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Use of the quantitative descriptive analysis for sensory assessment of tapiocas with adding waste from soy processing

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Abstract

Okara is a byproduct obtained in the processing of water-soluble soy extract. The objective of this work was to use the quantitative descriptive analysis to develop the descriptive terminology and the sensory profile of tapioca formulations with the addition of okara. Four tapioca formulations were developed with the addition of okara to replace the cassava starch in concentrations of 15%, 30%, 40% and 50%. The descriptive terms generated for sensory profile were: color, soy aroma, soy taste, starch taste, softness and crispness. From the descriptors, a 9 cm scale was defined for each term with the extremes varying from weak to strong. After conducting the training and the sensory tests, the data obtained were submitted to ANOVA and the means compared by the Tukey test ($p<0.05$). The F50 formulation showed superior scores for the attributes color, soy aroma, and softness. The intensity of soy taste did not differ between the formulations F40 and F50. There was an increase in the softness of tapioca with the addition of okara. The addition of okara to the tapioca formulations allowed us to obtain a product with its own characteristics such as color and softness, maintaining the overall quality close to the traditional tapioca.

Keywords: descriptive sensory analysis; global quality; okara, tapioca.

Practical Application: This research proposes to use okara in tapioca formulations, aiming to obtain a product enriched in proteins and fibers. This work shows that the use of okara flour can be an alternative in the search for a balanced diet and an important perspective for the development of new products with this residue.

1 Introduction

Soy is a food rich in proteins, fibers, lipids, minerals, vitamins and has important components that give the product functional properties. One of the forms of consumption is the hydrosoluble soy extract (HSE), a drink obtained from hydrated grains, which is used by people who have lactose intolerance and/or allergy to cow's milk and those who seek healthier products (Canaan et al., 2019).

The production of HSE generates a significant amount of waste, called okara, a cohesive and moist mass that has interesting nutritional properties, enabling its use in natura and as a raw material for the production of okara flour. The most common destination for industries is animal feed or disposal as common waste. The dehydration of okara, followed by crushing, results in flour with better preservation characteristics, in addition to reducing the volume of the product, facilitating the storage and transportation (Canaan et al., 2019).

The viability of using okara in food has been studied by several authors aiming to add nutritional value to products, obtaining satisfactory results from a nutritional and sensory point of view (Paula et al., 2019a; Guimarães et al., 2018a; Ostermann-Porcel et al., 2017; Santos et al., 2017; Leite et al., 2013; Aplevicz & Demiate, 2007; Bowles & Demiate, 2006; Rossi et al., 2004).

One of the main results obtained with the addition of okara flour in foods is the increase in its fiber and protein content, in this sense, the incorporation of okara flour into the starch, can generate a result of products with better nutritional value and still be an alternative for the destination of the waste generated in the soy processing (Paula et al., 2019a; Bowles & Demiate, 2006).

According to Fiorda et al. (2013), cassava starch, a raw material used to prepare tapioca, contains a high carbohydrate content, consisting mainly of starch, and low protein levels of soluble and insoluble dietary fiber.

However, according to Barboza & Cazal (2018), factors associated with the sensory aspects, such as appearance, taste, color and texture, have a strong influence on the purchase of products by consumers. The sensory analysis involves the evaluation of a product's sensory attributes through human senses (Paula et al., 2019b). The sensory assessment has been used as a valid tool for assessing the quality of food products, bringing predictive results on the acceptance of a product by consumers (Alcantra & Freitas-Sá, 2018).

The Brazilian Association of Technical Standards (Associação Brasileira de Normas Técnicas, 1993) defines the sensory analysis as a scientific discipline used to "evoke, measure, analyze and interpret the reactions of the characteristics of food and materials as they are perceived by the senses of sight, smell, taste, touch and hearing". The method of quantitative descriptive sensory analysis (DSA) is used to trace, in a more complete way, the sensory profile regarding the attributes of appearance, aroma, texture and taste. The method identifies

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the attributes and quantifies them in the order of occurrence (Instituto Adolfo Lutz, 2008).

