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Sensory acceptability of sweet potatoes: Influence of the cultivar, cooking method and the city

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Abstract

Background: This study aimed to evaluate the sensory acceptability of four sweet potato cultivars (Beauregard, Morada-INTA, Colorado-INTA, and Arapey), considering two cooking methods: boiled and baked; and two cities, 9 de Julio (9DJ) and San Pedro (SP), of Buenos Aires province. 120 women were recruited in each city. A home use test was carried out. Each consumer received at home each sample in a bag containing three sweet potatoes and the evaluation form. The sensory acceptability of different characteristics of the samples was evaluated, before and after cooking. To inquire the reasons for consumption of each sample, the methodology check all that apply (CATA) was used.

Results: Of the two factors evaluated (city and cooking method), city had a significant influence when evaluating the samples. Participants of SP gave higher acceptability to Beauregard cultivar than 9DJ in most attributes. Colorado INTA had greater acceptability in some descriptors by the consumers of 9DJ. While Arapey and Morada INTA had the greatest acceptability in 9DJ trial. In CATA results 9DJ consumers associated the Beauregard cultivar with negative phrases: *It tastes weird* and *It has little flavor/tasteless* and to a lesser extent to *The internal color is artificial* and *It breaks when cooking*. While SP consumers characterized with negative phrases the Arapey and Morada INTA samples as follows: *It changes color (brown) quickly, Its shape is not regular* and *When cooked, it has threads or fibers*.

Conclusion: Consumer preferences provide opportunities for the development or improvement of new cultivars. It would be interesting to extend this study to other regions and/or countries.

KEYWORDS

consumers, cultivars, home use test, penalty, sweet potatoes

INTRODUCTION

The sweet potato (*Ipomoea batatas* L. Lam) is the fifth most important food in developing countries due to its outstanding nutritional and culinary characteristics.[1]

Production in South America is concentrated (97%) in Brazil, Argentina, Peru, and Uruguay, being one of the most relevant among root and tuber products.[2] In Argentina, the sweet potato cultivated area in 2020 was about 22,800 ha with a production of 339,900 tons and an apparent consumption per capita per year of 7.5 kg.[3] The main producing regions are the Pampas (Buenos Aires, Córdoba, and Santa Fe) with 43% and the Northeast (Entre Ríos, Corrientes, Formosa, and Chaco) with 40%.[4] San Pedro, a city located in the Pampas, is a traditional area for this crop.

The sweet potato crop presents an ecological and agroeconomic adaptability, which contributes to the existence of a great genetic diversity among cultivars with different agronomic, organoleptic, and nutritional characteristics. Different genotypes may be related to diverse flesh colors and bioactive compounds: while purple-fleshed sweet potatoes have higher anthocyanin contents and antioxidant activities, orange-fleshed ones have higher concentrations of carotenoids.[5,6]

In Argentina, generally yellow, cream, and white-fleshed sweet potatoes are chosen by the local producers. However, in some specific area's orange-fleshed ones, like Beauregard cultivar, have been introduced.[7] Previous studies have shown large differences in the sensory characteristics of cream-fleshed and orange-fleshed genotypes. The flavor of the former has been described as sweet potato, while the flavor of orange-fleshed genotypes has been described as pumpkin. Regarding color and texture, cream-fleshed cooked varieties have been reported to show intense yellow-green color, and to show low perceived graininess.[8] Orange flesh cultivars are appreciated by their attractive color, sweet taste, extended postharvest storage, and high β-carotene (provitamin A) content.[9,10]

Sweet potato breeding programs worldwide are integrating sensory characteristics with agronomic and postharvest behavior[11,12] to provide global markets with widely accepted cultivars. The characterization of diverse genotypes from a sensory perspective gives valuable information for improving the flavor and texture of the product, contributing to consumer acceptance. In the last decade, the Instituto Nacional de Tecnología Agropecuaria (INTA), through a sweet potato genetic breeding program, began to study the characteristics and the agronomic adaptation of different genotypes, with the aim to select those cultivars with high productivity, tolerance to pests and abiotic stress and with better chemical and nutritional properties[7]; moreover, a few years ago they have incorporated sensory analysis as a complementary tool to determine by the acceptance by the consumer.

Different sweet potato cultivars are planted in various regions, and differences in flavor and texture in cultivars may influence the taste acceptability.[13] Tomlins[14] evaluated the preference of different cultivars in three districts of the Lake Zone of Tanzania and observed that there were differences in preference for the cultivars evaluated between consumers in the districts.

The consumption of sweet potatoes is mainly due to their sensory characteristics, ease preparation (cooking and baking), and favorable nutritional profile.[15] The methods of cooking and form utilization have a critical influence on taste and overall consumptive quality. Common methods include boiling, roasting, baking, steaming, microwaving, and deep-fat frying. These cooking processes lead to changes in physical, sensory, and chemical characteristics of the final product.[10,16,17]

This study aimed to evaluate the sensory acceptability of four different sweet potato cultivars, considering two cooking methods and two cities in Buenos Aires, Argentina.

MATERIALS AND METHODS

Samples

Four cultivars (samples) of sweet potato that are marketed in Argentina, with different agronomic and sensory characteristics, were evaluated. Table 1 shows the samples evaluated and their skin and flesh colors. The samples were harvested in San Pedro, Buenos Aires for personnel of INTA. In the period of 2 weeks, the different samples were collected from places of producers in the area. The sweet potatoes were stored in a chamber at 13 ± 2°C until all cultivars were harvested. Then it was transported to the sensory laboratory of the Instituto Superior Experimental de Tecnología Alimentaria (ISETA) in 9 de Julio City, Buenos Aires, Argentina, and stored at 13 ± 2°C.

Each sample was presented in a bag with three sweet potatoes (approximately 700–800 g) and identified with a randomly selected 3-digit label.

