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DEVELOPMENT OF CEREAL BARS CONTAINING PINEAPPLE PEEL FLOUR (*ANANAS COMOSUS* L. MERRIL)

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ABSTRACT

Cereal bars are nutritious food composed of several ingredients including cereals, fruits, nuts and sugar among others. Thus, this study aimed to develop cereal bars containing pineapple peel flour. A completely randomized design was used with four treatments, as follows: Control (0% flour); T1 (3% flour); T2 (6% flour); and T3 (9% flour), for the variables moisture, ash, protein, fat, crude fiber and carbohydrates. It was observed that the higher the pineapple peel flour content, the greater the crude fiber content in the cereal bars was, evidencing the significant amounts of crude fiber in the pineapple peel. In the texture analysis, although an increase in bar consistency was observed with increasing concentrations of pineapple peel flour, no differences were observed up to 6% flour addition when compared to the control. With respect to the sensory attributes, the samples scored among the hedonic terms 7.0 (moderately good) and 9.0 (very good). It can be concluded that the pineapple peel flour is a good alternative to be introduced in human diet, in addition to significantly reduce waste generation in the pulp industries.

PRACTICAL APPLICATIONS

In this study, we produced cereal bars using different concentrations of pineapple peel flour (PPF), a co-product of the fruit industry. We observed that the addition of up to 6% PPF in the cereal bars did not alter the sensory acceptance and increased the fiber content. We believe that these findings may be useful for the production of cereal bars with healthier characteristics and reduce the environment impact caused by industrialization of pineapple.

INTRODUCTION

Food industry has aroused public concern to achieve a healthy and balanced diet, evidenced by the increasing consumption of diet/light foods and the so-called functional foods, due to its nutritious effects and health benefits. In this sense, cereal bars market has grown considerably in recent years due to the trend of consumption of healthy foods.

Cereal bars are classified as a fast meal, having three or more types of properly prepared foods that will contribute directly to its nutritional value and characteristic flavor (Sampaio *et al.* 2009). The attributes texture and flavor, and the physical properties are defined by the combination of the ingredients, which must complement each other so as to reveal a sweet and pleasant taste (Esteller *et al.* 2004). The cereal bars are a multicomponent mixture with a very complex formulation, since the ingredients must be combined appropriately so that they complement each other.

According to the FAO (2008), Brazil is the world's largest pineapple producer. The pineapple peel is hard and irregular but can be used for various culinary purposes as teas, juices and even candy preparation. It is rich in Vitamin A, C, B complex, calcium, iron, potassium and fibers containing significant amount of insoluble fibers. Fibers play important roles in the body such as interfere in the metabolism of lipids and carbohydrates, act against constipation, and promote feelings of satiety, thus being considered as a functional food (Slavin 2013).

Peel, stems, crowns and pineapple cores are considered waste by the fruit pulp industry, and stand out for their high sugar content particularly by having pectin which is an insoluble fiber, besides high contents of crude fiber and proteins. The edible portion is from 22.5 to 35% of the fruit, and the remaining is usually discarded after the manufacturing process (Paiva 2008). This amount of discarded waste – about 3/4 of the fruit – is a source of potential nutrients for diet supplementation, due to its nutritional character and low cost. Pineapples are commonly processed into canned fruit and juice, in addition to being eaten fresh. Since the peel of a pineapple accounts for 34.7% of the whole fruit mass, there is a great interest in utilizing this biomass as a source of dietary fiber, instead of feeding it to livestock (Huang *et al.* 2011). According to Chau and Huang (2004); Figuerola *et al.* (2005), dietary fiber prepared from seeds, peels and pomace from fruits has been found to possess excellent physicochemical properties. Given that dietary fiber with desirable nutritional and physicochemical properties plays an important role in the food industry, it is worthwhile to process agricultural by-products to exploit fiber-rich fraction as a potential functional food ingredient. The waste of pineapple peel can also be a potential source for vinegar production, alcohol and animal feed (Roda *et al.* 2014; Tropea *et al.* 2014). Obtaining a cereal bar with an acceptable appearance and that meets the nutritional benefits is rather difficult, considering that cereal bars consists in joining together various ingredients that will complement each other. Furthermore, fiber addition may cause an increase in volume of the food, reducing water loss and providing a suitable combination of ingredients, thus obtaining a product with better sensory aspect (Martin *et al.* 2012).