Therefore, the present work had the objective to use the quantitative descriptive analysis to develop the descriptive terminology and to trace the sensory profile of tapioca formulations with the addition of okara.

2 Materials and Methods

2.1 Elaboration of tapioca enriched with okara flour

The raw material used to obtain the okara flour was composed of wet okara obtained from the cooking of soy liquefied in water, the obtaining of okara was performed according to, Guimarães et al. (2018b), drying at 70°C for 12 hours.

After obtaining the okara flour, four tapioca formulations were prepared with the addition of okara and traditional tapioca, as shown in Table 1.

To prepare the tapioca, the starch/okara mixtures (Table 1) were hydrated in 50 mL of water, added 0.5 g of salt, manually homogenized, sieved, and placed in a pre-heated 15 cm non-stick frying pan, so that its entire surface was filled, with the aid of a polyethylene spoon, the tapioca was shaped so that it was flat and uniform until the tapioca acquired the necessary firmness, then it was turned with the aid of a spoon and sequentially served to the tasters.

2.2 Test conditions

The sensory tests were performed at the Sensory Analysis Laboratory of the Federal University of Tocantins - UFT. The discussions to obtain the list of attributes and training of tasters were held at a conference table. For the sensory tests, 30 grams of each sample were served on disposable plastic plates coded randomly with three-digit numbers.

2.3 Quantitative descriptive sensory analysis

2.3.1 Recruitment of judges

The tasters were recruited from UFT servers through an appropriate questionnaire, to verify good health, availability of time, ability to work with unstructured scales and familiarity with sensory terms. For conducting sensory tests, this work was approved by the Research Ethics Committee, technical advice number 3.147.012.

Table 1. Formulations of standard tapioca enriched with okara flour.

	Tapioca formulations (g)				
Ingredients	FP	F15	F30	F40	F50
Cassava starch (g)	100	85	70	60	50
Okara flour (g)	-	15	30	40	50
Salt (g)	0.5	0.5	0.5	0.5	0.5
Water (mL)	50	50	50	50	50

FP: Standard tapioca containing 100% of cassava starch. F15: Tapioca containing 15% of okara flour; F30: Tapioca containing 30% of okara flour; F40: Tapioca containing 40% okara flour; F50: Tapioca containing 50% of okara flor.

2.3.2 Pre-selection of tasters

The judges who showed a maximum error of 10% in the use of the unstructured 9 cm scales were selected. To perform the pre-selection, the tasters were evaluated for the taste recognition test, whose approval criterion consisted of obtaining 70% of the correct answers. For the basic taste recognition test, diluted solutions of the basic tastes were used (acid, sweet and salty), for which the tasters who obtained 100% of the correct answers for the samples were approved and finally, the tasters were evaluated through the application of a series of six discriminatory tests (triangular method). In each session of the triangular test, three samples were presented, two equal and one different. The tasters were asked to indicate the different sample on their own form. Tasters who approved 60% of the test were approved (Meilgaard et al., 1988).

2.3.3 Survey of descriptive terminology

Attributes were surveyed using the network method ("The Kelly Repertory Grid Method" - Moskowitz, 1988). Open discussion sessions were held, under the supervision of a moderator, and tapioca samples with different concentrations of okara were presented, and tasters were asked to describe similarities and differences between them in sensory terms.

2.3.4 Training

After surveying the descriptive terms, the team met and discussed the listed terms. In this step, those who expressed the same meaning were grouped into a single attribute. The few terms used by the tasters were, by consensus, withdrawn. At the end of the sessions, a list of descriptive terms was generated with the definitions and respective ends of each scale.

During the training, the tasters were asked to assess the intensity of each sensory attribute of the tapioca samples using a 9 cm unstructured scale, anchored at the ends with terms defined by the team. The various training sessions played an important role in understanding these attributes and allowed the team to distinguish and evaluate the samples quantitatively and qualitatively concerning those attributes. The list of attributes with their definitions is shown in Table 2.