Subjects

To find out if the place of residence influences the sensory acceptability of sweet potatoes, the study was carried out in two different cities in the interior of the province of Buenos Aires: 9DJ and SP; this last city is an important area that produces the crop. The distance between both cities is approximately 300 km.

A total of 120 women were recruited in each city, habitual consumers of sweet potatoes, aged between 20 and 60 years. The study was approved by the ISETA and INTA, and consent was obtained from each consumer before their participation in the study.

Methodology

Ethics statement: This study was approved by the ethical committee of the ISETA and consent was obtained from each subject before their participation.

Sensory acceptability

Consumer acceptance tests are largely divided into laboratory tests or central location tests and home use tests (HUT). HUT is conducted at home where the consumers can evaluate in natural circumstances. Thus, it is one of the most noticeable methods to measure acceptability in real consumption. The other case where the HUT test is required is for products that are difficult to test anywhere other than at home; for example, shampoo or a cake where issues other than sensory are of importance.[18] In this study, in addition to measuring the sensory characteristics of the samples, there was interest in their handling/preparation characteristics and cooking method (baked and boiled). For these reasons, a HUT trial was carried out.

TABLE 1 Color characteristics of the peel and flesh of the samples.

	Arapey	Colorado-INTA	Morada-INTA	Beauregard
Peel color	Purple	Purple	Purple	Light copper
Flesh color	Yellow with orange inclusions	Orange with purple inclusions	Yellow with orange inclusions	Orange

Abbreviation: INTA, Instituto Nacional de Tecnología Agropecuaria.

TABLE 2 Scales used for the evaluation of attributes.

		Scales
Before cooking	Overall appearance	9-point hedonic scale (1 = I dislike it, 9 = I like it)
	Raw flesh color	9-point hedonic scale (1 = I dislike it, 9 = I like it)
	Difficulty peeling	9-point hedonic scale (1 = very difficult; 9 = very easy)
	Difficulty cutting	9-point hedonic scale (1 = very difficult; 9 = very easy)
After cooking	Overall appearance	1 (I dislike it) to 10 (I like it)
	Cooked flesh color	9-point hedonic scale (1 = I dislike it, 9 = I like it)
	Sweet Potato flavor	9-point hedonic scale (1 = I dislike it, 9 = I like it)
	Sweet flavor	JAR scales, (1 = Not sweet enough to 9 = Too sweet, with 5 = just about right)
	Overall flavor	1 (I dislike it) to 10 (I like it)
	Hardness	JAR scales, (1 = Not sweet enough to 9 = Too sweet, with 5 = just about right)
	Overall liking	1 (I dislike it) to 10 (I like it)

Abbreviation: JAR, Just About Right scale.

Before selecting cooking methods to be evaluated, a total of 84 housewife women completed an online survey. These participants had to select the different cooking options (boiled, fried, baked, microwaved) for the sweet potatoes that they usually use. Based on the results, the most mentioned were boiled (48%) and baked (28%).

Each consumer was visited at home four times every 3 or 4 days. At each visit, they were given a sample and the evaluation form, and the previous one was withdrawn. In each cooking method, the delivery order of samples was made in a balanced way. Of 120 consumers that participated in each Ciudad, half were instructed to bake the sweet potato samples and the other half of consumers to boil them.

Sensory evaluation was divided into two parts: before and after cooking the sample. Table 2 shows the attributes and scale used to evaluate the samples.

Check all that apply

To inquire about influential reasons for the consumption or not of each sample, the methodology check all that apply (CATA) was used. Cardinal[19] generated the terms based on non-formal sensory evaluation of the products, followed by discussion. In this work, the same strategy was considered, using our sensory-trained panel. The resulting phrases were:

> It is healthy, It is expensive, It is easy to prepare, It is yielding, It is consumed all year round, I don't find good quality, The internal color is artificial, The size is too small, It tastes weird, I would use it to accompany different meals, I would use it to cook sweets/cakes, It is cheap, It makes me feel bad: inflamed, My family doesn't like it, It has little flavor/tasteless, I like it, It is caloric: this makes me gain weight, I don't always find this on the market, It is ideal to consume in winter, It is unhealthy, It changes color (brown) quickly, It breaks when cooking, I consume it only in season, The skin color is attractive, The size is too big, It has purple lines inside, Its shape is not regular, When cooked, it has threads or fibers, I would use it for another type of cooking, not the one I used.

Consumers were asked to select how many terms they considered appropriate to describe the samples.

Data analysis

Sensory acceptability

In sensory evaluation of unpeeled sweet potato (before cooking), the descriptors: overall appearance, peeling difficulty, and cutting difficulty were analyzed by analysis of variance (ANOVA) considering samples and cities as fixed effects, and subjects as random effects. Subjects were nested within cities.

To determine if cooking affects the acceptability of sweet potato flesh color, the "moment" (before cooking and after cooking) was included as a fixed factor in the previous model.

The ANOVA model used for the attributes evaluated after cooking (overall appearance, sweet potato flavor, global flavor, and overall acceptability) was follows: samples, cities, and cooking method

(boiled/baked) as fixed effects; and subjects as random effect. Subjects were nested within cities.

For all analyses, $p \leq 0.05$ was considered significant. Means were compared using Fisher's least significant difference (LSD) at a 5% significance level.

