







Original Articles

Savory cereal bars made with seed, fruit peel, and fish meal

Barras de cereais salgadas feitas com sementes, cascas de frutas e farinha de peixe

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ABSTRACT

Cereal bars are practical, popular, and represent a multicomponent food with market potential. This work aimed to develop tasty cereal bars with kabocha seeds (*Cucurbita moschata*), kabocha peels, pineapple peel (*Ananas* sp.), and passion fruit peel (*Passiflora* sp.) with different levels of fishmeal, as nutritional enrichment. To this purpose, the fish meal was prepared with tilapia and salmon carcasses added to the basic ingredients of the bar. The fish concentrate levels used were 0% (control), 5%, 10% and 15%, amounting to four treatments, with five replications. The elaborated bars were analyzed for proximate compositional, sensory properties, and microbiological contamination. The results indicated high levels of protein (49.65%) and lipid (32.40%) for fishmeal. The inclusion of this concentrate in cereal bars interfered with their composition by increasing protein content and reducing the content of carbohydrates and caloric value. As for sensory properties, the average scores were around 6, which indicates that the panelists slightly liked the product. It can be concluded that the addition of up to 15% of tilapia fishmeal with salmon in savory cereal bars containing seed and fruit peel, improve their nutritional composition without adversely affecting their sensory quality.

RESUMO

As barras de cereais são práticas, populares e representam um alimento multicomponente com potencial de mercado. Este trabalho teve como objetivo desenvolver saborosas barras de cereais com sementes de kabocha (*Cucurbita moschata*), cascas de kabocha, casca de abacaxi (*Ananas* sp.) e casca de maracujá (*Passiflora* sp.) Com diferentes níveis de farinha de peixe, como enriquecimento nutricional. Para tanto, a farinha de peixe foi preparada com carcaças de tilápia e salmão adicionadas aos ingredientes básicos da barra. Os níveis de concentrado de peixe utilizados foram 0% (controle), 5%, 10% e 15%, totalizando quatro tratamentos, com cinco repetições. As barras elaboradas foram analisadas quanto à composição centesimal, propriedades sensoriais e contaminação microbiológica. Os resultados indicaram altos níveis de proteína (49,65%) e lipídio (32,40%) na farinha de peixe. A inclusão desse concentrado nas barras de cereais interferiu em sua composição, aumentando o teor de proteínas e reduzindo o teor de carboidratos e o valor calórico. Quanto às propriedades sensoriais, as notas médias ficaram em torno de 6, o que indica que os provadores gostaram um pouco do produto. Pode-se concluir que a adição de até 15% de farinha de tilápia com salmão em barras de cereais salgadas contendo semente e casca de fruta melhora sua composição nutricional sem afetar negativamente sua qualidade sensorial.

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INTRODUCTION

The demand for nutritious, practical, and safe food is a global demand that has increased in recent years. The food industry has arisen the concern about a balanced and healthy diet, proof of this is that after the boom of diet/light food, now is the time of so-called functional foods, which in addition to being nutritious, bring benefits to health (LEAL, 2010).

The cereal bars cater to this trend perfectly, because independent of the various formulations on the market, they are a source of vitamins, minerals, fiber, protein, and complex carbohydrates. These products have gained popularity for meeting different audiences, representing a practical food of pleasant taste (SAMPAIO, 2009, SOUZA et al., 2017).

To meet this demand, researchers have sought to develop cereal bars with differentiated, nutritious, and functional food ingredients. Some studies have been conducted in the search for alternatives to formulations of cereal bars including fruit peel, vegetable seed, oilseed, industrial waste, opting for alternatives using more nutritious and healthy ingredients that add a high concentration of dietary fiber, polyphenols, without damaging sensory attributes (FREITAS; MORETTI, 2006, GUTKOSKI; BONAMIGO; TEIXEIRA, 2007, MENDES et al., 2013, SOUZA et al., 2017).