2.3.5 Selection of tasters

After the training, the tasters evaluated the samples in four repetitions, using the developed form. The tasters were selected due to the ability to discriminate samples and repeat results in evaluations, excluding those who did not have discriminatory power and repeatability of results in more than two attributes, according to the methodology proposed by Damasio & Costell (1991).

2.3.6 Evaluation of the samples

The samples were evaluated concerning the attributes identified by trained tasters, in terms of appearance (color), aroma (soy), taste (starch and soy) and texture (softness and crispness) on unstructured 9 cm scales previously defined by the team, presented monadically on plates encoded with three-digit numbers,

Table 2. Sensory attributes raised by the team of judges, their respective definitions and standards that anchor the extremes of the unstructured scale.

Sensory attributes	Definitions	References
Appearance		
Characteristic color	Refers to the color of the tapioca.	White: Tapioca without adding okara Brown: Tapioca with 60% of okara
Aroma		
Soy aroma	Olfactory sensation associated with soy.	Weak: Tapioca without adding okara Strong: Tapioca with 60% of okara
Taste		
Soy taste	Intensity of characteristic soy taste.	Weak: Tapioca without adding okara Strong: Tapioca with 60% of okara
Taste of cassava starch	Intensity of the characteristic taste of cassava starch.	Weak: Tapioca with 60% of okara Strong: Tapioca without adding okara
Texture		
Softness	Force by which the material breaks	Weak: Tapioca without adding okara Strong: Tapioca with 60% of okara
Crunchiness	Refers to the properties of certain foods or objects that emit a dry noise when they click their teeth	Weak: Tapioca with 60% of okara Strong: Tapioca without adding okara
Global quality	Refers to the concept of global quality of the product	Bad – 0 Excellent - 9

adopting a random and balanced presentation order. The tests were carried out in individual booths to maintain the isolation of each tester. The tasters received, together with the samples, a glass of water at room temperature and an evaluation form containing the descriptive terms and an unstructured scale of nine centimeters.

2.4 Affective sensory analysis

The tasters were instructed to judge the samples according to their preference by assigning 1 for the most preferred sample and 5 for the least preferred sample (Instituto Adolfo Lutz, 2008). After the tasters judgment, the data were tabulated and then the sum was performed for later comparison of the values.

2.5 Statistical analysis

The DSA data were analyzed using analysis of variance (ANOVA) and the means compared by the Tukey test to verify differences at a 95% confidence interval ($p \leq 0.05$) using the statistical program SISVAR 5.0 (Ferreira, 2000).

For the statistical analysis of the ordering test, the Friedman method was used (Dutcosky, 2013).

3 Results and Discussion

3.1 Quantitative Descriptive Sensory Assessment

A total of 23 tasters were recruited to participate in the sensory tests with tapioca with the addition of okara. In the aroma recognition test, of the 23 participants, 17 of them reached the minimum of correct answers, which is 70% of the aromas with a normal degree of difficulty. For the basic taste tests, the 17 tasters participated, and all of them obtained the criterion of approval of 100% of the correct answers. For the triangular tests of tastes and aromas, of the 17 tasters who participated, 15 tasters remained in the team of quantitative descriptive sensory analysis of tapioca with the addition of okara.

Table 3. Average scores given to the sensory analysis attributes for tapioca formulations with the addition of okara evaluated by the DSA method.

Attributes	Samples				
	FP	F15	F30	F40	F50
Color	1.00^{e}	2.83^{d}	4.43^{c}	7.39^{b}	8.75^{a}
Soy aroma	1.00^{e}	2.82^{d}	4.42^{c}	7.37^{b}	8.14^{a}
Softness	1.00^{d}	2.87^{c}	7.28^{b}	7.30^{b}	8.38^{a}
Crispness	8.67^{c}	6.33^{b}	6.4^{b}	4.39^{a}	4.35^{a}
Soy taste	1.00^{d}	2.70^{c}	4.40^{b}	7.78^{a}	7.92^{a}
Cassava starch	9.00^{a}	7.14^{b}	4.38^{c}	1.86^{d}	1.81^{d}
Global quality	7.20^{b}	8.10^{a}	8.30^{a}	7.20^{b}	5.80^{c}

FP: Standard tapioca containing 100% of starch F15: Tapioca containing 15% of okara flour; F30: Tapioca containing 30% of okara flour; F40: Tapioca containing 40% of okara flour; F50: Tapioca containing 50% of okara flour. Means followed by the same letters horizontally (line) do not differ significantly at the 5% level of significance by the Tukey test.