The sweetness and hardness attributes were analyzed by penalty analysis, to identify potential directions for product improvement on the basis of consumer acceptance by highlighting the most penalizing attributes in liking terms. The respondent percentages (x-axis) were plotted against the penalties (y-axis), and an attribute was considered significant when the respondent percentage was higher than 20%[20] and the penalty score (drop in overall liking) was higher than 1. This technique is used to relate Just About Right (JAR) scales to liking data, particularly in order to understand which side of the JAR scale is linked to lower hedonic ratings. The usefulness of the method is that it provides guidance for product reformulation or a better understanding of attribute adequacy in relation to liking in terms of direction, with the assumption that the maximum hedonic score will occur at the "just about right" point.[21]

In order to identify groups of consumers with similar acceptability patterns, subjects were clustered using Ward's hierarchical clustering technique with Euclidean distances.[22]

Check all that apply

Frequency of mention of each phrase was determined by counting the number of consumers that used it to describe each sample. A multiple factor analysis (MFA) was performed on the frequency table containing the answers to the CATA question, with three categorical variables: samples (four sweet potatoes cultivars), cities (9DJ and SP), and phrases. The analysis was carried out for sensory and no sensory phrases (habits, consumer behavior, and others). Consumer overall liking scores were considered as supplementary variable.[23,24]

Penalty analysis was performed using XLSTAT® Software package (Addinsoft SARL, New York, NY, USA). The other statistical analyses were performed using Genstat (VSN International Ltd., Hempstead, UK).

RESULTS

Sensory acceptability

Analysis of variance

Before cooking
Overall appearance: the two-way city*sample interaction was significant (Table 3). The city factor affected the acceptability of this attribute only in the Beauregard cultivar, where the SP consumers presented greater acceptability than the 9DJ consumers. This cultivar is the only one, of the four evaluated in this study (Table 1), that has a different skin color; was influenced positively only by SP consumers.

TABLE 3 Mean (±standard deviation) of the sensory acceptability of different evaluated attributes of sweet potato cultivars for two cities.

City	Arapey	Colorado-INTA	Morada-INTA	Beauregard
Overall appearance (before cooking)				
9DJ	6.33 (1.94)	5.72 (2.12)	6.23 (1.82)	5.87* (2.35)
SP	6.22 (2.04)	6.26 (2.18)	5.77 (2.35)	7.04* (2.08)
Flesh color				
9DJ	6.51 (1.92)	5.16* (2.46)	6.69* (1.84)	5.40* (2.66)
SP	6.46 (2.11)	6.87* (2.19)	6.02* (2.04)	7.60* (1.62)
Overall appearance (after cooking)				
9DJ	7.56 (1.46)	6.70* (1.86)	7.86 (1.40)	7.04* (2.15)
SP	7.65 (1.41)	7.77* (1.62)	7.44 (1.51)	8.61* (1.22)
Sweet potato flavor				
9DJ	6.55 (2.11)	5.45* (1.86)	7.21 (1.40)	5.82* (2.15)
SP	6.65 (2.26)	6.59* (1.62)	6.89 (1.51)	7.32* (1.22)
Overall flavor				
9DJ	7.27 (1.90)	6.43* (2.18)	8.02 (1.55)	6.96* (2.49)
SP	7.46 (1.85)	7.62* (1.79)	7.78 (1.59)	8.28* (1.78)
Overall liking				
9DJ	7.55 (1.62)	6.80* (1.95)	7.91 (1.74)	7.17* (1.92)
SP	7.70 (1.35)	7.67* (1.60)	7.73 (1.41)	8.37* (1.40)

Note: Means with asterisk in each column and for each attribute, differ significantly ($p < 0.05$). For attributes, Overall appearance (before cooking), flesh color and sweet potato flavor a 9-point hedonic scale (1 = "I dislike it," 9 = "I like it") was used. For the rest attributes a 10-point scale (1 = I dislike it, 10 = I like it) was used.
Abbreviations: 9DJ, 9 de Julio; INTA, Instituto Nacional de Tecnología Agropecuaria; SP, San Pedro.

Difficulty peeling and Difficulty cutting showed differences between the samples, where, in both attributes, the Beauregard cultivar presented less difficulty than the other samples. The averages of all the samples were between 5.8 and 7.2, on a 9-point hedonic scale (1 = very difficult [I dislike it] and 9 = very easy [I like it]); that is, no sample presented much difficulty.

In the comparison of flesh color acceptability before and after cooking, the "moment" factor was not significant. That is, the color of the flesh, both raw and cooked, had the same behavior among the cultivars. There were significant differences in the city*sample interaction (Table 3), where the Beauregard and Colorado-INTA cultivars, with orange flesh color, presented higher acceptability for SP consumers than for 9DJ consumers. While 9DJ consumers presented higher acceptability for Morada-INTA cultivar (yellow flesh color) than SP consumers.

After cooking
The 3-way interactions city*samples*cooking method (boiled/baked) were not significant for any of the evaluated attributes. Only two-way interactions that were significant are presented.

Overall appearance: the two-way city*sample interaction was significant (Table 3). This attribute had a similar behavior to flesh color

TABLE 4 Mean (±standard deviation) of the sensory acceptability of different attributes evaluated of sweet potato cultivars for two cooking method.

Cooking method	Arapey	Colorada-INTA	Morada-INTA	Beauregard
Overall appearance (after cooking)				
Baked	7.46 (1.60)	7.18 (1.79)	7.85* (1.48)	8.05* (1.69)
Boiled	7.75 (1.23)	7.30 (1.88)	7.45* (1.42)	7.60* (2.10)
Overall flavor				
Baked	7.43 (1.87)	7.32* (1.98)	8.12 (1.38)	8.18* (1.66)
Boiled	7.30 (1.90)	6.72* (2.12)	7.70 (1.71)	7.06* (2.29)

Note: Means with asterisk in each column and for each attribute, differ significantly ($p < 0.05$). For both attributes, a 10-point scale (1 = I dislike it, 10 = I like it) was used.

Abbreviation: INTA, Instituto Nacional de Tecnología Agropecuaria.

acceptability, where the Beauregard and Colorado-INTA samples, with orange flesh color, presented higher acceptability for SP consumers than for 9DJ consumers.

