Rev. Bras. Eng. Pesca (2024) 15 (1): 1-7
DOI:10.18817/repesca.v15i1.3371

ARTIGO *REVISTA BRASILEIRA DE ENGENHARIA DE PESCA*

MICROBIOLOGICAL CHARACTERIZATION AND INTERFERENCE OF PH AND WASHES ON THE MINCED FROM MAPARÁ RESIDUALS

CARACTERIZAÇÃO MICROBIOLÓGICA E INTERFERÊNCIA DO PH NO TRITURADO DE RESÍDUOS DE MAPARÁ

Ana Rízia Nascimento Marinho[1], Ellen Kaline Miranda de Figueiredo[2], Mila Katrielle de Sousa Marinho[3], Waldinete de Fátima Freitas Lobato[4], Hérlon Mota Atayde[5]*

[1]Fisheries Engineer, Universidade Estadual do Oeste do Paraná (Estadual University of Western Paraná) – UNIOESTE - Campus Toledo.
[2]Sanitary and Enviromental Engineer, Universidade Federal do Oeste do Pará (Federal University of Western Pará) - UFOPA - Campus Santarém.
[3] Undergraduate student in Fisheries Engineering, UFOPA - Campus Santarém
[4] M.Sc. in Amazonian Inland Aquatic Resources, Aquaculture Technician - UFOPA - Campus Santarém.
[5] PhD. in Fisheries Sciences in the Tropics, research coordinator, Professor, UFOPA – Campus Santarém. Rua Vera Paz, s/n, 68135-110, Instituto de Ciências e Tecnologia das Águas, Bloco Modular Tapajós 1, sala 401, Santarém, PA, Brazil,
*e-mail: herlon.atayde@ufopa.edu.br

Recebido: 16/08/2023 / Publicado:18/07/2024

Abstract Fish residuals from industry are potentially harmful to the environment, but nutritionally valuable when used. To contribute to this use, this research verified the interference of pH and washes quantity on the minced fish yield made from residuals of mapará (*Hypophthalmus* spp.) from the fishery industry of Santarém – Pará. Additionally, point out the microbiological characteristics of the minced fish and relate them to human food production. The residuals (neural and haemal spines with adhered muscle) were used to produce the minced and washed meat, using chlorinated water with pH (4.2, 5.2, 6.2 and 7.2) previously adjusted, and different quantities (1, 2, 3, and 4) of washes. Weighing was carried out at each wash to verify the yield. The number of washes and pH significantly influenced the minced yield. Although more washes caused lower yield, four are still recommended to obtain minced from mapará, because they reduce the marked taste and smell of fatty fish. The water pH 7.2 is recommended because it provided a higher minced yield. Any microbiological contamination of the minced was detected. The neutral pH is important for washed minced from mapará residuals, because it provides adequate yield and it is among the recommended values for water intended for food production.

Key words: fish; Hypophthalmus; disposal; recycling; grinded meat

Resumo Resíduos de pescado da indústria são potencialmente danosos ao meio ambiente, porém nutricionalmente valiosos quando aproveitados. Para contribuir nisso, esta pesquisa verificou a interferência do pH e da quantidade de lavagens no rendimento do triturado dos resíduos de mapará (*Hypophthalmus* spp.) da indústria frigorífica de Santarém – Pará. Foram apontadas as características microbiológicas dele e relacionadas com a produção de alimento humano. Os resíduos de filetagem (espinhas neurais e hemais com músculo aderido) foram preparados com água clorada e pH previamente ajustado (4,2, 5,2, 6,2 e 7,2), em diferentes quantidades (1, 2, 3 e 4) de lavagem. Pesagens foram efetuadas após cada lavagem para verificar o rendimento. O número de lavagens e o pH influenciam significativamente no rendimento. Embora mais lavagens diminuam-no, quatro são recomendadas para o mapará porque reduzem o sabor e o odor acentuados de peixe gordo. O pH 7,2 é recomendado porque proporciona maior rendimento em triturado. Nenhuma contaminação microbiológica foi detectada no triturado. O pH neutro é importante para a obtenção do triturado porque ele proporciona adequado rendimento e está entre os índices recomendados para a água empregada na produção de alimentos.

