Original Article
Food Science and Technology

ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)

DOI: https://doi.org/10.1590/fst.49821

Fish breaded made with tilapia fillet and inclusion of minced fish derived from salmon processing: nutritional, technological, and sensory properties

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Abstract

The fish processing processes generate a large volume of residues, so, an alternative for the use is the production of minced fish (MF). Thus, this study aimed to develop breaded with different concentrations of MF of salmon and tilapia fillet, and to analyze the chemical, physical and microbiological characteristics, as well as to determine the acceptability and purchase intention of the formulations. In technological and nutritional terms, the use of salmon MF in the production of breaded products did not detract from the quality of the final product, indicating a viable alternative for the use of salmon waste.

Keywords: waste utilization; development of new products; *Salmo salar*.

Practical Application: Sensory, healthiness, practicality, and sustainability are new product trends.

1 Introduction

Sensory, healthiness, practicality, reliability, and sustainability are seen as the pillars of the food trend (Instituto de Tecnologia de Alimentos, 2020), thus, the search for new processing techniques and also the use of raw materials that add value to the final product and provide reduction costs, are of great relevance to the food industries.

In the meat products sector, beef, pork and poultry foods have been satisfactorily attending to these criteria, as can be seen by the increase in the consumption of fast-prepared foods in recent years (Garcia-Santos et al., 2019). On the other hand, the association of fast food consumption with the increase in diseases, such as obesity, makes it necessary to search for raw materials and ingredients that improve the nutritional value of these products. In this sense, nutrients can be acquired in greater quantity and more efficiently in fish meats, since they have proteins of high biological value, due to the presence of all essential amino acids, in addition to vitamins, minerals and polyunsaturated fatty acids (Santos et al., 2018; Ogawa & Maia, 1999).

Among the fish, the main highlight in fish farming is tilapia, which remained the leader of aquaculture species produced in Brazil in 2019, reaching 432,149 tons, 57% of all national fish farming. Besides, due to the increase in demand for traditional cuisines from all over the world, mainly Japanese, salmon was the main species imported by Brazil in 2019, totaling US$ 579 million (Associação Brasileira da Piscicultura, 2020).

As a consequence, the industrialization of these raw materials is increasing, however, the fish processing processes generate a volume greater than 50% of residues, which when not properly used, in addition to being a source less than a monetary resource, may become harmful and polluting to the environment (Pinto et al., 2017). Considering that these residues contain a high nutritional value, it is necessary to use them for the development of new products to add economic and environmental value to the final product. For this, an alternative for the fish industry to take advantage of the agro-industrial residues generated and to diversify the portfolio is the production of minced fish (MF) and its application in the formulation of fish meat products.

Among the various possibilities of using fish in semi-finished products, breaded products are products that fit the preference of the consumers because they are easily prepared foods, which suggests their good acceptance by the population. Normative Instruction No. 6 of February 15, 2001, of the Ministry of Agriculture, Livestock and Supply (MAPA), defines breaded as a product obtained from the meat of different species of animals of the butcher, plus ingredients and coated with an appropriate cover that characterizes it (Brasil, 2001).

Thus, to improve the nutritional quality of this meat product, as well as to meet market demand and meet consumer expectations, this study aimed to develop and characterize the different formulations of breaded fish, made with minced fish from salmon and tilapia fillet.

2 Material and methods

2.1 Raw materials and ingredients

The salmon fillet residues were donated by the Clube do Sushi Restaurant, located in Lavras, Minas Gerais, Brazil. The residues, composed of the ridge of the spine without head and

Received 01 Jul., 2021
Accepted 09 Nov., 2021
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viscera, were washed as soon as received and stored in a vertical freezer (GTPC555 model, Gelopar, Chapada Araucária, Brazil) at -18 °C, until the time of preparation of the MF.

The carcasses that presented good quality, with characteristics of color, odor and texture inherent to the fish, were submitted to the band saw table (1.69 model, CAF Máquinas, Rio Claro, Brazil) to remove the skins and fins. Soon after, they were processed in an electric pulper (HT 100C model, High Tech, Chapecó, Brazil), obtaining the minced fish (MF). The MF of salmon was packaged in plastic polyethylene bags, where it was added in each package approximately 1000 g and were immediately stored in a vertical freezer at a temperature of -18°C until the preparation of breaded.

The frozen tilapia fillets and other ingredients used in the formulation were purchased from commercial establishments in the city of Lavras. For the preparation of the breaded products, in addition to raw materials (salmon MF and tilapia fillet), the following ingredients were used: textured soy protein (Nayná Produtos Naturais), corn starch (Pachá Alimentos), refined iodized salt (Swan), soybean oil (Concórdia), monosodium glutamate (Ajinomoto), garlic powder and onion powder. Besides, a liquid was used to powder, composed of powdered milk (Cotochés), corn starch (Pachá Alimentos), wheat flour (Santa Luzia), salt (Swan) and water. To powder, rose flour (Pachá Alimentos) and flaked corn flour (Yoki Alimentos) were used.