According to Silva et al. (2018), the use of quantitative descriptive assessment is important in sensory analysis studies, as it has the advantage of allowing several attributes to be investigated to acquire a complete sensory profile of the product.

Table 3 presents the average values of the marks attributed for each sensory attribute evaluated considering the unstructured scale from 1 to 9.

According to the color attribute, it is possible to observe that there was a significant difference between all the formulations evaluated, with the traditional sample presenting the lowest score when compared to the other tapioca, since, according to the scale, the tasters gave scores between one (white) and 9 (brown). It is worth noting that the sample with 50% of okara added had a high mean score, indicating that it shows a darker color in the analysis of the tasters.

The color is an important parameter of appearance, as it is perceived at the consumer's first contact with the product and can provide information about processing (Generoso et al., 2009). It is possible to observe in Figure 1, that as the concentration of okara flour was increased in each formulation, the dark color conferred by the presence of okara flour stood out, which reflected in the sensory results pointed out by the judges as shown in Table 3 of this work concerning the color attribute.

According to Taghdir et al. (2017), the darker color given by the okara flour to some foods, can be attributed to the yellow pigment present in the okara flour and the Millard's reaction during processing.

As for the aroma attribute, it can be observed that there was also a significant difference between all obtained. The sample from the control group with the lowest sensory scores for the soy aroma attribute, while the sample with 50% of okara added showing higher values than the others. As for the characteristic aroma of tapioca enriched with okara flour, the judges did not recognize the aroma of starch in any of the formulations, and the aroma of soy was predominant in all tapioca with the addition of okara.

The aroma of food products is one of the main drivers of consumer acceptance. Its characterization therefore represents a major challenge for the food industry (Paravisini et al., 2014).

Regarding the texture sensory attribute (softness and crispness), it is possible to observe in Table 3 that there is an inverse relationship in these parameters. As okara flour was added to the formulations, there was a reduction in crispness (8.67 in FP and 4.35 in F50) and an increase in the softness of tapioca (1 in FP and 8.38 in F50).

The tasters evaluated the traditional tapioca sample as the least tender sample with an average score of 1.0. There was an increase in the mean scores with the increase in the addition of okara. However, the tasters did not observe any significant difference in the softness between the samples with the addition of 30% and 40% of okara with average values of 7.28 and 7.30, respectively, indicating a high softness of tapioca. Tapioca with the addition of 50% of okara flour was considered the softest according to the tasters, reaching average scores of 8.38.

Yoshida et al. (2014) when preparing cookies containing okara flour, obtained as a result a greater water retention capacity (assessed by the IAA) as the okara flour was added. The authors justified the fact observed due to the greater amount of hydrophilic molecules in the matrix of cookies with okara flour, including fibers, which tend to absorb water. According to the same authors, cookies containing okara flour tend to have lower density and greater expansion.

With the addition of okara flour made in this study, it is possible that the softness of tapioca is related to the moisture retention caused by the water absorption capacity provided by the fibers present in the okara flour. In the analysis of the proximate composition of this research, the tapioca formulation enriched with 50% of okara flour presented the highest moisture content (39.80%) among the analyzed samples, as well as the highest fiber content (3.17) (data not shown).

As for the crispness attribute, the tasters did not observe any significant difference between the formulations with the addition of 40% and 50% of okara or between the samples with 15% and 30% of okara, however, all formulations with the addition of okara differed statistically from the traditional sample that was considered by the tasters as the most crunchy with average scores of 8.67. However, it is worth noting that the samples with the addition of okara had average scores ranging from 4.35 to 6.4, indicating that they still have a certain crunchiness, characteristic of this food.

