BOLETIM DO INSTITUTO DE PESCA
ISSN 1678-2305 online version
Scientific Note

QUALITY OF MECHANICALLY SEPARATED MEAT (MSM) AND SURIMI OBTAINED FROM LOW COMMERCIAL VALUE FISH

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Received: May 23, 2017,
Approved: January 31, 2018

ABSTRACT

This study aimed to analyze the quality of and differences between mechanically separated meat (MSM) and surimi obtained from red porgy (*Pagrus pagrus*) and Brazilian flathead (*Percophis brasiliensis*) fish caught in the "mixed" trawl category at Niterói, Rio de Janeiro, Brazil. The surimi was produced from the MSM of both fish species subjected to washing. The chemical characterization of the products was carried out by chemical composition analyses (moisture, protein, lipids and ash content). Microbiological analyses, namely coagulase positive staphylococci, coliforms at 35 ° C, thermotolerant coliforms and *Salmonella* sp. counts, were performed. Surimi produced from red porgy and Brazilian flathead presented lower protein (7.84% and 7.34%) and lipid (0.73% and 0.74%) content and higher moisture content (91.71% and 90.15%), respectively, compared to MSM (P <0.05). The microbiological analyses indicated that the products were within the sanitary standards required by Brazilian legislation. In sum, the low added value fish from the "mix" category resulted in viable products (MSM and surimi) for use in fish technology. The MSM product exhibited higher nutritional richness than surimi, but with a higher bacterial load.

Key words: accompanying fauna; quality; fish derivatives; added value.

QUALIDADE DA CARNE MECANICAMENTE SEPARADA (CMS) E DO SURIMI OBTIDOS DE PEIXES DE BAIXO VALOR COMERCIAL

RESUMO

Este estudo teve como objetivo analisar a qualidade e as diferenças entre a carne mecanicamente separada (CMS) e surimi obtidos a partir de pargo (Pagrus pagrus) e o tira-vira (Percophis brasiliensis) capturados na categoria "mistura" da modalidade da pesca de arrasto de Niterói, RJ. Para elaboração do surimi, as CMS de pargo e tira-vira foram submetidas à lavagem. A caracterização química dos produtos foi determinada pelas análises da composição química (umidade, proteína, lipídeos e cinzas). Para as análises microbiológicas foram realizadas contagens de Estafilococos coagulase positiva, coliformes a 35 °C, coliformes termotolerantes e pesquisa de Salmonella sp. Os surimis de pargo e tira-vira apresentaram menores teores proteico (7,84% e 7,34%) e lipídico (0,73% e 0,74%) e maior umidade (91,71% e 90,15%), respectivamente, em comparação à CMS (P<0,05). A análise microbiológica demonstrou que os produtos estavam dentro do padrão sanitário exigido pela legislação. Com base nos resultados obtidos, conclui-se que os peixes de baixo valor agregado da categoria "mistura" resultaram em produtos (CMS e surimi) viáveis para o uso na tecnologia do pescado. O produto CMS apresentou-se mais rico nutricionalmente do que o surimi, porém com maior carga bacteriana.

Palavras-chave: fauna acompanhante; qualidade; derivados de pescado; valor agregado.

INTRODUCTION

Fish trawling is considered a highly impacting method. As it is not selective, in addition to target species, this method removes several accompanying species from the sea that often do not display commercial value, since they are small-sized animals. ALVERSON *et al*. (1994) named these accessory species "by-catch" (accompanying fauna). International literature points to accompanying or "by-catch" fauna as one of the major problems in the fish chain (FAO, 2016), resulting in high mortality rates for many marine species and large numbers of juvenile species, interrupting their growth cycle and reproduction.

Due to the low selectivity and small mesh size of traditional nets, trawling has become responsible for the largest fauna by-catch among all fishing modalities worldwide. Concerning shrimp fisheries alone, an annual production of 1.3 million tons and approximately 7.3 million tons of discarded catches are estimated (KELLEHER, 2005). When accompanying fauna species are selected on the boat during the fishery activity, they are categorized as "mixed" fauna. The "mixture" is composed of low commercial value fish, such as the Brazilian flathead, or smaller noble fish, like the red porgy, which usually appear in high amounts at fish landings. The use of fish from the "mix" category in the development of new products can be a viable alternative to provide excellent quality protein and minimize environmental impacts (PIRES *et al*., 2014).