An interesting alternative is a use of fruit waste (mostly peel) as a raw material for the production of functional ingredients, as is the case of pectin extracted from orange, lemon, apple, and passionflower peels (SAMPAIO, 2009, SILVA; OLIVEIRA; LOPES, 2009, NUNES; SANTOS; OLIVEIRA, 2013). The dried pineapple peel or pineapple peel meal has fibers (21.7g 50g⁻¹) and high citric acid content, which reduces the action of microorganisms in the product (MENDES et al., 2013). Another byproduct that has been tested in the formulation of various foods is fishmeal or protein concentrate which as well as fish is rich in minerals, especially calcium, phosphorus and iron, high-quality protein, source of amino acids as lysine and leucine, and fatty acids (GODOY et al. 2012, SOUCI; FACHMAN; KRAUT, 2000, SOUZA et al., 2017). The inclusion of fishmeal or protein concentrates on daily products such as cakes (GOES et al., 2016), biscuit (CORADINI et al., 2015) and cereal bars (SOUZA et al., 2017) may contribute to improving their nutritional composition.

Given the inefficient waste treatment of the fishing industry and consequently supply of this type of protein in the market, the use of such waste in the preparation of fish meal or fishmeal purposing its inclusion in food products to increase protein and mineral content and even fatty acids, especially of omega-3 series (GODOY et al., 2012; PETENUCCI et al., 2010), is an alternative way to add value to products such as cereal bars, using the waste of high biological value, such as the fish protein, contributing to the sustainability of agro-industrial sectors.

Owing to the above, savory cereal bars were developed including fruit seeds and peels and different levels of tilapia and salmon fishmeal, aiming to evaluate their acceptance by consumers and their nutritional value and microbiological characteristics.

MATERIAL AND METHODS

Development of the fishmeal from carcasses of tilapia and salmon

The fishmeal was produced at the Fish Technology Laboratory, State University of Maringá, with carcasses of Nile tilapia (*Oreochromis niloticus*) and salmon (*Salmo salar*) from local industries (Maringá, state of Paraná). The carcasses (spines without the fillets) from processing tilapia and salmon were frozen and taken to the Fish Technology Laboratory, where they were thawed at room temperature and prepared, removing the fins and head. Different raw materials were washed, weighed, cooked in a pressure cooker with the inclusion of antioxidants (BHT = 5mg kg⁻¹) for 60 minutes. Then, the material was pressed (10-ton capacity hydraulic press) and ground in a meat grinder. After the masses obtained were dehydrated in a drying oven at 60°C for 24 hours, ground in a knife mill (Willye TE-650), vacuum packed and frozen (-18°C). To obtain tilapia and salmon fish meal were included 10% of salmon dehydrated products into the tilapia dehydrated product (90%) in order to smooth out the taste of the concentrate since the salmon has more marked sensory characteristics than tilapia.

Development of cereal bars

Prior to the preparation of the bars, the skin of kabocha (*Cucurbita moschata*), peel of pineapple (*Ananas* sp.), and passion fruit (*Passiflora* sp.) peel and kabocha seeds selected for preparation of the bars were washed with water and sodium hypochlorite 1%, for 15 minutes. Subsequently, the peels were cut and dehydrated with seeds in a forced air circulation oven at 60°C for 24h, according to Souza et al. (2017), to the study, completely randomized design was used, containing four treatments and five repetitions

For the development of bars, we used a base formulation with the following ingredients: fine oats, whole wheat flour, rice flakes, oat flakes, pineapple peel, kabocha skin, passion fruit peel, Brazilian nut, peanuts, sesame, dried tomatoes, onion cream, yeast, margarine, garlic, oregano, commercial seasoning (ARISCO®), dehydrated parsley, dehydrated green onions, basil, whipped egg whites, emulsifier (EMUSTAB®), glutamate sodium, guar gum, and crushed crackers. To this base, there were included 0%, 5%, 10% and 15% fishmeal of tilapia with salmon, composing the 4 treatments, namely, Treatment 1 = without the inclusion of fishmeal, Treatment 2 = 5% inclusion, Treatment 3 = 10% inclusion and Treatment 4 = 15% inclusion of tilapia with salmon fishmeal. The bars were molded separately, according to the

treatments, in aluminum molds previously smeared with soybean oil and baked for 20 minutes at 280°C. After this period, cereal bars were taken to a forced-air circulation oven for 20 hours to reduce as much as possible the moisture content and increase the crispness of the product. After natural cooling, savory cereal bars were unmolded, weighed, separated into smaller pieces identified, and wrapped in aluminum foil.

