Use of Multivariate Analysis Methods in the Sensory Evaluation of Sweet Potato Chips

ABSTRACT

Aims: To determine the acceptance of sweet potato chips through the application of multivariate analysis methods.
Study design: Sweet potato chips were subjected to sensory analysis.
Place and Duration of Study: Study was carried out at Laboratory of Agriculture of the State Technical School Arlindo Ferreira dos Santos, Sertânia-PE, Brazil, During the pedagogic show held on November 23rd and 24th, 2017.
Methodology: The sweet potato was minimally processed with the aid of a multiprocessor of food (Metvisa) to obtain the chips. Sensory analysis was performed according to the hedonic scale of nine points: 9 = as extremely and 1 = not extremely like. The tasters attributed notes to the appearance of the attributes, aroma, flavor and color.
Results: Factorial analysis made it possible to reduce the variables for two common factors, being factor 1, the factor containing the highest original information (88.05% of the original variation was explained by this factor). Subsequently, the cluster analysis allowed the formation of three groups of tasters presenting different characteristics.
Conclusion: These results demonstrate that the use of multivariate analysis methods becomes important in the verification of the acceptance of new products to be submitted to the evaluation by the consumer, taking into account the differences presented in this evaluation, aiming at the commercialization of these products.

Keywords: Ipomoea batatas;*organoleptic characteristics*;*acceptance*;*factor analysis*; *cluster analysis.*

1. INTRODUCTION

Sweet potato (*Ipomoea batatas*) is a tuberous root from Central and South America that has a high carbohydrate content providing energy for daily activities. In addition, it has a low glycemic index helping to control glucose [1]. In regions of tropical climate it presents high productivity, with high temperatures throughout the year, is cultivated in soils of low fertility due to being a plant little demanding nutritionally. Its production is usually linked to family farming [2].

In Brazil sweet potatoes are highly appreciated by the population, being the fourth most consumed vegetable in the country [3]. However, its commercialization is made mostly by middlemen, which results in a lower profitability on the part of the producers of this crop,

decreasing year after year their production areas.The sweet potato crop, as well as other tuberous roots, is usually marketed in open-air fairs in the natural form, demonstrating the possibility of growth, with respect to their commercialization.

According to Rogério and Leonel [4], it is necessary to carry out researches that show marketing alternatives, aiming at a greater investment in the production sector, as well as the insertion of tuberoses with raw materials in agroindustry. As well as other tuberous roots, sweet potato presents a marked deterioration post-harvest, becoming unfit for consumption in a few days, so its period of consumption becomes short, presenting portability and it is necessary to prolong its shelf life, applying different conservation methods, such as dehydration [5, 6].

The use of sweet potatoes in human food provides the consumer with a source for the supply of calories, minerals and vitamins.Carbohydrates are found in carbohydrates between 25% and 30%, of which 98% are easily digested. In addition, they present in their nutritional composition B vitamins, carotenoids, iron, potassium and calcium minerals [7].The development and production of by-products using sweet potato as raw material in agroindustry can contribute to increase consumption of this tuberous root in different consumer market niches. According to Araújo et al. [8], the production of new products becomes important in the diversification of products offered in the market and with greater possibility of acceptance by the consumer. These innovations enable the food industry to serve different target audiences, where each consumer has their own preferences.

With the diversification of products with sweet potato as the main raw material, the producer of this root gains an alternative as regards the value added to its product, instead of marketing the roots *in natura* form, often with low value, one can produce products of a greater value added, increasing the income of the producer. However, products often lack information on what products they can produce within their property, as well as on the agroindustry yield of sweet potatoes and the acceptance of by-products by the consumer.

Hence, a greater investment by the producer in the processing of the roots in the property itself.

Acceptance analysis may indicate a choice for a particular product. However, when the acceptance analysis is performed using univariate statistics, it is assumed that the acceptability by the consumers is homogeneous, indicating that the values obtained from this estimate may not represent the real mean [9].

In this case, individual variability must be taken into account. The evaluation of this variability to be evaluated with multivariatestatistical methods.Such analyzes allow graphical representation of the evaluated criteria, allowing the data to be presented as points and consumers as the main criterion of preference, as vectors [9].

Thus, the use of multivariate statistical methods can help the acceptance analysis of food products, elucidating the preferences of the tasters, making it possible to obtain more consistent information on the acceptance of a particular product.

Therefore, the aimof the study was to evaluate the acceptance of sweet potato chips by adolescents, applying multivariate analysis methods.

2. MATERIAL AND METHODS

2.1Study location

The study was developed in the agricultural laboratory of the State Technical School Arlindo Ferreira dos Santos, Sertânia - PE, Brazil.

2.2 Plant Material and Minimum Processing

Sweet potatowas purchased from a vegetable house in the city of Sertânia, state of Pernambuco, Brazil. Soon after, the vegetal material was transported to the agricultural laboratory, undergoing a selection process and washed with running water with the aid of a brush.After this step were conditioned in a refrigerator at a temperature of 5 ± 2 º C, thus delaying its physiological deterioration.

