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GENIPAPO FLOUR ADDITION IN CEREAL BARS: STUDY WITH CHILD CONSUMERS

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ABSTRACT

The aim of the study was to evaluate the sensory acceptability of cereal bars with the addition of several levels of genipapo flour (GF) among children. Additionally, we wanted to determine the physicochemical composition of the control product and of the one with a higher GF level, and which formulation would have an acceptability level similar to the control product. Five cereal bars formulations were developed with the addition of different levels of GF: F1 (0%), F2 (1%), F3 (2%), F4 (3%) and F5 (4%). Sixty-two untrained consumers, of both genders, aging from 7 to 10 years old took part in the sensory evaluation. Their physicochemical characteristics and acceptability were analyzed through a mixed structured facial hedonic scale. There was no significant difference between the formulations for the aroma and texture attributes, and for purchase intent. Generally, the addition of levels ≥ to 4% reduced the cereal bar's acceptability ($p \leq 0.05$) in the attributes appearance, flavour and colour. The F3 formulation was the one with greatest GF addition and whose acceptance was similar to the control formulations. There was no significant difference ($p > 0.05$) between F1 and F3 regarding their moisture, ash, protein, and soluble fiber contents. Lower lipid and calorie levels and higher carbohydrate, insoluble fiber, and total dietary fiber levels were reported in F3. A GF addition level of up to 2% in cereal bars was well accepted by the children, enabling us to improve the product's nutritional profile.

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INTRODUCTION

Brazil has a great diversity of tropical fruits, including exotic and little explored species. One example of these is genipapo (*Genipa americana* L.). It comes from the Amazon region, but it is widely distributed in Central and South America, especially in the Brazilian Cerrado biome (Souza *et al.*, 2012; Bentes *et al.*, 2015). It has globose berries, brown colour, thin skin, and a succulent pulp of characteristic flavour and aroma (Hamacek *et al.*, 2013). In Brazil, genipapo's fruiting happens once a year, usually between the months of May and August, which reduces its commercialization due to its high perishability.

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The drying method is used by the industry as an alternative for a better food use. This kind of processing extends the use period of very perishable products, reducing their deterioration and increasing their shelf-life. Usually, fruit flours, when compared with those originating from cereals, present higher concentration of nutrients, especially of fibers, vitamins, and minerals, which is good for our health. Additionally, the processing technology required to process them is minimum, being composed of easy-to-handle pieces of equipment (Ribeiro *et al.*, 2016). Fruit flours can be used as ingredients in several products, like cakes, cookies, and cereal bars. The purpose thereof is to improve the food's nutritional profile and ensure a good sensory acceptability. Among the products with high potential to use fruit flours are cereal bars, a rectangular-shaped bakery product class made from the compression of several cereals, dry fruits, and sugar (Agbaje *et al.*, 2014).

Cereal bars are sold in individual packages and have been growing quickly in the market. In Brazil, the production and commercialization of cereal bars began in 1990's, with an average growth of 14% a year. We estimate that 500 million units are annually sold, which corresponds to an invoicing of around 95 million (Santos *et al.*, 2015). Cereal bars present a great acceptability among children, especially due to their consumption practicability and low purchase cost. They represent a dietary complement alternative in small snacks, and already belong to the child public's diet (Sanigorski *et al.*, 2015). In spite of that, they may contain high levels of sugars and fats, since they usually receive the addition of frostings and other caloric ingredients (Brito *et al.*, 2013; Agbaje *et al.*, 2014). Therefore, using healthier raw materials in products like cereal bars can help them to become a more nutritious food and prevent the development of future non-communicable chronic diseases.

The group age that comprises the school period (7 to 10 years old) represents a period of intense changes. In this phase, children become more independent and better understand the food recommendations. However, choosing products with high calorie values and low levels of fibers, vitamins and minerals is common in this stage of life. The natural preference for sweets predisposes children to consume high caloric density foods that generate greater satiety feelings and usually have good palatability. In this sense, the school environment is indicated to develop actions to teach children to adopt healthy dietary practices (Corkins *et al.*, 2016). These interventions can provide access to foods usually consumed by the child public. However, they must have nutrients that are proper for the children's growth and development, originating especially from natural foods, like fruits and vegetables.