Microbiological analysis

Microbiological analysis of the fishmeal and cereal bars was carried out at the laboratory of the Department of Clinical Analysis of Food Microbiology and Microscopy, State University of Maringá - UEM. These analyses were performed for the most probable number (MPN) of coliforms at 35°C/gram and at 45°C/gram, coagulase-positive *Staphylococcus* count in CFU/g and *Salmonella* spp, according to American Public Health Association - APHA (1992). The microbiological protocol followed the standards recommended by Resolution RDC 331 of December, 2019, of the National Health Surveillance Agency (BRASIL, 2019). Microbiological analysis was performed only for characterizing the profile of cereal bars.

Chemical analysis of cereal bars

For composition analysis, moisture and ash content were determined according to the methodology of the Association of Official Analytical Chemists (AOAC, 2002). The crude protein was evaluated by the method of semi-micro Kjeldahl (SILVA & QUEIROZ, 2002). Lipid extraction was performed according to the adaptation of the method reported by Bligh & Dyer (1959), using a mixture of chloroform, methanol, and water at a ratio of 2:2:1.8 (v/v/v), respectively. The carbohydrate content was estimated using a mathematical formula that considers the sum of values of moisture, protein, lipids, and ash replaced with 100% (BRASIL, 2003).

The total caloric value was obtained by summing the multiplication of the mean values of protein, lipid, and carbohydrate multiplied by the factors 4, 9, and 4, respectively (SOUCI et al., 2000).

Considering the analysis of calcium and iron of the fish meal and cereal bars, samples were digested in an acid medium, and the determinations made by flame atomic absorption spectrometry (FAAS). The total phosphorus was determined using ammonium phosphomolybdate by UV-VIS spectrometry, according to AOAC (2002).

Sensory analysis of cereal bars

The methods of sensory analysis were approved by the *Comitê Permanente de Ética em Pesquisa com Seres Humanos (COPEP)* of the Universidade Estadual de Maringá, Maringá - PR, Brazil (CAE 458.151/2013-COPEP). As for sensory analysis of cereal bars was made

according to the methodology described by Dutcosky (2011), using 9 points structured hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely) to evaluate the attributes of aroma, color, flavor, texture, consistency, bitterness, overall impression. Purchase intent was also evaluated for the products, with a 5 points hedonic scale from 1 (definitely would not buy) to 5 (definitely would buy) (DAMÁSIO & SILVA, 1996). Analyses were performed 72 hours after the preparation of cereal bars, being offered +/- 20g sample to 50 untrained panelists, undergraduate students, teachers, and employees of the Universidade Estadual de Maringá (UEM - PR). The samples were given to tasters on disposable plastic dishes identified with a sequence of three random numbers. Together with the form of sensory analysis, it was offered a cup containing water to remove the residual taste.

Experimental design

The data of the sensory analysis were subjected to the UNIVARIATE procedure of the SAS, to check the assumptions of ANOVA. It was considered the effect of treatment and panelists, testing the inclusion against control, through the test of means, and the behavior of the scores of tasters according to the inclusion of fishmeal. The mean values obtained for chemical composition were subjected to regression analysis (SAS, 2001).

RESULTS AND DISCUSSION

Microbiological analysis of the fishmeal of tilapia with salmon and the cereal bars

Microbiological analysis of the fishmeal and cereal bars developed with the inclusion of different levels of fishmeal of tilapia and salmon, as well as the meal showed good microbiological quality (Table 1). The flour and all treatments showed that coliforms at 35 and 45 °C were less than 3 MPN / g. There was a concentration of $<1 \times 10^2$ CFU/g of *Staphylococcus* coagulase-positive in the microbiological profile of fish meal and cereal bars, while the research with *Salmonella* sp. indicated its absence in 25 grams of each sample examined. Mean values of coliforms and absent *Salmonella* were within the standards established by RDC 331 of December, 2019, of the National Health Surveillance Agency (Brasil, 2019).

