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Roll enriched with Nile tilapia meal: sensory, nutritional, technological and microbiological characteristics

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Abstract

This study evaluated the chemical composition, fatty acid profile, technological quality, sensory profile and microbiological characteristics of rolls with inclusion of 0, 5, 10 and 15% meal prepared with tilapia carcasses. Moisture and carbohydrate content were linearly reduced ($P < 0.05$) with increasing inclusion of tilapia meal, but a linear increase ($P < 0.0001$) was observed in protein (9.91 to 14.30%) and ash (1.74 to 4.65%) content. Lipids and calorific value of the rolls were not affected ($P > 0.05$) by inclusion levels, but 15% tilapia meal resulted in greater amount of polyunsaturated fatty acids (4.63%) in relation to 0% inclusion (4.46%). There was a linear increase ($P < 0.0001$) in the firmness of the breads (3.65 to 13.17N) and a linear decrease ($P < 0.001$) in volume and specific volume. Sensory attributes showed a negative linear effect ($P < 0.01$), with acceptance rates ranging from 85.24% (0% inclusion) to 70.57% (15% inclusion). It can be concluded that the inclusion of 5 to 15% tilapia meal in roll is effective to increase the protein, mineral matter, polyunsaturated fatty acids and the firmness of the roll, in addition to reducing carbohydrates and volume. Considering the reduction in sensory acceptance, it is recommended to use up to 10% tilapia meal in rolls.

Keywords: *Oreochromis niloticus*; waste reuse; fish protein concentrate.

Practical Application: Rools with meal prepared with tilapia carcasses have high nutritional value and great sensory profile.

1 Introduction

The eating habits has undergone diverse changes resulting from social, environmental and technological factors, replacing the consumption of natural foods with industrialized products, consequently reducing the intake of some essential nutrients, such as vitamins, minerals and fiber, and increasing the consumption of carbohydrates and fats. These changes have provided great business opportunities to the food industry, which has shown particular interest in improving the nutritional value of processed products (Collar, 2015), giving rise to fortified and enriched products.

Roll is present in 85% of the bread market in Brazil, the preferred product in all social levels (Carr et al., 2006). Nutritionally, this bread contains low protein content, high percentage of carbohydrates and small amounts of dietary fiber (Dhinda et al., 2012), and vitamins and minerals are also present in minor proportions (Adeleke & Odedeji, 2010). The inclusion of ingredients or partial replacement of wheat flour with other flours, of vegetable or animal origin, can increase the nutritional value of the bread.

Several techniques have been used to improve the nutritional composition of foodstuffs, for example, the partial or total replacement of some traditional ingredients with alternative products and developing products that add nutritional and technological quality associated with a low cost. Therefore, the fortification of these products can be made by the addition of cereals (e.g. barley, spelt, rye, einkorn, millet, oat, sorghum) or pseudocereals (e.g. quinoa, amaranth, buckwheat) (Angioloni & Collar, 2011) and food sources of animal protein, such as fish (Centenaro et al., 2007).

Fish and fish products are sources of protein with high biological value and excellent balance of essential amino acids (Centenaro et al., 2007), they are source of vitamins, minerals and essential fatty acids (Tacon & Metian, 2013; Cho & Kim, 2011) and, therefore, capable of increasing the nutritional value of the diet and foods receiving their supplementation.

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The goal of the present study was to evaluate the chemical composition, technical quality, sensory and microbiological profile of rolls added with meal prepared with Nile tilapia carcasses.

2 Material and methods

The bread making process was based on that described by El-Dash et al. (1994). The production of standard roll used the following proportion of ingredients: 100% special wheat flour for roll; 58% water; 1% yeast. The production of fortified rolls used three levels of inclusion of fish meal (5%, 10% and 15%) into the dough, replacing wheat flour.

Fish meal was produced from carcasses (spine with ribs and meat attached to bones after filleting) of Nile tilapia (*Oreochromis niloticus*) without head and fins. These were washed, weighed, added with BHT (0.01%) and cooked for 60 minutes. After, the material was drained and pressed in a hydraulic press (10 tons) to remove excess natural fat and the press cake was ground in an electric meat grinder (CAF). The obtained mass was evenly distributed on trays and dried in a forced ventilation oven at 60 °C for 24 hours. The dehydration product was ground in a knife mill, vacuum packed and frozen at -18 °C for later inclusion in the dough of rolls.