Some alternative tools are essential during the development of new products. Sensory analyses, for example, are essential to determine how the food's characteristics and raw materials are perceived by the consumer. In case of children, the measurement scales are adapted with facial pictures, which facilitate their understanding and interpretation to their different reactions to a same food (Laureati *et al.*, 2015). As for the physicochemical characterization, it should be applied to analyze the final product's technological parameters and nutritional value (Souza *et al.*, 2012). With it, we can ensure the food's quality and widen the perspectives of its future commercialization. In this context, the purpose hereof was to evaluate the sensory acceptability of cereal bars with the addition of several levels of genipapo flour (GF) among children. Additionally, we wanted to determine the physicochemical composition of the control product and of the one with higher GF levels and which formulations would have an acceptability level similar to the control product.

MATERIALS AND METHODS

Raw material

We used average-sized genipapos, of uniform colour, with the best visual aspect, and smooth surface, without imperfections, purchased in the state of Mato Grosso do Sul, Brazil.

Preparation of the Genipapo flour

The genipapos (700 g) were cleaned under drinkable running water. Then they were sanitized with 1 L of water and 10 ml of bleach for 15 minutes, and washed under drinkable running water again. After peeling, the pulp (520 g) was dried in an air forced circulation dehydrator (Pardal®, PE 60, Brazil) at 60 °C for 36 hours. The pulp was shredded in a mill (Tecnal®, Tec mill TE-633, Brazil), obtaining a yield of 190 g of flour. The product was bagged in polyethylene plastic bags and stored under -18 °C until the analyses.

Preparation of the cereal bars

Five cereal bar formulations were developed, each one receiving the addition of different GF levels: F1 (0%, control), F2 (1%), F3 (2%), F4 (3%) and F5 (4%). These addition levels were defined through preliminary sensory tests made with the product. Besides the GF percentages, the following ingredients were used: peanuts (15.72%), Brazil nuts (15.72%), honey (12.58%), wheat flour (F1: 11%, F2: 10%, F3: 9%, F4: 8% and F5: 7%), rolled oats (10.38%), oat bran (10.38%), bananas (8.48%), raisins (7.86%) and rice flakes (7.86%). To prepare the cereal bars, the peanuts and the nuts were previously shredded in a domestic blender (Phillips®, Brazil). Then all ingredients were manually mixed until their total homogenization, respecting the aforementioned GF and wheat flour addition percentage. The resulting dough was cut into similar pieces (10 cm long, 3 cm width and 2 cm thick) with the assistance of a stainless still blade. The products were laid in aluminum containers (24 x 11.5 cm) and baked in a conventional preheated (180 °C) oven (Fischer®, Brazil), for approximately 15 minutes. After cooking, the cereal bars remained at room temperature (22 °C) until their complete cool down and then were stored in airtight plastic containers until the analyses.

Sensory analysis

Sixty-two untrained volunteer, usual cereal bar consumers, took part in the sensory test. The children were enrolled in a Municipal School of Guarapuava, PR, Brazil and were of both genders, aging from 7 to 10 years old. The consumers tasted the formulations in a classroom, individually, receiving orientation of the researchers on how to fill their answers. The attributes of appearance, aroma, flavour, texture and colour were evaluated through a mixed structured facial hedonic 7-points scale, varying from 1 ("super bad") to 7 ("super good") (Dutcosky, 2013). Additionally, overall acceptance and purchase intent questions were also applied and evaluated through a 5-point mixed structured scale (1, "dislike extremely"/"definitely would not buy it" to 5, "like extremely"/"definitely would definitely buy it", respectively) (Dutcosky, 2013). The consumers received a piece of each sample (approximately 10 g), on disposable white plates, coded with three-digit numbers, randomized and balanced. A glass of water was offered to clean their palate. The formulations were delivered to the consumers through a sequential monadic method. The Acceptability Index (AI) was calculated through the multiplication of the mean score informed by the consumers to the product by 100, dividing the result by the maximum mean score given to the product.