The two-way cooking method*sample interaction was also significant (Table 4). The Beauregard and Morada-INTA samples had higher acceptability when they were baked than when they were boiled. In the Arapey and Colorado-INTA samples, the cooking method did not influence the acceptability of the cooked appearance.

Sweet potato flavor: The city*sample interaction was significant (Table 3). The sensory acceptability of the Beauregard and Colorado-INTA samples had different behaviors depending on the city, where both samples had higher sensory acceptability for SP consumers. The Arapey and Morada-INTA cultivars were not influenced by the city factor.

Overall Flavor: The city*sample and cooking method*sample interactions were significant (Tables 3 and 4, respectively). Again, the Beauregard and Colorado-INTA samples were influenced by city factors, the SP consumers had higher sensory acceptability for both samples. For the cooking method, the "baked" option had higher sensory acceptability for Beauregard and Colorado-INTA samples. In the Arapey and Morada-INTA samples, the cooking method and city did not influence the acceptability of the overall flavor.

Overall liking: In general, the samples presented good overall liking, with values between 6.8 and 8.4 on a scale of 1 to 10 points. The city*sample interactions were significant (Table 3). As observed in most of the descriptors that showed differences in this factor, Beauregard and Colorado-INTA had higher sensory acceptability for SP consumers than for 9DJ consumers.

Attribute adequacy and its relation to liking-Penalty analysis

Penalty analysis was used to gain an understanding of the descriptors (sweet flavor and hardness) that most affected liking ratings. Figure 1

displays the significant penalties (drops in overall liking) by proportion of consumers.

A sweet potato with attributes in the upper right-hand corner of the penalty plot is considered more penalty than one with attributes located in the lower left-hand corner. The "desired response" is attributes located in the lower left area of the penalty plot, meaning that only a few consumers say the attribute level is not right and the impact on overall liking is small. None of the samples evaluated were in this favorable situation. The opposite position, the upper right-hand corner, contains the attributes that a new reformulation would aim to change: those which are responsible for the largest drops in overall liking and which high percentages of consumers' rate as "not right."

The Arapey and Colorado-INTA samples were penalized for sweet and hardness attributes. In the case of sweet flavor, consumers thought that both samples were "too little sweet," with an associated drop in overall liking of around 1.89 and 1.97, respectively; and in the case of hardness that they were "too hard," with an associated drop in overall liking of around 1.18 and 1.32.

The Beauregard sample was also penalized for both attributes, but in this case, the penalty was due to the fact that consumers considered this cultivar "too little sweet," with an associated drop in overall liking of around 2.55. The hardness attribute was penalized for "Not Strong Enough," with an associated drop in overall liking of around 1.59.

The Morada-INTA sample was only penalized for "too little sweet," with an associated drop in overall liking of around 1.54. The texture of this sample was not responsible for the drop in acceptability.

Cluster analysis

Figure 2 shows subject clusters corresponding to sweet potatoes acceptability patterns. Three clusters were identified: Cluster 1 ($n = 85$), Cluster 2 ($n = 67$), and Cluster 3 ($n = 88$). Cluster 1 gave a medium acceptability to Colorado-INTA and Beauregard cultivars and a high acceptability to Arapey and Morado-INTA (average values 5.5 and 7.7 on a scale of 1 to 9). The opposite was observed in Cluster 2, where it was observed a medium-high acceptability to Arapey and Morado-INTA, and a high acceptability to Colorado-INTA and Beauregard (average values between 6.9 and 8.4). A high acceptability (average values greater than 8.2) was observed in all samples in Cluster 3.