For production of rolls, ingredients were mixed in a spiral kneader (AES-25-Braesi) for 13 minutes (6 minutes at 90rpm, and 7 minutes at 180rpm). They were then divided into 60 g portions and rounded up. After resting for 20 minutes, balls were shaped with the aid of table moulder (MB35- Braesi), poured into molds and fermented for 105 minutes in a fermentation chamber for 24 trays. Breads were baked in a Tedesco gas oven (FTT240) at 180 °C for 20 minutes with forced air circulation and without steam injection. After cold, rolls were packed in plastic bags.

Microbiological analyses included the most probable number (MPN) of coliforms at 35 °C/gram and 45 °C/gram, *Staphylococcus* coagulase-positive count in CFU/gram and *Salmonella* spp, according to Americam Pubblic Health Association (1992).

Analyses for moisture, ash and proteins were carried out according to the methodology of Association of Official Analytical Chemists (2005) for samples of breads and tilapia meal. For lipids, we used the methodology of Bligh & Dyer (1959). Total carbohydrates were calculated by the difference in the sum of percentages of the compounds analyzed by 100%. The caloric value was calculated for 100g sample and for a serving of the product. Analyses were performed in triplicate for bread and tilapia meal, but for bread, five rolls were randomly selected per treatment.

To determine the fatty acid profile, total lipids were transesterified in accordance with the ISO method. Fatty acid methyl esters were separated on a gas chromatograph (Varian 3380) equipped with a flame ionization detector and a fused silica capillary column CP-7420 Select FAME (100 m long, 0.25 mm internal diameter, 0.25 μm cyanopropyl). The H_2 flow (carrier gas) was 1.0 mL/min, with 30 mL/min N_2 (makeup); 30 and 300 mL/min for H_2 and synthetic air for the flame detector. The injected volume was 0.2 μL, using a 1:80 split ratio, injector and detector temperatures were 220 and 240 °C, respectively, while the column temperature was 165 °C during 18min and raised to 235 °C at a rate of 4 °C/min, held for 24.5 min.

The identification of fatty acids were made using the following criteria: comparison of retention times of Sigma standard methyl esters (USA) with the samples and comparison of ECL (Equivalent Chain Length) values of methyl esters of samples with values found in Strànsky et al. (1997).

Technological characteristics of roll were evaluated about one hour after baking, determining the specific volume ($mL{\cdot}g^{-1}$) of the rolls obtained by the ratio between the apparent volume (mL) by the millet seed displacement, and weight (g) of bread (El-Dash et al., 1982). For pH, 10 grams of each sample was homogenized with 90 mL distilled water and the pH of this was measured using a potentiometer (0400, Quimis, São Paulo, Brazil), previously calibrated and operated according to the manufacturer's instructions.

For analysis of the bread texture profile, we evaluated firmness (N) and maximum compression (g) with the aid of a texturometer (TA-XT2i, Stable Micro Systems, Surrey, UK), equipped with cylindrical compression probe (TA -11), 35 mm in diameter. We used 2.0 mm/s pre-test speed and 5.0 mm/s test and post-test speed, 20 mm distance, 20 g trigger type and 5s time between compressions. For analysis of these parameters, the ends of the roll were removed, resulting in a cylinder with approximately 6.0 cm long (Carr & Tadini, 2003).

Values of lightness (L*) were measured using a colorimeter (MINOLTA CR-10, Minolta Camera Co., Osaka, Japan), at an angle of 90°, at room temperature, wherein L* defines the lightness (L*=0 black and L*=100 white), a* (red-green component) and b* (yellow-blue component).

