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Development of fish hamburger with reduced sodium content using sweet passion fruit shell flour

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Abstract
Fish burgers were developed with the substitution of sodium chloride (NaCl) by using sweet passion fruit peel flour. Tambacu (a Brazilian freshwater fish) burgers were prepared with a 50% reduction of sodium chloride and an addition of 0, 3.1, 3.7, and 4.3% of sweet passion fruit peel flour. The burgers with higher levels of flour were less hard and less elastic and required less chewing to be swallowed. Significantly lower ash and sodium contents were found in the formulations in which flour was used. The formulations did not differ concerning the color and aroma, as well as texture, flavor, and overall impression. The burger with 0% flour have greater acceptance when compared to the other fish burgers, which did not differ from each other in sensory characteristics, obtaining scores corresponding to the descriptions of liked moderately and liked slightly. The partial substitution of NaCl by using sweet passion fruit peel flour resulted in fish burgers with reduced sodium content and good physical and sensory characteristics, demonstrating the potential demand for its use.

Keywords: *Passiflora allata cutis*; meat products; products with low sodium content.

Practical Application: Use of sweet passion fruit peel flour in the production of fish burgers with reduced sodium content.

1. Introduction

Fish has long played an important role in providing a food-based source of nutrients (Kwasek et al., 2020), including being a rich source of bioavailable micronutrients that are essential for human health (Hicks et al., 2019). Thus, the importance of the varied application of this food is highlighted, as well as being an ingredient in the development of burgers (Fogaça et al., 2015).

Food products, in general, tend to have a high sodium content, including meat products, and its reduction is not an easy task because of its preservative action and expected sensory characteristics (Gómez-Salazar et al., 2021). Aiming to meet current legislation, as well as consumer demand for healthier foods, the food industry has sought to develop products with lower sodium content (Brasil, 2019; Tribuna de Ituverava, 2020). The Brazilian Society of Cardiology (SBC) states that if the consumption of sodium for healthy individuals above 2 years of age were reduced to 2,000 mg, the number of deaths from vascular and cerebral incidents and infarction would reduce by 15 and 10%, respectively (SBC, 2012), confirming the importance of controlling sodium intake in food and, consequently, the development of products with lower sodium content in their composition.

Solutions to replace and/or reduce NaCl content in foods consider the use of substitute chloride salts such as KCl, $CaCl_2$, $MgCl_2$, natural flavor enhancers, and new process technologies in combination with other barriers to meet physicochemical, microbiological, and sensory stability (Santos et al., 2023). Many studies indicate substitutes for sodium in embedded and/or processed foods, most of which are potassium chloride, monosodium glutamate, and potassium lactate, the products that result in the smallest change in sensory characteristics (Fieira et al., 2015; Giese et al., 2019; Mitterer-Daltoé et al., 2017).

Organic residues that would generally be discarded can be used to nutritionally enrich food (Sampaio et al., 2022; Santos & André, 2021), as already observed in the use of flour from sweet passion fruit peel flour in sheep meat products (Maia, 2017) with increased fiber and minerals (Borges et al., 2020; Vasconcellos et al., 2001). The benefits also extend to its way of acting in the human body, being rich in antioxidants and presenting anti-inflammatory effect, which reduces the risk of inflammatory diseases and even cancer (Ozarowski et al., 2018; Wasicky et al., 2015).

Thus, given the food products with fish, this study considers using flour from sweet passion fruit peel in the partial replacement of sodium chloride in fish burgers. As the use of flour in the form presented has not been considered in the literature and is a by-product of natural food, this could provide a good substitute for those who wish and/or need to reduce sodium in food. This idea arose following a sensory test that detected a slightly salty flavor of sweet passion fruit peel flour. Thus, this

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study aimed to evaluate the use of sweet passion fruit peel flour as a partial substitute for sodium chloride, aiming at sodium reduction in meat products.

