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Descriptive sensory analysis and acceptance of leaves of smooth and curly kale

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ABSTRACT

Curly and smooth kale hybrids grown in both field (conventional) and hydroponic systems were sensory-analyzed using the descriptive and affective sensory technique. The treatments comprised hydroponic-cultivated Darkibor (A), Darkibor cultivated in field (B), HS2O (C), Arielli (D) and Kobe (E), these last three cultivated under conventional system (field-cultivated). The panelists indicated the significant attributes that described the differences in kale sensory profiles. Darkibor (A) and Arielli (D) kale leaves had the lightest green color. Regarding their format, the kales were classified into smooth and curly. Both the Darkibor grown in field (B) and Arielli (D) had the most intense bitter taste. Darkibor (A) showed the highest intensity for sweet taste, followed by Arielli (D). The field-cultivated Darkibor (B) ranked the highest crispness and mouthfeel (sensation produced by a particular food in the mouth). The color and texture of the kale leaves affected purchase intention by the consumer, and the color showed a difference among the kales, with Darkibor kale (A) receiving the lowest score. Darkibor (A) obtained lower buying-likelihood scores, reinforcing that color affects consumers' purchase intention.

Keywords: *Brassica oleracea* var. *acephala*, sensory acceptance, purchase intention.

RESUMO

Analise sensorial descritiva e aceitação de folhas de couve lisa e crespa

Folhas de couve lisa e crespa cultivadas em sistema convencional e hidropônico foram analisadas sensorialmente utilizando a técnica sensorial descritiva e afetiva. Foram utilizados quatro híbridos de couve de folha (*Brassica oleracea* var. *acephala*), sendo eles: Darkibor em cultivo hidropônico (A), Darkibor cultivado em campo (B), e três híbridos de couve-manteiga, HS2O (C), Arielli (D) e Kobe (E), todas três cultivadas em campo. Os provadores indicaram que os atributos que descreveram o perfil sensorial das folhas de couve apresentaram diferenças significativas. As folhas de couve Darkibor (A) e Arielli (D) apresentaram cor verde mais clara; para formato as couves foram separadas em lisas e crespas; para o gosto amargo Darkibor cultivado em campo (B) e Arielli (D) apresentaram maior intensidade; para o gosto doce a Darkibor (A) apresentou maior intensidade, seguida da Arielli (D) e para crocância e sensação bucal (sensação produzida por um determinado alimento na boca) o híbrido Darkibor cultivado em campo (B) apresentou maior intensidade. No teste de aceitação, a cor foi o único atributo que apresentou diferença entre as couves, onde a couve Darkibor (A) apresentou menor nota. Para intenção de compra das couves em maço, a Darkibor (A) obteve notas inferiores, concluindo que a cor afeta a compra do consumidor.

Palavras-chave: *Brassica oleracea* var. *acephala*, aceitação sensorial, intenção de compra.

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Regular consumption of fruits, vegetables and greens is crucial for protecting and preventing various chronic, non-transmissible diseases. The appropriate recommendation for the daily consumption of these foods is 400 g day^{-1}, equivalent to five portions of 80 g day^{-1} (WHO, 2003, 2014). Fresh kale is a popular vegetable and a portion of 100 g can provide more than 10% of the mineral micronutrients stipulated by RDA (USDA, 2013). Furthermore, adequate quantities of prebiotic carbohydrates have been identified, in addition to low levels of calories (36-98 Kcal 100 g^{-1}) and moderate levels of protein, varying between 1.6–5.9 g 100 g^{-1} according to the genotypes (Thavarajah *et al.*, 2016). Thus, it is proposed that kale is a good source of nutrients that could be used to improve health habits.

Kale (*Brassica oleracea* var. *acephala*) is characterized as a biennial vegetable of extreme importance in this category because of its widespread acceptance and high productivity. There is a diverse range of kale cultivars, from smooth to curly typology, with different leaf shapes and colors (Novo *et al.*, 2010). Nevertheless, curly kale (known as kale) is still not widely adopted in Brazil. Kale is readily incorporated into food in the form of salad, sautéed, and often included in detox juices. Formulations of this drink were developed by Fouchy *et al.* (2019) and have gained a high level of acceptance.