Sensory analysis was performed with 50 untrained panelists, randomly selected and without any knowledge of the composition of the samples. Methods of sensory analysis was approved by the Comitê Permanente de Ética em Pesquisa com Seres Humanos (COPEP) of the Universidade Estadual de Maringá, Maringá PR Brazil (Protocol 458.151/2013-COPEP). We evaluated the attributes surface color, crumb color, appearance, aroma, texture, flavor and overall impression, using a 9-point hedonic scale, anchored between minimum and maximum: dislike extremely (1) to like extremely (9) (Dutcosky, 2011). With these data, we calculated the Acceptability Index (AI) using Formula 1 (Dutcosky, 2011):

$$IA\% = \frac{average\,score}{\max imum\,score} \times 100 \quad (1)$$

In addition, the panelists were asked about the purchase intent with a 5-point hedonic scale ranging from 1 (definitely will not buy) and 5 (definitely will buy), according to Dutcosky (2011).

For statistical analysis, we used the methodology of generalized linear models (GENMOD procedure) considering the distribution of variables as gamma with inverse link function, using the Statistical Analysis System (SAS, SAS Inst. Inc. Cary, NC, USA). It was considered the effect of treatment and panelists, testing the inclusion levels from regression analysis. A regression analysis at 5% significance level tested the other parameters. Fatty acid profile, pH and microbiological analysis were descriptively analyzed.

3 Results and discussion

The microbiological analysis of roll with different levels of inclusion of tilapia meal indicated a low number (<3 Most Probable Number/gram) of coliforms at 35 °C and 45 °C, < 10^2 Colony-Forming Units/gram of *Sthapylococcus* coagulase positive, as well as absence of *Salmonella* sp., showing that the rolls were fit for human consumption and within the microbiological standards required by the Brazilian legislation (Brasil, 2001).

The proximate composition of roll showed a significant effect ($P < 0.01$) between treatments for moisture, protein, ash and carbohydrates (Table 1). The contents of moisture and carbohydrates decreased linearly ($P < 0.05$) as increased inclusion of tilapia meal ($y = -0.20118x + 36.04926$, $R^2 = 0.58$ for moisture and $y = -0.28884x +50.90774$, $R^2 = 0.90$ for carbohydrates).

The decrease in moisture content may be related to moisture in the tilapia meal, which was 1.78%. Wheat flour contains average of 14.2% moisture (Van Steertegem et al., 2013), and when replacing the flour with tilapia meal (1.78% moisture), there was a reduction in the moisture content of the roll. Moisture is one of the most sensitive quality attributes, significantly interfering with deterioration after a few days of storage (Besbes et al., 2014), thus the reduction in moisture can be important to increase the shelf life of the product.

There was a linear increase ($P < 0.0001$) for crude protein ($y = 0.28142x + 10.28392$ $R^2=0.94$) and ash ($y = 0.192386x + 1.876885$ $R^2 = 0.97$), with 0% inclusion resulted in 9.91% protein and 1.74% ash, and 15% inclusion resulted in 14.30% and 4.65% of protein and ash, respectively. This increase was due to the protein and ash content present in Nile tilapia meal (51.13% crude protein and 37.66% ash).

Centenaro et al. (2007) developed bread with inclusion of wet and dried washed pulp of *Prionotus punctatus* and obtained average values of 11.0% crude protein for bread without inclusion of pulp, 15.5% with 3% dry pulp, 17.1% with 5% dry pulp and 17.5% with 50% wet pulp.

In breads added with 0, 5, 10, 15 and 20% tilapia protein concentrate, we can observe a linear increase in crude protein (9.08, 10.59, 12.14, 16.45 and 18.01%, respectively) and a decrease in carbohydrates (60.20, 58.00, 57.86, 48.91 and 49.05% respectively) (Adeleke & Odedeji, 2010), similar to the effect observed in this study for these variables. These results demonstrate that inclusion of fishmeal is effective to enrich bread with protein and other products such as pasta (Goes et al., 2016); khitchri (Hussain et al., 2007), snacks (Justen et al., 2016), salt biscuits (Ibrahim, 2009), among other products.

The reduction in carbohydrate content with the addition of fishmeal to roll is due to the reduced amount of wheat flour. Considering that wheat flour represented the largest source of carbohydrates in roll, this decrease was possibly because the inclusion of tilapia meal was over the total wheat flour; thus, the greater the inclusion, the lower the amount of wheat flour, which influenced directly on the roll carbohydrate content. Furthermore, carbohydrates values found in rolls of this study are lower than those obtained by Centenaro et al. (2007), who obtained carbohydrates from 77.6 to 83.5%.