Palavras-Chave: peixe; Hypophthalmus; descarte; reciclagem; carne moída

Introduction

Approximately 60% of processed fish is responsible for residual generation, while only 40% is for human consumption according to Chalamaiah, Kumar, Hemalatha & Jyothirmayi (2012). These residuals are potentially harmful to the environment, but nutritionally valuable if they are transformed into new products, that can become a new income option for entrepreneurs, increasing profitability and reducing the volume of waste generated by processing, as declared by Jamas (2012) and Palmeira et al. (2014).

The mechanically separated meat (MSM) and the surimi are alternatives legally recognized for the elaboration of fish derivatives (Brasil, 2017), but other similar foods may be produced, and their names will differ according to the employed technique, the added ingredients and the geographic region as an example the minced fish.

The minced fish is an intermediate product, and its production process is relatively simple when compared to surimi and more applicable in several locations on the planet (Hall & Ahmad, 1997). For obtaining minced meat and similar, washing promotes the removal of sarcoplasmic proteins, blood, fats and other compounds capable of compromising the storage and acceptability of the product, improving its odor and color, among other attributes (Hassan, Balange, Senapati, & Xavier, (2017; Neiva, 2021).

For surimi, the number of washes, the cycle and the proportion of used water are variable among the processors, and its good quality depends on the type, composition, and freshness of the raw material (Hassan et al., 2017). For minced fish, information on these aspects are lacking.

The mapará (*Hypophthalmus* spp., Siluriformes, Pimelodidae) used by the fish processing industries of Santarém to produce fillet generates an important number of residuals. In this city, the water for urban supply is acidic, ranged from 3.53 to 5.94 (Gonçalves, 2021), fact potentially harmful for food production.

This study aims to verify the microbiological characteristics and operational details (pH of washing water and number of washing cycles) that affect the viability and good yield of minced fish from mapará residuals.

Material e Methods

Study area and sampling: This research was conducted in the municipality of Santarém, located in the Western Pará, where the residuals of mapará filleting (*Hypophthalmus* spp.) were collected – consisting of head and spine containing adhered muscle mass. These residuals were obtained from the local fish industry, and taken to the Laboratório de Ensino Multidisciplinar em Recursos Aquáticos, Instituto de Ciências e Tecnologia das Águas, Universidade Federal do Oeste do Pará (Laboratory of Multidisciplinary Teaching of Aquatic Resources, Institute of Water Sciences and Technology, Federal University of Western Pará). All the laboratory procedures below were concluded between the end of October 2018 and the beginning of December 2018.

Obtaining the minced meat from mapará residuals: The residuals were washed with chlorinated water and weighed. Then, the muscle part was manually extracted with the aid of sharp instruments (Neiva, 2021), and this meat was called mapará mass meat (MMM), which was submitted to weighing and later used to produce the washed minced mapará (WMM).

Washing of mapará minced meat: The MMM was submitted to different amounts of washes (1, 2, 3 and 4), using treated water with pH previously adjusted in the indexes 4.2; 5.2; 6.2 and 7.2 (Pereira, 2016). For washing, the MMM was crushed, then immersed in cold water (10 ± 1 °C) previously treated and adjusted pH, all in a 1:3:1 ratio (MMM: treated water: ice, respectively), keeping this mixture under agitation for 3 minutes, plus 5 decanted minutes, to facilitate separation

of elements. The solid part – WMM – was retained in the filtration with commercial sieve of 1.49 mm and its weight was measured.

Meat yield: For yield (Y), the formula $Y = (Wf + Wi) \times 100$ (10) were used, where Wf is equivalent to the final weight achieved by the product (MMM or WMM), and Wi is equal to the initial weight of the part (residual or MMM) necessary to its obtainment. The results were expressed as a percentage (%).

Microbiological analyses: The minced meat was submitted to the quantification of: a) thermotolerant coliforms by the multiple tube technique, whose results were expressed in MPN/g; b) quantification of coagulase-positive *Staphylococcus* by the standard colony counting technique developed on the surface of Baird-Parker Agar, whose results were expressed in FCU/g; c) analysis of the presence or absence of *Salmonella* sp. per 25 g of product. All analytical procedures followed the recommendations of Silva et al. (2017), which permitted comparison with Brazilian standards valid at the time of this study (Brazil, 2001, in course until December 25, 2020).