According to Souza & Menezes (2006), products with low moisture content, baked or extruded, such as breakfast cereals, cookies, wafers, and snacks, have a crunchy texture. If the moisture content of these products increases, due to the absorption of water from the atmosphere or the mass transport of neighboring components, it results in moistening and soft textures, that is, loss of crispness.

According to Torres et al. (2020) the decision related to not buying the product studied in his research (petit-Suisse cheese) involves negative aspects indicated in the research related to the composition and nutritional aspect of food, such as: "Not being a healthy product", "Containing sugar", "High fat content", "Added with additives and preservatives", and the fact that consumers considered food as an "industrialized product". Batista et al. (2020) in an approach on the acceptance of foods with changes in their composition with a view to improving nutritional quality informing consumers about food-promoting health can increase the acceptability of alternative food products.

As for the taste attribute, the tasters evaluated the distinction in two categories, being the taste of starch and soy taste. No definite difference was observed between those added with the addition of 40% and 50% of okara as to the soy taste attribute. However, all those added with the addition of okara differed completely from the control sample, which presented an average score of one, indicating absence/low soy taste. After the judges were presented with tapioca as a reference for the soy taste attribute, which was enriched with 60% okara flour, the tasters stated that tapioca with the addition of 40% and 50% okara had a soy taste, however, no unpleasant characteristics such as that of "raw beans" common to soy were submitted.

The heat treatment carried out in the wet okara to obtain okara flour used in the production of tapioca, as recommended by Ostermann-Porcel et al. (2017), allows the inactivation of lipoxygenases, which according to Santos et al. (2004), prevents the formation of undesirable compounds such as n-pentanal and n-hexanal, giving the residue of the water-soluble soy extract a smoother taste.

As for the taste of the starch, the behavior was reversed, and the highest scores were found for the control sample. There was also no significant difference between the samples with 40% and 50% of okara, and between samples with 15% and 30% of okara.