Considering the number of subjects in each cluster according to the city, it was observed that this factor had an incidence on acceptability patterns. Cluster 1 ($n = 85$) was composed of 59 participants who lived in 9DJ, and 26 in SP; Cluster 2 ($n = 67$) was composed of 24 9DJ consumers and 43 SP consumers; and Cluster 3 ($n = 88$) wascomposed of 37 of 9DJ and 51 of SP consumers. Considering the number of subjects in each cluster according to the cooking method, it was observed that this factor had an incidence on acceptability patterns in Cluster 1 ($n = 85$) composed by the majority of the participants who used the boiled method.
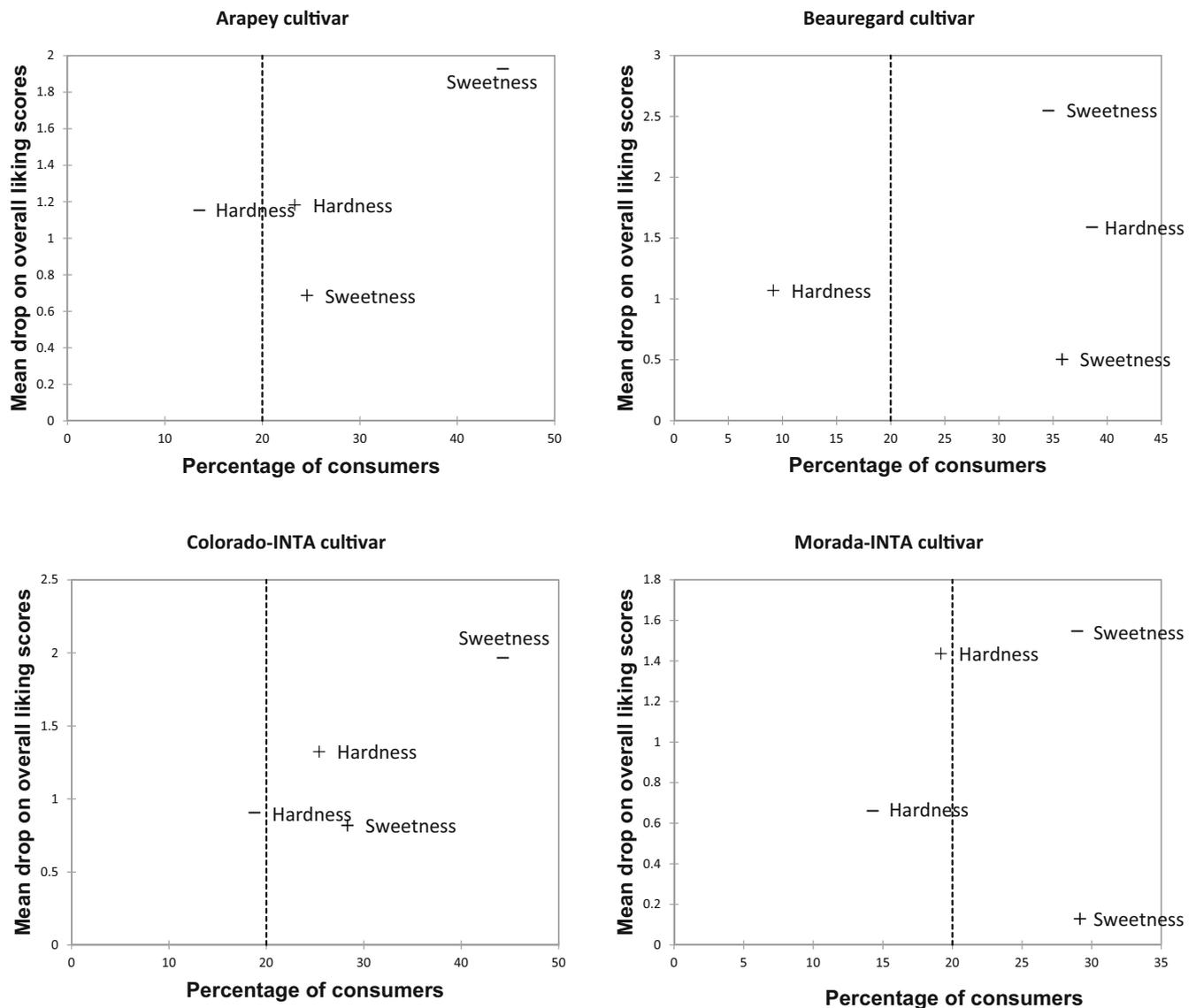
FIGURE 1 Penalty analysis for JAR sweet and hardness of the sweet potato samples and evaluated by all consumers. The cut-off point was 20% of consumers stating that an attribute was "not enough" (−) or "too much" (+). It is only above this point (>20% of consumers) that it is important to take the deviation into account. JAR, Just About Right.

Check all that apply

Figure 3 presents MFA maps for sensory descriptors in both cities, where dimensions 1 and 2 represented 44% and 27% of the variation of the experimental data, respectively. Acceptability for SP and 9DJ was associated with Beauregard and with Morada-INTA, respectively.

It was also observed that 9DJ consumers associated the Beauregard cultivar with the phrases: *It tastes weird* and *It has little flavor/tasteless* and to lesser extent to *The internal color is artificial* and *It breaks when cooking*. While SP consumers characterized the Arapey and Morada INTA samples as *It changes color (brown) quickly*, *Its shape is not regular* and *When cooked, it has threads or fibers*.

Colorado-INTA was related to *The size is too big, It has purple lines inside* and *My family does not like it*; and it was the cultivar that was further away from the acceptability of the two cities.

Figure 4 shows MFA map for non-sensory descriptors for 9DJ and SP consumers. Dimensions 1 and 2 represent 68% and 7% of the variation in the data, respectively. Acceptability for SP was associated with Beauregard and Colorado-INTA cultivars, and acceptability for 9DJ was associated with Arapey and Morada-INTA cultivars.

SP consumers characterized the samples Beauregard and Colorado-INTA were associated with *It is unhealthy, I do not always find this on the market* and *I do not find good quality*. On the other hand, 9DJ consumers associated the Arapey cultivar with *It is consumed all year round and It is ideal to consume in winter*; and Morada-INTA with *It is easy to prepare, It is expensive and I would use it to accompany different meals*.
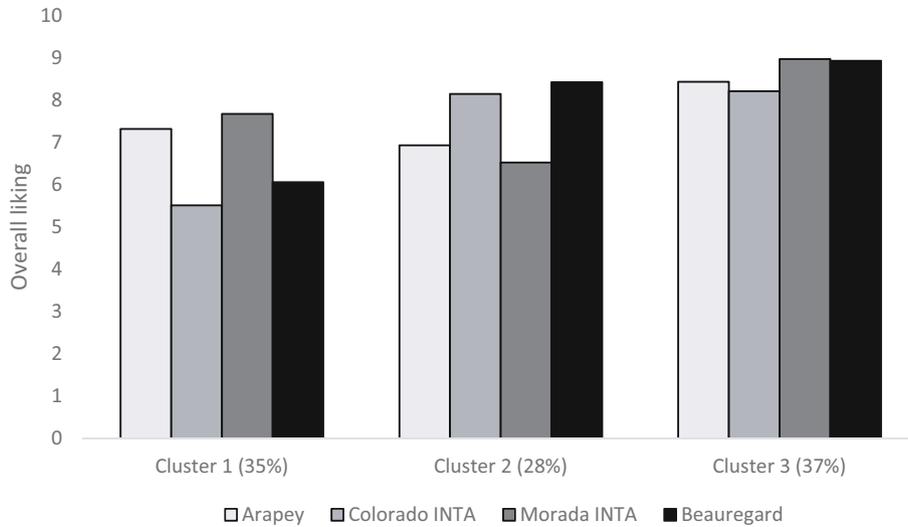
FIGURE 2 Cluster analysis-based acceptability patterns of sweet potatoes. The percentage of subjects in each cluster is shown in parenthesis.
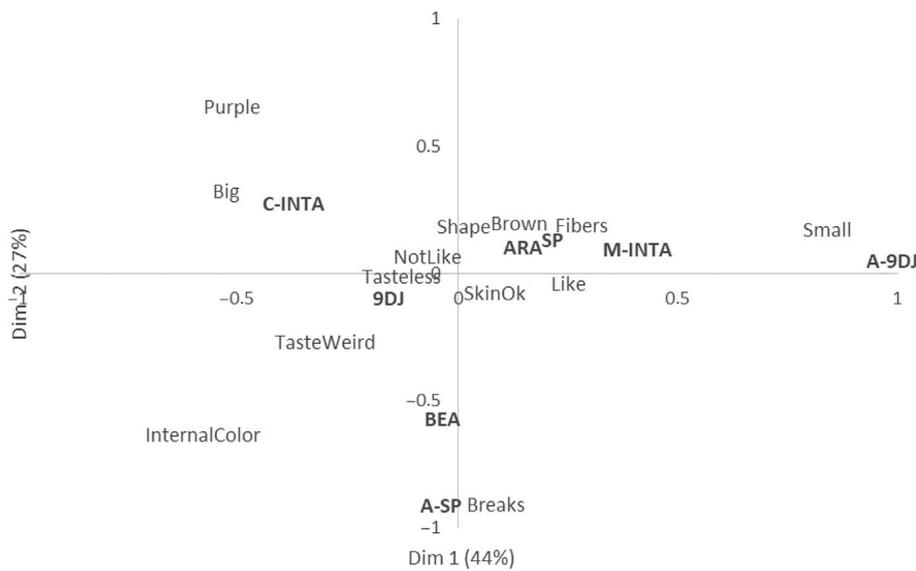