The primary cultivation system of this kale is the conventional, in the soil, with no production records for the hydroponic system. The latter system offers advantages such as early harvest, carried out within 30 days of crop establishment (Noboa *et al.*, 2019) as young plants. In contrast, with the conventional system, the harvest begins two to three months after the crop has been planted.

A characterization study of kale diversity in Apulia, Southern Italy, highlighted the great variation concerning flavonoid, anthocyanin content, and antioxidant activity, explained by the genetic variation among the samples (Lotti *et al.*, 2018). These results can lead to a sensory change perceived by the consumer. Given the diversity of genetic materials and different vegetable crops, sensory analysis is essential for assessing sensory quality and identifying preferences and differences related to the varieties and type of cultivation.

The quantitative descriptive analysis enables the identification of sensory attributes of food products and their description and quantification (Stone, 2015). The results provide information about the product (Stone *et al.*, 2012), which can be linked to consumers' acceptance. Since there is a range of kale varieties, distinct sensory aspects can emerge with different cultivation systems (field and hydroponic). Therefore, the sensory analysis was used to assess the possible differences and likelihood of smooth and curly kale acceptance in the field and hydroponic systems.

MATERIAL AND METHODS

Curly kale (*Brassica oleracea* var. *acephala*) were evaluated in the study: Darkibor cultivated in a hydroponic system (A); field-cultivated Darkibor (B); and three kale hybrids, HS2O (C), Kobe (D), and Arielli (E), all grown in field (conventional) (Figure 1). Darkibor, a curly kale, was grown in the Campus of UFSCar, in Araras-SP, and the other hybrids, all smooth kales, were obtained directly from producers in São Carlos-SP. For the sensory analysis, the kale plants cultivated in the hydroponic system were harvested 30 days after transplantation, and those cultivated in the conventional system were harvested 60 days after transplantation. All treatments were analyzed on the same day.

Sensory analysis

The curly and smooth kale leaves used for the sensory analysis were taken from the middle part of the plant, sanitized in running water, and immersed in sodium hypochlorite solution (150 ppm v/v) for 10 minutes, then washed in running water. A domestic centrifuge was used to remove the water.

The sensory tests were conducted in individual stations with white light, and each evaluator received a rawcut leaf of each kale at 24-25°C on white, three-digit coded plastic dishes. The panelists used mineral water to wash the palate between samples.

Quantitative descriptive analysis

For the description of the sensory profile, the methodology of quantitative descriptive analysis of Stone & Sidel (1993) was used with adaptations, since the training was shorter due to the perishable condition of the samples. The recruited panelists were University students and employees.

The survey of descriptive terms for attributes of appearance, aroma, taste, and texture was performed using the Repertory Grid (Moskowitz, 1983). After surveying the attributes, the team met and discussed the terms raised. Those who had the same meaning were grouped into an attribute, while the less described were excluded by consensus. A list of descriptive terms with the definitions of each attribute and the respective extremes was built (Table 1). During the training, the panelists were requested to evaluate the intensity of each sensory attribute generated. The samples were analyzed in triplicate, using a sheet with the terms and unstructured scale (9 cm).

Sensory acceptance analysis

Before the acceptance test, a questionnaire was applied, with questions about age, gender, occupation, frequency, way, and kale consumption. For the preference test, 65 consumers participated, evaluating color, aroma, taste, texture, and overall acceptance, using the 7-point structured facial hedonic scale of Meilgaard *et al.* (2007), where 1 = disliked a lot and 7 = I liked a lot.

The order of sample presentation was balanced and followed a complete block design (MacFie *et al.*, 1989). Purchase intention was analyzed for the bundle of each kale (5 leaves), mounted according to the supermarket standard, and presented in line. In this study, all kales, evaluated in packs, were given the scores of 3 = maybe I would / maybe I would not, and 4 = probably would, using a 5-point category scale, ranging from 5 = certainly would buy to 1 = certainly would not buy.