2.2 Breaded developments

The formulations for obtaining breaded products, with different salmon MF percentages (0%, 25%, 50%, 75%, and 100%) are described in Table 1. The other ingredients used in the preparation of breaded products were added in the same proportions in five treatments.

For the preparation, initially, the hydration of the textured soy protein (TSP) was carried out and for the grinding of the tilapia fillet, a multiprocessor was used (103301022 model, Philco, Manaus, Brazil). Then, MF, TSP already hydrated and corn starch were added to form a meat mass. Subsequently, the rest of the ingredients were added until a homogeneous mass was obtained, massaging it for 10 minutes. The air was removed from the dough and left under refrigeration at 4 °C for about 15 minutes, so that the product was then molded, in units of approximately 30 g of dough, with standard aluminum shapes and breaded following the order: 1) Breading liquid; 2) Rose flour; 3) Breading liquid and 4) Flaked corn flour. Finally, they were stored under freezing in a vertical freezer at -18 °C, until the time of analysis.

2.3 Analysis

The analysis of breaded were performed in four replications. For characterization, the analysis of the proximal composition, texture profile and color (L*, a* and b*) were performed on breaded. Besides, the microbiological quality was verified, as well as the acceptance and purchase intention of the formulations by consumers through sensory analysis.

2.4 Proximal composition

The proximate evaluation of the different breaded samples was carried out, determining the degree of moisture and ash content by the gravimetric method, the levels of fat by the Soxhlet method, crude protein by the Kjeldahl method, and the calculation of the carbohydrates levels was performed using the difference method, following the methodology proposed by the Association of Official Analytical Chemists (2005).

Table 1. Fish breaded formulations prepared with different percentages of minced fish from salmon (0%, 25%, 50%, 75%, and 100%) replacing the tilapia fillet.

Ingredients	Treatments (wt. %)				
	F1	F2	F3	F4	F5
Tilapia fillet	56.00	42.00	28.00	14.00	0.00
MF of salmon	0.00	14.00	28.00	42.00	56.00
Textured soy protein	9.34	9.34	9.34	9.34	9.34
Maize starch	16.46	16.46	16.46	16.46	16.46
Salt	4.21	4.21	4.21	4.21	4.21
Soy oil	1.05	1.05	1.05	1.05	1.05
Monosodium glutamate	1.27	1.27	1.27	1.27	1.27
Garlic powder	5.27	5.27	5.27	5.27	5.27
Powdered onion	6.40	6.40	6.40	6.40	6.40
Breading liquid					
Powdered milk	11.75	11.75	11.75	11.75	11.75
Wheat flour	29.38	29.38	29.38	29.38	29.38
Water	58.87	58.87	58.87	58.87	58.87
Breading flour					
Rose flour	50.00	50.00	50.00	50.00	50.00
Corn flour	50.00	50.00	50.00	50.00	50.00

F1 – 0% of MF; F2 – 25% of MF; F3 – 50% of MF; F4 – 75% of MF; F5 – 100% of MF.

2.5 Physical characterization

2.5.1 Sample preparation

To carry out the instrumental color analysis, the samples used were raw and without breading, being fragmented and homogenized. In determining the texture profile, the different breaded formulations were subjected to cooking by immersion in oil and cut into cylindrical slices 25 mm high and 15 mm in diameter.

2.5.2 Instrumental color

The color measurement was performed in a colorimeter (CM5 model, Konica Minolta Spectrophotometer, São Paulo, Brazil), using the CIELab color system, defining the parameters L*, a* and b* where: L* provides us with luminosity and varies from white (L = 100) to black (L = 0); a* characterizes the intensity of red (+ a*) to green (-a*) and b * indicates coloration in the range of yellow (+ b*) to blue (-b*) (Harder et al., 2007).

2.5.3 Texture profile

The parameters of the texture profile (TPA) - hardness, cohesiveness, elasticity, adhesiveness and chewability - were obtained according to Nascimento et al. (2007), using a previously calibrated texturometer (TA. XT Plus/50 model, Stable Micro Systems, Godalming, UK). To perform the tests, the measurement conditions were standardized in: I) pre-test, test and post-test speed of 2 mm/s; II) compression distance of 25 mm; III) axial compression of 50% of the size of each sample in two consecutive cycles; and IV) 36 mm diameter stainless steel cylindrical probe. Data collection and construction of TPA curves were performed using the Exponent Lite Express program (version 5.1).

2.6 Microbiological analysis

To guarantee the microbiological quality of the breaded, a total count of aerobic mesophilic microorganisms (in plates) was performed; the coliform count at 35 °C and 45 °C, positive coagulase *Staphylococcus* and *Salmonella* sp., and the total count of filamentous and yeast-like fungi. For each analysis, the samples were homogenized and diluted according to the methodology described in Normative Instruction No. 30 (Brasil, 2018) and Normative Instruction No. 60 (Brasil, 2019).