2. Materials and methods

2.1. Preparation of sweet passion fruit peel flour

To obtain the flour from the sweet passion fruit peel, the fruits were washed using a 2% sodium hypochlorite solution for 20 min, with subsequent rinse. Then, they were pulped, and the shells were manually separated and immersed in water for 24 h, changing the water 18 times. Subsequently, they were dried in an oven with air circulation at 60 °C for 24 h (Figure 1A), crushed with the aid of a blender, and sieved in a mesh sieve of 28 mesh to obtain the flour (Figure 1B) that was used in the development of fish burger formulations (Table 1).

Each 100 g of flour obtained contains 4.04 g of moisture, 6.08 g of ashes, 10.41 g of protein, 0.64 g of lipids, 78.83 g of total carbohydrate obtained by difference, of which 69.42 g of dietary fiber, and 22.77 mg of sodium.

Figure 1. (A) Peel of dehydrated sweet passion fruit and (B) the flour obtained.

Table 1. Formulations of fish burgers with the inclusion of sweet passion fruit peel flour.

Ingredients (g)	Inclusion levels of sweet passion fruit peel flour			
	0%	**3.1%**	**3.7%**	**4.3%**
Crushed tilapia fillet	550	550	550	550
Ground tambacu fish*	550	550	550	550
Corn starch	37.5	0	0	0
Textured soy protein	31.25	0	8	15.75
Sweet passion fruit peel flour	0	39.25	47	55
Soybean oil	31.25	31.25	31.25	31.25
Cool water	25	25	25	25
Sodium chloride	21.25	10.75	10.75	10.75
Dehydrated onion	7.5	7.5	7.5	7.5
Dehydrated chives	3.75	3.75	3.75	3.75
Dehydrated parsley	3.75	3.75	3.75	3.75
Garlic powder	3.75	3.75	3.75	3.75
Antioxidant	1.875	1.875	1.875	1.875
Black pepper	1.25	1.25	1.25	1.25

*Ground fillet shaves. Standard formulation, without the addition of passion fruit peel flour (0%) and formulations with the addition of 3.1, 3.7, and 4.3% sweet passion fruit peel flour, respectively, and with a 50% reduction of sodium chloride in relation to the 0% sample.

2.2. Development of fish burgers

Four burger formulations were adopted, one standard (0%) without the addition of peel flour, and the other three with added sweet passion fruit peel flour in the proportions of 3.1, 3.7, and 4.3%, partially replacing sodium chloride and textured soy protein (TSP) in the standard formulation, considering the water retention properties of the TSP as well as the peel flour, and based on preliminary tests considering sensory characteristics (Table 1).

TSP was hydrated for 10 min in water, and all ingredients were mixed until a homogeneous mass was obtained, which was molded and frozen (Figure 2). The burgers were grilled using 1 mL of oil in a frying pan, for 10 min on each side.

2.3. Physical properties of fish burgers

All formulations were submitted to shear force analysis, texture profile analysis (TPA), fluid retention, shrinkage percentage, and color tests. A TA texturometer was used to determine the texture and shear force. The XT Plus (Stable Micro Systems Texture Analyser, United Kingdom) was used to evaluate the texture profile related to firmness, and a portable colorimeter (Konica Minolta Optics, Chroma Meter CR-400, Japan) was used to assess color. The caliper 150/6 "X0.01MM/0.0005" (Electronic Digital Calliper, Germany) was used to obtain the shrinkage percentage value.

The parameters for TPA analysis were 1.00 mm/s in the pre-test, 5.00 mm/s of speed in the test and post-test, distance of 10,000 mm and time of 5 s, type of g high and force of 0.04903 N, and auto tare mode. In the shear force, 1.00 mm/s was used in the pre-test, 2.00 mm/s in the speed test, and 10.00 mm/s of post-test speed, distance of 35,000 mm and time of 5 s, type of g high g and force of 0.04903 N, and auto tare mode. The parameters of the colorimeter were luminosity (L*), tint or matrix (a*), and saturation or chromaticity (b*).