Statistical analysis

The results obtained in the quantitative descriptive analysis and the preference test were subjected to analysis of variance (ANOVA) and, when necessary, the Tukey's mean comparison test was applied, considering a 5% significance level.

For the mean of each sample in each evaluated attribute, Multivariate Grouping Analysis and Principal Component Analysis techniques (PCA) were applied, the latter resulting in the Biplot chart. All analyses were performed using the R software (R Core Team, 2020).

RESULTS AND DISCUSSION

Descriptive sensory analysis

For the appearance attribute, two different color groups were identified among the samples: light green and dark green. Darkibor kale (hydroponic) and Arielli smooth kale (field) were classified as light green (samples A and D), and the other hybrids as dark green (Darkibor, H2SO and Kobe, all field crops), samples B, C and E, respectively (Table 2). The Darkibor grown in the hydroponic system was harvested at an earlier age than the others (30 days before), explaining the lowest value for green tone. Genetic, environmental, nutritional and cultivation factors may influence the final color of the leaves, related to quality and the amount of chlorophyll in a plant (Cassetari, 2012).

The panelists indicated higher aroma intensity in the Darkibor kale grown in the field (B) than in that grown in the hydroponic system, besides hybrids H2SO and Kobe. Swegarden *et al.* (2019) observed significant differences in the leaves among different kale hybrids for the same attribute. The aroma of this leafy vegetable is not a factor of consumers' purchasing decisions.

There are relevant differences between kale genotypes and morphological characteristics, which can be used to differentiate them from each other. Among them are leaf margin, apex, ribs and coloration (Azevedo *et al.*, 2014). In this study, regarding leaf shape (lowest score: smooth, highest score: curly), the descriptors evaluated that all kales were distinct. Darkibor (B) was the curliest, followed by Darkibor (A), Arielli (D), Kobe (E) and HS2O (C) (Table 2, Figure 1), with cultivar HS2O (C) considered the smoothest.

Regarding bitter taste, the most prominent kales were Darkibor (B) and Arielli (D). The others had a low intensity of the bitter taste. Between the Darkibor kale that grew in the field and the hydroponic, this variation in bitterness intensity can be directly influenced by the time of harvest. Another factor that can interfere with this parameter is plant nitrogen (N) supply. Although this was not a parameter evaluated in this study, Groenbaek *et al.* (2016) demonstrated that reduced N fertilization in curly kale decreases the intensity of sensory attributes such as bitterness, astringency and pungent aroma.

Which parameter influences taste perception among those hybrids is still unclear, since the focus of this study was to verify whether there are sensory differences and to quantify them.

Table 1. Sensory attributes of the kales raised by the team of panelists, respective definitions, and references used. Araras, UFSCar, 2020.

Attribute	Definition	Reference
Green color	refers to the color shade of the kale leaves	Light: lettuce, chard
		Dark: broccoli, arugula
Leaf format	refers to leaf shape	Smooth: kale
		Curly: curly kale
Characteristic aroma	refers to the characteristic aroma of kale	Kale
Sweet taste	refers to sweet taste	There are no references
Bitter taste	refers to the bitter taste felt when chewing the kale leaf	Weak: chard
		Strong: chicory
Crunchiness	refers to the application of mechanical force to the leaf. A dry noise is produced when cracked, crushed	Weak: arugula
		Strong: American lettuce
Mouthfeel	Refers to the force required in chewing to deform the kale	Low resistance: soft
		High resistance: tough

The hybrids hydroponic Darkibor (A) and Kobe (E) presented the highest means for sweetness according to the panelists (Table 2), not significantly differing from each other. Nevertheless, Kobe (E) did not differ from Arielli (D) nor HS2O kale (C). Furthermore, Arielli (D), HS2O (C) and Darkibor grown in field (B) also did not differ for sweet taste. Note that all values of the kales were below 3.91, indicating the kale is not considered a vegetable with sweet taste.

