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Enrichment of fishburgers with proteins from surimi washing water

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Abstract

The proteins recovered by ultrafiltration (UF) represent a co-product of fish industrialization and can be used as a protein ingredient in the fortification of food formulations. The objective of this study was to evaluate the quality of surimi fishburger elaborated with the proteins recovered by UF from the wastewater generated in the production of surimi. The water generated in the washing operations of trims of farmed tilapia (*Oreochromis niloticus*) were filtered in a 30 kDa polyethersulfone membrane. The recovered proteins were dehydrated in spray dryer and added at 5 and 10% into fishburgers made with tilapia surimi. The fishburgers were evaluated for proximal composition, cooking yield, sensory parameters and acceptability. The incorporation of proteins into the fishburgers improved the sensory aspects of the final product and provided greater acceptability while maintaining the same manufacturing yield. The addition of 10% of the recovered proteins increased the nutritional value of surimi fishburgers.

Keywords: ultrafiltration; tilapia; co-product; sensory analysis

Practical Application: The recovery of proteins from surimi wastewaters reduces organic matter, makes the production process more profitable and less aggressive to environment and, in addition, provides a protein-rich ingredient that may find use in food industry. The use of this protein concentrate in food products like surimi increases nutritional quality and productivity and so may reach consumers and producers demands.

1 Introduction

Proteins have a great impact on the growth and maintenance of tissues and, in children and adolescents, their ingestion influences bone growth and accumulation of bone mass (Conigrave et al., 2008). Fish proteins are nutritionally complete. Their digestibility is around 90%, their protein efficiency coefficient is higher than caseins' (2.9), and some freshwater fish have a 100% chemical amino acid score (Ei & Kavas, 1996; Machado & Sgarbieri, 1991).

With the awareness of the importance of fish in the human diet, its consumption has been growing steadily. In 2015, global per capita consumption reached 20.2 kg, with estimates of 20.3 and 20.5 kg for 2016 and 2017, respectively (Food and Agriculture Organization, 2018). With increasing productivity and better utilization of fisheries resources, surimi processors are seeking alternative technologies to make production more economically and environmentally efficient (Stine et al., 2012).

Surimi is a concentrate of myofibrillar proteins obtained from solid residues from fish processing, which is minced, washed, drained and stabilized with cryoprotectants (Barreto & Beirão, 1999; Mello et al., 2010; Park, 2014). The washing operations carried out in the manufacture of surimi eliminate large amounts of proteins. It is estimated that, in an annual production of 200.00 tonnes of surimi, more than 6.000 tonnes of protein residues are eliminated, which means loss of nutrients and increase in treatment steps and costs for effluent disposal (Ding et al., 2017; Lin et al., 1995).

Studies have shown that the use of ultrafiltration (UF) in fish industry effluent allows a recovery of more than 65% of proteins (Afonso & Bórquez, 2002; Khatprathum et al., 2010; Wibowo et al., 2007), resulting in a functional food component due to its antioxidant activity (Lin et al., 1995; Zhou et al., 2016). In addition, the use of the UF-recovered protein concentrate back to the surimi production line can increase the yield of the product by 1.7% without reducing its final functionality (Lin et al., 1995).

Among products elaborated with surimi, fishburger stands out for having good nutritional value, appreciated sensory characteristics and reasonable prices, which facilitates its acquisition (Fogaça et al., 2015; Marengoni et al., 2009). The incorporation of the protein recovered by UF into fishburgers can enhance the nutritional value of these products and prevent or correct nutritional deficiencies.

In order to offer the consumer a new convenience product and to present to the industry an alternative to make the productive process more profitable and less aggressive to the environment, the present study aimed at recovering proteins from surimi washing water, adding them into fishburgers and analyzing their chemical, physical and sensory aspects .

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2 Materials and methods

2.1 Raw material and surimi preparation

For the elaboration of surimi, trims of farmed tilapia (*Oreochromis niloticus*) obtained after filleting were stored in polyethylene bags and maintained at - 20 °C. After thawing at 5 °C for 24 h, trims were ground and washed three times with 3:1 water:muscle (6 °C) and alternation of 5 min gentle stirring/5 min of rest (Oliveira et al., 2017). After each washing cycle, the water was drained through a 100% polyester bag and reserved for the UF. Sodium chloride (2% w /w) and sucrose (1% w /w) were added to the washed proteins to make the surimi, which was packed in plastic film and frozen at -20 °C.

2.2 Obtention of the proteins

The water generated in the washing operations of the surimi was filtered in a UF system with a 5.0 m^2 30 kDa polyethersulfone membrane (FE10-FC-FUS0382) at room temperature (29 ± 3ºC) and 2 bar. The liquid flow and the operating time were previously determined in order to minimize membrane clogging. The proteins recovered from UF were dehydrated in spray dryer MSD 1.0 (Labmaq do Brasil, Ribeirão Preto, SP) at 120 °C, with feed flow of 0.81 L h-1 and compressed air flow of 30 L min -1. The proteins recovered contained 66.49% amino acids, including all the essential ones, with leucine (5.47%), lysine (6.49%), valine (3.59%) and phenylalanine (3.68%) as the major components.