Considering all the factors previously discussed, the use of pineapple peel flour to make a cereal bar may be a viable alternative from the nutritional, functional and economic standpoint. Thus, this study aimed to evaluate the impact of the addition of different concentrations of pineapple peel flour on the physicochemical characteristics and sensory quality of cereal bars.

MATERIAL AND METHODS

Manufacturing Process of Pineapple Peel Flour

Perola pineapple (*Ananas comosus* L. Merrill) peels were used to produce the pineapple peel flour. The fruits were purchased in grocery shops in the city of Uberaba, Minas Gerais, Brazil. To prevent contamination from chemicals and pesticides, the pineapples were washed in clean tap water, sanitized in chlorinated water with 200 ppm sodium hypochlorite for 15 min and then peeled. Peels were cut into sizes of approximately 2 cm^2, and dried in an air circulating oven (Pardal P3 60), at 65C for 17 h. After drying, the peels were first fragmented in an industrial blender (Vitalex IL-02) to obtain smaller particles and immediately crushed into micro mill thermostatic propellers (IKA A11B) until obtaining fine flour. Then, the flour was vacuum-packed and stored at room temperature in a cool and ventilated place, without incidence of light until utilization.

TABLE 1. CEREAL BARS FORMULATION CONTAINING PINEAPPLE PEEL FLOUR

Ingredients	Control (g)	T1 (g)	T2 (g)	T3 (g)
Rice flakes (ball)	70	70	70	70
Rice flakes (long)	30	30	30	30
Rolled oats	96	96	96	96
Dehydrated banana	150	150	150	150
Nuts	80	80	80	80
Cornflakes	50	50	50	50
Pineapple peel flour	–	24	48	72
Glucose syrup	210	210	210	210
Invert sugar	35	35	35	35
Crystal Sugar	20	20	20	20
Palm fat	20	20	20	20
Soya lecithin	3	3	3	3
Salt	2	2	2	2
Maltodextrin	25	25	25	25
Water	20	20	20	20

Formulation and Manufacturing of Cereal Bars

Cereal bars were produced at the Federal Institute of Triângulo Mineiro (IFTM), agro-industry sector (vegetable processing) in the ratio of 60:40 (cereals and binding solution, respectively), according to the bar formulation shown in Table 1. Two independent replicates of each treatment were made. All ingredients were weighed, and syrup was prepared as follows: the binding solution was heated to a maximum temperature of 105C, at 85° Brix. The dry ingredients were mixed and slowly incorporated into the warm syrup, under continuous agitation the cooking pan, until a complete homogenization of cereals and binding solution. Then lamination was performed with the initial temperature of 38C in an inert stainless steel surface, and the mixture was spread with the aid of a cylinder to the average thickness of 1 cm. The following treatments were prepared: Control (without addition of pineapple peel flour); T1 (3% flour), T2 (6% flour) and T3 (9% flour). The percentage of pineapple peel flour was chosen under 10%, once after tests done previously, the cereal bars obtained great hardness when added above 9% of pineapple peel.

The mixture was cooled to 28C and cut into pieces (10 cm × 3 cm × 1 cm) of approximately 25 g, equivalent to the cereal bars found in the market. The bars were packed in polystyrene trays (23.5 cm × 18.0 cm × 3.3 cm) using PVC film, and stored in a cool and ventilated place until the time of analysis.

pH Determination of Pineapple Peel Flour and Cereal Bars

The pH values of the pineapple peel flour and the cereal bars were carried out in triplicate byusing a pH meter (T-1000, Tekna, Brazil).

Proximate Composition of Pineapple Peel Flour and Cereal Bars

The moisture content was determined by oven drying at 105C ± 2C; Nitrogen content was determined by the Kjeldahl method and the protein was calculated by multiplying the nitrogen content by the conversion factor 6.25 (Association of Official Analytical Chemists – AOAC 1990); crude fiber was determined by gravimetric method after digestion in acidic media; The lipid content was determined by the method of Soxhlet using petroleum ether, and ash content was determined by incineration in a muffle at 550C (AOAC 1990). All analyses were carried out in triplicate.