Mechanically separated meat (MSM) from fish is defined as a product obtained from a single or a mixture of fish species presenting similar sensory characteristics, through a mechanical separation process of the edible parts, generating bone free muscle particles, viscera, scales and skin (KIRSCHNIK, 2007). This process leads to the development of a versatile product capable of being processed into sausages, nuggets, or breaded and canned products with adequate nutritional quality and acceptability in the consumer market.

Surimi consists of a protein base, obtained from fish muscle, subjected to successive washes (in which fat, blood, odoriferous substances and water-soluble proteins are eliminated), followed by refining, dehydration, the addition of cryoprotectants and a final freezing step for preservation (LEE, 1984). Due to its characteristics, such as lack of fish odor, high protein and low lipid content, surimi can be added to all types of food, such as soups, hamburger and sausages, among others. Surimi processing technology is a way of adding value to MSM from fish, increasing its shelf life and allowing for more industrial flexibility regarding product design (ALFARO *et al*., 2004).

In this context, the aim of this study was to analyze the quality and differences in chemical parameters between MSM and surimi obtained from red porgy (*Pagrus pagrus*) and Brazilian flathead (*Percophis brasiliensis*) as a results of fish trawl activities at Niterói, Rio de Janeiro, Brazil.

MATERIAL AND METHODS

To choose the species to be utilized in the present study, a characterization of the "mix" trawl category was carried out during four months. Seven representative samples of the "mix" category were collected at shrimp trawler landings in the Rio de Janeiro metropolitan region, totaling 75 kg of fish. The most common fish (kg) in the "mix" category were the red porgy (*Pagrus pagrus*) (25 kg) and Brazilian flathead (*Percophis brasiliensis*) (22 kg), which were, thus, chosen for product development.

After defining the species, 30 kg of red porgy and Brazilian flathead were collected for processing. The fish were collected at the moment of quayside landing at the municipality of São Gonçalo (RJ), and transported in isothermal boxes on ice to the FIPERJ School of Fisheries laboratory. At the laboratory, the fish were washed, gutted, beheaded and filleted. The filleting residues (bone skeleton and skin) were weighed, packed separately in plastic bags and stored at -18 °C.

The filleting residues (bony skeleton and skin) were transported in isothermal boxes to the Fish Processing Laboratory at Embrapa Agroindústria de Alimentos. Processing was performed separately for each species, according to the flow chart below (Figure 1).

For MSM development, the filleting residues (bony skeleton and skin) were processed in an MSM fish machine (Mec Fish brand, Brazil), subsequently weighed and aliquots were separated for analysis.

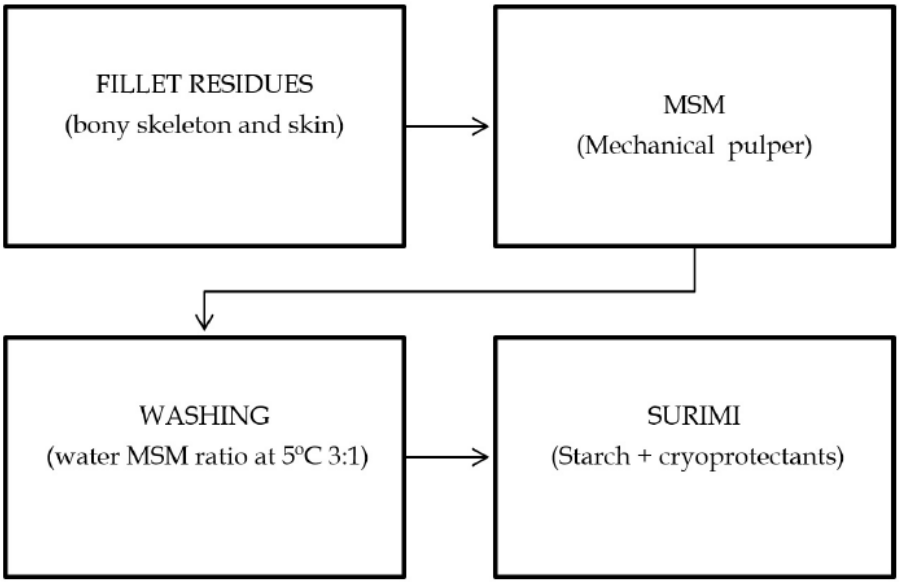

Figure 1. Flowchart of the MSM and surimi production processes.