Statistical analyses: The gross yield data were submitted to descriptive and inferential statistical analysis. The influence of pH and quantity of washes on yield at the level of 5% significance was verified using the analysis of variance in Past 3.19 program (Hammer, Harper, & Ryan, 2001).

Results and Discussion

According to Aberoumand (2010), minced fish is more susceptible to microbiological spoilage due to its greater surface than whole fish, and this characteristic affects the bacterial count, usually higher than other fish products. So, the microbiological characteristics need to be determined to protect the public health.

In this study, the microbiological analyses [whose results were thermotolerant coliforms = <10 MPN/g, coagulase-positive *Staphylococcus* = <10 FCU/g and *Salmonella* sp. = absence in 25 g, all below the Brazilian standards (Brazil, 2001)] did not detect contamination of the minced meat from mapará residuals by any of the analyzed biological agents. Despite coming from solid residual, the mapará minced meat presents satisfactory sanitary conditions, within the microbiological standards in course until the modification published by Brazil (Dec 26, 2019), with effects from Dec 26, 2020.

The tilapia (*Oreochromis* spp.) solid residuals were used by Leira et al. (2019) for minced fish production and their microbiological data (thermotolerant coliforms = <3 MPN/g, coagulase-positive *Staphylococcus* = absent/g and *Salmonella* sp. = absent in 25 g) indicates this product as adequate as an ingredient of other culinary preparations, results that mirrored those of the present study.

Catfish (*Brachyplatystoma rousseauxii*) residuals from the processing industry used by Caldas et al. (2018) to obtain minced fish reveal the absence of these same microbiological agents and generate a pâté well accepted by the sensory judges. So, the mapará residuals can be used in human food preparations, too.

Aberoumand (2010) said that processing plants constantly need to check the temperature, cleaning system, and staff hygiene, to avoid high bacterial content. This study indicates that the fish processing plant of Santarém adopts good handling practices and, if continued in other locations, allows edible products from mapará residuals. Additionally, the washed minced originated, according to continuous and correct handling, can be characterized as safe for people to preparing foods.

It's important to emphasize that Brazilian standards changed in 2019, and the quantification of thermotolerant coliforms presented here was replaced by mandatory *Escherichia coli* enumeration (optional until Jan 25, 2020).

The minced fish yields made of mapará residuals concerning to the washes with treated water in different pH's are expressed in Figure 1.