Chemical composition of the fishmeal of tilapia with salmon and cereal bars

The proximate composition of the fishmeal of tilapia with salmon indicates the possibility of using it as a source of protein and minerals, such as iron, in addition to having a low-fat content when compared to other products of animal origin (Table 2).

Table 1. Microbiological analysis of the fishmeal of tilapia with salmon and the savory cereal bars with the inclusion of different levels of the fishmeal.

Treatment	Microbiological analysis			
	Coliforms at 35°C (MPN/g)	Coliforms at 45°C (MPN/g)	Coagulase positive <i>Staphylococcus</i> (CFU/g)	<i>Salmonella</i> sp. 25g
Fish meal				
Tilapia/Salmon	<3	<3	<10 ²	absent
Cereal bars with the inclusion of different levels of fish fishmeal				
0 %	<3	<3	<10 ²	absent
5 %	<3	<3	<10 ²	absent
10 %	<3	<3	<10 ²	absent
15 %	<3	<3	<10 ²	absent

MPN - Most probable number; CFU- Colony-forming unit.

Table 2. Proximate composition and caloric value of the fishmeal and cereal bars containing different levels of inclusion of fishmeal.

Levels (%)	Nutrients (%)					
	Moisture	Crude protein	Lipids	Ash	Carbohydrates	Caloric Value ^b
Fish meal ^a	6.51±0.35	49.65±0.36	12.85±0.05	32.40±0.25 ^c	1.38±0.20	308.47±2.60
Cereal bars						
0	9.28±0.15	13.84±0.06	12.56±0.02	4.12±0.22	60.21±0.03	409.24±0.21
5	11.53±0.11	13.95±0.13	12.82±0.27	4.52±0.28	57.18±0.53	399.94±0.16
10	11.26±0.41	14.71±0.12	12.36±0.06	4.48±0.44	57.20±0.23	398.83±1.59
15	11.13±0.26	17.20±0.26	12.33±0.02	4.57±0.12	54.78±0.10	398.86±1.60
CV (%)	2.42	1.10	1.12	4.35	0.51	0.28
Mathematical model						
P-value	<0,01	<0,01	0,07	0.23	<0,01	<0,01
y ^c	9.409+ 0.466x- 0.024x ²	13.296+0.217x	-	-	59.782-0.325x	406.55- 0.646x
R ²	0.89	0.80	-	-	0.89	0.68
Minerals ^d						
Calcium (g.100g ⁻¹)				9.10±0.32		
Iron (mg.100g ⁻¹)				44.32±1.26		
Phosphorus (g.100g ⁻¹)				5.78±0.14		

Data expressed as mean ± standard deviation. ^a Fishmeal contained 10% salmon meal and 90% tilapia meal. ^b Caloric value refers to the kcal 100g⁻¹ sample. ^c Regression equation of the cereal bars with the inclusion of levels of fish meal for the centesimal composition. ^d Calcium, iron, and phosphorus content of fishmeal.

Godoy et al. (2012) reported values of 17.41% moisture, 32.51% crude protein, 19.72% total lipids, 26.22% ash, 1.78g.100g⁻¹ calcium, 2.36g.100g⁻¹ iron and 5.47mg.100g⁻¹ phosphorus for flavored flour developed from smoked carcasses of Nile tilapia. Matos; Franco; Galan, (2009) analyzed carcasses fish meal from with and without the head of Nile tilapia and verified that the meal developed from carcasses with the head of Nile tilapia showed 5.76% moisture, 9.26% crude protein, 39.60% lipids, 4.25g.100g⁻¹ calcium, 3.02g.100g⁻¹ phosphorus and 3.09mg.100g⁻¹ iron, and values for flour made with carcasses without head were 5.09% moisture, 10.17% crude protein, 33.05% lipids, 0.38% ash, 4.10g.100g⁻¹ calcium, 2.68g.100g⁻¹ phosphorus and 3.44 mg.100g⁻¹ iron. Nonetheless, it can be observed that the values differ slightly and differences found in the literature are usually related to raw material or the technique used to obtain concentrate protein or fishmeal.