FIGURE 3 Biplot representation of the four samples and sensory phrases, considering overall liking scores for each city as supplementary variables. Reference: Acceptability for 9DJ consumers (A-9DJ), Acceptability for SP consumers (A-SP). Arapey (ARA), Beauregard (BEA), Colorada-INTA (C-INTA), Morada-INTA (M-INTA). The internal color is artificial (InternalColor), It has little flavor/tasteless (Tasteless), I like it (Like), It breaks when cooking (Breaks), The skin color is attractive (SkinOk), It has purple lines inside (Purple), Its shape is not regular (Shape), It tastes weird (TasteWeird), The size is too small (Small), My family does not like it (NotLike), It changes color (brown) quickly (Brown), The size is too big (Big), When cooked, it has threads or fibers (Fibers). INTA, Instituto Nacional de Tecnología Agropecuaria.

DISCUSSION

Of the two factors evaluated (city and cooking method), the city had a significant influence when evaluating the samples. In this study, in general, the highest acceptability of the Beauregard cultivar, with orange flesh, was given by consumers from SP; while Arapey and Morada INTA, both with yellow with orange lines, had greater acceptability for consumers from 9DJ. This could be due to the fact that the Beauregard cultivar was not as well-known on 9 de Julio as it was in San Pedro, which was an area that produces this crop and this cultivar. Food preference may vary among

individuals, age groups, gender, and sometimes culture as well as geographical locations.[25,26] Tomlins[14] interviewed 100 consumers about sweet potatoes' preferences, in three districts in Tanzania[26] in each of the two seasons (1998 and 2000) and location seemed to have an effect in 1 year only. Other cultivars varied in preference from year to year and with location.

A mixture of sensory attributes of the sweet potato root can impact consumer taste and overall acceptability. Before cooking, the overall appearance without peeling, and the difficulty to peel and cut were not influential characteristics when evaluating the samples, since only one of them presented differences with respect to the rest. The Beauregard
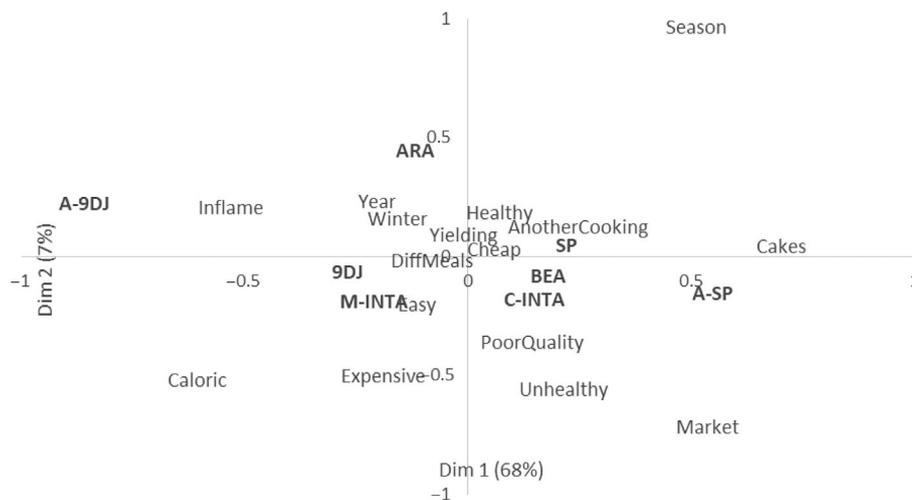
FIGURE 4 Biplot representation of the four samples and non-sensory phrases, considering overall liking scores for each city as supplementary variables. Reference: Acceptability for 9DJ consumers (A-9DJ), Acceptability for SP consumers (A-SP). Arapey (ARA), Beauregard (BEA), Colorada-INTA (C-INTA), Morada-INTA (M-INTA). I would use it to accompany different meals (DiffMeals), It is cheap (Cheap), It is healthy (Healthy), It is easy to prepare (Easy), It is yielding (Yielding), It is consumed all year round (Year), I do not find good quality (PoorQuality), I do not always find this on the market (Market), It is ideal to consume in winter (Winter), I consume it only in season (Season), I would use it for another type of cooking, not the one I used (AnotherCooking), It is expensive (Expensive), I would use it to cook sweets/cakes (Cakes), It makes me feel bad: inflamed (Inflame), It is caloric: this makes me gain weight (Caloric), It is unhealthy (Unhealthy). INTA, Instituto Nacional de Tecnología Agropecuaria.

cultivar had higher appearance values given only by consumers from SP; and in turn, it was the least difficult to peel and cut between the samples, which would be related to its wet texture.[4] But in the two last attributes, the city was not an influencing factor. Leighton[13] compared the instrumental texture between boiled orange-fleshed sweet potatoes (including the Beauregard cultivar) and white-fleshed sweet potatoes and they showed that there were no significant differences in the shear force measurement of the different sweet potato cultivars.