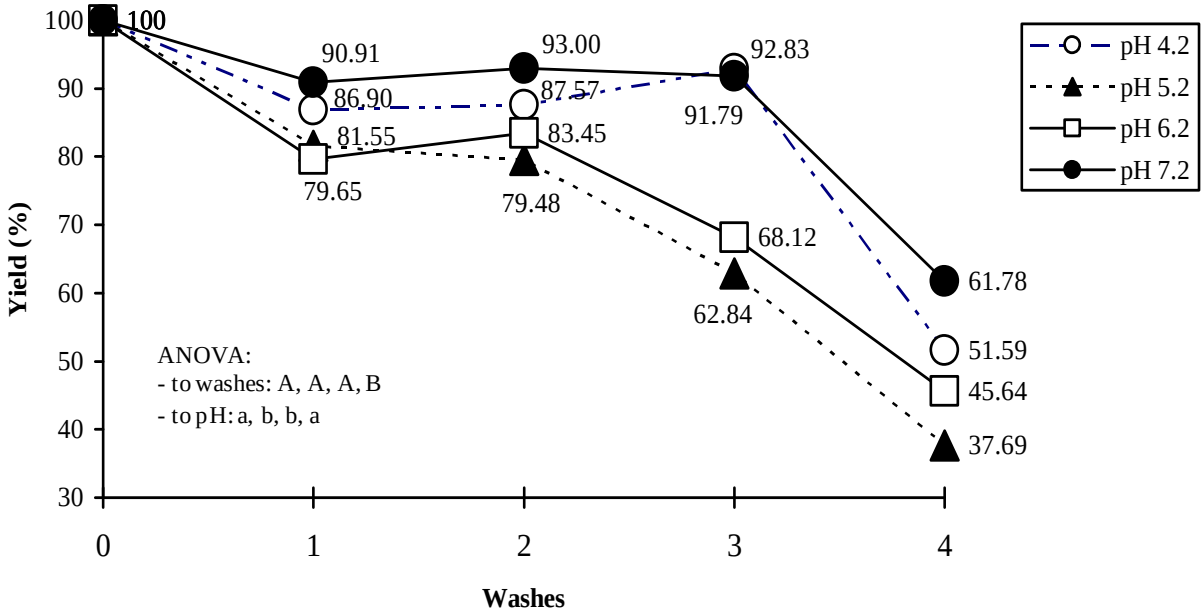

Figure 1 –Yields of the mapará (*Hypophthalmus* spp.) minced meat after washes at different water pH's. Note: The letters at the bottom of the graph point to the result of the analysis of variance, with the uppercase (in the ascending order of the amount of washes) being the relationship between washes vs. yield, and the lowercase (in the ascending order of pH), between the pH vs yield. Different letters indicate statistically significant differences.

Yields were influenced by pH ($F = 16.48$; $p > 0.05$) of washing water. The highest and lowest yield indices were recorded after the fourth wash for the pH 7.2 and 5.2, respectively. Considering the index obtained in this fourth wash, the highest yield in this research was close to that obtained by Medeiros, Lima, & Guimarães (2016), with MSM from Nile tilapia, but lower than that obtained by Murthy, Panda, & Shamasundar (2011), also with MSM. Both studies did not mention the pH of the washing water used in their procedures.

Probably, pH 7.2 is closer to the isoelectric point of the minced meat (or most of the proteins present there), which caused a lower loss of this biomolecule during this procedure. Mello (2009) states that pH values closer to the isoelectric point favor the more efficient removal of meat water. This measurement was not performed due to equipment limitations in the laboratory.

The number of washes also affected this yield ($F = 62.63$; $p > 0.05$), where an inverse relationship was noticed to the quantity of these washes. This finding had already been observed by Grott, Façanha, Furtado, Cunha & Cunha (2018), who also pointed out as influencing factors the efficiency in water withdrawal and the type of equipment.

A very pasty aspect and increased volume of the mapará minces meat during washing were noticed, predominantly occurring in the second wash for most of the pH's used in this research, except for pH 5.2, which continuously showed a decrease in yield. According to Hassan et al. (2017), this swelling is caused mainly by the complex actomyosin abundant in this type of product.

Statistically, the yield according to the number of washes or the pH differed at the level of 5% significance (both with p-value > 0.05). According to the Tukey test, the quantitative of four washes was statistically different from the others; among the pH's, at least two statistically significant differences were demonstrated for each pH.

Mello (2009) states that often the characteristic taste of fish meat does not please everyone, so it is possible to choose to remove this characteristic through washes, providing the addition of various flavors to fish products, making them healthier and more inviting for a part of the population.

Although more washes lead to lower yield, Pereira (2016) recommends four washes to obtain the mapará paste, as these provide a reduction of the marked flavor and smell of fatty fish. In his research, this reduction was verified by the sensory analysis of his derived product – the mapará hamburger – for which the tasters showed a preference for those prepared from the most washed paste (four washes).

Murthy et al. (2011) considered moderate the formation of gel when washing tilapia meat with pH 6.0 water and suggested that the yield may be a consequence of the protein quantity of the raw material, and this gel formation occurs by the presence of myofibrillar proteins that considered extremely gelling and emulsifying. Antagonistically, the results of this research suggest that the yield is a consequence of the pH of the washing water, and the values obtained seem to vary according to the species and cannot be generalized to the whole group.

Among the analyzed pH's, the value 7.2 is recommended because it provides higher minced meat yield (61.78%). Currently, it is recommended that the pH should be kept in the range of 6.0 to 9.5 in the water supply network for human consumption (Brasil, 2021). This range is less controllable when the water supply is via groundwater system, using wells, a reality of many inland towns and cities of the Amazon, exemplified below.