2.4. Nutritional composition of fish burgers

Moisture quantification was performed by drying in an oven with forced air circulation at 105 °C. The mineral matter was determined by incineration in a muffle furnace at 550 °C. Lipids were obtained through the Soxhlet hot extraction method, using petroleum ether as solvent. The protein content was obtained by nitrogen determination using the Kjeldhal method and the conversion factor 6.25, and carbohydrates were obtained by difference. Sodium was determined by atomic emission spectrometry (AOAC, 1995).

2.5. Sensory analysis

The analysis of sensory acceptability of the fish burgers was performed in the Laboratory of Sensory Analysis of Food in individual cabins, under white light with 40 tasters made up of employees and students of the Universidade da Grande

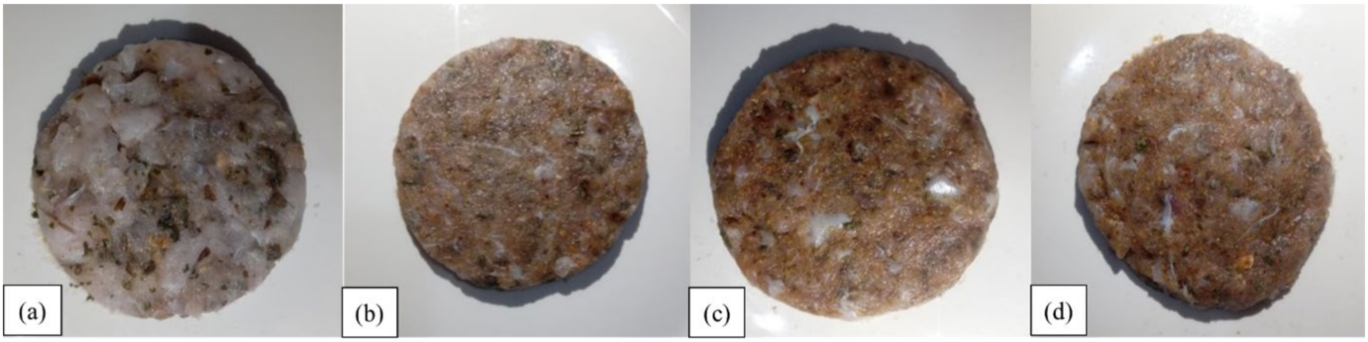

Figure 2. Raw fish burgers: (A) standard formulation, without added passion fruit peel flour (0%) and formulations with added sweet passion fruit peel flour of (B) 3.1, (C) 3.7, (D) 4.3%, with a 50% reduction in sodium chloride compared to the 0% sample.

Dourados who consented to participate in the research and signed the free and informed consent form, previously approved by the Ethics Committee on Research with Humans of the Universidade Federal da Grande Dourados, with the certificate number for ethical assessment (CAAE) 1005028. The samples were served on small disposable plates coded with random three-digit numbers, in a random way (Macfie et al., 1989).

For the acceptance test, a structured hedonic 9-point scale was used, containing the descriptions "I greatly disliked it" and "I liked it very much," evaluating the attributes of color, aroma, flavor, texture, and overall impression. The purchase intention was evaluated using a scale containing the options of would certainly buy, probably buy, maybe buy/maybe not, probably would not buy, and would not buy (Dutcosky, 2019).

2.6. Statistical analysis

The results obtained represent the mean and standard deviation of three determinations per sample (in the case of physical and chemical analyses) and 40 tasters (in the case of sensory analysis) submitted to analysis of variance (ANOVA) and means compared by the Tukey's test (p≤0.05), using the Origin 6.0 software.