The increased ash content of the roll (from 1.74 to 4.65% for 0 to 15% inclusion of fishmeal, respectively) can be considered beneficial, since aquatic animal food products are a richer source of most essential minerals and trace elements than most terrestrial meats (Tacon & Metian, 2013). In pasta with different levels of inclusion (0, 10, 20 and 30%) Nile tilapia meal, Goes et al. (2016) observed a linear increase in the concentrations of calcium, phosphorus, magnesium, sodium and zinc, showing that the inclusion of tilapia meal can improve the mineral profile of the product.

Lipid content and caloric value of rolls were not affected ($P > 0.05$) by different levels of inclusion of Nile tilapia meal, averaging 1.00% for lipids and 253.58 kcal/100 g for caloric value. However, the Nile tilapia meal used had 5.82% fat, and despite the lack of difference in lipid content, it can be verified changes in the fatty acid profile of the rolls, according to the different inclusion levels of fishmeal.

The fatty acid profile (Table 2) detected the predominance of oleic (18:1n-9c), palmitic (16:0) and stearic (18:0) acids in all rolls. This is due to tilapia meal composition, because in meals prepared with heads or spine of tilapia, there was a predominance of palmitic (16:0), oleic (18:1n-9) and linoleic (18:2n-6) acids (Souza et al., 2008).

The inclusion of 15% Nile tilapia meal into roll resulted in higher amounts of polyunsaturated fatty acids (4.63%), compared to roll without inclusion (4.46%). Moreover, the inclusion of 5, 10 or 15% Nile tilapia meal promoted an increase

Table 1. Proximate composition and caloric value of rolls with different levels of inclusion of Nile tilapia meal.

	Inclusion levels				P value
	0%	5%	10%	15%	
Moisture	37.00 ± 0.18	33.69 ± 0.69	33.89 ± 0.02	33.58 ± 0.09	0.0271[a]
Crude protein	9.91 ± 0.25	12.24 ± 0.04	13.13 ± 0.08	14.30 ± 0.19	<0.0001[b]
Lipids	0.82 ± 0.03	0.95 ± 0.01	1.26 ± 0.03	0.99 ± 0.01	0.1431
Ash	1.74 ± 0.04	3.01 ± 0.18	3.88 ± 0.11	4.65 ± 0.13	<0.0001[c]
Carbohydrates	50.53 ± 0.40	50.11 ± 0.54	47.84 ± 0.17	46.48 ± 0.23	0.0003[d]
Calorie (kcal/100g)	249.14 ± 0.53	257.97 ± 2.08	255.21 ± 0.39	251.99 ± 0.14	0.6599

[a]$y = -0.20118x + 36.04926$. $R^2 = 0.58$; [b]$y = 0.28142x + 10.28392$. $R^2 = 0.94$; [c]$y = 0.192386x + 1.876885$. $R^2 = 0.97$; [d]$y = -0.28884x + 50.90774$. $R^2 = 0.90$.Values presented as mean ± standard error of the mean.

in the content of omega-3 fatty acids (0.46, 0.49 and 0.49%, respectively) compared to the control roll (0.44%). For omega-6 fatty acids, the levels of 10 and 15% inclusion of meal had higher values (3.90 and 3.96%) in comparison with roll without Nile tilapia meal (3.84%). The highest amount of omega-6 in the rolls is related to the greater presence of this series of fatty acids in Nile tilapia, as pointed out by Bonafé et al. (2013).

The highest content of polyunsaturated fatty acids in roll added with tilapia meal demonstrates the improvement in the nutritional profile of roll, as these fatty acids, especially omega-3, are associated with many health benefits, mainly by reducing the incidence of cardiovascular diseases (Walker et al., 2013; Marik & Varon, 2009).

Table 2. Fatty acid profile (%) of rolls with different levels of inclusion of Nile tilapia meal.