Titratable Acidity and Water Activity of the Cereal Bars

The titratable acidity was determined as the predominant acid present in the sample, according to the methodology of the Instituto Adolfo Lutz (2008) and water activity (A_w) was measured in Aqualab 4TE instrument by dew point technique (Brasil, Resolução-RDCn. 263 22 de setembro de 2005). Analyses were performed in triplicate.

Instrumental Color of the Cereal Bars

Color determination was performed on the triturated cereal bars, with measurements in a Minolta CR-400 colorimeter (Konica Minolta Sensing Inc., Japan), according to CIE L^* a^* b^* system, using spectral reflectance included as calibration mode, illuminant D65, and observation angle of 10°. The L^* (lightness), a^* (red intensity) and b^* (yellow color intensity) values were measured at six different points for each sample.

Instrumental Texture of the Cereal Bars Containing Pineapple Peel

The cereal bars were subjected to texture analysis using a TA-TX2 Texture Analyzer (Stable Micro Systems Ltd., Surrey, England) with a load cell of 25 kg. The compression force and hardness of the product was measured with the 36 mm cylindrical aluminum probe (P/36R) with the flat ends. The force (N) applied was set to 5 mm compressive force corresponding to a deformation of 50%. The configuration parameters were: distance 5.00 mm, pre-test speed: 5.00 mm/s, test speed: 5.00 mm/s post-test speed 5.0 mm/s. Each sample was analyzed separately in triplicate.

Sensory Evaluation of the Cereal Bars

Acceptance test was carried out using a nine point hedonic scale with extremes ranging from extremely disliked (1) to extremely liked (9). The attributes color, aroma, flavor, texture and overall acceptance were evaluatedby 64 cereal bars consumers (Meilgaard *et al.* 2006). Consumers were recruited among students and staff of the Federal Institute of Education, Triângulo Mineiro (48% female and 52% male, aged from 18 to 60 years). A three-digit code has been assigned to the samples, which were evaluated by each consumer in a monadic order, following a balanced design as described by Stone *et al.* (2012). Consumer's test was performed in normalized booths under fluorescence lighting. Two cubic samples of 10 mm^2 were offered to each consumer, who was provided with room temperature water and salted crackers for palate cleansing. The sensory acceptance index was calculated by dividing the average obtained in the global acceptance and the maximum score of the hedonic scale (9.0), and the result multiplied by 100.

Statistical Analysis

A randomized complete block design was used and the entire experiment was replicated two times in two different days. The results were analyzed by analysis of variance (ANOVA) and the means were compared by Tukey's test, at a 5% significance level ($P \leq 0.05$) using the statistical software Sisvar (Ferreira 2010).

RESULTS AND DISCUSSION

The pineapple peel flour presented low pH value (4.6 ± 0.02), which is higher than the pH of Perola pineapple (3.4–3.8) (Silva *et al.* 2003), variety used in this study to obtain the flour. This result was close to that found by Selani *et al.* (2014), who reported pH values of 3.86 in pineapple pomace. Changes in pH values are directly related to the maturation stage of the fruits. Considering the low pH of the material evaluated in this study, it has low risk of food deterioration by microorganisms, enzymes or non-enzymatic reactions.

The physicochemical composition of the pineapple peel flour is shown in Table 2. Moisture and protein contents of the pineapple peel flour were 6.78 ± 0.5% and 6.93 ± 0.5%

TABLE 2. PHYSICOCHEMICAL COMPOSITION OF THE PINEAPPLE PEEL FLOUR

Components	(%)
Moisture	6.78 ± 0.5
Protein	6.93 ± 0.39
Fat	1.17 ± 0.08
Ash	4.57 ± 0.04
Crude Fiber	4.92 ± 0.5
Carbohydrates*	75.63 ± 2.33

Mean ± standard deviation of triplicate determinations. Dried and crushed pineapple peel flour.
*Calculated by difference.