Beauregard also had high acceptability in appearance after cooking and flavor in SP, but this did not occur in 9DJ. The characteristic color of Beauregard pulp was due to its high concentration of beta-carotene, which is the precursor of vitamin A and a powerful antioxidant.[10]

As occurred in appearance, 9DJ consumers had lower acceptability in overall flavor for the Beauregard cultivar; in accordance with this, in the CATA question, characterized this cultivar with negative phrases, such as follows: *It tastes weird* and *It has little flavor/tasteless.* Nwosisi[27] found that Beauregard and two other cultivars were consistently among the least preferred for all sensory descriptors.

The taste acceptability of Colorado INTA was similar to that of Beauregard in SP. This could be due to the fact that it was also an orange-fleshed variety, presenting certain characteristics similar to them.[4] Sugri[25] suggested that pulp color after cooking was one of the most critical descriptors influencing consumer preference. Leksrisompong[28] tested orange, purple, and yellow-fleshed sweet potato cultivars and indicated that consumers preferred orange-fleshed roots.

In general, the attribute related to the low acceptability of the four cultivars studied was sweet flavor, with nearly 30% of consumers finding it "too little." Similar results were found by Lado,[29] where "not sweet" was, among other attributes, the most relevant attribute that decreased overall liking score in sweet potato samples. This is in line

with Mwanga,[26] who found that penalty analysis of consumer data showed that sweetness was a key driver of overall liking.

As for the mouth texture, only hardness was evaluated and had a lower influence on consumers overall liking than sweetness, where Beauregard was considered not very hard, and Colorado INTA and Arapey were considered very hard. Similar results were found by Mwanga,[26] that hardness influenced overall acceptability. Some studies found that texture, or mouthfeel, was a major attribute in deciding overall consumer acceptance of sweet potato cultivars. Nwosisi[27] observed that the textures of white-fleshed cultivars were among the least liked; the purple-fleshed and orange-fleshed cultivars received the most favorable panelist preference. Sugri[25] found sensory descriptors of the most preferred cultivars to be a starchy–soft texture. Tomlins[4] identified important sensory descriptors influencing acceptability as starch and stickiness, stating that consumers preferred starchy but not sticky.

The other factor that was taken into account in this work, the cooking method, influenced by only two descriptors, in which baked was more acceptable considering appearance and overall flavor. Sugri[25] found that the methods of cooking influenced product quality as well as consumer judgment. The boiled method showed minimal masking of sensory qualities. There were significant differences among cultivars for flavor, color, and texture when samples were boiled. Differences were noticed in only taste and color when fried. Badiane[30] also found differences between cooking methods. They evaluated orange-fleshed sweet potato fried and boiled and found that samples boiled had lower acceptability.

Cost and health benefits were not important factors for consumers in the two cities. Only 9DJ participants labeled Morada INTA as *Expensive,* and related to a lesser extent to negative

phrases such as *It makes me feel bad: inflamed* and *It is caloric: this makes me gain weight*. Henderson[31] observed that price was positively viewed by participants and people know intrinsically that sweet potato consumption provides health benefits. However, the knowledge that most participants had was patchy and uncertain. Differently from CATA results, women were consciously cooking with low or no fat, and sweet potato was well placed in the weight loss repertoire of food.

CONCLUSION

The four cultivars scored differently for appearance, flavor, and texture, so consumer preferences provide opportunities for the development or improvement of new cultivars with known properties for future production.

The type of cooking was not a significant factor, so cultivars could not be recommended for baking or boiling, as the results showed that the interaction of the two factors influenced the acceptability of only two attributes. The city factor was the most influential in the sensory acceptability of the samples. It would be interesting to extend this study to other regions and/or countries.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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REFERENCES