Fatty acid (%)	Inclusion levels (%)			
	0	5	10	15
14:0	2.49	2.46	2.48	2.44
14:1	1.00	1.02	1.09	1.02
15:0	0.46	0.44	0.45	0.45
16:0	25.74	25.83	25.83	25.70
16:1n-9	0.29	0.21	0.23	0.29
16:1n-7	3.01	2.94	3.18	3.10
16:1n-5	0.56	0.41	0.53	0.58
17:0	1.08	1.07	1.07	1.08
18:0	15.61	15.54	15.03	15.70
18:1n-9c	42.62	43.50	43.24	42.12
18:1n-7	1.36	1.04	1.10	1.53
18:2n-6c	3.56	3.56	3.51	3.60
18:3n-6	0.15	0.15	0.15	0.16
18:3n-3	0.44	0.46	0.49	0.46
20:0	0.82	0.84	0.88	0.85
20:1n-9	0.37	0.39	0.37	0.39
21:0	0.13	0.14	0.13	0.14
20:3n-6	ND	ND	0.06	0.05
20:4n-6	0.13	ND	0.18	0.14
20:3n-3	ND	ND	ND	0.03
24:1n-9	0.17	ND	ND	0.18
Sum of saturated fatty acids	46.34	46.32	45.87	46.35
Sum of monounsaturated fatty acids	63.62	64.02	63.67	63.37
Sum of polyunsaturated fatty acids	4.46	4.17	4.39	4.63
n-3 sum	0.44	0.46	0.49	0.49
n-6 sum	3.84	3.70	3.90	3.96

ND = Non-detected.

As for the texture of roll (Table 3), the weight and the compression were not affected ($P > 0.05$) by different levels of inclusion of tilapia meal, with a mean weight of 49.82 g and mean compressive deformation of 961.90 Kgf. These values are within the standard range, since a typical roll in Brazil has 50 g final weight, 12.5 cm long and 5.5 cm in diameter (Carr et al., 2006).

Additionally, there was a linear increase ($P < 0.0001$) in the firmness of rolls, ranging from 3.65 N (0% inclusion) to 13.17 N (15% inclusion), according to equation $y = 0.6860x + 2.069$ ($R^2 = 0.74$). This indicates that, as fishmeal was added into the dough, there was an increase in dough stiffness and hardness, resulting in a more compacted mass (Figure 1). The increase in firmness may be due to the decrease in the amount of gluten as a function of the substitution of part of the wheat flour for fishmeal. According to Esteller et al. (2005), the addition of 3 and 6% of freeze-dried gluten lowered the firmness of hamburger buns.

For volume and specific volume (Table 3), it was observed that with increasing inclusion of fishmeal, there was a linear decrease in these parameters ($P < 0.001$). The roll volume decreased from 245.00 mL (0% inclusion) to 131.33 mL with 15% inclusion of fishmeal ($y = -7.4467x + 247.7667$; $R^2 = 0.92$). The specific volume showed a similar behavior, ranging from 4.53 mL g^{-1} with 0% inclusion to 2.33 mL g^{-1} with 15% inclusion ($y = -0.1438x + 4.566$ $R^2 = 0.99$), which represents a reduction of almost 50% of its specific volume. In this way, although the weight of roll has not changed, the specific volume varied significantly between treatments, with a linear reduction with increasing levels of inclusion of Nile tilapia meal. From a technological perspective, the reduced specific volume of rolls is a disadvantage, because it changes the conventional characteristics of the dough and can affect their acceptance.

The decrease in specific volume of roll was because the roll volume is given by entrapment of carbon dioxide, from the fermentation, by the gluten network (Verheyen et al., 2015). Therefore, replacing part of the wheat flour, which is the main source of sugars in the formulation, with fishmeal, a non-fermentable product, in addition to reducing carbon dioxide production tends to reduce the strength of the gluten network, resulting in a lesser entrapment of gas and, consequently, a smaller volume.

This same technology characteristic was also observed by Centenaro et al. (2007), where the specific volume of breads diminished gradually with the addition of 3 and 5% fish dried

Table 3. Analysis of texture, volume and pH of rolls with different levels of inclusion of Nile tilapia meal.