The curly-leaved kale (Darkibor) grown in field (B) showed the highest intensity for crunchiness. However, the kale grown in the hydroponic system had a crunchiness similar to the other kales, which did not significantly differ from each other. The kale hybrids showed crunchiness values from 2.77 to 3.83. Regarding mouthfeel, which panelists referred to as the force required in chewing to produce deformation in the food, there was no difference between the kales, except for the Darkibor kale grown in the hydroponic system, with values of 2.49. Since the leaves of kale cultivated in the hydroponic system were younger than the field-grown ones, they offered less resistance to chewing than those harvested later, which remained for an extended period in field conditions. The Darkibor kale grown in field (B) showed the highest means for all evaluated attributes, except sweet taste (Figure 2).

Acceptance test and purchase intention

According to the sensory acceptance analysis, the least accepted leafy kales concerning appearance were the lightest green ones: Darkibor grown in the

A: Darkibor Hydroponic **B:** Darkibor Conventional **C:** HS2O Conventional **D:** Arielli Conventional **E:** Kobe Conventional

Figure 1. Curly and smooth leaves of kale and the respective production system (hydroponic or conventional). Araras, UFSCar, 2020.

hydroponic system (A), and Arielli (D) grown in the field (Table 3), although there was no difference between Arielli and the other hybrids for color.

Color was the only attribute that demonstrated differences in the results among the samples in the acceptance test, which possibly influenced the intention to purchase the analyzed samples. In this study, all kales, evaluated in packs, were given the scores 3 = maybe I would / maybe I would not, and 4 = probably would.

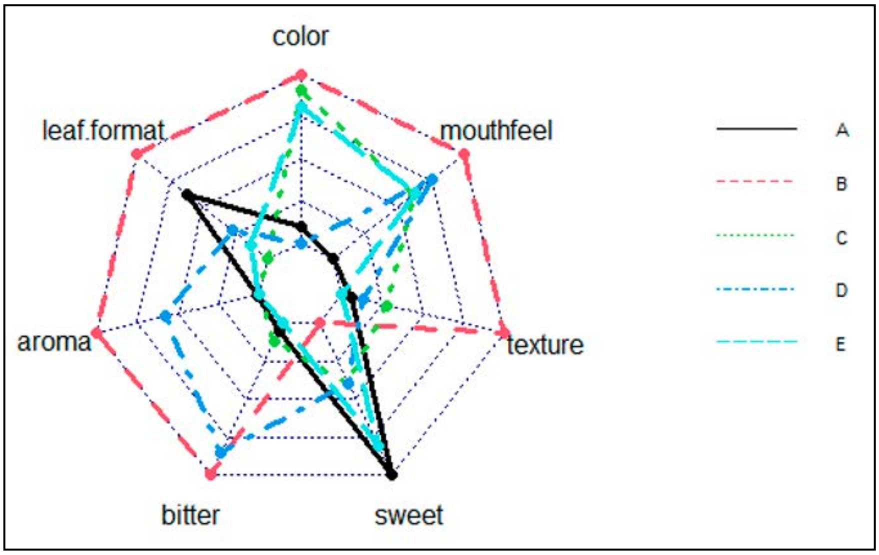

Figure 2. Radar graph of the seven attributes evaluated (color, leaf format, characteristic aroma, sweet taste, bitter taste, crunchy texture, and mouthfeel) of the five samples of kale leaves under study: Darkibor, hydroponic (A); Darkibor, field (B); HS2O, field (C); Arielli, field (D); Kobe, field (E). Araras, UFSCar, 2020.

According to Della-Modesta (1994), appearance is an important attribute involved in consumers' acceptance or rejection. Additionally, color is the most prominent characteristic within appearance because this attribute characterizes the product. In kale, overall appearance, freshness and color are related to visual quality, which leads the consumer to decide whether he/she will purchase the product. Chitarra & Chitarra (2005) also stated that coloration is the most attractive quality attribute for the consumer, although often not significantly related to an increase in the product's nutritional value or good satisfactory quality.