Souza et al. (2017) reported that fishmeal the proximate composition in general, thus the meal produced whit the

carcass of fish species had varied values, the fishmeal obtained from tilapia carcass showed 51.13% protein, 37.66% fiber, and 5.83% lipids, while that of salmon contained 44.63%, 30.20%, and 18.81%, respectively, however, the tuna meal presented higher protein content (83.28%) and lower ash (5.32%) and lipids (5.60%) when compared to a salmon meal.

According to recent surveys, data on the chemical composition of the fishmeal of tilapia, reported by Petenuci et al. (2010) were 14.2% moisture, 40.8% protein content, 18.3% ash, and 25.3% lipid. Godoy et al. (2012) evaluated a meal developed from smoked carcasses of tilapia and observed 17.41% moisture content, 32.51% protein, 19.72% ether extract, and 26.22% ash. These values were higher than those obtained here, in the present study, in for moisture and lipids, and lower considering protein and ash. This is mainly because the aforementioned authors have not pressed the raw material after cooking, which interfered with the fat and moisture content of the meal, as this

procedure, i.e. the pressure exerted by the device, removes a high amount of these nutrients.

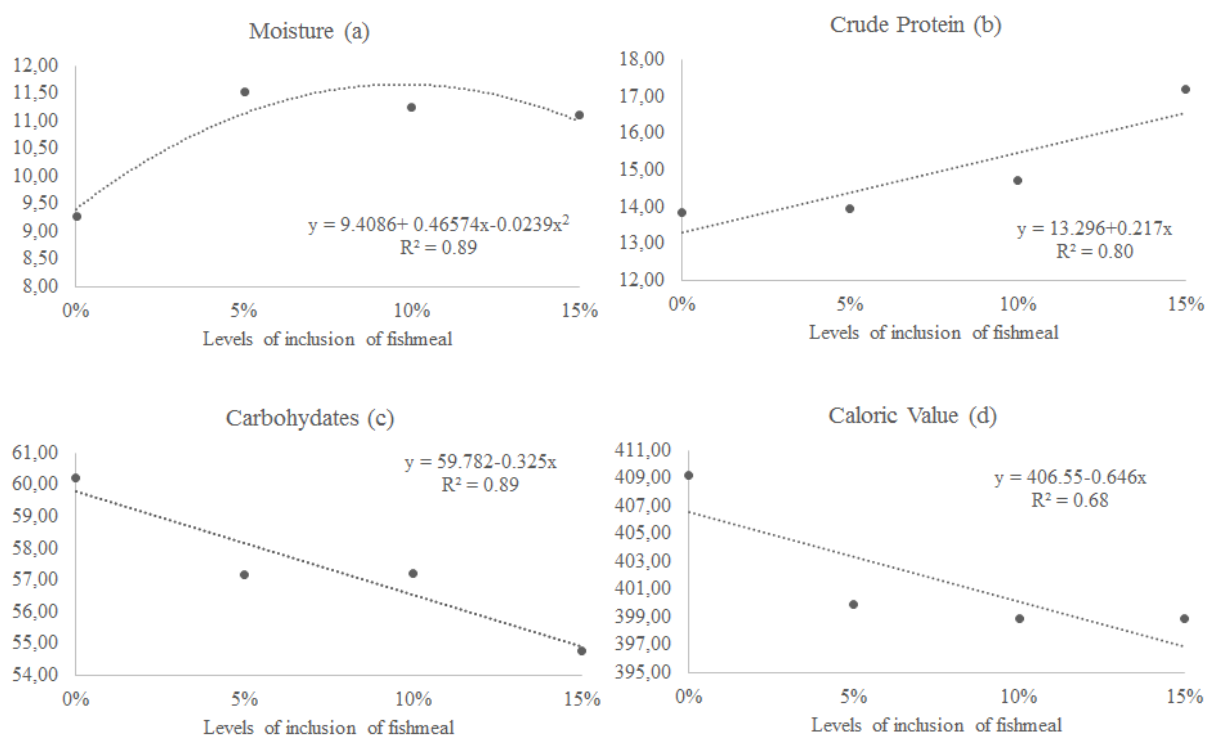
The number of carbohydrates in the meal was low, which is expected for fish products, because, according to Gonçalves (2011), carbohydrates are found at very low concentrations in fish, ranging from 0.3 to 1.0%.