2.7 Sensory analysis

Before conducting the sensory analysis, the project was submitted to the Research Ethics Committee in human beings linked to the Dean of Research, at UFLA. The project was approved with opinion number 2.995544. After the approval, a sensory analysis was carried out with 100 tasters of different ages, who reported not having experiences of allergic reactions or intolerance to the ingestion of product intake fish-based and seafood. About 10 g of breaded from each formulation were offered in disposable plastic cups, coded with three-digit numbers, and presented to the tasters in a balanced and randomized way, in addition, mineral water was offered for cleaning the taste buds (Stone & Sidel, 2004).

2.7.1 Acceptance test and purchase intention

The test affective of acceptance was applied to determine how much the tasters liked or disliked the final product. The tasters were asked to evaluate the sensory attributes (color, appearance, texture, taste and overall liking), using a nine-point structured hedonic scale (9 - I extremely liked it; 1 - I extremely disliked it). Together, the purchase intention test was carried out, using the five-point structured scale, the ends of which correspond to certainly not buy (1) and certainly buy (5), according to the methodology described by Stone & Sidel (2004).

2.8 Experimental design and statistical analysis

The experiment was conducted in a completely randomized design (DIC), with 5 treatments (formulations) and 4 repetitions for all analysis. The effects of the different treatments were evaluated by analysis of variance (ANAVA), followed by the Tukey mean test ($p \leq 0.05$). These analyses were performed using the Sisvar software version 5.6.

To verify the data on the global acceptance of the product, considering the individual response of each consumer, in correlation to the data obtained in the chemical (chemical composition) and physical (texture profile) analyzes, it was carried out through the multivariate analysis called Map of Vector External Preference (MPE), which is based on Principal Component Analysis (PCA). Plotting was performed with the aid of SensoMaker version 1.8 (Pinheiro et al., 2013).

The analysis of the results of the purchase intention test (structured five-point scale) was performed using univariate analysis (ANAVA) and Tukey's means test ($p \leq 0.05$) using the SensoMaker version 1.8 software.

3 Results and discussion

3.1 Proximal composition

Table 2 shows the mean values (%) of the proximal composition of breaded products, prepared with partial replacement of the tilapia fillet with minced fish from salmon.

Table 2. Mean values (%) of the proximal composition of fish breaded made with different percentages of salmon MF and tilapia fillet.

Formulations	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	Carbohydrates (%)
F1	58.18 ± 1.60^a	1.08 ± 0.10^e	12.74 ± 0.25^a	2.65 ± 0.14^a	24.35 ± 1.47^e
F2	51.13 ± 1.68^b	3.03 ± 0.20^d	11.26 ± 0.69^b	2.61 ± 0.09^a	31.97 ± 1.98^d
F3	48.68 ± 0.58^c	6.51 ± 0.39^c	9.55 ± 0.49^c	2.56 ± 0.08^a	31.73 ± 1.75^c
F4	47.52 ± 1.01^c	7.91 ± 0.22^b	9.45 ± 0.56^c	2.60 ± 0.48^a	32.52 ± 1.21^b
F5	45.87 ± 1.07^d	10.52 ± 1.15^a	7.72 ± 0.48^d	2.92 ± 0.08^a	32.97 ± 1.89^a

F1 - 0% MF; F2 - 25% MF; F3 - 50% MF; F4 - 75% MF; F5 - 100% MF. Means followed by the same letter in the column do not differ by the Tukey test at the 5% level of significance.

According to the results presented, the replacement of the tilapia fillet by the salmon MF had a significant effect ($p \leq 0.05$) on the degree of moisture on the levels of fat, protein, and total carbohydrates. Only the ash content has not undergone any significant change. Table 2 shows that the formulation F1 (0% MF) obtained the highest mean humidity value (59.18%) followed, in decreasing order, by the other formulations F2, F3, F4 and F5. This behavior can be explained by the fact that the MF has a lower water content when compared to the fillet.

According to Lago et al. (2018), due to rigorous grinding during the process of obtaining the MF, there is a breakdown of the organizational structure of the muscle causing water loss. That is, when MF is added to the formulation it causes a decrease in moisture compared to a fillet formulation. Humidity is related to stability, quality and composition, which can affect the product's storage, packaging and processing (Barreto et al., 2017).

Concerning the fat, the samples were influenced by the increasing substitution of the fillet by MF, and the fat content showed an increase due to the higher concentrations of MF in the samples. In addition to salmon having a higher fat content (10.0% or more) when compared to tilapia (2.0-5.0%), this increase in the fat percentage of the products is also related to the fact that minced fish is extracted from the fish's abdominal muscles, which are rich in lipids (Taşbozan & Gökçe, 2017). Besides, according to Olopade (2015), moisture has an inverse correlation to fat content. This statement is consistent with the results found in the present study, since, when the sample had a higher percentage of moisture, it had a low percentage of lipids. The fat content in breaded products increased from 1.07% to 10.51% and the degree of humidity decreased from 59.18% to 45.87%, as the substitution of 0 to 100% of MF, in that order.