(Table 2), respectively, which are similar to the moisture and protein contents of the pineapple co-product (peel and heart) studied by Martinez *et al.* (2012). The pineapple peel flour had low fat content (1.17 ± 0.08%) (Table 2), which is in agreement with the percentage of 0.69% reported by Sousa *et al.* (2011) for pineapple residue obtained from a fruit pulp industry. This study found higher ash values (4.57 ± 0.04%) (Table 2) when compared to industrial pineapple residue (0.53%) (Sousa *et al.* 2011) and similar values when compared to pineapple fiber concentrate (4.5%) (Martinez *et al.* 2012). Although differences in fruit variety can influence the ash content, according to Lombardi-Boccia *et al.* (2004), the main factor influencing mineral concentration in vegetable products is the type of soil used for cultivation. The pineapple peel flour had fiber content (4.92 ± 0.5) similar to the reported by Costa *et al.* (2007) in pineapple peel powder. A large amount of carbohydrates was observed in the pineapple peel flour (75.63%), which was expected, once the fruits are rich in sugars (glucose and fructose). This result is in disagreement with that noticed by Huang *et al.* (2011), who found lower carbohydrate content (42.3%) in pineapple peel. It is noteworthy that the differences observed in the physicochemical composition of the pineapple peel flour can be due to the different cultivars and crop conditions, such as soil composition and fertilization.

The physicochemical composition of the cereal bars is shown in Table 3. The moisture content varied from 7.89% (control) to 9.40% (T2), and the treatment T2 was significantly different from both the control and T3. This change in moisture content may be due to the addition of up to 6% pineapple peel flour contributed to water retention, probably due the ratio of soluble to insoluble fiber in the pineapple peel. The cereal bars had relatively low moisture content, when compared with the findings of Silva *et al.* (2009), who produced cereal bars containing industrial residue of passion fruit, and found values ranging from 10.9 to 11.9%, close to those found by Mello *et al.* (2012), who evaluated the physicochemical composition and labeling of cereal bars in the São Paulo market, and found values of 12.6 to 13.06%. The highest moisture content found in this study was 9.40%, which is low when compared to the literature and legislation guidelines that established a maximum moisture content of 15% for cereal-based products (Brasil, Resolução-RDCn. 263 22 de setembro de 2005). Therefore, all treatments met the current legislation.

No significant differences were observed in protein, fat and carbohydrates for all samples, since the addition of pineapple peel flour did not affect the content of these variables in the cereal bars. The protein levels were similar to those found in commercial cereal bars, with mean values of 6.5%. The protein levels ranged from 6.31 to 7.08%, similar to the values of 4.47–6.62% found by Aigster *et al.* (2011), therefore the results of both studies were satisfactory if we consider that the protein values found in this type of product typically vary from 3 to 4% (Santos *et al.* 2011). The fat content ranged from 6.48 to 7.73%, similar to those found by Mello *et al.* (2012) ranging from 6.45 to 8.42%, Silva *et al.* (2009), who found 7.5 to 7.8% and Appelt *et al.* (2015) who found fat levels of 8.2 and 8.3%. It is noteworthy that no major changes are observed in literature for this variable. As reported by Sampaio *et al.* (2010), cereal bars available on the market have lipid values ranging from 4 to 12%.

The ash content is an important parameter, once it establishes the mineral content of the sample. The results showed that the treatments T1 and T2 were significantly different from each other, and did not differ from the other treatments. This difference may be due to other factors rather

TABLE 3. PHYSICOCHEMICAL COMPOSITION OF THE CEREAL BARS CONTAINING PINEAPPLE PEEL FLOUR

(%)	Control	T1	T2	T3
Moisture	7.89 ± 0.01^{b}	8.82 ± 0.02^{ab}	9.40 ± 0.02^{a}	8.19 ± 0.01^{b}
Protein	7.08 ± 0.01^{a}	6.94 ± 0.01^{a}	6.71 ± 0.02^{a}	6.31 ± 0.02^{a}
Fat	7.73 ± 0.01^{a}	7.26 ± 0.01^{a}	6.99 ± 0.01^{a}	6.48 ± 0.01^{a}
Carbohydrates*	72.77 ± 0.02^{a}	71.76 ± 0.02^{a}	71.33 ± 0.03^{a}	72.52 ± 0.02^{a}
Ash	2.81 ± 0.05^{ab}	3.19 ± 0.04^{a}	2.63 ± 0.04^{b}	3.09 ± 0.05^{ab}
Fiber	1.70 ± 0.01^{d}	2.02 ± 0.02^{c}	2.94 ± 0.02^{b}	3.39 ± 0.01^{a}

Values represent means (±standard deviation). Means followed by the same letter on the same line were not significantly different ($P > 0.05$) by Tukey's test. Control formulation without addition of pineapple peel flour, T1 3% flour, T2 6% flour and T3 9% flour.
*Calculated by difference.