2.3 Microbiological analysis of surimi

Surimi was tested for *Salmonella* sp., coagulase-positive staphylococci and coliforms at 45 °C, according to American Public Health Association (APHA) (Downes & Ito, 2001).

2.4 Elaboration of fishburgers with tilapia surimi

Surimi was thawed at 5 °C for 24 hours and added of ingredients and dehydrated proteins to compose the three treatments of the experiment (Table 1). The blending was performed manually until a homogeneous mass was obtained, then fishburgers with approximately 60 g were shaped into circular mold (9 cm diameter), individually wrapped in plastic wrap and kept under refrigeration (5 °C) for 24 hours. Good hygiene practices were adopted at all stages of processing and handling in order to produce a suitable product for consumption.

Table 1. Formulations of tilapia surimi fishburgers.

Ingredients (%)	Treatments		
	1	2	3
Surimi	94.52	89.52	84.52
Dehydrated proteins	-	5	10
Salt	0.57	0.57	0.57
Fine herbs	0.28	0.28	0.28
Whole oat flour	4.63	4.63	4.63

2.5 Proximate composition of fishburgers

Moisture, total protein and ash were determined according to AOAC methodology (Horwitz & Latimer, 2006) and lipids were determined by Folch method (Folch et al., 1957). Analyzes were performed in triplicate.

2.6 Sensory analysis

Procedures used in the sensory analysis of the fishburguers were approved by the Human Research Ethics Committee of the University of Dentistry of Araçatuba / Unesp (opinion no. 2.352.730) and the participating volunteers signed a consent term for the research.

An affective test was performed with 52 untrained panelists of both sexes, aged between 23 and 45 years old, selected for habitually consuming fish products and for being interested in participating of the test. Each participant evaluated the attributes flavor, aroma, color, texture and appearance using a structured hedonic scale of 5 points (1 = "didn't like"; 5 = "liked very much").

The fishburgers were grilled at 350° C, for 20 min (10 min on each side). Each panelist received ¼ of each formulation (approximately 15 g) on a white disposable dish coded with three random digits. Panelists also received a glass of water and cream cracker to clean the taste buds between the samples.

The acceptability index (AI) was calculated according to Equation 1, described by Dutcosky (2011). According to the author, a product is considered to be well accepted when AI is higher than or equal to 70%.

$$AI\ (\%) = \frac{Average\ score\ obtained\ on\ attribute\ x\ 100}{Highest\ grade\ given\ to\ attribute} \quad (1)$$

2.7 Cooking measurement of fishburgers

Percent cooking yield was determined according to Berry (1992) and Seabra et al. (2002). Six samples of each formulation were weighed before and after grilling and the percent cooking yield was obtained according to Equation 2.

$$\%\ Cooking\ yield = \frac{Cooked\ weight\ x\ 100}{Raw\ weight} \quad (2)$$

2.8 Statistical analysis

The results of the proximal composition and yield were submitted to analysis of variance and the averages were compared by Tukey's test. The results of the sensory analysis were evaluated by Friedman test and the multiple comparison between the means was performed by Dunn`s test. The analyses were performed with the statistical package SAS (Statistical Analysis System, version 9.3) at 5% significance level

3 Results and discussion

3.1 Microbiological analyses of surimi

Table 2 shows the results for the microbiological analysis of surimi, as well as the microbiological standards defined in the Resolution of the Collegiate Board of Directors (RDC) nº 12 of

the National Sanitary Surveillance Agency (Brasil, 2001), for comparison.

The results were within the standards required by current legislation, which reflects the appropriate conditions of hygiene in processing, which provided a product suitable for consumption. Similar microbiological quality was found by Fogaça et al. (2015), who used mechanically separated meat of tilapia to obtain the surimi.

3.2 Proximate composition of fishburgers

Formulation 3 (10% protein) had a significantly higher protein content ($p < 0.05$) than formulation 1 (without protein addition), whereas lipid, moisture and ash concentrations did not differ statistically ($p > 0.05$) between treatments (Table 3). This result indicates that the addition of 10% of the dehydrated protein recovered by UF from the washing water of surimi may contribute to the protein enrichment of the fishburgers.

The type of raw material and the number/kind of washings used for the surimi elaboration determine the amount of materials eliminated in the wastewaters. According to Lin et al. (1995), 0.04 to 0.19% fat and 0.09 to 0.41% ash may result from the various washing cycles, whereas 2.5% proteins are eliminated right at the first washing operation. Even though the washing operations provide the removal of lipids and minerals, the UF membrane cutoff (30 kDa) was not able to recuperate these compounds due to their small sizes. Moreover, the deformable character of fat globules helps the transmembrane pression imparted during UF to induce their migration across the membrane (Ebrahimi et al., 2010; Chakrabarty et al., 2008).