The crude protein content decreased from 12.74% (without the addition of MF) to 7.72% (100% of MF). The behavior of the crude protein values is inversely correlated with the behavior of the fat values of the breaded, since formulation F5 (100% MF) had the highest lipid content (10.51%) and the lowest protein content gross (7.72%). Similar results were observed by Fukushima et al. (2014), in breaded of fish with a reduction of 18.08% to 11.94% of the protein content with the increased inclusion of the salmon pulp.

The Brazilian legislation regulates that breaded products made with meat from butchers must have a minimum of 10% protein (Brasil, 2001). Taking into account the standard deviation of the means, shown in Table 2, formulation F5 (100% MF) does not reach the minimum required protein value. It is worth mentioning that the aforementioned legislation does not establish criteria for breaded made with fish meat.

Regarding the calculated carbohydrate content, the results show that the F1 (0% MF) and F5 (100% MF) formulations had the lowest mean value (24.35%) and the highest mean (32.97%), respectively. The Brazilian law establishes that breaded products must have a maximum of 30% of carbohydrates (Brasil, 2001), considering the values of standard errors obtained in the analysis of variance and presented in Table 2, the formulations F4 (75% MF) and F5 (100% MF) would exceed this limit. However, carbohydrates are present in fish in the form of glycogen in the connective tissue in a minimal percentage (Minozzo, 2011), so the levels of carbohydrates are related to breadcrumbs, which increases the product's yield levels, thus, excessive crunching should be avoided.

3.2 Instrumental color

The instrumental color evaluation of fish breaded samples was carried out to verify if there were changes in the color intensity between the different formulations, due to the increasing addition of salmon MF. Table 3 shows the means obtained for the parameters L* (brightness from white to black), a* (intensity of the color red to green) and b* (intensity of the color yellow to blue).

The L* value (luminosity) of the breaded was influenced by the different concentrations of MF in the formulations. It is noted that there was a decrease in this parameter as the percentage of MF concerning the fillet increased. Similar results were observed by Lago et al. (2018) in tilapia sausages, which noticed lower luminosity the greater the amount of MF added to the formulation, that is, darker color.

As for the parameter a*, it was possible to observe an increase in the intensity of red with the inclusion of MF in the formulations, the higher the mean, the greater the intensity of the red color. This was already expected, as the MF of salmon has an intense orange-red color, due to the astaxanthin pigment present in the musculature of the fish. Uyhara et al. (2008), also found that the use of MF caused the darkening of fish sausages, and justified this fact due to the incorporation of flippers pigments and skin debris present in the carcasses during the passage of leavings through the meat and bone separating machine.

For the b* value, there was also an influence of the MF content between the samples, showing an increasing behavior of the means along with the addition of salmon pulp. This means that the higher the MF content, the greater the intensity of the yellow color in the analyzed sample.

3.3 Texture profile

Table 4 presents the means and standard deviations of the analysis of the texture profile of the different breaded treatments.

As for elasticity or flexibility of breaded, there was a decrease ($p \leq 0.05$) in the formulation means, due to the addition of salmon MF. Similar to this work, Jiménez-Colmenero et al. (2010), associated the highest mean values determined for

Table 3. Mean instrumental color and standard deviation, of the parameters L*, a* and b* of the tilapia fillets and salmon MF.

Formulations	L*	a*	b*
F1	53.75 ± 0.31^{a}	5.88 ± 0.03^{e}	23.60 ± 0.23^{d}
F2	52.36 ± 0.13^{b}	8.51 ± 0.20^{d}	24.89 ± 0.26^{c}
F3	51.94 ± 0.25^{c}	11.70 ± 0.09^{c}	26.63 ± 0.15^{b}
F4	51.80 ± 0.11^{c}	12.51 ± 0.15^{b}	26.73 ± 0.10^{b}
F5	51.11 ± 0.09^{d}	14.44 ± 0.08^{a}	27.49 ± 0.06^{a}

F1 - 0% MF; F2 - 25% MF; F3 - 50% MF; F4 - 75% MF; F5 - 100% MF. Means followed by the same letter in the column do not differ by the Tukey test at the 5% level of significance.

the elasticity at the lowest levels of fat in the samples. In other words, the formulation F1 (0% MF) which has the lowest lipid content (Table 2) and the highest moisture content, showed the highest mean elasticity, as the starch used as an ingredient in the formulations establishes interactions with the moisture of the sample, forming elastic bonds.

Concerning cohesiveness, the inclusion of MF resulted in a decrease ($p \leq 0.05$) of this parameter. Lago et al. (2018), shows that the food matrix maintains its structure with the inclusion of MF up to values close to 50%. From this concentration the structure this raw material becomes predominant over the product, generating weaker networks, which reduces the cohesiveness values.

The hardness of breaded decreased from 595.98 g (0% MF) to 198.02 g (100% MF). The behavior showed a 66.77% decrease in hardness comparing the formulation without adding MF and the formulation with 100% MF. For the chewability parameter, lower means are also observed for formulations added with higher percentages of MF, which ranged from 172.38 g.mm to 26.64 g.mm. This behavior can be explained due to the increased content of fat during the addition of MF in the formulations (Table 2), which causes an increase in the softness of the samples and juiciness to the products developed.