TABLE 4. COLOR PARAMETERS (L^*, A^* AND B^*) OF THE CEREAL BARS CONTAINING PINEAPPLE PEEL FLOUR

	L^*	a^*	b^*
Control	58.68 ± 1.66^a	5.53 ± 0.80^a	33.98 ± 2.03^a
T1	51.81 ± 6.07^a	6.36 ± 1.02^a	34.19 ± 2.32^a
T2	58.66 ± 1.47^a	4.24 ± 0.48^a	23.11 ± 1.97^b
T3	52.13 ± 4.32^a	5.20 ± 1.76^a	24.68 ± 4.83^b

Values represent means (±standard deviation). Means followed by the same letter on the same line were not significantly different ($P > 0.05$) by Tukey's test. Control formulation without addition of pineapple peel flour, T1 3% flour, T2 6% flour and T3 9% flour.

than the addition of pineapple peel flour. The ash contents obtained in this study (ranging from 2.81 to 3.19%) were higher than those found by Lima *et al.* (2012) (ranging from 0.85 to 1.11%) in cereal bars containing omega-3 and chitosan, probably due to the addition of pineapple peel flour in the cereal bars formulation.

The modified treatments presented crude fiber levels ranging from 2.02 to 3.39% (Table 3) due to the incorporation of pineapple peel flour. These significant fiber contents show that waste from fruit processing, including peels are rich in crude fiber. A similar trend was observed by Fonseca *et al.* (2011) and Silva *et al.* (2009) in cereal bars produced with waste from fruit processing. From the point of view of human health, fibers reduce the risk of colonic cancer, diabetes, gall stone formation, obesity related complications, and atherosclerosis (Fuentes-Zaragoza *et al.* 2010). Considering the recommendation intake of 30 g/day of dietary fiber, the consumption of 100 g of the modified formulations would supply from 6.7% (T1) to 11.3% (T3) of that intake. In addition, according to the current European Regulation on nutrition claims (UE Regulation (EC), 2006), the treatment T3 can be considered as a "source of fiber" because it contains more than 3 g of RS per 100 g.

The carbohydrates levels ranged from 71.33 to 72.80%, and this higher percentage was due to the high concentration of cereals, invert sugar, crystal sugar and glucose syrup in the cereal bars formulation. Lima *et al.* (2012), found carbohydrates levels ranging from 60 to 97% in cereal bars, due to the different ingredients and proportions used in each formulation.

The results of instrumental color are shown in Table 4. Regarding the lightness (L^*) no significant differences were observed among the treatments, thus the addition of pineapple peel flour did not change this parameter. Similar behavior was observed for the a^* value, which represents the red (positive values) and green (negative values) color. For the color parameter b^*, coordinate that defines the yellow (positive values) and blue (negative values) color, no significant differences were observed for the treatment T1 when compared to the control. In contrast, the treatments T2 and T3 significantly differed from control. These results demonstrate that the addition of 6 and 9% of pineapple peel flour modified the color intensity of the product when compared with the other formulations. Sun-Waterhouse *et al.* (2009) found similar results for the coordinate b^* when assessing the instrumental color of fruit-based functional cereal bars. In contrast, Silva *et al.* (2009) observed a progressive darkening as the passion fruit peel flour was added to the cereal bars, and the results of the coordinate b^* evidenced a trend of low-intensity yellow color of the formulations. Therefore the use of pineapple peel flour in the cereal bars did not provide a darkening of cereal bars, however it reduced its tendency to yellow chromaticity in the formulations containing 6 and 9% pineapple peel flour.

The values for pH, titratable acidity and water activity are shown in Table 5. Significant differences in pH values were observed for the control when compared with the other treatments, because the addition of pineapple peel flour caused a significant decrease in pH values, as expected. The results of titratable acidity were expressed as citric acid. Despite the control differed from the treatment T3, no significant differences were observed for the other formulations, probably because the treatment T3 had the highest concentration of pineapple peel flour, thus organic acids were present in greater quantities, thus conferring a higher acidity to the products. Similar results were observed by Silva (2012), who added pumpkin seed flour to cereal bar formulations, and found a reduction in pH levels, with values of 5.43, 5.75 and 5.6 and an increase in acid content ranging from 2 to 3.58%.