Table 2. Microbiological evaluation of surimi.

Microbial group	Surimi	RDC nº 12/2001
Salmonella sp	Absence in 25 g	Absence in 25g
Coliforms at 45 °C (MPN/g)	0.1	≤ 100
Coagulase positive staphylococci (UFC/g)	Negative	$\leq 5.0 \times 10^2$

MPN/g - Most Probable Number per gram of product; UFC/g - Colony Forming Unit per gram of product; RDC - Resolution of the Collegiate Board (Brasil, 2001).

Table 3. Proximate composition of fishburgers made with proteins recovered from surimi washing water (mean ± standard deviation).

Parameters (%)	Treatments[1]		
	1	2	3
Lipid	1.268 ± 0.378	1.864 ± 0.231	2.018 ± 0.476
Moisture	74.727 ± 2.219	69.579 ± 3.142	66.886 ± 4.19
Ash	2.586 ± 0.091	3.172 ± 0.261	3.315 ± 0.408
Protein	15.415 ± 0.829[b]	17.628 ± 1.177[ab]	20.527 ± 0.733[a]

[1]1 (no protein added), 2 (5% protein), 3 (10% protein). Means followed by different letters in the row differed by Tukey's test ($p < 0.05$).

3.3 Percent cooking yield (%)

All formulations of fishburgers reached more than 90% yield (T1 = 92.29%, T2 = 90.55%, T3 = 92.01/ p > 005). Other authors found lower yields for fishburgers made from filleting residues of tilapia (Bainy et al., 2015) and catfish (Bochi et al., 2008). In the present study, the addition of oatmeal to the fishburgers contributed to the good yield indexes because it provides water retention in the final product (Aleson-Carbonell et al., 2005).

3.4 Sensory analysis

The fishburgers added of proteins recovered by UF had better scores for color and appearance than the standard formulation (Table 4), which was reported as "very clear" and "unattractive" by some tasters. The formulations added of proteins were considered well accepted since they graded 4 (liked moderately) for all the attributes in the 5-points hedonic scale, while the minimum score expected was 3.5 (Dutcosky, 2011). This result has great relevance when evaluating a new product, since in the first contact of the consumer with the product, the visual presentation (in which color and appearance stand out) arises personal reactions of acceptance, indifference or rejection (Teixeira, 2009).

The addition of proteins to the fishburgers probably favored Maillard reaction, in which browning occurs due to the formation of melanoidins arisen from the reaction between proteins and reducing sugars during thermal processing (Shibao & Bastos, 2011). Denaturation of proteins and the exudation of fat and water may also be related to color enhancement in products during heating (Bochi et al., 2008).

3.5 Acceptability Index (AI)

Fishburgers added of UF proteins had higher AI than the standard formulation in all sensory attributes analyzed (Table 5). According to Dutcosky (2011), so that a product is accepted and find insertion in the market, it must reach at least 70% for AI. These results, therefore, attest the acceptability of fishburgers enriched with proteins recovered from the UF in the market.

Table 4. Median, minimum and maximum values assigned by the panelists in the sensory analysis of the fishburgers.

Sensory attribute	Treatments[1]						P value[2]
	1		2		3		
	Md	Min – Max	Md	Min – Max	Md	Min – max	
Flavor	3,5	1 - 5	4	1 - 5	4	1 - 5	0.1101
Aroma	4	2 - 5	4	2 - 5	4	1 - 5	0.6482
Color[3]	3[b]	1 - 5	4[a]	2 - 5	4[a]	2 - 5	< 0.0001
Texture	4	1 - 5	4	2 - 5	4	2 - 5	0.0505
Appearance[3]	3[b]	1 - 5	4[a]	2 - 5	4[a]	3 - 5	< 0.0001

[1]1 (no protein added), 2 (5% protein), 3 (10% protein); [2]Friedman's Test; [3]Medians followed by distinct letters, in the row, differed by Dunn's test ($p < 0.05$).

Table 5. Acceptability index (AI) of the fishburgers sensory characteristics.

Sensory attribute (%)	Treatments[1]		
	1	2	3
Flavor	65	71	71
Aroma	71	72	70
Color	57	75	86
Texture	67	73	74
Appearance	61	76	83

[1]1 (no protein added), 2 (5% protein), 3 (10% protein).

4 Conclusion

The incorporation of the proteins recovered by UF of the washing water of surimi into fishburgers improved the sensory aspects of the final product and provided greater acceptability without affecting manufacturing yield. The addition of 10% of proteins to the fishburgers increased the protein content of the final product, contributing to its nutritional enrichment.

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