We noted that the intention to purchase the bundle is significantly correlated to the attributes of color (0.96) and texture (0.85) (Figure 3), corroborating the descriptive sensory analysis (Table 2), where purchase intention preference is given to the darkest and most crunchy kales. It should be noted that the main characteristics of kale are the distinctly smooth, light green-colored leaves, which resulted in

Table 2. Mean score (m) and standard deviation (s) were given to the attributes of the sensory analysis for smooth and curly-leaved kales. Araras, UFSCar, 2020.

Kale	Appearance				Taste			
	Color		Leaf format		Bitter		Sweet	
	m	s	m	s	m	s	m	s
Darkibor (hydroponic)	3.20b	±1.64	5.32b	±1.08	2.86b	±2.23	3.91a	±2.70
Darkibor (field)	6.95a	±1.56	7.82a	±0.78	5.12a	±2.44	0.92c	±1.02
HS2O (field)	6.60a	±1.21	1.32e	±0.89	3.20b	±2.36	2.10bc	±2.39
Arielli (field)	2.77b	±1.50	3.12c	±1.46	4.64a	±2.53	2.12bc	±1.87
Kobe (field)	6.16a	±1.47	2.20d	±1.42	2.62b	±2.28	3.35ab	±2.66
N°. of panelists	12		12		9		8	

Kale	Texture				Characteristic aroma	
	Crunchy		Mouthfeel			
	m	s	m	s	m	s
Darkibor (hydroponic)	3.02b	±1,89	2.49b	±1.89	2.46c±	2.09
Darkibor (field)	6.59a	±1,35	5.38a	±2.03	5.98a±	2.46
HS2O (field)	3.83b	±2,30	4.27a	±1.69	2.42c±	2.18
Arielli (field)	3.27b	±2,03	4.67a	±2.41	4.47b±	2.53
Kobe (field)	2.77b	±1,91	4.31a	±1.84	2.42c±	2.08
N°. of panelists	9		10		9	

Means of the Tukey's test in the column followed by the same letters do not differ significantly ($p \geq 0.05$).

a reduction in purchase intention by the panelists in this study. A possible reason for the lowest intention to purchase Darkibor (A) may have been the smaller leaf size, making it the smallest volume bundle of the sample preparations.

Trani *et al.* (2015) reported that kale is sold in bundles of approximately 400 g, or semi-processed, where the leaves are cut, sanitized, and packaged in trays or plastic bags, which adds more value to the product. Darker-colored leaves are ideal for the semi-processed product.

The mean response values of the samples related to the sensory profile of the kales (Table 2), and the acceptance and purchase intention tests (Table 3), were subjected to grouping analysis in order to search for possible kale groupings for all studied attributes (Figure 4). Three groups were formed based on the following observations: (i) HS2O (C) and Kobe (E) kales were the most similar, which in turn are more similar to kale Arielli (D); (ii) kale Darkibor (B); and lastly (iii) kale Darkibor (A) being the most dissimilar of all.

The assessed variables displayed significant dependence, justifying the analysis. The first Principal Component (PC) is responsible for explaining 58.69% of the total data variability, and the second PC for 26.92%, accounting for 85.61% of the total variability (Figure 5). Kales Arielli (D), HS2O (C) and Kobe (E) are close in origin, indicating similarity and stability in all attributes, corroborating the information obtained in the grouping analysis (Figure 4). However, the samples of the Darkibor variety, regardless of crop type, demonstrated differences. The kale grown in hydroponics (A) received negative scores for all attributes, standing alone in the 3rd quadrant, and received the lowest overall acceptance and purchase intention values. Nonetheless, this group presented the highest values for sweet taste. The kale grown in field (B) obtained the lowest score for sweet taste and the highest scores for the other attributes.

Note also that kale B (Figure 5) is represented mainly by the sensory attributes of crunchiness, bitter taste and leaf format together with the preference in aroma and overall acceptance. The values are represented in Tables 1 and 2, where this variety received the highest values for each of these attributes, including global acceptance, not differing from the other kales.