Determination of physicochemical composition

All analyses were performed in triplicate in the GF, in the control formulation and in the one with greatest GF level and whose sensory acceptability was similar to the control formulation. The moisture, ash, protein and lipid content were determined by the AOAC methods (2011). The moisture content was determined through the drying-in-oven method

(105 ± 2 ºC). The lipid content was determined through the cold extraction method (Bligh and Dyer, 1959). The protein content was analyzed through to the Kjeldahl method. The factor 6.25 was used for the nitrogen conversion into crude protein. The ash was obtained by muffle. The soluble and insoluble fibers were determined through the enzymatic method (AOAC, 2011). The total dietary fiber was calculated by the difference of the soluble and insoluble fiber results. The carbohydrate content was evaluated through theoretical calculation (by difference) in the triplicates' results, according to the formula: *% carbohydrate = 100 – (% moisture + % protein + % lipid + % ash + % fiber).* The total energy value (kcal) was theoretically calculated using the following factors: lipid (8.37kcal/g), protein (3.87 kcal/g) and carbohydrate (4.11 kcal/g) (Merrill and Watt, 1973). The Daily Reference Values (DRV) was calculated for 25 g of the sample, based on the average values recommended for children of 7 to 10 years old (DRI, 2005), resulting in: 2.008 kcal/day, 22.21 g/day carbohydrate, 69.43 g/day protein, 73.42 g/day lipid and 13.49 g/day dietary fiber.

Statistical analyses

The results were analyzed using the analysis of variance (ANOVA). The means were compared through Tukey's test and Student's t-test at a significance level of 5% ($p \leq 0.05$). The Statistical Package for Social Sciences software (SPSS, Chicago, IL, USA) was used to perform the statistical calculations.

Ethical issues

This paper was previously approved by the Research Ethics Committee of the Midwest State University (UNICENTRO), ruling no 608.950/2014.

RESULTS AND DISCUSSION

Sensory analysis

Table 1 presents the sensory evaluation results of the control cereal bars and of the ones that received the addition of GF. There was no significant difference ($p > 0.05$) between the formulations for the attributes aroma, texture and purchase intent. However, in the appearance and flavor attributes, there was a greater acceptance for the control formulation ($p < 0.05$) in comparison with F4 and F5, with no statistical difference between the other samples. Higher scores ($p < 0.05$) for colour were seen for F1 in comparison with F4 and F5, likewise for F2 and F3 in comparison with F5. The addition of higher GF levels (4%) also reduced the cereal bars' sensory acceptability in comparison with the control product. Similar results were seen by Torres *et al.* (2009) when they evaluated the cereal bars acceptability with the addition of GF (5, 10 and 15%) among adults.

During the cereal bar preparation, we noticed that the addition of GF gave a purple colour to the products (Figure 1). According to Abud and Narain (2009), fruit flours naturally have sharper colours. As for GF, when the fruit is cut and exposed to the air, its pulp, which initially has a light colour, gradually becomes darker, acquiring an intense blue colour.
The blue pigment is created from the reaction between the iridoid genipin and primary amine sources, like amino acids and proteins. This process is the result of a polymerization and dehydrogenation induced by oxygenation, producing water-soluble polymers of high molecular weight that responsible for the blue colour (Bentes *et al.*, 2015).

Table 1. Sensory scores (mean ± standard deviation) and Acceptability Index (AI) of the cereal bars with addition of different levels of genipapo flour