The surimi products were obtained after a washing cycle with water at 5 °C at a 3: 1 (water:meat) ratio. The water and MSM mixtures were stirred for five minutes and subsequently allowed to stand for two minutes. Excess water was removed manually with a 100 micron screen and the samples were then vacuum-pumped for five minutes. At the end of the processing, cryoprotectants were added, namely 2% sodium chloride and 1% sucrose. After this step, the surimi products were weighed and aliquots were collected and frozen (-18 °C).

The following physico-chemical analyses were performed: pre-dried matter at 105 °C (humidity); ash content; crude protein (Micro Kjedahl) and ethereal extraction (Soxlet method) (BRASIL, 1981). All samples were evaluated in triplicate at the State Center for the Control of Research in Food Quality (CEPQA) laboratories, located at the Agricultural Research Company of the State of Rio de Janeiro (PESAGRO-RJ).

The following microbiological analyses were carried out for MSM and surimi: *Salmonella* sp. detection and counts for coliforms at 35 °C, thermotolerant coliforms and coagulase positive *Staphylococcus*. All analyses were performed according to the methodology described in the Brazilian Ministry of Agriculture's Normative Instruction No. 62 of August 26, 2003 (BRASIL, 2003).

Data between the types of processing for both species were compared by Student's t-test. The statistical analyses were previously submitted to a normality of the errors test (Cramer-von Mises) and homoscedasticity of the variances (Levene's) test. The data were analyzed by the "Statistical Analysis System" software package (SAS Institute, version 8.0).

RESULTS

The MSM extraction yield was of 57.7% for red porgy (*Pagrus pagrus*) and 55.2% for Brazilian flathead (*Percophis brasiliensis*) in relation to total residue weight. After washing, surimi yields were of 56.4% (red porgy) and 54.1% (Brazilian flathead) relative to MSM weight.

MSM moisture, protein, lipid and ash contents for both species are displayed in Table 1 (raw material) and Table 2 (dry matter).

A loss of all evaluated parameters was observed for both species when comparing the raw material for each species (MSM and surimi). Moisture content was higher for surimi, although MSM protein, lipid and ash contents were higher for both species. The washing of the raw material altered MSM composition, increasing moisture (26.9% percentage increase for red porgy and 24.8% for Brazilian flathead) and, consequently, reducing protein (59.5% loss for red porgy and 61.8% for Brazilian flathead), lipid (88.0% loss for red porgy and 86.5% for Brazilian flathead) and ash (59.1% loss for red porgy and 86.7% for Brazilian flathead) contents.

When the obtained products are compared as dry matter, no statistically significant differences were observed between species for protein values, while lipid results differed significantly for both species. Concerning ash content, only Brazilian flathead showed statistically significant differences.

Table 3 displays the microbiological results for MSM and surimi obtained from both species. All samples were within the standards imposed by Brazilian legislation, indicating correct hygiene and concerns with good handling practices during the product elaboration processes. Washing was more efficient in reducing microorganism loads for the red porgy samples.

Table 1. Centesimal composition of red porgy (*Pagrus pagrus*) and Brazilian flathead (*Percophis brasiliensis*) raw material in the form of MSM and surimi.