The breaded showed greater adhesiveness with the increase in the MF concentration, between 1.32 and 1.90 (from 0% to 100%). Carneiro et al. (2011), define adhesiveness as the force necessary to remove a material that adheres to the mouth, so the more difficult it is to detach food from the teeth, the greater its adhesiveness. A similar result was observed by Lago et al. (2018) tilapia sausages, who noticed an increase in this parameter (4.35 g.s to 10.97 g.s) with the inclusion of MF.

In practice, the greater inclusion of MF contributed to the formation of products with a more brittle texture, which showed a tendency to disintegrate during the processing of frying and cutting. Lago et al. (2018), highlights that the processing of minced fish causes ruptures and protein denaturation and, consequently, there is a loss of functional properties. Thus, as observed in this study, the addition of minced fish to products results in a significant variation in texture parameters.

3.4 Microbiological analysis

In Table 5, are represented the criteria and results found for the microbiological analysis performed.

Fish is a food that is easily contaminated and decomposed, due to factors inherent to fish, especially high pH, water activity, nutrient content and endogenous proteins (Santiago et al., 2013). Because of this, it is necessary to adopt good practice measures in the handling and conservation of fish. To guarantee the quality of food, it must comply with the microbiological standards defined by ANVISA, as shown in Table 5, the formulations of breaded analyzed in this study presented results according to the criteria established by Normative Instruction No. 60 (Brasil, 2019) that tend to ensure the supply of hygienic-sanitary quality food.

3.5 Sensory analysis

Of the total of 100 tasters who participated in the sensory test, 65% were female and 35% male, among 80% were between 18 and 25 years old. When asked about the frequency of consumption of fish meat, only 3% said they consume fish twice a week; the remainder showed a balance between consumption once a month (28%), twice a month (27%) and rarely (23%). These data corroborate the fact of the low consumption of fish in Brazil, because according to Peixe BR (Associação Brasileira da Piscicultura, 2019), the Brazilian has an mean consumption of 9,0 kg per inhabitant/year, and, according to the report of the Food and Agriculture Organization of the United Nations (2020), the global consumption per capita is 20.5 kg/year. Therefore, there is a need for the fish industry to seek solutions to improve the commercialization of fish, to serve the public that is increasingly looking for ready-made products.

Table 4. Texture profile of the tilapia fillets and salmon MF.

Formulations	Elasticity (mm)	Cohesiveness	Hardness (g)	Chewiness (g.mm)	Adhesiveness
F1	0.651 ± 0.01^a	0.354 ± 0.02^a	595.98 ± 54.69^a	172.38 ± 16.44^a	-1.32 ± 0.17^a
F2	0.435 ± 0.04^b	0.324 ± 0.01^a	262.82 ± 23.31^b	24.51 ± 2.01^b	-1.34 ± 0.27^a
F3	0.441 ± 0.02^b	0.328 ± 0.01^a	212.71 ± 20.31^b	38.49 ± 6.60^b	-1.30 ± 0.28^a
F4	0.459 ± 0.02^b	0.335 ± 0.01^a	223.28 ± 18.37^b	26.06 ± 3.71^b	-1.74 ± 0.16^a
F5	0.332 ± 0.01^c	0.272 ± 0.02^b	198.02 ± 24.38^b	26.64 ± 5.02^b	-1.90 ± 0.46^b

F1 - 0% MF; F2 - 25% MF; F3 - 50% MF; F4 - 75% MF; F5 - 100% MF. Means followed by the same letter in the column do not differ by the Tukey test at the 5% level of significance.

Table 5. Microbiological pattern of breaded.

Analysis	*Staphylococcus positive coagulase* (CFU/g)	*Salmonella* sp. (CFU/g)	Total coliforms (MPN/g)	Aerobic mesophiles (CFU/g)	Fungi and yeasts (CFU/g)
Limits	10^2 (1)	Absent (1)	-- (2)	-- (2)	-- (2)
F1	$< 10^2$	Absent	$< 10^3$	$< 10^2$	$< 10^2$
F2	$< 10^2$	Absent	$< 10^3$	$< 10^2$	$< 10^2$
F3	$< 10^2$	Absent	$< 10^3$	$< 10^2$	$< 10^2$
F4	$< 10^2$	Absent	$< 10^3$	$< 10^2$	$< 10^2$
F5	$< 10^2$	Absent	$< 10^3$	$< 10^2$	$< 10^2$

F1 - 0% MF; F2 - 25% MF; F3 - 50% MF; F4 - 75% MF; F5 - 100% MF.(1) Normative Instruction No. 60 (Brasil, 2019), (2) - No limit established by law.

Table 6. Mean scores attributed by the tasters to the breaded of fish in terms of sensory attributes (appearance, texture, taste and overall liking) and purchase intention test, and standard deviation.