Parameter	F1	F2	F3	F4	F5
Appearance	5.76±0.17[a]	5.10±0.17[ab]	5.24±0.18[ab]	4.98±0.17[b]	5.02±0.19[b]
AI (%)	82.29	72.86	74.86	71.14	71.71
Aroma	5.78±0.13[a]	5.47±0.18[a]	5.44±0.17[a]	5.53±0.17[a]	5.17±0.19[a]
AI (%)	82.57	78.14	77.71	79.00	73.86
Flavour	6.46±0.11[a]	5.90±0.19[ab]	6.03±0.17[ab]	5.74±0.20[b]	5.66±0.21[b]
AI (%)	92.29	84.29	86.14	82.00	80.86
Texture	5.81±0.15[a]	5.68±0.15[a]	5.61±0.15[a]	5.56±0.16[a]	5.68±0.18[a]
AI (%)	83.00	81.14	80.14	79.43	81.14
Colour	5.61±0.18[a]	5.36±0.17[ab]	5.34±0.19[ab]	4.87±0.17[bc]	4.60±0.19[c]
AI (%)	80.14	76.57	76.29	69.57	65.71
Overall acceptance	4.68±0.07[a]	4.45±0.12[ab]	4.47±0.12[ab]	4.43±0.11[ab]	4.22±0.12[b]
AI (%)	93.60	89.00	89.40	88.60	84.40
Purchase intent	4.45±0.10[a]	4.40±0.12[a]	4.34±0.12[a]	4.40±0.11[a]	4.19±0.14[a]

Distinct letters in row indicate significant differences by Tukey's test ($p \leq 0.05$). Values are mean of three replicates. Addition of genipapo flour: F1: control (0%); F2: 1%; F3: 2%; F4: 3%; and F5: 4%.

Table 2. Physicochemical composition (mean ± standard deviation) of the genipapo flour (GF), of the control cereal bar (F1) and with 2% GF addition (F3)

Parameter	GF	F1	DRV (%)*	F3	DRV (%)*
Moisture ($g.100g^{-1}$)	5.31±0.05	11.20±0.04[a]	NA	11.14±0.07[a]	NA
Ash ($g.100g^{-1}$)	3.47±0.03	1.85±0.05[a]	NA	1.87±0.07[a]	NA
Protein ($g.100g^{-1}$)	5.75±0.10	12.55±0.06[a]	4.52	12.60±0.05[a]	4.54
Lipid ($g.100g^{-1}$)	5.07±0.09	19.13±0.08[a]	6.51	18.07±0.06[b]	6.15
Carbohydrate ($g.100g^{-1}$)**	80.41±0.54	55.28±0.33[b]	5.08	56.32±0.22[a]	5.18
Total energy value ($kcal.100g^{-1}$)	395.13±1.25	435.85±0.89[a]	5.43	431.52±0.78[b]	5.37
Soluble fiber ($g.100g^{-1}$)***	1.44±0.07	1.58±0.08[a]	NA	1.61±0.07[a]	NA
Insoluble fiber ($g.100g^{-1}$)***	29.21±0.10	4.73±0.09[b]	NA	5.26±0.08[a]	NA
Total fiber ($g.100g^{-1}$)***	30.65±0.09	6.31±0.10[b]	11.69	6.87±0.09[a]	12.73

Distinct letters in row between F1 and F3 indicate significant difference by Student's t-test ($p \leq 0.05$). Values are mean of three replicates. *DRV (Daily Reference Values): nutrients evaluated by DRI (2005) mean, based on a diet of 2.008 kcal/day and a portion mean of 25 g of the product. Values expressed in wet base. **Includes dietary fiber. ***Dietary fiber. NA: not available.

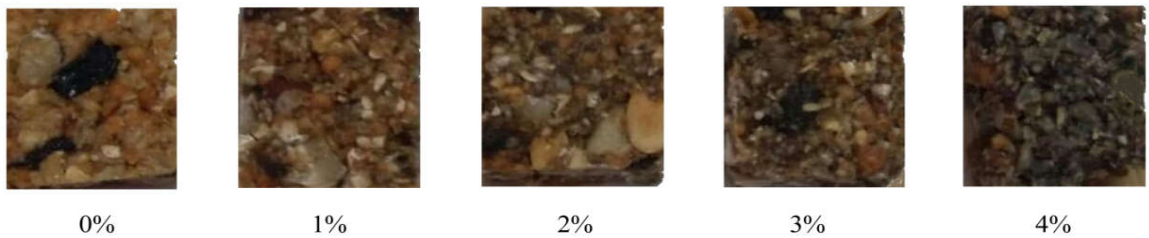

Figure 1. Cereal bar formulations with the addition of genipapo flour: F1 (control), F2 (1%), F3 (2%), F4 (3%) and F5 (4%)