The inclusion of different levels of fishmeal of tilapia and salmon changed ($P < 0.05$) the nutritional composition of the cereal bars (Table 2). The protein content increased according to inclusion levels ($y = 13.296 + 0.217x$; $R^2 = 0.80$), a relationship inversely proportional to that observed for carbohydrate composition ($y = 59.782 - 0.325x$; $R^2 = 0.89$). The caloric value was also influenced ($y = 406.55 - 0.646x$; $R^2 = 0.68$), being superior in the treatment without inclusion of fishmeal (Figure 1).

However, the mean values of ash (4.42%) and lipids (12.52%) were not different between treatments (Table 2). The lowest moisture value refers to treatment without the inclusion of fishmeal ($y = 9.4086 + 0.46574x - 0.0239x^2$; $R^2 = 0.89$).

Other factors may have influenced the moisture content of the samples, not presenting a linear behavior. However, the bar without the inclusion of fishmeal had moisture levels lower than the value obtained for the values obtained in the bars with fishmeal inclusion (Figure 1). According to Resolution RDC 263 of September 22, 2005 (Brazil, 2005), cereal products, such as cereal bars, must have a moisture content lower than 15.0 g.100g⁻¹. Therefore, the humidity of the salted cereal bars was in with conformity than recommended.

Figure 1. Regression was obtained from the proximate evaluation of savory cereal bars with different inclusion levels of fishmeal of tilapia with salmon.



Moisture values of the bars developed in this study were similar to those obtained by Gutkoski et al. (2007), who found moisture content, ranging from 9.79 to 12.37 g.100g⁻¹ in oat-based cereal bar. These same authors obtained protein values close to 10%, however, in the present study, we observed that the inclusion of fishmeal certainly increased the values of crude protein (Figure 1), which were above 13.95 from 5% inclusion of the concentrate. In turn, Freitas & Moretti (2006) carried out the characterization and sensory evaluation of functional cereal bars with high protein and vitamin content. The authors reported that, in the final formulation of the functional cereal bar, with textured soy protein, wheat germ, oat, and vitamins, the crude protein content was on average 15.31%, a greater content, desirable for products found in the market (with average 4.4%

protein), and the bars presented a lower carbohydrate content.

The inclusion of fishmeal as a form of nutritional enrichment has been successfully tested in several products. The inclusion of protein concentrates from marine and freshwater fish in the preparation of cereal bars were tested by Souza et al. (2017). These authors reported values similar to the present study for moisture (21.32%), protein (11.36%), fat (10.84%), ash (2.38%), carbohydrates (54.25%), and caloric value (359.37%). However, the inclusion of fish meal did not interfere in the protein composition of the bars, differing from the present study.

Goes et al. (2016) when trying to include of a dehydrated mixture of salmon (20%) and tilapia (80%) at 0, 5, 10, and 15% inclusion levels in spinach cake, obtained a linear increase in protein and mineral contents and consequently a decrease in carbohydrate content and caloric value, as well as in the present study, with only the mineral increase. This same behavior was observed by Coradini et al. (2015) when evaluating onion biscuits with the inclusion of different levels of aromatized fishmeal from the carcasses of the Nile tilapia.