1. Zamudio N, Borioni RHE, Leiva N, Cusumano CO. Selección participativa de variedades de batata (*Ipomoea batatas* L. Lam) con agricultores minifundistas del sur de Tucumán. Rev Agron Noroeste Arg. 2014;34(2):175–6.
2. Fuentes S, Chujoy E. Sweetpotato in South America. In: Loebenstein G, Thottappilly G, editors. The Sweetpotato. Dordrecht: Springer; 2009. p. 415–40.
3. FAOSTAT. Statistics division of food and agriculture Organization of the United Nations, (2022). Available from: http://www.faostat.fao.org/ [Feb 2022].
4. Martí R. Producción de batata. Ediciones INTA (1er Ed.). 2018. Available from: https://www.researchgate.net/profile/Hector_Marti/publication/335501356_Produccion_de_Batata/links/5d6929cf92851c85387eed2c/Produccion-de-Batata.pdf [Feb 2022].
5. Kurata R, Sun HN, Oki T, Okuno S, Ishiguro K, Sugawara T. Sweet potato polyphenols. In: Mu TH, Singh J, editors. Sweet potato: chemistry, processing and nutrition. Amsterdam: Academic Press; 2019. pp. 177–222.
6. Wang S, Nie S, Zhu F. Chemical constituents and health effects of sweet potato. Food Res Int. 2016;89:90–116.
7. Pazos J, Zema P, Corbino GB, Gabilondo J, Borioni R, Malec LS. Growing location and root maturity impact on the phenolic compounds, antioxidant activity and nutritional profile of different sweet potato genotypes. Food Chem: Mol Sci. 2022;5:1–8.
8. Laurie SM, Faber M, Calitz FJ, Moelich EI, Mullerd N, Labuschagnee MT. The use of sensory attributes, sugar content, instrumental data and consumer acceptability in selection of sweet potato varieties. J Sci Food Agric. 2013;93:1610–9.
9. Zaccari F, Galietta G, Soto B, Las R. Color y contenido de β-carotenos en boniatos, crudos y cocidos, durante su almacenamiento en Uruguay. Agrocienc Urug. 2012;16(1):24–32.
10. Gabilondo J, Corbino G, Chludil H, Malec L. Bioactive compounds of two orange-fleshed sweet potato cultivars (*Ipomoea batatas* (L.) Lam.) in fresh, stored and processed roots. Appl Food Res. 2022;2:1–9.
11. Vicente E, Ares G, Rodríguez G, Varela P, Bologna F, Lado J. Selection of promising sweet potato clones using projective mapping. J Sci Food Agric. 2017;97(1):158–64. https://doi.org/10.1002/jsfa.7704
12. Barkley SL, Schultheis JR, Chaudhari S, Johanningsmeier SD, Jennings KM, Truong VD. Yield and consumer acceptability of 'Evangeline' Sweetpotato for production in North Carolina. Horttechnology. 2017;27(2):281–90.
13. Leighton CS, Schoenfeldt HC, Kruger R. Quantitative descriptive sensory analysis of five different cultivars of sweetpotato to determine sensory and textural profiles. J Sens Stud. 2010;25:2–18.
14. Tomlins K, Rwiza E, Nyango A, Amour R, Ngendello T, Kapinga R, et al. The use of sensory evaluation and consumer preference for the selection of sweet potato cultivars in East Africa. J Sci Food Agric. 2004;84:791–9.
15. Machado Soares J, de Oliveira AF, da Silva EC, Loubet Filho PS, Vilela de Resende JT, Schiessel DL, et al. Sensory, chemical and nutritional characterization of sweet potatoes submitted to cooking process in water inmersion. Int J Dev Res. 2017;07(12):17578–84.
16. Brigatto Fontes LC, Oliveira FG, Queiros C. Optimizationof the deepfat frying procees of sweetpotato chips in palm olein or stearin. Am J Food Technol. 2011;6:348–61.
17. Vitrac O, Trystram G, Raoult-Wack AL. Deep-fat frying of food: heat and mass transfer, transformations and reactions inside the frying material. Eur J Lipid Sci Technol. 2000;102(8–9):529–38.
18. Hough G. Sensory shelf-life estimation of food products. 1st ed. Boca Raton, FL: CRC Press; 2010. p. 264.
19. Cardinal P, Zamora MC, Chambers E, Carbonell Barrachina A, Hough G. Convenience sampling for acceptability and CATA measurements may provide inaccurate results: a case study with fruit-flavored powdered beverages tested in Argentina, Spain and U.S.A. J Sens Stud. 2015;30(4):1–10.
20. Xiong R, Meullenet JFA. PLS dummy variable approach to assess the impact of jar attributes on liking. Food Qual Pref. 2006;17(3–4):188–98.
21. Rothman L. The use of just-about-right (JAR) scales in food product development and reformulation. In: Macfie H, editor. Consumer-led food product development. UK: Elsevier; 2007. p. 407–33.
22. McEwan J. Cluster analysis and preference mapping. Review No. 12. Project No. 29742. Chipping Campden, UK: Campden & Chorleywood. Food Research Association; 1998.
23. Bécue-Bertaut M, Álvarez-Esteban R, Pagèsc J. Rating of products through scores and free-text assertions: comparing and combining both. Food Qual Pref. 2008;19:122–34.
24. Bécue-Bertaut M, Pagès J. Multiple factor analysis and clustering of a mixture of quantitative, categorical and frequency data. Comput Stat Data Anal. 2008;52(6):3255–68.
25. Sugri I, Nutsugah SK, Wiredu AN, Johnson PNT, Aduguba D. Kendall's concordance analysis of sensory descriptors influencing consumer preference for sweet potatoes in Ghana. Am J Food Technol. 2012;7:3142–50.
26. Mwanga ROM, Mayanja S, Swanckaert J, Nakitto M, zum Felde T, Grüneberg W, et al. Development of a food product profile for boiled and steamed sweetpotato in Uganda for effective breeding. Int J Food Sci. 2020;56:1385–98.

27. Nwosisi S, Nandwani D, Hui D, Ravi R. Sensory evaluation of organic sweet potato cultivars. Int J Veg Sci. 2017;23:536–51.

28. Leksrisompong PP, Whitson ME, Truongi VD, Drake MA. Sensory attributes and consumer acceptance of sweetpotato cultivars with varying flesh color. J Sens Stud. 2012;27:59–69.

29. Lado J, Vicente E, Moltini AI, Alcaire F, Ares G. Integrating consumer perception in the selection of purple skin sweetpotato cultivars. J Sci Food Agric. 2020;101(9):3620–9.

30. Badiane A, Sylla PMDD, Diouf A, Tall L, Mbaye MS, Cisse NS, et al. Sensory evaluation and consumer acceptability of orange fleshed sweet potato by lactating women and children <2 years old in Kaffrine, entral groundnut basin of Sénégal. Afr J Food Sci. 2018;12(11): 288–96.

31. Henderson C, Gething K, McIntyre A, Dennien S. Sweetpotato consumer research: insights to increasing consumption. Brisbane: Queensland Government; 2012. p. 34.