Species/prduct	Moisture (%)	Protein (%)	Lipids (%)	Ash (%)
Red porgy MSM	72.24	19.38	6.12	1.15
Red porgy SURIMI	91.71	7.84	0.73	0.47
Brazilian flathead MSM	72.23	19.23	5.50	2.56
Brazilian flathead SURIMI	90.15	7.34	0.74	0.34

DISCUSSION

The MSM results reported herein were close to the 57.7% yield for MSM extraction reported by KIRSCHNIK *et al*. (2013) and higher than the 37.1% observed by CABRAL *et al*. (2013) when working with Nile tilapia (*Oreochromis niloticus*) filleting residues.

The yield values for surimi reported herein are are below the 84.7% reported by KIRSCHNIK and MACEDO-VIEGAS (2009) and the 82.08% found by CABRAL *et al*. (2013). Both MSM and surimi yields can be influenced by the regulation of the pulper, the number of washes and the method used to drain excess water from the products (CABRAL, 2012). In the present study, high losses of protein, lipid and ash contents were detected during washing, which may have been responsible for the low process yield.

An increase in MSM moisture content was observed after the washing process for both fish species, probably due to the increased hydration capacity of the myofibrillar proteins present in high amounts in MSM. Increases in the moisture percentages in washed MSM and surimi have also been observed by other authors. KIRSCHNIK and MACEDO-VIEGAS (2009) observed 88.7% moisture levels in washed Nile tilapia residue (*Oreochromis niloticus*) MSM, while SIMÕES *et al*. (1998) reported 92.7% moisture content in washed striped weakfish (*Cynoscion striatus*) MSM. MIRA and LANFER-MARQUEZ (2005) reported moisture contents of 79.5% and 88.7% in surimi samples obtained from low commercial value marine fish (*Paralonchurus brasiliensis* and *Cynoscion virescens*). Moisture determinations are also a way of evaluating the quality of the surimi or washed MSM, which, in the case of surimi elaborated with Alaska pollock (*Theragra chalcogramma*), is classified into four categories: S (superclass), with moisture content ranging from 76, 1% and 79.0%; class A, moisture content between 79.1% and 80%; class B, moisture content between 80.1% and 81.5%; class C, when moisture exceeds 81.5% (MIRA and LANFER-MARQUEZ, 2005). According to this classification, the results of the present study (red porgy 91.7%, Brazilian flathead 90.1%) fall into class C.

Table 2. Mean (± standard deviation) results for protein, lipid and ash content for red porgy (*Pagrus pagrus*) and Brazilian flathead (*Percophis brasiliensis*) in the form of MSM and surimi, as dry matter.

Species/product	Protein (%)	Lipids (%)	Ashes (%)
Red porgy MSM	69.76± 5.41 a	22.08± 0.99 a	4.88± 0.15 a
Red porgy SURIMI	88.01± 10.89a	8.97± 1.37 b	5.77± 0.72 a
Brazilian flathead MSM	69.41± 9.42 A	19.82± 0.25A	9.21± 1.57A
Brazilian flathead SURIMI	74.57± 11.32 A	7.48± 0.27B	3.47± 0.04 B

Lower cased letters indicate comparisons between red porgy products while upper case letters indicate comparisons between Brazilian flathead products.

Table 3. Microbiological characteristics of porgy (*Pagrus pagrus*) and Brazilian flathead (*Percophis brasiliensis*) MSM and surimi.

Species/product	*Salmonella* sp.	Coliforms at 35º C	Thermotolerant coliforms	Coagulase positive *Staphylococcus*
Red porgy MSM	Absent/25g	< 2.4 x 10^3 UFC/g	< 10 UFC/g	< 10^2UFC/g
Red porgy SURIMI	Absent/25g	< 3.3 x 10 UFC/g	< 10 UFC/g	< 10^2UFC/g
Brazilian flathead MSM	Absent/25g	< 9.3 x 10^3 UFC/g	< 10 UFC/g	< 10^2UFC/g
Brazilian flathead SURIMI	Absent/25g	< 4.4 x 10^2 UFC/g	< 4.4 x 10^2 UFC/g	< 10^2UFC/g

Similar to the current study, in which decreases in protein, lipid and ash contents were observed (raw material), losses of solids during the washing process have been observed by other authors. SIMÕES *et al*. (1998) observed decreases in protein, lipid and ash contents of approximately 53%, 62%, and 89%, respectively, during the striped weakfish MSM washing process, while BISCALCHIN-GRŸSCHEK *et al*. (2003) reported solids losses of approximately 37% during rockfish (*Sebastes* sp.) MSM washing.

