CONSUMER SENSORY CHARACTERIZATION OF PURPLE MAIZE EXTRUDED CEREALS USING THE *Check-All-That-Apply* (CATA) METHODOLOGY

Rebeca SALVADOR-REYES[1*]; Ulliana SAMPAIO[1]; Aline BRITO[1]; Thaísa MORO[1]; Maria T. P. S. CLERICI[2]; Jorge BEHRENS[3]

[1] Postgraduate student, Department of Food Technology, University of Campinas.
[2] Professor, Department of Food Technology, University of Campinas.
[3] Professor, Department of Food and Nutrition, University of Campinas.
*E-mail for correspondence: salvadorreyesrebeca@gmail.com

ABSTRACT: Andean purple maize (APM) contains fibers and natural pigments which could improve the quality of extruded products. *Check-all-that-apply* (CATA) questions are a simple alternative to gather information about consumers' perception of the sensory characteristics in the development of new products. This study aimed to evaluate the sensory characteristics of breakfast cereals formulated with APM whole-flour. The extruded products were developed with 25, 50, 75, and 100% of APM, complemented with commercial yellow corn, and without the addition of flavor or dying agents. These four samples were evaluated by 117 consumers through an acceptability test (nine-point hedonic scale) followed by CATA questions (35 descriptive terms), and a market research questionnaire. The results showed that most scores were above 6 to the overall liking, color, aroma, and texture liking, indicating that the products were liked slightly. Penalty-lift analysis of the CATA terms demonstrated that the most important drivers of liking were "attractive", "crunchy", "purple", "naturally colored" and "innovative color", while "hard" and "brown" had a negative effect. The market research revealed that consumers would like the final products to be commercialized with honey & nuts, and they would pay up to 30% more for them.

Keywords: clean-label, natural dying, pigmented cereal, sustainability, anthocyanins.

INTRODUCTION

Andean Purple maize (APM) is a native crop commonly used to give color, flavor, and texture to traditional Peruvian drinks and desserts (SALVADOR-REYES e CLERICI, 2020). According to the literature, APM is rich in bioactive compounds such as anthocyanins, phenolic acids, and flavonoids, which have health benefits (LAO e colab., 2017). The APM extract has been used as a colorant in products such as beverages, jams, and yogurts, (ORTEGA, 2017; PÉREZ, 2014). However, few studies have focused on its use as a whole grain.

In the food industry, maize is the most used cereal to produce breakfast cereals. However, most of them contain excessive amounts of sugar, artificial dying, and flavors, and due to the use of corn gritz, they have a low fiber content (PERDON e HOLOPAINEN-MANTILA, 2020). The addition of fruits (CAMIRE e colab., 2002) and the use of pigmented cereals (MEZA e colab., 2019)

in the formulation of extruded cereals is an alternative that avoids the use of artificial additives, however, it can lead to alterations in their sensory attributes (ALAM e colab., 2016).

Information about the product sensory characteristics is essential for the success of its development. The *check all-that-apply* (CATA) is rapid and reliable to determine the sensory attributes of food products (JAEGER e colab., 2015). In this sense, this study aimed to evaluate the sensory characteristics of breakfast cereals, formulated with APM, using a CATA test.

MATERIALS AND METHODS

Four formulations were prepared with 25, 50, 75, and 100% APM whole flour, complemented with commercial yellow corn gritz. Approved by the Ethics Committee of the University of Campinas (CAAE-86901818.1.0000.5404), the sensory test was performed by 117 consumers. Each one received four samples in a sequential monadic series in a single session, following a balanced complete block experimental design. The samples were presented in plastic glasses coded with three-digit random numbers, and the consumers could choose to taste the cereal with or without whole milk.

The sensory evaluation was divided into three stages: first, it was performed an acceptability test using a nine-point hedonic scale (9 = like extremely and 1 = dislike extremely); then, in the CATA test, consumers linked each sample with a list of 35 attributes (obtained by focus group with 14 panelist) divided into five groups (appearance, color, aroma, flavor, texture, and mouthfeel); and finally, it was applied a market questionnaire to evaluate consumers' expectations and desires for a product elaborated with APM.

RESULTS AND DISCUSSION

The extruded products received similar scores in aroma, flavor, and texture in the acceptability test (Table 1), however, differences were observed in the overall linking and color where APM25 obtained the lowest scores.