The color and texture of the kale

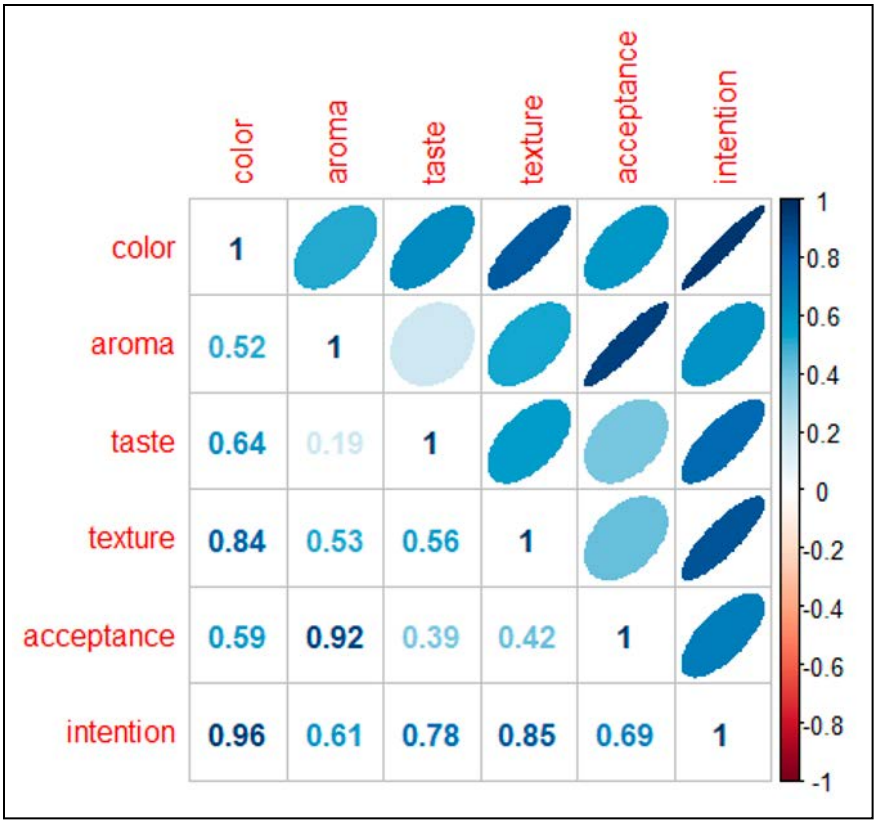

Figure 3. Correlation matrix of the six assessed attributes (color, aroma, taste, texture, overall acceptance, and intention to purchase the bundle) for the kale leaf samples: Darkibor, hydroponic; Darkibor, field; HS2O, field; Arielli, field; Kobe, field. Araras, UFSCar, 2020.

Table 3. Results of the means and standard deviation of samples of smooth and curly-leaved kale, and results of acceptance and purchase intention analyses. Araras, UFSCar, 2020.

Sample	Color[1]	Aroma	Taste	Texture	Overall acceptance	Purchase intention[2]
Darkibor (hydroponic)	4.69b ±1.37	4.14a ±1.38	4.29a ±1.56	4.81a ±1.33	4.64a ±1.30	3.42b ±1.13
Darkibor (field)	5.52a ±1.30	4.65a ±1.30	4.48a ±1.52	5.05a ±1.47	5.14a ±1.21	3.98a ±1.11
HS2O (field)	5.61a ±1.43	4.21a ±1.46	4.53a ±1.48	5.02a ±1.39	4.77a ±1.32	3.92a ±1.18
Arielli (field)	5.30a ±1.18	4.32a ±1.23	4.66a ±1.59	4.86a ±1.38	5.00a ±1.31	3.86ab ±1.04
Kobe (field)	5.48a 1.28	4.33a ±1.20	4.81a ±1.42	5.09a ±1.18	4.88a ±1.25	4.02a ±1.14

Means in the column, followed by the same letters, do not differ significantly ($p \geq 0.05$) by the Tukey's test; [1]7-point facial hedonic scale for color, aroma, taste, texture, and overall acceptance; [2]5-point scale for purchase intention.