The water activity values did not differ significantly among the treatments (Table 5). The values were relatively low, and the presence of sugars and antimicrobials in cereals makes the product microbiologically safe. The A_w values observed by Srebernich *et al.* (2011) and Silva (2012) ranged from 0.520 to 0.630, which is lower than the values found in this study. However, it is worth mentioning that this difference may be due to the different formulations and methodologies used for the manufacture of the cereal bars, among other variables. Aigster *et al.* (2011) observed a significant

TABLE 5. PH, WATER ACTIVITY AND TITRATABLE ACIDITY OF THE CEREAL BARS CONTAINING PINEAPPLE PEEL FLOUR

	pH	Titratable acidity %	A_w
Control	5.80 ± 0.01^a	0.18 ± 0.01^b	0.72 ± 0.01^a
T1	5.28 ± 0.07^b	0.23 ± 0.02^{ab}	0.69 ± 0.01^a
T2	5.16 ± 0.07^b	0.30 ± 0.05^{ab}	0.66 ± 0.02^a
T3	4.91 ± 0.02^b	0.38 ± 0.03^a	0.70 ± 0.01^a

Values represent means (±standard deviation). Means followed by the same letter on the same line were not significantly different ($P > 0.05$) by Tukey's test. Control: formulation without addition of pineapple peel flour, T1: 3% flour, T2: 6% flour and T3: 9% flour.

TABLE 6. INSTRUMENTAL TEXTURE OF THE CEREAL BAR CONTAINING DIFFERENT CONCENTRATIONS OF PINEAPPLE PEEL FLOUR

	Force (*N*)	Hardness (*N*)
Control	66.24 ± 7.23^{b}	112.52 ± 10.64^{b}
T1	66.53 ± 6.38^{b}	107.50 ± 8.71^{b}
T2	70.35 ± 7.90^{b}	99.60 ± 45.05^{b}
T3	86.61 ± 7.04^{a}	157.95 ± 14.35^{a}

Values represent means (±standard deviation). Means followed by the same letter on the same line were not significantly different ($P > 0.05$) by Tukey's test. Control: formulation without addition of pineapple peel flour, T1: 3% flour, T2: 6% flour and T3: 9% flour.

increase in A_w in the cereal bars containing different concentrations of resistant starch during the storage period, probably due to starch retrogradation and further syneresis. The physicochemical parameters evaluated are considered intrinsic factors, as they may contribute to the increased product shelf life, once they prevent the development of pathogenic and spoilage microorganisms.

The results of instrumental texture of the cereal bars containing pineapple peel flour are shown in Table 6. The compressive force increased significantly with the addition of 9% pineapple peel flour. This result may be due to the treatment T3 contained a higher amount of flour, therefore it exhibited greater consistency when compared with the control, and consequently the compressive force exerted on this. This can be explained by the ability of flour to absorb the sugar syrup, allowing the ingredients to agglomerate, and the cereal bars becoming more compressed. Similar results were observed by Silva *et al.* (2011) and Silva (2012). Aigster *et al.* (2011) evaluate the instrumental texture of cereal bars containing different concentrations of resistant starch stored in a 21-day period, and found that the higher concentration of resistant starch and the longer the storage time (0, 7, 14 and 21 days), the greater the compression force exerted by texturometer. The author stated that the consistency of the bar increased due to the increase in resistant starch, caused by the retrogradation of the amylose chains throughout 21 days of storage.

The results of sensory acceptance are shown in Table 7. Significant differences were observed among the treatments. Although treatment T3 containing 9% pineapple peel flour was significant different from the control, it did not differ from the other treatments for the attributes color, flavor, texture and overall acceptance. With respect to the attribute aroma, no significant differences were observed for all treatments.

These results were positive, showing that the addition of up to 6% pineapple peel flour in the cereal bars did not alter the sensory acceptance. The results of the sensory analysis were consistent with the instrumental texture, because the hardness found in the treatment T3 was identified by the assessors in the sensory evaluation, with a significant difference when compared to control, not differing from the other samples. This result demonstrates that the cereal bar with addition of 9% pineapple peel flour had a higher consistency when compared with the control, evidenced by both the texture profile and the sensory analysis. This fact was identified by both the texturometer as the panelists participating in the sensory analysis.