According to Medeiros et al. (2016), the communities of Maranhão (Abaetetuba - PA) and Vila do Conde (Barcarena - PA) have pH values below 6. In Macapá - AP, the result of Grott et al. (2018) shows that water consumed in 52 households in the dry and rainy seasons has pH values below 6. For Santarém - PA, data from Bentes, Almeida Neto & Meschede (2020) demonstrated the range from 3.53 to 5.94 as the pH values of the supplied water. All these studies indicate that the water used by the residents of these places and from artesian wells is unfit for human consumption and food production.

Therefore, government actions that ensure the supply of water with adequate pH for the population of Santarém are needed. Meanwhile, the local business community in the food production sector needs to adjust the pH of the water before use. Particularly, to produce minced fish and derived products, this measure is pivotal.

It is noteworthy that the acidic pH in the city's water, based on the indication of Almeida et al. (2017), may be caused by chemical contamination, which was not the subject of research in this study and, therefore, this investigation is urgent. Furthermore, complementary analyses in this minced mapará need to be performed, such as the shelf life of the product, whose results can support future entrepreneurial actions. The microbiological indexes point to the possibility of using fish residuals in human food preparations, being an important measure to reduce or eliminate its inadequate disposal.

Conclusions

To obtain the washed minced mapará (*Hypophthalmus* spp.) from residuals of the fish processing industry it is recommended to guarantee the microbiological quality adopted by the commercial establishment and ensure the continuity of this quality in the treatment of residuals. In the minced processing, it is necessary to use water-cooled with pH previously adjusted at 7.2 because it provides a higher yield of the final product, is safer for the health of the consumer, and allows the entrepreneur to produce a greater amount of products derived from this minced meat.

Acknowledgments

Edifrigo Comercial e Industrial Ltda. (by donation of fish residuals), Universidade Federal do Oeste do Pará – UFOPA (by physical infrastructure and personnel), Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – CAPES and Fundação Amazônia de Amparo a Estudos e Pesquisas – FAPESPA (by financial supporting).

References

Aberoumand, A. Estimation of microbiological variations in minced lean fish products. World Journal of Fish and Marine Sciences, v. 2, n. 3, p. 204-207, 2010.

Almeida, A. G., Carvalho, L. R., Alves, F. Q., Adry, A. P., Santini, A. C. & Aleluia, M. M. (2017). Análise microbiológica e físico-química da água de bebedouros em unidades de ensino no município de Ilhéus - BA. *SaBios-Revista Saúde e Biologia*, 12 (2), 20–26. Available from: https://revista2.grupointegrado.br/revista/index.php/sabios/article/view/2157

Bentes, V., Almeida Neto, G. & Meschede, M. (2020). Qualidade da água utilizada para consumo humano proveniente do Aquífero Alter do Chão em Santarém (Oeste do Pará) e sua relação com a saúde pública. *Geochimica Brasiliensis*, 34 (1), 101–109. doi: 10.21715/GB2358-2812.2020341101

Brasil. Decreto n° 9013, de 29 de março de 2017. Dispõe sobre a inspeção sanitária de produtos de origem animal. *Diário Oficial da União* (DOU) Brasília, DF, Brasil. p. 3.

Brasil. Aprova o Regulamento Técnico sobre padrões microbiológicos para alimentos. *Diário Oficial da União* (DOU) Brasília, Brasil; Jan 10, 2001 p. 45-48.

Caldas, K. D. P. P., Santos, P. R. B. & Atayde, H. M. Patê de peixe usando resíduos da indústria pesqueira amazônica: produção e aceitação. Revista Ibero-Americana de Ciências Ambientais, v. 9, n. 6, p. 188-198, 2018. doi: 10.6008/CBPC2179-6858.2018.006.0020

Chalamaiah, M., Kumar, B. D., Hemalatha, R. & Jyothirmayi, T. (2012). Fish protein hydrolysates: Proximate composition, amino acid composition, antioxidant activities and applications: A review. *Food Chemistry*, 135 (4), 3020–3038. doi: 10.1016/j.foodchem.2012.06.100

Gonçalves, A. A. (2021). Produção de surimi e suas aplicações. In: *Tecnologia do Pescado: ciência, tecnologia, inovação e legislação*. 2nd ed. Rio de Janeiro, Brazil: Atheneu Editora, p. 228–235.