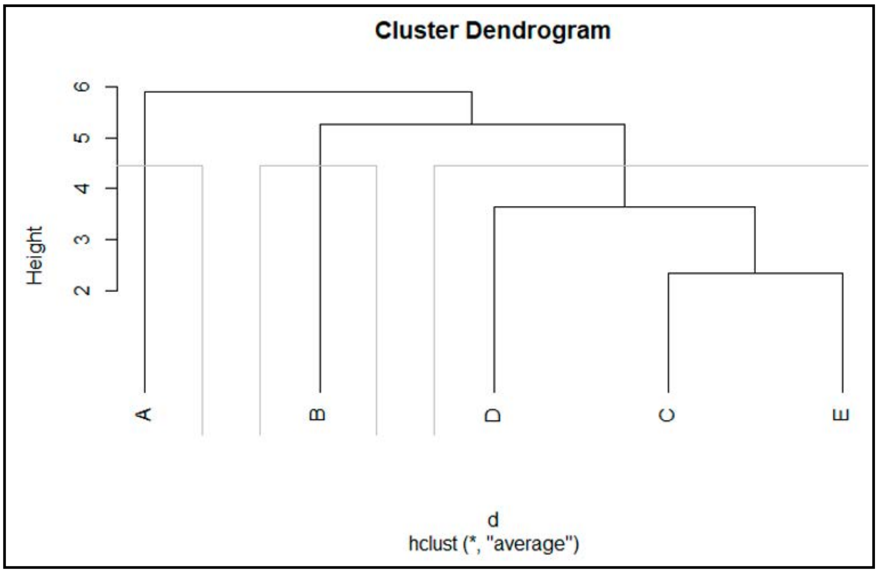

Figure 4. Dendrogram of the grouping obtained, using the Euclidean distance and the hierarchical method of meaningful connection, kale samples. A= Darkibor (hydroponic), B= Darkibor (field), C= HS2O (field), D= Arielli: (field), E= Kobe (field). Cophenetic correlation: 0.8459. Araras, UFSCar, 2020.

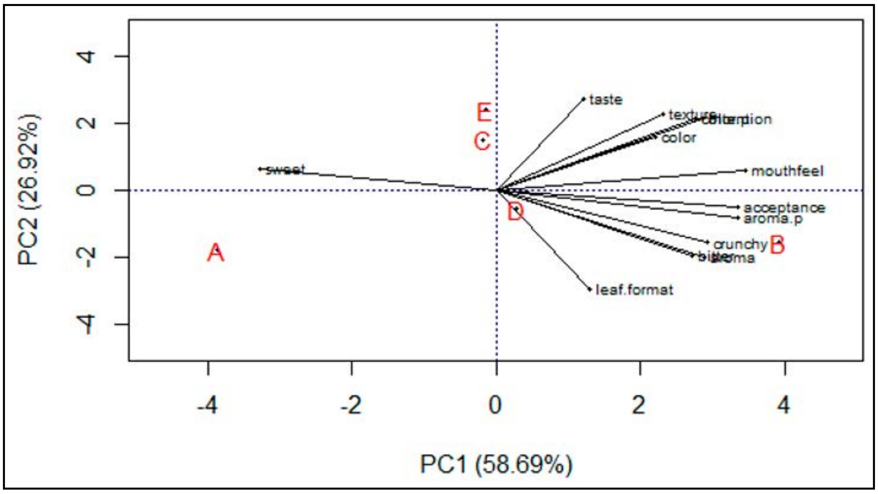

Figure 5. Biplot sensory characterization of the kales by the evaluated attributes. A= Darkibor (hydroponic), B= Darkibor (field), C= HS2O (field), D= Arielli: (field), E= Kobe (field). Araras, UFSCar, 2020.

leaves affected purchase intention by the consumer. All conventionally cultivated hybrids obtained widespread acceptance and purchase intention, which is an interesting fact, given that the Darkibor hybrid also proved to be accepted by the consumers, which allows excellent prospects for its commercialization. In this regard, a physicochemical study monitoring cultivation conditions in the field and hydroponic systems among those hybrids are still necessary to evaluate whether the differences found in this sensory study derive from a genetic influence or from management.

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