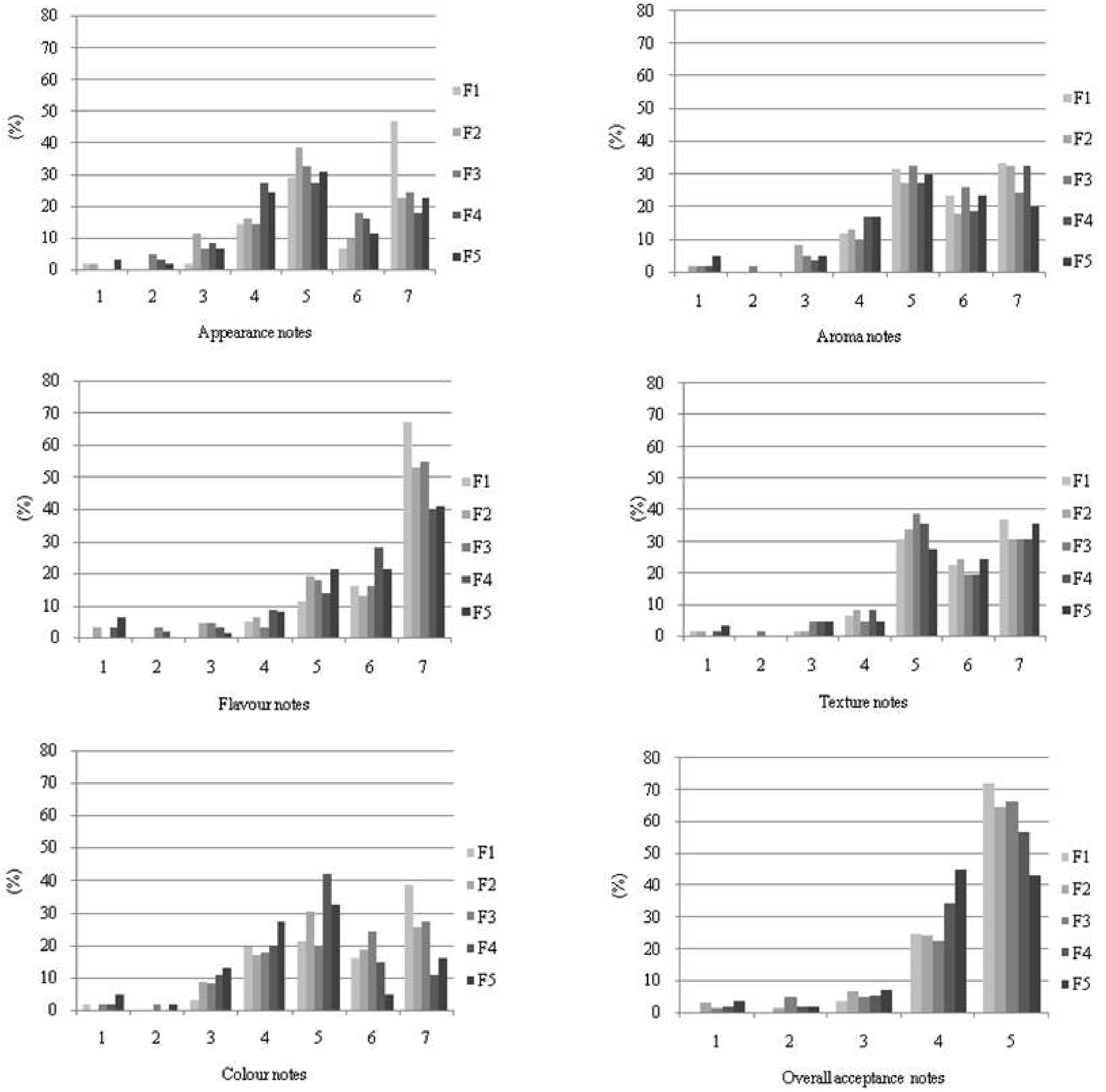

Figure 2. Distribution of the consumers by the hedonic values obtained in the cereal bar sensory evaluation with addition of different levels of genipapo flour: F1 (0%, control), F2 (1%), F3 (2%), F4 (3%) and F5 (4%)