Formulations	Appearance	Texture	Taste	Overall liking	Purchase intention
F1	7.22 ± 1.50[a]	6.93 ± 1.38[a]	7.14 ± 1.42[a]	7.17 ± 1.27[a]	3.94 ± 0.99[a]
F2	7.09 ± 1.42[a]	7.08 ± 1.37[a]	7.22 ± 1.41[a]	7.11 ± 1.34[a]	3.84 ± 1.06[a]
F3	6.82 ± 1.58[ab]	6.72 ± 1.83[a]	7.08 ± 1.56[a]	6.95 ± 1.58[a]	3.67 ± 1.13[a]
F4	6.92 ± 1.38[ab]	7.03 ± 1.63[a]	7.18 ± 1.43[a]	7.13 ± 1.38[a]	3.82 ± 1.01[a]
F5	6.44 ± 1.70[b]	6.44 ± 1.85[b]	6.31 ± 1.70[b]	6.28 ± 1.70[b]	3.19 ± 1.16[b]

F1 - 0% MF; F2 - 25% MF; F3 - 50% MF; F4 - 75% MF; F5 - 100% MF.Means followed by the same letter in the column do not differ by the Tukey test at the 5% level of significance.

Regarding the acceptance of breaded, the mean values of the grades attributed by the tasters are shown in Table 6, observing a significant difference ($p \leq 0.05$) in the acceptance of the different formulations of the breaded concerning all the evaluated attributes (appearance, texture, taste, and overall liking).

In general, it can be observed that the F5 formulation (100% MF) was the one that most differed ($p \leq 0.05$) significantly from the other treatments in practically all attributes, except concerning the appearance, where it presented a behavior similar to formulations F3 (50% MF) and F4 (75% MF), but differed from the others. Besides, it was found that F5 had the lowest means concerning all the sensory attributes evaluated, demonstrating to be the formulation less accepted by the tasters.

Regarding the formulations F1, F2, F3 and F4 these did not differ significantly for any of the evaluated sensory attributes. One of the most important factors for the development of new products is the acceptance by consumers (Correia et al., 2001). In general, the mean scores of the samples for the sensory attributes were on the hedonic scale between 6 and 8, the region of the category "I liked it a little" and "I liked it a lot", respectively. Thus, it can be said that the different formulations of the breaded presented satisfactory results and that the inclusion of MF is a viable alternative to reduce product cost and waste disposal, promoting the development of new quality products, with value aggregate and that meet consumer satisfaction.

To assess the overall acceptance of the samples taking into account the opinion of each taster and, also, to correlate this preference with the data of the chemical and physical analyzes, the External Preference Map (MPE) was made with the parameters of hardness and chewability (texture profile), moisture and fat (proximal composition), since, during the tasting, they are easily perceptible and directly influence the sensory acceptance of the product developed. Through the MPE (Figure 1) it was possible to view the attributes that characterized each sample.

According to the MPE, the spatial distribution of the F1 sample was directly influenced by hardness, and also by chewability and moisture content. The formulation F5 was the least accepted sample and was influenced by the fat content present in its proximal composition, standing out from the other samples. Formulations F3 and F4 suffered little influence from physical parameters, and the fat content, although little influential, interfered in the preference of these samples. As for the formulation F2, it was the least affected by all the parameters analyzed.

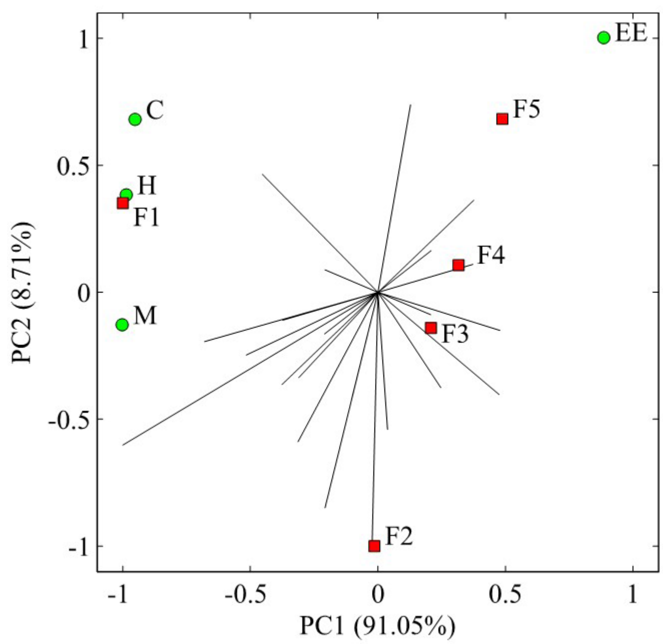

Figure 1. External preference map for the global impression of breaded correlated with the chemical and physical parameters. F1 - 0% MF; F2 - 25% MF; F3 - 50% MF; F4 - 75% MF; F5 - 100% MF. M - moisture; EE - ether extract (fat); H - Hardness and C - Chewiness.

The mean scores for the purchase intention parameter ranged from 3.19 to 3.94, standing on the hedonic scale of 5 points between 3 and 4, the region of the category corresponding to "maybe buy" and "probably buy" the product, respectively. In general, the result found shows that there was an interest in the tasters in the breaded developed, being that the formulations F1, F2, F3 and F4, obtained the highest scores and not differed statistically from each other.