	Inclusion levels				P value
	0%	5%	10%	15%	
Weight (g)	49.30 1.22	50.50 ± 0.50	49.50 ± 0.50	50.00 ± 0.32	0.7017
Firmness (N)	3.65 ± 0.13	5.16± 0.47	7.68 ± 0.31	13.17 ± 0.59	<0.0001[a]
Compression (Kgf)	826.90 ± 78.51	1078.00 ± 93.77	1045.70 ± 104.53	897.00 ± 94.57	0.3350
Volume (ml)	245.00 ± 2.89	211.33 ± 9.26	180.00 ± 10.78	131.33 ± 5.92	<0.0001[b]
Specific volume (ml·g^{-1})	4.53 ± 0.09	3.84 ± 0.30	3.25 ± 0.33	2.33 ± 0.18	<0.001[c]
pH	6.04	5.89	5.94	5.89	-

[a]$y = 0.686033x + 2.069833$ $R^2 = 0.74$; [b]$y= -7.4467x + 247.7667$ $R^2 = 0.92$; [c]$y = -0.1438x + 4.566$ $R^2 = 0.99$. Values presented as mean ± standard error of the mean.

pulp (4.08 and 3.32 mL g^{-1}) and 50% fish wet pulp (2.29 mL g^{-1}). This suggests that when working with inclusion of fishmeal into bakery products, its inclusion should be done with caution to not harm the technological characteristics of the product. Sidwell & Hammerle (1970) concluded that an addition of 10% or more of fish protein concentrate changes the texture of breads, making dough coarser and more compact.

Moreover, the inclusion of tilapia meal in roll led to a reduction in pH (Table 4), which varied between 6.04 in the control roll and 5.89; 5.94 and 5.89 for 5, 10 and 15% inclusion, respectively. However, this pH remained within the expected range for bread (Buddrick et al., 2014).

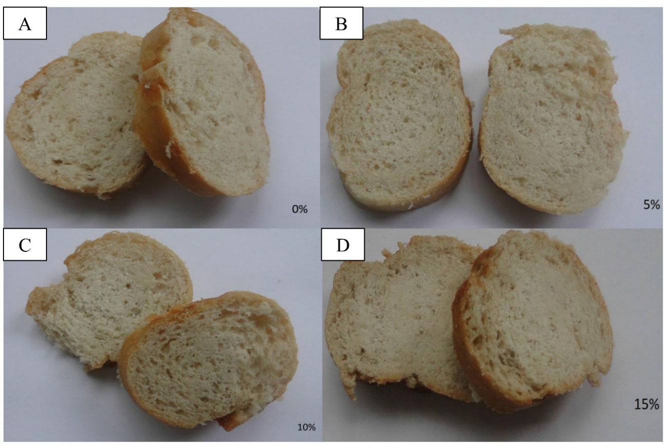

Figure 1. Roll with (A) 0%; (B) 5%; (C) 10% and (D) 15% inclusion of Nile tilapia meal.

Regarding the results of color of rolls with addition of Nile tilapia meal (Table 4), it can be seen that the lightness decreased linearly ($P < 0.0001$) with increasing levels of addition of tilapia meal. The chroma b* (yellow-blue component) showed a linear increase ($P = 0.0002$), from 17.30 for the level 0 to 19.03 for 15% inclusion. This demonstrates that the rolls became darker with the increase in inclusion levels of fishmeal, and this may occur by the color of the meal.

The sensory profile of roll (Table 5) clearly showed that the increase in fishmeal inclusion level caused a decrease in acceptance of the rolls, once there was a negative linear effect ($P < 0.01$) for all properties.

For the acceptability index, the control roll averaged 85.24%, and this value decreased linearly to 70.57% in roll with 15% inclusion of fishmeal. This reduction in acceptance may be related to increased firmness of rolls, as well as changes in color due to the inclusion of tilapia meal, as seen in the instrumental color analysis. Despite the decrease in acceptance of the roll containing fishmeal, the lower observed value (70.57%) can still be considered good, since Dutcosky (2011) recommends a minimum acceptance of 70% for the product is well accepted. Furthermore, scores above 6 (like slightly) indicate that the tasters had a positive acceptance of the product, regardless of treatment.

Breads included with 0, 5, 10, 15 and 20% tilapia protein concentrate developed by Adeleke & Odedeji (2010) had the same sensory acceptance up to 15% inclusion, and only the level of 20% protein concentrate resulted in lower preference. Also, Centenaro et al. (2007) reported an increasing rejection by panelists according to increased concentration of fishmeal in the formulation of bread, due to changes in flavor.

Table 4. Colorimetry of of rolls with different levels of inclusion of Nile tilapia meal.