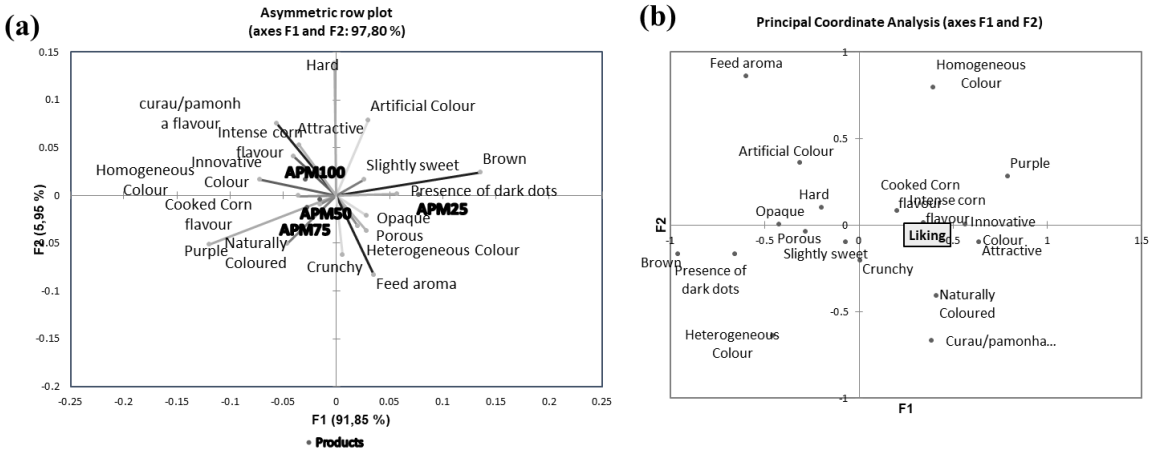
Table 1 - Average acceptance scores for the overall linking, color, aroma, flavor, and texture likings of extruded products with purple maize

	APM25	APM50	APM75	APM100
Overall liking	5.39 ± 1.77^{b}	6.15 ± 1.59^{a}	6.21 ± 1.58^{a}	5.86 ± 1.66^{ab}
Color linking	4.75 ± 2.12^{b}	6.60 ± 1.72^{a}	6.85 ± 1.68^{a}	6.72 ± 1.83^{a}
Aroma linking	$5.18\pm1.23^{n.s.}$	$5.49\pm1.18^{n.s.}$	$5.47\pm1.22^{n.s.}$	$5.47\pm1.19^{n.s.}$
Flavor liking	$5.61\pm1.76^{n.s.}$	$5.88\pm1.67^{n.s.}$	$5.74\pm1.79^{n.s.}$	$5.77\pm1.69^{n.s.}$
Texture liking	$6.21\pm1.70^{n.s.}$	$6.43\pm1.81^{n.s.}$	$6.62\pm1.78^{n.s.}$	$6.20\pm2.01^{n.s.}$

Samples are extruded products with 25 (APM25), 50 (APM50), 75 (AM75), and 100% (APM100) of Andean Purple maize whole flour. Values within a row with different letters are significantly different through Tukey's test ($p < 0.05$).

Regarding the CATA test results, from the 35 attributes evaluated, only 18 were considered significative to differentiate the samples by Cochran-Q analysis ($p \leq 0.10$). In general, the extruded products were most frequently described as *dry*, *porous*, *opaque*, *with no aroma*, *presence of light dots*, *crunchy* and *sticky on the teeth*, with a frequency of more than 60% for all of them. Amid these, *the presence of light dots*, *with no aroma* and *sticky on the teeth* showed no significant differences among the samples, being equally used to describe them. The color term *brown* was strongly associated with extruded product APM25, with a frequency of about 74%, while the other samples were associated with *purple*, *innovative color* and *naturally colored*.