It is also observed that the F5 formulation (100% MF) showed a lower mean value of buy intention and according to Table 6, this formulation presented the lowest means concerning all evaluated sensory attributes (appearance, texture, taste and overall liking), demonstrating to be the formulation less accepted by the tasters. This because it is the formulation with the highest mean concerning the parameters: lipid content (Table 2), hardness and chewiness (Table 4). These attributes directly influence the acceptance of the formulations by the tasters, with the fat content being the parameter that most influenced the acceptance of formulation 5, as evidenced by Figure 1.

4 Conclusions

In technological and nutritional terms, the use of salmon MF in the production of breaded products did not detract from the quality of the final product. It was verified that, in general, the breaded products developed met the requirements established by the legislation, regarding breaded products for human consumption. Except for the carbohydrate content in samples F4 (75% MF) and F5 (100% MF), which were above the permitted level, requiring a reduction in the flour of breading.

In relation to sensory analysis, it was found that consumers showed a high level of acceptability for formulations with 0, 25, 50 and 75% MF of salmon, and it is also possible to state that these formulations showed satisfactory results in the purchase intention. This demonstrates that if the product were made available on the market, it would possibly be purchased by consumers. Therefore, the preparation of this product is a viable alternative for the use of salmon waste.

Acknowledgements

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001. The authors wish to thank the financial support the Conselho Nacional de Desenvolvimento Científico e Tecnológico – Brasil (CNPq) and the Fundação de Amparo à Pesquisa do Estado de Minas Gerais – Brasil (FAPEMIG).

References

Associação Brasileira da Piscicultura – PEIXE BR. (2019). *Anuário Peixe BR da Piscicultura*. Retrieved from https://www.peixebr.com.br/anuario-peixe-br-da-piscicultura-2019/

Associação Brasileira da Piscicultura – PEIXE BR. (2020). *Anuário Peixe BR da Piscicultura*. Retrieved from https://www.researchgate.net/publication/339303553_Anuario_PeixeBR_2020_-_BRASIL_EXPORTA_US_12_MILHOES_EM_PEIXES_DE_CULTIVO_TILAPIA_LIDERA

Association of Official Analytical Chemists – AOAC. (2005). *Official Methods of Analysis of the AOAC International* (16th ed.). Arlington (USA): AOAC.

Barreto, E. H., Stocco, C. W., Almeida, L., Nascimento, R. F., & Bittencourt, J. V. M. (2017). Parâmetros de qualidade no processamento de mortadela. *Revista Espacios*, 38(2), 1-10.

Brasil. Ministério da Agricultura, Pecuária e Abastecimento. (2001). Aprova os Regulamentos Técnicos de Identidade e Qualidade de Paleta Cozida, de Produtos Cárneos Salgados, de Empanados, de Presunto tipo Serrano e de Prato Elaborado Pronto ou Semipronto Contendo Produtos de Origem Animal (Instrução Normativa nº 6, de 15 de fevereiro de 2001). *Diário Oficial [da] República Federativa do Brasil*. Retrieved from https://pesquisa.in.gov.br/imprensa/jsp/visualiza/index.jsp?data=19/02/2001&jornal=1&pagina=180&totalArquivos=192

Brasil. Ministério da Agricultura, Pecuária e Abastecimento. (2018). Oficializa os Métodos Analíticos Oficiais para Análises Microbiológicas para Controle de Produtos de Origem Animal e Água (Instrução Normativa nº 30, de 26 de junho de 2018). *Diário Oficial [da] República Federativa do Brasil*. Retrieved from https://www.gov.br/agricultura/pt-br/assuntos/laboratorios/legislacoes-e-metodos/poa/IN3013_07_2018POA.pdf

Brasil. Agência Nacional de Vigilância Sanitária. (2019). Estabelece as listas de padrões microbiológicos para alimentos (Instrução Normativa n° 60, de 23 de dezembro de 2019). *Diário Oficial [da] República Federativa do Brasil*. Retrieved from https://www.in.gov.br/en/web/dou/-/instrucao-normativa-n-60-de-23-de-dezembro-de-2019-235332356

Carneiro, A. P. G., Fonteles, T. V., Costa, M. G. M., Rocha, E. M. F. F., & Rodrigues, M. C. P. (2011). Parâmetros de textura em barras de chocolate ao leite. *Alimentos e Nutrição*, 22(2), 259-264.

Correia, R. T. P., Mendonça, S. C., Lima, M. L., & Silva, P. D. (2001). Avaliação química e sensorial de linguiças de pescado tipo frescal. *Boletim do Centro de Pesquisa e Processamento de Alimentos*, 19(2), 183-192. http://dx.doi.org/10.5380/cep.v19i2.1232.

Food and Agriculture Organization of the United Nations – FAO. (2020). *The State of World Fisheries and Aquaculture. Sustainability in Action*. Retrieved from http://www.fao.org/3/ca9229en/online/ca9229en.html.