	Inclusion levels				P-value
	0%	5%	10%	15%	
L*	76.78 ± 0.12	76.40 ± 0.28	76.11 ± 0.18	74.47 ± 0.25	<0.0001[a]
a*	6.39 ± 0.08	6.48 ± 0.12	6.15 ± 0.08	6.43 ± 0.14	0.6983
b*	17.30 ± 0.23	18.19 ± 0.18	17.93 ± 0.19	19.03 ± 0.28	0.0002[b]

[a]$y = -0.1443x + 77.0235$ $R^2=0.63$; [b]$y= 0.0991x + 17.3705$ $R^2=0.45$. Values presented as mean ± standard error of the mean. L*= lightness; a*= red-green component; b*= yellow-blue component.

Table 5. Sensory profile, acceptability index, purchase intent of of rolls with different levels of inclusion of Nile tilapia meal.

Attributes	Inclusion levels				P-value
	0%	5%	10%	15%	
Surface color[1]	7.96 ± 0.17	7.90 ± 0.15	7.78 ± 0.15	7.10 ± 0.17	0.0002[a]
Crumb color[1]	7.44 ± 0.18	7.20 ± 0.23	6.42 ± 0.27	6.04 ± 0.28	< 0.0001[b]
Appearance[1]	7.12 ± 0.21	7.12 ± 0.21	6.24 ± 0.28	5.70 ± 0.31	< 0.0001[c]
Aroma[1]	7.98 ± 0.17	7.74 ± 0.16	7.18 ± 0.21	6.98 ± 0.26	0.0001[d]
Texture[1]	7.58 ± 0.23	7.56 ± 0.19	7.10 ± 0.18	6.32 ± 0.25	0.0002[e]
Flavor[1]	7.64 ± 0.21	7.54 ± 0.19	6.90 ± 0.22	5.84 ± 0.27	< 0.0001[f]
Overall impression[1]	7.98 ± 0.18	7.76 ± 0.16	7.02 ± 0.21	6.48 ± 0.26	< 0.0001[g]
Acceptability index (%)	85.24 ± 1.37	83.84 ± 1.14	77.21 ± 1.48	70.57 ± 1.83	< 0.0001[h]
Purchase intent[2]	4.50 ± 0.11	4.26 ± 0.10	3.64 ± 0.13	3.14 ± 0.16	< 0.0001[i]

[1]Hedonic scale from 1 (dislike extremely) to 9 (like extremely); [2] Hedonic scale from 1 (definitely will not buy) to 5 (definitely will buy). [a]$y = -5.4x + 8.09$ $R^2 = 0.77$; [b]$y = -9.96x + 7.522$ $R^2 = 0.96$; [c]$y = -10.28x + 7.316$ $R^2 = 0.89$; [d]$y = -7.12x + 8.004$ $R^2 = 0.96$; [e]$y = -8.48x + 7.776$ $R^2 = 0.86$; [f]$y = -12.08x + 7.886$ $R^2 = 0.88$; [g]$y = -10.48x + 8.096$ $R^2 = 0.96$; [h]$y = -101.28x + 86.811$ $R^2 = 0.93$; [i] $y = -9.4x + 4.59$ $R^2 = 0.97$. Values presented as mean ± standard error of the mean.

The sensory characteristics most altered by the inclusion of 15% fishmeal in the roll were appearance (5.70) and flavor (5.84), indicating a lower acceptance for these characteristics, since the scores were between 5 (neither like nor dislike) and 6 (like slightly). The lowest score for purchase intent (3.14) was also observed for 15% inclusion, indicating indecision of tasters as too the purchase of this bread (score 3 = maybe buy/maybe not buy).

As rolls are accepted and consumed by people of any age and social class, the products developed in this work represent a practical and healthy option that can be used to improve the profile of protein, mineral and fatty acids taken daily.

4 Conclusion

The addition of 5 to 15% Nile tilapia meal to roll has proven to be effective to increase the content of protein and mineral matter of the roll, besides reducing carbohydrate content. The increase in the level of inclusion of Nile tilapia meal increases the firmness of roll and decreases its volume and reduces the acceptance of the product. Therefore, it is recommended to use up to 10% of tilapia meal in roll.

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