Figure 2- (a) Correspondence analysis and (b) Principal Coordinate Analysis obtained from the CATA test for the breakfast cereals formulated with 25, 50, 75 and 100% of Andean Purple maize



In the correspondence analysis (Figure 1a), it was observed discrimination between APM25 from the other samples, in the first dimension (F1: 91.85%). The discrimination was based on products associated with the terms *brown*, *presence of dark dots*, *opaque*, *porous*, *slightly sweet*, *heterogeneous color*, *artificial color* and *feed aroma* (APM25) and products associated with the terms *innovative color*, *homogeneous color*, *intense corn taste*, *purple*, *naturally colored*, *curau/pamonha flavor*, *attractive* (APM75 and APM100), which can be considered positive terms, once these terms are associated to *liking* in the Principal Coordinate Analysis (Figure 1b). This was backed by the penalty-lift analysis, which shows that the most important drivers of *liking* were *attractive*, *crunchy*, *purple*, *naturally colored*, and *innovative color*, so it is possible to say that these are "must-haves" in the development of this new breakfast cereal, while attributes as *hard* and *brown* which have a negative effect on liking, decreasing about 0.63 and 0.80 points in the average acceptance of products, should be avoided.

In marketing research, 90% of consumers expressed liking a product formulated with APM. Likewise, 44.4% and 38%of them suggested that for the final version of the product it should be added of nuts and honey, respectively, to maintain the healthy characteristics.

CONCLUSION

The application of acceptability tests followed by CATA questions allowed a better understanding of the consumers' perception of the sensory characteristics of a new product, associated with health and clean label claims. The formulation of breakfast cereal with 50 to 75% APM whole flour, allows us to obtain a product with acceptable characteristics of color, flavor, and texture according to the preferences of the consumers.

REFERENCES

ALAM, M. S. e colab. **Extrusion and Extruded Products: Changes in Quality Attributes as Affected by Extrusion Process Parameters: A Review**. Critical Reviews in Food Science and Nutrition, v. 56, n. 3, p. 445–473, 2016. https://doi.org/10.1080/10408398.2013.779568

CAMIRE, M.E. e colab. **Blueberry and Grape Anthocyanins as Breakfast Cereal Colorants**. Journal of Food Science, v. 67, n. 1, p. 438–441, 2002. https://doi.org/10.1111/j.1365-2621.2002.tb11425.x

JAEGER, Sara R e colab. **Check-all-that-apply (CATA) questions for sensory product characterization by consumers: Investigations into the number of terms used in CATA questions**. Food Quality and Preference, v. 42, p. 154-164, 2015. https://doi.org/10.1016/j.foodqual.2015.02.003

LAO, Fei e SIGURDSON, Gregory T. e GIUSTI, M. Mónica. **Health Benefits of Purple Corn (Zea mays L.) Phenolic Compounds**. Comprehensive Reviews in Food Science and Food Safety, v. 16, n. 2, p. 234–246, 2017. https://dx.doi.org/10.1089%2Fjmf.2010.0342

MEZA, Silvia Leticia Rivero e colab. **Production of innovative gluten-free breakfast cereals based on red and black rice by extrusion processing technology**. Journal of Food Science and Technology, v. 56, n. 11, p. 4855–4866, 2019. https://doi.org/10.1007/s13197-019-03951-y

ORTEGA TONELLO, Cindy Adriana. **ESCUELA DE GASTRONOMÍA APLICACIÓN GASTRONOMICA DEL MAIZ MORADO**. [S.l.]: Quito: Universidad de las Américas, 2017, 2017. Disponível em: <http://dspace.udla.edu.ec/handle/33000/7057>. Acesso em: 5 set 2020.

PERDON, Alicia A. e HOLOPAINEN-MANTILA, Ulla. Cereal grains and other ingredients. Breakfast cereals and how they are made. [S.l.]: Elsevier, 2020. p. 73–96. Acesso em: 5 set 2020.

PÉREZ SAUÑI, Hugo Fernando. **Utilización de la antocianina del maíz morado (Zea mays L.) y stevia (Stevia rebaudiana bertoni) en la elaboración de un producto tipo mermelada y su aceptabilidad**. Repositorio de Tesis - UNMSM, 2014. Disponível em: <http://cybertesis.unmsm.edu.pe/handle/20.500.12672/3857#.X1Vs-EAX8Fw.mendeley>. Acesso em: 5 set 2020.

SALVADOR-REYES, Rebeca e CLERICI, Maria Teresa Pedrosa Silva. **Peruvian Andean maize: General characteristics, nutritional properties, bioactive compounds, and culinary uses**. Food Research International, v. 130, p. 1089, 2019. https://doi.org/10.1016/j.foodres.2019.108934