Grott, S. L., Façanha, E. B., Furtado, R. N., Cunha, H. F. A. & Cunha, A. C. (2018). Space-seasonal variation of groundwater parameters used for human consumption in the city of Macapá, Amapá, Brazil. *Engenharia Sanitária e Ambiental*, 23 (4), 645–654. doi: 10.1590/S1413-41522018162018

Hall, G. M. & Ahmad, N. H. Surimi and fish-mince products. *Fish Processing Technology* (1997). doi: 10.1007/978-1-4613-1113-3_3

Hassan, M. A., Balange, A. K., Senapati, S. R. & Xavier, K. A. M. (2017). Effect of different washing cycles on the quality of *Pangasius hypophthalmus* surimi. *Fisheries Technology*. doi: 10.21077/ijf.2017.64.special-issue.76245-20

Jamas, E. (2012). Valor agregado aos resíduos do processamento de tilápia: aspectos tecnológicos, químicos e microestruturais. (Thesis). [Jaboticabal, Brasil]: Universidade Estadual Paulista. Available from: http://hdl.handle.net/11449/86666

Leira, M. H., Nascimento, A. F., ALVES, F. R., Orfao, L., Lacerda, Y. G., Botelho, H. A., Reguim, L. & Lago, A. A. Characterization of different techniques for obtaining minced fish from tilapia waste. *Food Science and Technology*, n. 39, suppl. 1, p. 63-67, 2019.

Medeiros, A. C., Lima, M. de O. & Guimarães, R. M. (2016). Assessment of the quality of water for consumption by river-bank communities in areas exposed to urban and industrial pollutants in the municipalities of Abaetetuba and Barcarena in the state of Pará, Brazil. *Ciência e Saúde Coletiva*, 21(3): 695–708. doi: 10.1590/1413-81232015213.26572015

Mello, S. C. R. P. (2009). Caracterização físico-química, bacteriológica e sensorial de "fishburger" e "kamaboko" obtidos da polpa e "surimi" de tilápia (*Oreochromis niloticus*). [Niterói, RJ, Brasil]: Universidade Federal Fluminense.

Murthy, L. N., Panda, S. K. & Shamasundar, B. A. (2011). Physico-chemical and functional properties of proteins of tilapia (*Oreochromis mossambicus*). *Journal of Food Processing Engineering*,34(1):83–107. doi: 10.1111/j.1745-4530.2008.00338.x

Neiva, C. R. P. (2021). Carne Mecanicamente Separada (CMS) de Pescado. In: *Tecnologia do Pescado: ciência, tecnologia, inovação e legislação*. p. 217–27.

Palmeira, K. R., Máralém, E. T., Doro, L., Lemos, M., Teixeira, C. E., Paschoalin, V. M. F., ... Conte Júnior, C. A. (2014). Quality of semi-prepared products from rainbow trout waste (*Onchorynchus mykiss*) by using different technological strategics. *Food Nutrition Science*, 571–80. doi: 10.4236/fns.2014.56067

Pereira, E. C. (2016). Influência das lavagens no rendimento, aceitabilidade e preço mínimo do fishburguer de mapará (*Hypophthalmus* spp.). Monography. [Santarém - PA].

Hammer, Ø., Harper, D. A. T., Ryan, P. D. (2001). *Past: Palaeonthological statistics software package for education and data analysis* (3.19 version).

Silva, N., Junqueira, V. C. A., Silveira, N. F. de A., Taniwaki, M. H., Gomes, R. A. R. & Okazaki, M. M. (2017). *Manual de métodos de análise microbiológica de alimentos e água*. 5th ed. Editora Atheneu; 535 p.

Souza, A. F. L. & Inhamuns, A. J. (2011). Análise de rendimento cárneo das principais espécies de peixes comercializadas no Estado do Amazonas, Brasil. *Acta Amazonica*, 41(2): 289–96. doi: 10.1590/S0044-59672011000200015