Minor processing of the sweet potato was performed to obtain the chips. First, the potatoes were peeled, washed in running water, then cut with a food multiprocessor (Metvisa) to obtain the chips.After the chips were obtained the sanitization in water at 5 ± 2 º C (containing 10 mg L^{-1} of active chlorine) was carried out for 10 minutes; immersion in chlorine (containing 5 mg L^{-1} active chlorine) for 5 minutes, then drain was performed to remove excess water from the product.

After the draining process the chips were stored refrigerated at a temperature of 5 ± 2 ° C until the time of the frying. Subsequently, the chips were fried with the help of soybean oil. Then, the chips were served to the tasters to perform the sensorial analysis of the product.

2.3Sensory analysis of sweet potato chips

Sensory analysis was performed with 108 untrained testers (54 men and 54 women) aged 16 to 18 years, public school students.

The score sheets were randomly numbered in three digits. Acceptance test, was carried out with the aid of a hedonic scale containing nine points, liked extremely (9); liked much (8); liked moderately (7); liked slightly (6); neither liked / nor disliked (5); disliked slightly (4); disliked moderately(3); disliked much (2); disliked extremely (1) [10].

Notes were awarded for the attributes global impression, aroma, flavor and color. Samples of sweet potato chips were standardized and served to the testers who performed the test in individual booths so that they would not have contact with other tasters.

2.4Statistical analysis

The data were subjected to normality and homoscedasticity tests, analysis of variance (ANOVA), and Tukey`s test at 5% of significance. Two multivariate techniques were used: factorial analysis and cluster analysis. The analyzes were performed with the statistical program, SAS 9.4.

3. RESULTS AND DISCUSSION

3.1 Sensory Analysis

The results obtained in the sensorial analysis showed that the tasters had a good acceptance of the sweet potato chips, regardless of the sex of the tasters [11]. The only organoleptic characteristic that presented significant difference at the 5% probability level was the color attribute (Table 1).

The results corroborate Araujo et al. [8], who performed a sensory analysis of fried sweet potato in the chip and toothpick formats, obtained significant differences between the average scores attributed by the tasters in the color sensory attribute.

This significant difference in the scores attributed by the tasters with respect to color may be related to the time of frying of the chips, in view that this may influence the color of the product and indirectly influence the assigned scores.

Table 1: Sensory analysis of sweet potato chips.

Tasters	Attributes evaluated			
	Appearance	Aroma	Flavor	Color
Men	8.19 ± 1.12 a	8.00 ± 0.00 a	8.11 ± 1.19 a	7,70 ± 1.41 b
Women	8.49 ± 0.88 a	8.04 ± 1.21 a	8.33 ± 0.95 a	8,18 ± 1.03 a

Data are means ± standard deviation. Means ± S.D with the same letter in the column are not significantly different by Tukey test ($p < .05$). Sensory analysis is based on nine-point hedonic scale ratings: 9 = like extremely and 1= dislike extremely.

Different studies show that food products containing sweet potato as an ingredient, have in their sensory analyzes good acceptance by the tasters, such products as, puree [12], bread [13], chips [14], ice cream [15], among others.

3.2 Factor Analysis

To verify the factorial analysis, the eigenvalues and the percentage of variance explained by each factor were obtained, as shown in Table (2).

Table 2: Eigenvalues and variation explained.

Factor	Eigenvalue	Accumulated eigenvalue	% Variance Explained	% Variance Explained Accumulated
1	1.94	1.94	48.49	48.49
2	0.90	2.84	22.56	71.05
3	0.68	3.52	17.00	88.05
4	0.48	4.00	11.95	100.00

Figure (1A) shows the matching graph for previous loads. It was observed that it was not possible to clearly elucidate which factor the flavor attribute (B) belonged to, requiring the use of rotation by the Varimax method.After the rotation of Varimax, it was verified that the attribute aroma (B) composes the factor 2 and the other attributes composes the factor 1 (Figure 1 B).

3.3 Cluster Analysis

With the obtained scores, a clustering analysis was performed by Ward's minimum variance method (Figure 2).After grouping analysis, three different groups formed by tasters with similar characteristics, regarding the assignment of notes to the sensory attributes evaluated in the study.

Group 1 is made up of 65 tasters (30 men and 35 women), corresponding to 60.19% of the total sample participants in the study. Group 2 consists of 14 tasters (4 men and 10 women), representing 12.96% of the total sample participants in the study.Group 3 is formed by 29 tasters (17 men and 12 women), corresponding to 26.85% of the total number of tasters in the study.

