0.102	−0.038	0.135	**0.811**	0.739
5. Preference	0.152	−0.051	0.451	**0.878**	0.874
6. Health	0.170	**0.875**	−0.121	−0.035	0.828
7. Freqhealth	**0.853**	−0.109	0.113	0.457	0.768
8. Why	**0.877**	0.387	0.479	−0.001	0.694
9. Quality	0.092	**0.789**	−0.189	0.059	0.884
10. Price	**0.841**	−0.601	−0.072	0.421	0.734
11. Acess	**0.884**	0.141	−0.138	−0.106	0.935
12. Toxic	0.222	**0.813**	0.085	−0.068	0.912

The bold values signifies the contribution factor load.

with red pulp, and price. The factor called "Perception" also brought together most of the issues, related to how the consumer perceives the trade or consumption of oranges, including the object of study, the blood orange. Thus, after a factorial exploratory analysis, a hypothetical model was obtained with 4 main factors, from 12 original domains.

The first factor, called "Consumption", comprised 5 of the 12 questions answered in the questionnaire. We observed that gender differences influence buying behavior, frequency and perception in associating the consumption of oranges with health. Women are typically responsible for preparing meals at home, so it is important that marketing strategies are more targeted to women, who have a stronger attitude toward buying functional foods (Küster-Boluda & Vidal-Capilla, 2017). The second "Quality" domain is associated with four issues regarding preference, the quality consumers enjoy in oranges and the price they are willing to pay.

The third factor, called "Health", is related to gender issues, the motive that drives people to buy fruits, the benefits of oranges with red pulp and the concern about the presence of pesticides or genetic modifications in food. The behavior of the consumer in relation to functional foods or the presence of antioxidants is increasing, since the population sees its relationship with health maintenance and the treatment of several diseases (Küster-Boluda & Vidal-Capilla, 2017). The domain pertaining to "Perception" reveals the consumption or purchase of blood oranges. It was observed during the survey that 73% of the participants in the questionnaire had never consumed or bought red oranges, which meets the questions related to the fourth factor, which corresponds to the reasons why the consumer does not make the purchase. In the case of the study in question, it was found that this type of orange was not found easily in commercial establishments, or when it was, the value was well above the other types of oranges. The domain "Perception" also covered the issue of the presence of pesticides or genetic modifications in fruit. The option to choose a food includes aspects such as the risk of ingesting chemical residues, understanding what a genetically modified food is, and the health and disease conditions related to food. Consumers have an interest in gaining more knowledge about pesticide residues and that they rely on government agencies and social media to provide this information (Rutsaert, Pieniak, Regan, McConnon, & Verbeke, 2013).

Conclusions

This study showed the high potential value of the blood orange, cultivar Cara Cara, reflected in its significant levels of phenols, carotenoids and flavonoids; it is also considered a source of vitamin C.

Through the sensorial analysis, we identified a strong acceptance and perception of the consumers and evaluators in relation to most attributes studied. It was also possible to identify four segments in the Word Association tests, including positive and negative hedonic attitudes. The exploratory factorial analysis of the applied questionnaire showed that four factors were sufficient to measure the main characteristics that should be considered in marketing strategies by industries and producers that want to increase the consumption of red-pulp citrus, among them the greater availability in commerce, affordable price, quality and dissemination of the nutritional benefits of blood oranges.

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Author contributions

Experimental design: Bianca Pio Ávila, Márcia Arocha Gularte; Analytical determinations: Bianca Pio Ávila, Gabriela Dutra Alves, Luis Otávio Cardozo; Statistical analysis and data interpretation: Bianca Pio Ávila, Aline Machado Pereira; Supervision: Márcia Arocha Gularte, Roberto Pedroso de Oliveira.

Disclosure statement

The authors declare that they have no conflict of interest

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