Sensory analysis of cereal bars

Although the inclusion of different levels of fishmeal had influenced the proximate composition of cereal bars,

there was no significant difference between treatments for sensory attributes (Table 3). Average values of color, aroma (6,89), texture (6,43), flavor (5,59), consistency (5,47) and bitterness (5,98). These values varied between 5 and 6 indicating that consumers slightly liked the product. According to the overall impression, the average score was 5.80, so, in general, panelists either liked or disliked the product. According to the purchase intent, the average score of the tasters was 3.04, thus panelists were not resistant to the products, indicating that "maybe bought, maybe didn't buy" this product (DAMÁSIO & SILVA, 1996). Because it is a product different from that consumers are used to find in the market, some resistance is natural in the acceptance of this product.

Table 3. Sensory analysis of cereal bars with the inclusion of fishmeal.

Parameters	Levels of inclusion of the fishmeal (%)				P-value ^a	CV (%)
	0	5	10	15		
Sensory properties ^b						
Color	7.06±0.17	7.02±0.13	6.72±0.17	6.76±0.13	0.628	23.53
Aroma	6.68±0.25	6.74±0.31	6.38±0.05	5.92±0.51	0.451	24.94
Texture	5.58±0.01	5.78±0.19	5.64±0.05	5.36±0.23	0.73	33.75
Flavor	5.6± 0.015	5.98±0.39	5.48±0.10	5.28±0.30	0.29	33.34
Consistency	5.59±0.12	5.57±0.09	5.28±0.19	5.45±0.02	0.82	33.29
Bitterness	6.04±0.05	6.19±0.20	5.88±0.10	5.83±0.15	0.69	27.58
Overall impression	5.76±0.03	6.26±0.46	5.62±0.17	5.54±0.25	0.16	29.86
Purchase intent ^c	3.08±0.04	3.26±0.22	3.02±0.01	2.78±0.25	0.212	37.57

Data expressed as mean ± standard deviation. ^a Tukey's test (p<0.05). ^b 9 point-hedonic scale. ^c 5 point-hedonic scale.

The similar results were recorded by Vitorino et al. (2019), who worked with the production, sensory analysis, and physical-chemical characterization of a sweet cereal bar prepared with the inclusion of tilapia and salmon flour, and presented average grades, according to the same application used (9-point hedonic scale), were 6.52, 5.80, 6.28, 6.30, 5.88 for color, flavor, texture, aroma and general impression, respectively.

Different from the present study Souza et al. (2017) observed the influence of the inclusion of fishmeal on sensory parameters of sweet cereal bars. However, these authors also obtained low intention to buy, even being conventional candy bars, which may be related to inclusion of fishmeal since this change characteristics as a color and a texture.

Thereby, further studies should address the inclusion of new ingredients and/or changes in the percentage of inclusion of these ingredients added in this experiment to check the acceptance. Also, the issue of agglutination of the ingredients for better compression of bars must be taken into account, which represented an obstacle found in this work.

For example, other products formulated with the inclusion of fishmeal and tested for their nutritional and sensory characteristics, such as spinach cake (GOES et

al., 2016) and onion biscuit (CORADINI et al., 2015) obtained good acceptance.

These results indicate a great technological application for fishmeal. It is a product that can be applied in several formulations and has shown significant results in the increase of nutrients such as proteins and minerals, which in the present study was not observed but reported by several authors. The use of this type of product in addition to improving the nutritional composition of foods also promotes an increase in fish consumption even indirectly. Another important point is that fishmeal is produced by fish industry waste, which prevents the waste from being discarded or subtilized, contributing to the sustainability of the sector and giving rise to a quality byproduct.

CONCLUSIONS

The fishmeal of tilapia with salmon has a high content of protein and minerals. Its inclusion in savory cereal bars increased the protein content by reducing the carbohydrate content. It can be concluded that, given the conditions evaluated, the addition of up to 15% fishmeal of tilapia with salmon into savory cereal bars improved their nutritional potential and these products were accepted by consumers. Other formulations should be tested, and can thus increase their overall impression

and eventually become a new product on the market, especially as an alternative to sweet products. The fishmeal of fish and cereal bars with the inclusion of different levels of this concentrate was within the microbiological standard for human consumption.

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