Fukushima, K. L., Oliveira, R. M. E., Pimenta, M. E. S. G., Oliveira, R. B. S., Reis, T. A., & Lago, A. M. T. (2014). Características químicas, microbiológicas e sensoriais de empanados formulados à base de polpa de Tilápia do Nilo (*Oreochromis niloticus*). *Higiene Alimentar*, 28, 181-186.

Garcia-Santos, M. S. L., Conceição, F. S., Villas Boas, F., Salotti De Souza, B. M., & Barretto, A. C. S. (2019). Effect of the addition of resistant starch in sausage with fat reduction on the physicochemical and sensory properties. *Food Science and Technology (Campinas)*, 39(2, suppl 2), 491-497. http://dx.doi.org/10.1590/fst.18918.

Harder, M. N. C., Canniatti-Brazaca, S. G., & Arthur, V. (2007). Avaliação quantitativa por colorímetro digital da cor do ovo de galinhas poedeiras alimentadas com urucum (*Bixa orellana*). *Revista Portuguesa de Ciências Veterinárias*, 102, 339-342.

Instituto de Tecnologia de Alimentos – ITAL. (2020). *Brasil Food Trends 2020*. Retrieved from https://alimentosprocessados.com.br/arquivos/Consumo-tendencias-e-inovacoes/Brasil-Food-Trends-2020.pdf

Jiménez-Colmenero, F., Herrero, A., Pintado, T., Solas, M. T., & Ruiz-Capillas, C. (2010). Influence of emulsified olive oil stabilizing system used for pork backfat replacement in frankfurters. *Food Research International*, 43(8), 2068-2076. http://dx.doi.org/10.1016/j.foodres.2010.06.010.

Lago, A. M. T., de Sousa Gomes Pimenta, M. E., Aoki, I. E., de Fátima Figueiredo, A., Schiassi, M. C. E. V., & Pimenta, C. J.. (2018). Fish sausages prepared with inclusion of Nile tilapia minced: correlation between nutritional, chemical, and physical properties. *Journal of Food Processing and Preservation*, 42(10), 13716. http://dx.doi.org/10.1111/jfpp.13716.

Minozzo, M. G. (2011). *Processamento e conservação do pescado*. Curitiba: Instituto Federal de Educação, Ciência e Tecnologia.

Nascimento, R., Campagnol, P. C. B., Monteiro, E. S., & Pollonio, M. A. R. (2007). Substituição de cloreto de sódio por cloreto de potássio: influência sobre as características físico-químicas e sensoriais de salsichas. *Alimentos e Nutrição*, 18, 297-302.

Ogowa, M., & Maia, E. L. (1999). Química do pescado. In M. Ogawa, & E. L. Maia. *Manual de Pesca: Ciência e Tecnologia do Pescado*. São Paulo: Atheneu.

Olopade, O. A. (2015). Effect of poor handling on the nutritional composition of some imported frozen fishes in Nigeria. *Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca Food Science and Technology*, 72(1), 20-26. http://dx.doi.org/10.15835/buasvmcn-fst:10893.

Pinheiro, A. C. M., Nunes, C. A., & Vietoris, V. (2013). SensoMaker: a tool for sensorial characterization of food products. *Ciência e Agrotecnologia*, 37(3), 199-201. http://dx.doi.org/10.1590/S1413-70542013000300001.

Pinto, B. V. V., Bezerra, A. E., Amorim, E., Valadão, R. C., & Oliveira, G. M. (2017). O resíduo de pescado e o uso sustentável na elaboração de coprodutos. *Revista Mundi Meio Ambiente e Agrárias*, 2(2), 15. http://dx.doi.org/10.21575/25254790rmmaa2017vol2n2223.

Santiago, J. A. S., Araújo, P. F. R., Santiago, A. P., Carvalho, F. C. T., & Vieira, R. H. S. F. (2013). Bactérias patogênicas relacionadas à ingestão de pescados – revisão. *Arquivos de Ciências do Mar*, 46(2), 92-103. http://dx.doi.org/10.32360/acmar.v46i2.908.

Santos, P. R., Vasconcelos, E. L. Q., Souza, A. F. L., Silva Júnior, J. L., & Inhamuns, A. J. (2018). Qualidade físico-química e microbiológica de pescado congelado consumido na merenda escolar do estado do Amazonas. *Pubvet*, 12(5), 172.

Stone, H., & Sidel, J. L. (2004). *Sensory evaluation practices*. London (UK): Elsevier Academic Press.

Taşbozan, O., & Gökçe, M. A. (2017). Fatty acids in fish. In A. Catala (Ed.), *Fatty acids* (cap. 8, pp. 143-159). London: IntechOpen Limited. http://dx.doi.org/10.5772/68048

Uyhara, C. N. S., Oliveira Filho, P. R. C., Trindade, M. A., & Viegas, E. M. M. (2008). Adição de corantes em salsichas de tilápia do Nilo: efeito sobre a aceitação sensorial. *Brazilian Journal of Food Technology*, 11, 271-276.