With respect to the overall acceptance, it accesses the overview of the consumer, showing that the control formulation was not different from the formulation T2. Indeed, the addition of up to 6% of the pineapple peel flour in the cereal bars did not change the sensory acceptance of cereal bars. Although the treatments T1 and T3 were significant different from the control, they presented higher scores when compared to the results observed by Klajn and Piovesana (2013), and lower scores than those found by Appelt *et al.* (2015) who studied similar products. The increase in consistency of the cereal bar with increasing the concentration of pineapple peel flour may have negatively affected the sensory acceptance of the products.

The treatment T2 had an acceptance index near 78%, which is closer to the control, which presented an acceptance index of 83%. The treatments T1 and T3 had 76 and 72% acceptability index, respectively. These are very good results, since a product with good acceptance must have acceptability index higher than 70%. Although the treatment T3 had 9% pineapple peel flour and obtained the lowest scores when compared with the other treatments, being the less accepted in the sensory evaluation, it presented a satisfactory sensory acceptability rate of about 72%. Therefore, it is important to take into consideration that the maximum addition of pineapple peel flour is 6% for a good sensory acceptance.

Appelt *et al.* (2015) developed formulations containing different amounts of (5, 10 and 15g) with okara, and

TABLE 7. SENSORY ACCEPTANCE OF THE CEREAL BARS CONTAINING PINEAPPLE PEEL FLOUR

	Control	T1	T2	T3
Color	7.47 ± 1.37^{a}	7.12 ± 1.32^{ab}	7.38 ± 1.22^{ab}	6.79 ± 1.42^{b}
Aroma	7.15 ± 1.68^{a}	6.89 ± 1.54^{a}	7.07 ± 1.34^{a}	6.67 ± 1.68^{a}
Flavor	7.32 ± 1.35^{a}	6.91 ± 1.69^{ab}	7.09 ± 1.53^{ab}	6.56 ± 1.79^{b}
Texture	7.48 ± 1.33^{a}	6.98 ± 1.46^{ab}	7.33 ± 1.22^{ab}	6.86 ± 1.45^{b}
Overall acceptance	7.50 ± 1.94^{a}	6.85 ± 1.84^{b}	7.00 ± 1.67^{ab}	6.51 ± 2.02^{b}

obtained scores above (7) for all the sensory attributes evaluated. These authors emphasized that the increase in jabuticaba peel flour did not affect the parameters texture and aroma, but resulted in a reduction in global acceptance due to the astringent taste of jabuticaba peel.

Klajn and Piovesana (2013) studied the replacement of 0, 50 and 100% raisin by grape bagasse in cereal bars. Lower sensory acceptance scores were observed with increasing the concentrations of grape bagasse, and the formulation containing 100% bagasse had the lowest score, despite no differences were observed among the different treatments for the attribute appearance.

In general, besides aggregating nutritional value to the product, the use of agro residues incorporated in products intended for human consumption contribute to the reuse of products that would normally be discarded.

CONCLUSIONS

It can be concluded that the pineapple peel flour may be a good alternative as a raw material to produce cereal bars, since it has substantial amounts of crude fiber, thereby improving the nutritional properties of the final product. The use of pineapple peel flour allows obtaining a new product and contributes to the reduction of waste generated by the pulp and juice industries, which when discarded improperly, can cause damage to the environment due to its high organic value.

The pineapple peel flour provided good technological characteristics to the cereal bars, such as lower pH and higher acidity, contributing to the microbiological quality of the bars. These results are quite satisfactory as these factors directly contribute to increase the product's shelf life.

The sensory quality of the cereal bars was not depreciated until the level of 6% pineapple peel flour, and the texture profile was consistent with the sensory evaluation. Therefore, the optimum level of addition of pineapple peel flour is up to 6%, since no changes in the texture and other sensory properties of the bars were observed when compared with the control treatment.

However, according to the result of the sensory acceptability index, all treatments can be used in the formulation of cereal bars, since they showed indices higher than 70%, which is the minimum required for a good sensory acceptance.

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