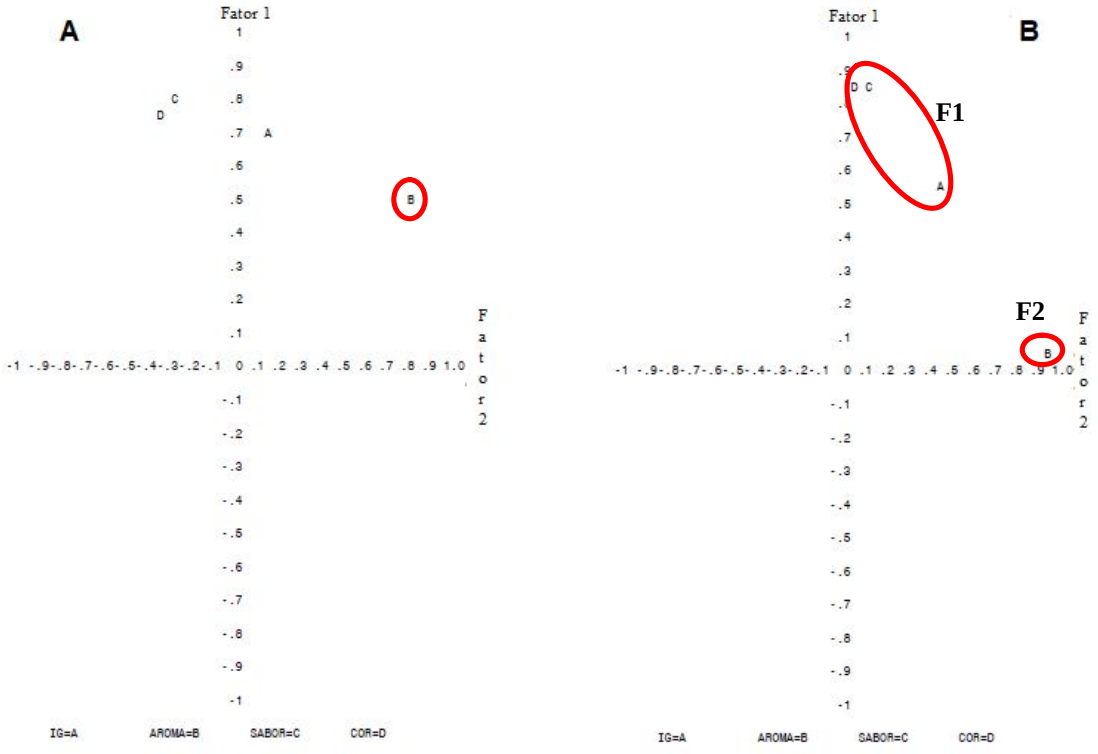

Figure 1: graph of factor 1 x factor 2 not rotated (A) and graph factor 1 x factor rotated using the Varimax method in relation to the attributes evaluated in the sensory analysis (Appearance = A, Aroma = B, Flavor = C and Color = D).

Based on the groups obtained through cluster analysis, where their means and standard deviation of the attributes in studies are demonstrated in Table (3), it is possible to identify the striking characteristics of each identified group.It is observed that group 1 presents a characteristic of homogeneity in the scores attributed by the tasters that compose this group. In group 2, the characteristics that most attracted the attention of the tasters was flavor and color, obtaining a higher mean and lower standard deviations (Table3).

Table3: Mean and standard deviation of each attribute under study for each of the identified groups.

Attributes	Group 1	Group 2	Group 3
Appearance	8.78 ± 0.41	7.17 ± 1.29	7.90 ± 1.18
Aroma	8.26 ± 0.54	6.64 ± 1.28	8.13 ± 0.52
Flavor	8.77 ± 0.46	8.12 ± 1.22	7.00 ± 1.07
Color	8.49 ± 0.69	8.14 ± 0.86	6.62 ± 0.86

Data are means ± standard deviation of the different groups obtained after cluster analysis.

Group 3, on the other hand, had lower mean values than groups 1 and 2 (table 3). The Analysis of grouping allowed to identify the different preferences by the tasters in the different groups, even if these tasters had the same age group, their preferences can be presented in different ways, the applied methodology was able to group testers homogeneously independent of the sex of these tasters.

The use of multivariate analysis methods is aided in elucidating the main characteristics taken into consideration by consumers in the choice of different products offered by the food and beverage industry.

This has been verified in the acceptance evaluation of spirits [9], potato straw [16], as well as in sweet potato mineral composition [17,18], okra [19], breadfruit [20], changes in this composition can promote changes in the organoleptic characteristics and thus influence the consumer in their choices.

4. CONCLUSION

Factor analysis made it possible to reduce the variables for two common factors, by factor 1 being the factor with the highest original information (88.05% of the original variation was explained by this factor).

The cluster analysis proved to be a powerful tool used in this study, considering the ANOVA result that did not present significant differences in most of the organoleptic characteristics studied, regardless of the gender of the tasters.Through the formation of three homogeneous groups among the 108 testers participating in this study, it was possible to identify which organoleptic characteristics were more important for the group of tasters in relation to their acceptance of sweet potato chips.

These results demonstrate that the use of multivariate analysis methods becomes important in the verification of the acceptance of new products to be submitted for evaluation by the consumer, taking into account the differences presented in this evaluation, aiming at the commercialization of these products.

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