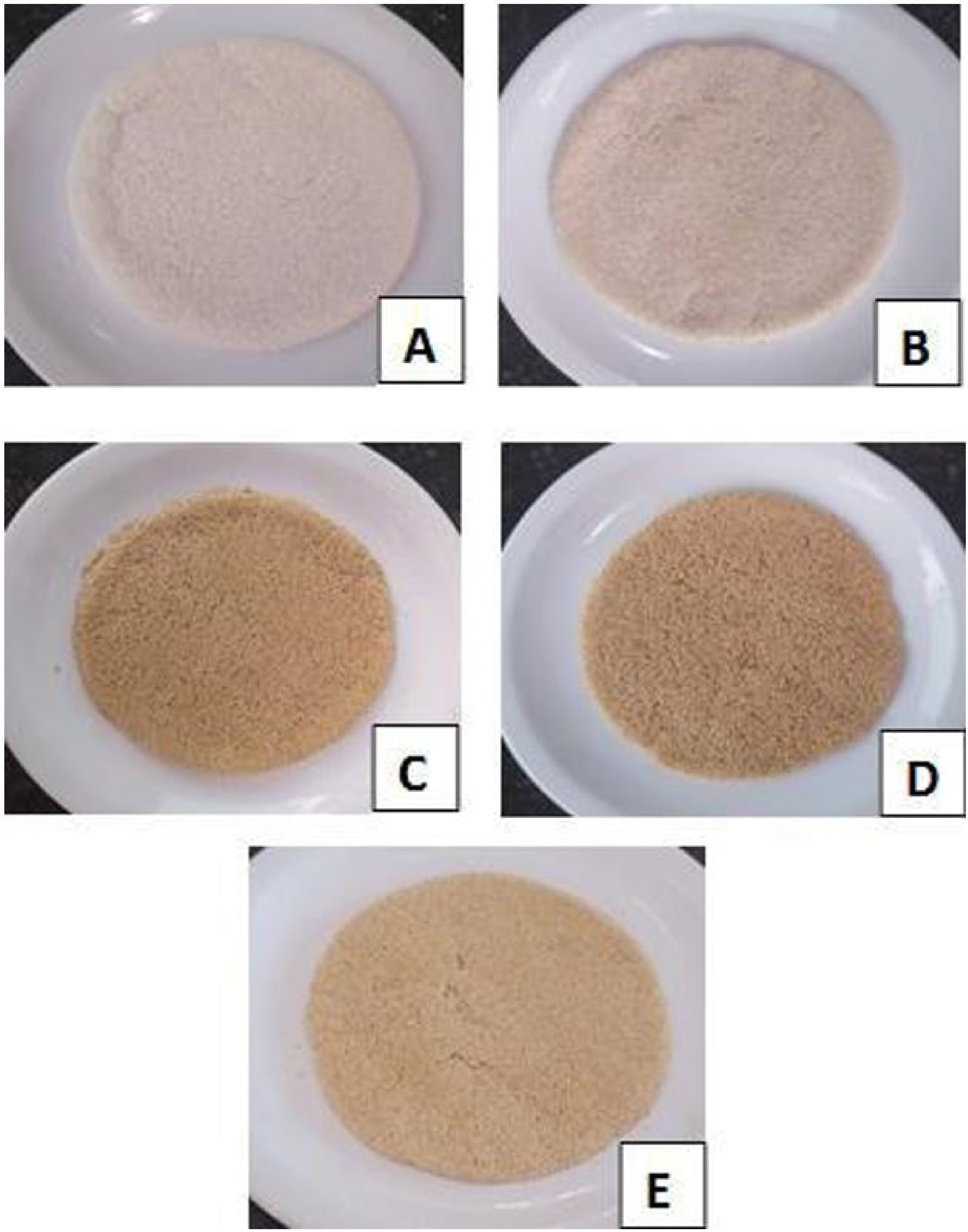

Figure 1. Tapioca formulations - A) FP: Standard tapioca containing 100% of starch; B) F15: Tapioca containing 15% of okara flour; C) F30: Tapioca containing 30% of okara flour; D) F40: Tapioca containing 40% of okara flour; E) F50: Tapioca containing 50% of okara flour.

Regarding the overall quality, it was observed that all classified a high global quality. No significant difference was found in relation to the overall quality of the samples in the control group and the samples with 40% of okara and also between samples with 15 and 30% of okara addition that had the highest mean score values. The sample with the addition of 50% of okara showed significantly lower values of average scores, which can be attributed to the high soy taste and its brownish color that negatively affects the acceptance of a product that has lighter color.

Bowles & Demiate (2006) identified significant losses in the volume of bread allocated from okara flour, reduced acceptance and purchase intention in addition to the addition of 15% of okara flour. According to the author, 10% of okara flour is the most suitable concentration to be used to replace wheat flour.

Figure 2 presents the representative sensory profile of the quantitative descriptive analysis of tapioca with the addition of okara.

According to the spider graph (Figure 2), it is possible to observe that the traditional sample presented a light color, less soy aroma, less softness and less soy taste. The sample with 50% of okara added had the highest scores of soy aroma, softness, soy taste and more intense dark color. Intermediate attribute values were obtained for samples with 15%, 30% and 40% of okara added.

3.2. *Affective sensory test*

Comparing the modules of the difference minimum significant (DMS) number 57, as observed in Table 4, it can be said that there was a statistically significant difference regarding the preference between the standard formulation (FP) and the formulation F30, the latter being described as the most preferred by the tasters.

Guimarães et al. (2019), when preparing gluten-free bread with the addition of okara flour and cornflour, found that concentrations with 10% and 30% of okara flour were most cited as the most preferred formulations by consumers, however, all gluten-free bread were also preferred.

According to Nascimento et al. (2020), considering that Brazil has a highly diversified culture, with variations in taste preferences, studies that involve evaluation of sensory acceptance of foods prepared with alternative products are important.