Genipapo has different volatile compounds that are responsible for its characteristic aroma. Some examples are the methylbutyric, hexanoic and octanoic acids, which give pungent and acid aroma characteristics to the fruit (Borges and Rezende, 2000). Additionally, genipapo's high acidity level (3.33%) may cause a bitter flavour in the product. In this case, the acidity values accepted by the consumers are within a range of 0.08 to 1.95% (Hamacek *et al.*, 2013).

These factors explain the lower scores obtained for the appearance, flavor and colour attributes, and overall acceptance of the formulations containing higher GF levels. The formulations presented AI over 70% for every evaluated attributes, except for colour (F4 and F5), which indicates a good acceptance of the products (Teixeira *et al.*, 1987). Similar effects were reported by the literature after the 4% genipapo pulp addition in cakes (Carvalho, 2008). Therefore, GF can be used in products made for children for nutritional enrichment and to prevent non-communicable chronic diseases, like hyper tension, diabetes and cancer (Torres *et al.*, 2009; Porto *et al.*, 2014). Most of the informed scores were superior to 5 (good) for the attributes and for a overall acceptance above 4 (liked), indicating that the formulations were well accepted by the children (Figure 2). The sample F3 was the one with the greatest GF level (2%) and whose sensory acceptance was similar to the control formulation in every evaluation (Table 1). Consequently, it was selected for the physicochemical comparison with the control formulation (F1) presented in Table 2.

Physicochemical composition

The GF's moisture level agrees with Loveday *et al.* (2009), who recommend a moisture maximum of 10-15% in cereal bars, which indicates a better microbiological stability during storage (Srebernich *et al.*, 2011). Genipapo is a fruit with high mineral levels in its composition, underscoring potassium (92.55 mg.100g^{-1}), calcium (13.23 mg.100g^{-1}) and magnesium (8.17 mg.100g^{-1}) (Souza *et al.*, 2012). This explains the high ash level found in GF.

There was no significant difference ($p > 0.05$) between the formulations regarding their contents of moisture, ash, protein and soluble fiber. All other parameters got few variations between the samples, corroborating with another study with the addition of 5% of genipapo pulp (Torres *et al.*, 2011). Lower levels of lipid and energy value, and higher levels of carbohydrate, insoluble fiber and total dietary fiber were noticed in F3. The total dietary fiber verified in the formulations with the addition of 2% of GF (F3) presents a significant increase of 8.9% in comparison with F1. This happens especially due to the elevated fiber level present in GF (30.65 g.100g^{-1}), much superior to the amount found in wheat flour (2.4 g.100g^{-1}) (USDA, 2016). This expressive increase in the fiber amount was also reported by other authors, who studied the inclusion of exotic fruits in cereal bars (Torres *et al.*, 2011; Munoz *et al.*, 2014). The samples F1 and F3 can be considered of high dietary fiber level because they have a minimum 6% fiber level in their composition (Brazil, 2012). Different studies already confirmed the importance of fiber consumption for the child public. According to Khan *et al.* (2015), the quality of the children's diet, specifically of dietary fiber, is essential to perform tasks that demand a greater cognitive effort. Additionally, the fiber intake is inversely linked to the body mass index and the circulating lipid levels. This reduces the risk of diseases like future obesity and hypercholesterolemia (Shinozaki *et al.*, 2015).

Conclusion

An addition level of up to 2% of genipapo flour in cereal bars was well accepted by the consumers, obtaining a sensory acceptance that was similar to the control product. Additionally, we can reduce the lipid and calorie levels and increase the contents of carbohydrate, insoluble and total dietary fiber. Genipapo flour may be considered a potential ingredient to be added in cereal bars, with the possibility of being offered to the child public and with high commercialization expectations. We suggest the development of similar products to diversify the use of fruits as ingredients in foods.

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