A decrease in surimi protein levels for both species was observed herein, probably due to the removal of most of sarcoplasmic soluble proteins and excess moisture. This has also been reported by KIRSCHNIK and MACEDO-VIEGAS (2009), who indicated a significant decrease in MSM protein levels for whole tilapia, reporting values of 15.1% and 8.9% crude protein in unwashed and washed MSM (surimi), respectively. This is in contrast with the results reported by FOGAÇA *et al*. (2015), who reported surimi protein percentages (14.81%) similar to the amount of protein found in unwashed MSM (15.87%). However, when compared to dry matter, the protein results reported herein for different products from the same species were not statistically different.

Conventional methods for obtaining surimi comprise three CMS washing cycles to eliminate up to 50% of the fat present in the raw material (MINOZZO and VAZ, 2007). In the current study, MSM lipid contents from both species was reduced (red porgy: 88.0%, Brazilian flathead: 86.5%) with only one wash cycle, displaying values close to those observed by MELLO *et al*. (2010), in which the lipid content of tilapia surimi was reduced by 73%, albeit by three washing cycles. However, when applying the same methodology applied in the current study, MELO *et al*. (2011) and KIRSCHNIK and MACEDO-VIEGAS (2009) obtained a lower percentage lipid content reduction (17%), also in tilapia MSM.

A loss of ash contents (raw matter) during surimi development for both fish species was observed. A significant decrease in ash content was observed in both red porgy (59%) and Brazilian flathead (61%) after washing, indicating loss of minerals during this process by leaching. Likewise, BISCALCHIN-GRŸSCHEK *et al*. (2003) reported an 80% decrease in ash contents after the Nile tilapia MSM washing process. However, when ash contents were analyzed in relation to dry matter, only the results for the Brazilian flathead products differed statistically, indicating that, despite the losses that occur during washing, no significant loss of minerals in the red porgy surimi production was observed.

The Brazilian legislation regarding microbiological standards in food, Resolution RDC No. 12 of January 2, 2001, enforced by the National Agency of Sanitary Surveillance (Anvisa) determines that chilled or frozen fish-based products must display a maximum count of 10^3 CFU/g thermotolerant coliforms (45 °C), 10^3 CFU/g coagulase positive *Staphylococcus* and absence of *Salmonella* sp. in 25 grams of evaluated sample (BRASIL, 2001).

In contrast to the results reported herein, MELLO *et al*. (2010), when evaluating tilapia MSM and surimi, detected microorganism counts above the standards for MSM and observed that increased care regarding the cleaning and sanitation of utensils and equipment, as well as increased personal manipulator hygiene, led to decreased surimi sample contamination levels. The current results indicate a decrease in the coliform group counts at 35º in both red porgy and Brazilian flathead surimi, demonstrating that the washing process contributed to improvements in MSM quality. KIRSCHNIK and MACEDO-VIEGAS (2009) observed lower microorganism counts in MSM submitted to washing, suggesting that the washing process may exert the beneficial effect of reducing microorganism counts. However, in Brazilian flathead surimi, an increase in the group of thermotolerant coliforms in relation to the MSM was observed, albeit still within the standards required by the enforced Brazilian legislation.

CONCLUSIONS

Low added value fish from the "mix" category resulted in viable products (MSM and surimi) for use in fish technology. The MSM products presented higher nutritional richness than surimi, but with higher bacterial load.

Although surimi is of great value for fish technology, for example reducing fish odors in the final product, the same final product presented decreases in composition, indicating nutritional losses during processing. However, in general, surimi presented better microbiological results, with special attention to this step required, since any failure in adequate manipulation or storage can cause severe problems since the product contains high water levels, available for bacterial multiplication.

Although presenting adequate chemical and microbiological performance for product use on an industrial scale, we suggest taking the same care during the freezing steps used in bovine and poultry MSM processing.

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