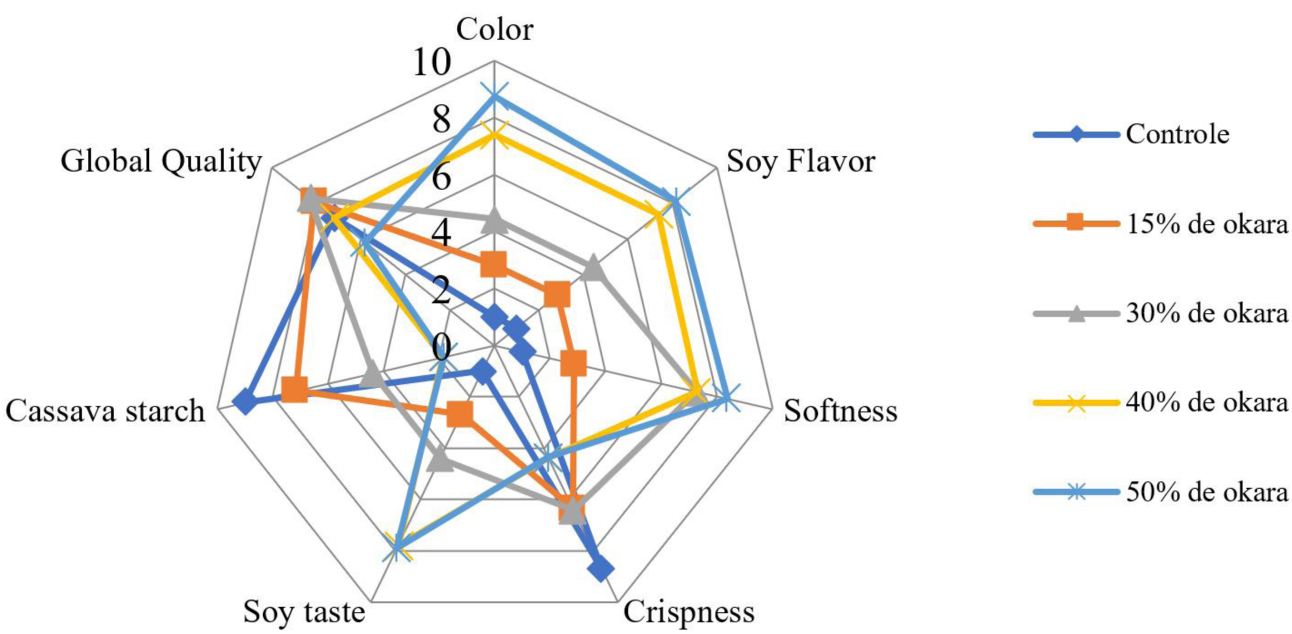

Figure 2. Spider graphic representative of the quantitative descriptive analysis of tapioca with the addition of okara.

Table 4. Difference in the sum of orders between the samples regarding the preference of the judges obtained by the preference ranking test.

Difference of sum of orders	Total	DMS	MD	DMS	MD	DMS	MD	DMS	MD
FP	298								
F15	262	FP x F15	36 (ns)						
F30	235	FP x F30	63 (s)	F15 x F30	27(ns)				
F40	250	FP x F40	48 (ns)	F15 x F40	12(ns)	F30 x F40	15(ns)		
F50	265	FP x F50	33 (ns)	F15 x F50	03(ns)	F30 x F50	30(ns)	F40xF50	15(ns)

DMS: Difference minimum significant; Modules of difference: MD; FP: Standard tapioca containing 100% of starch; F15: Tapioca containing 15% of okara flour; F30: Tapioca containing 30% of okara flour; F40: Tapioca containing 40% of okara flour; F50: Tapioca containing 50% of okara flour. (ns) = not significant. Critical difference of $\alpha = 0.05 = 57$.

4 Conclusions

The addition of okara flour to tapioca caused an increase in the brown color, an increase in the soy taste and aroma, an increase in the softness and a reduction in the crispness.

The affective sensory evaluation showed that the addition of okara flour in the proportion of 30% to replace the cassava starch resulted in tapioca with greater preference for the tasters.

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