3. Results and discussion

3.1. Physical properties of fish burgers

Color is one of the main parameters that determine the acceptance of a product by the consumer (Cofrades et al., 2008). For the color of fish burgers (Table 2), differences (p<0.05) were observed in all parameters. The luminosity (L*) was lower in the burger with greater inclusion of passion fruit peel flour, in relation to levels 0 and 3.1%. Higher red intensities (a*) were observed in burgers with intermediate levels of inclusion of passion fruit peel flour (3.1 and 3.7%). In general, all formulations presented more yellow (b*) when compared to the control treatment. These findings are not surprising, considering the dark color of sweet passion fruit peel flour that presented values of L*, chroma a*, and chroma b* of 64.17±1.66, 7.91±0.56, and 28.14±0.25, respectively. Grilled burgers based on the by-products of Nile tilapia filleting (*Oreochromis niloticus*) showed a

Table 2. Color (n=9), texture (n=6), and preparation characteristics (n=3) of grilled fish burgers (mean±standard deviation).

Features	Inclusion levels of sweet passion fruit peel flour			
	0%	3.1%	3.7%	4.3%
Color				
L*	59.6±1.1^{a}	58.9±1.9^{a}	59.2±2.8^{ab}	62.4±2.7^{b}
a*	3.1±0.5^{a}	5.9±0.4^{b}	6.2±1.2^{b}	4.3±1.2^{a}
b*	11.9±0.7^{a}	19.8±2.2^{b}	19.4±2.0^{b}	17.7±2.3^{b}
Texture profile				
Hardness (N)	17.0±5.2^{a}	23.1±10.3^{a}	0.0±0.0^{b}	0.0±0.0^{b}
Cohesiveness	0.2±0.0^{a}	0.2±0.0^{ac}	0.1±0.0^{b}	0.2±0.0^{c}
Elasticity	0.4±0.1^{a}	0.2±0.0^{bc}	0.1±0.0^{b}	0.2±0.0^{c}
Chewability	1.6±0.6^{a}	1.1±0.3^{b}	8.9^{E-4}±4.5E^{-4c}	0.0±0.0^{c}
Shear force (N)	3.5±0.4^{a}	2.8±0.4^{bc}	2.6±0.2^{b}	3.2±0.3^{ac}
Preparation yield (%)	87.7±1.3^{a}	79.2±0.4^{b}	83.8±3.2^{ab}	87.3±1.8^{a}
Shrinkage (%)	8.8±1.1	9.9±1.1	9.7±3.6	8.1±2.1

Formulations with added sweet passion fruit peel flour of 3.1, 3.7, and 4.3%, respectively, and with a 50% reduction of sodium chloride in relation to the 0% sample. Different letters on the same line indicate significant differences by Tukey's test (p≤0.05).

luminosity of 45.4, a red intensity of 7.2, and a yellow intensity of 22.5 (Muzzolon et al., 2018). However, grilled burgers of tilapia fillets obtained a luminosity of 63.89, chroma a* of 4.11, and chroma b* of 21.62 (Bainy et al., 2015).

The instrumental texture is strongly correlated with organoleptic characteristics (Steele et al., 2015). In meat products, salt content is important for the texture because of the large impact on the water-holding capacities that will affect the product texture (Delgado-Pando et al., 2018). In the TPA of the burgers (Table 2), it was observed that the inclusion of the highest levels of sweet passion fruit flour (3.7 and 4.3%) resulted in a drastic decrease in hardness and chewability (p≤0.05). The hardness describes the force required for the deformation of the fish burger between the molar teeth (Presenza et al., 2022), while chewability is a secondary parameter related to hardness, and lower chewability means less energy to compress the burger (Jiménez Muñoz et al., 2019). Regarding cohesiveness, burgers with 0 and 3.1% inclusion of sweet passion fruit peel flour presented higher values (p≤0.05), indicating greater strength needed to break them when bitten (Costa et al., 2019).

It is known that the addition of ingredients with high dietary fiber content to food modifies both texture and stability in ways determined by processing conditions, but the mechanisms differ depending on the solubility of the fibers (Atitallah et al., 2019). Gao et al. (2014) stated that there is an inversely proportional relationship between humidity and hardness. In tambaqui burgers (*Colossoma macropomum*) with the addition of oatmeal and cassava starch, the highest concentrations of these ingredients indicated an increase in hardness and cohesiveness, possibly because these ingredients are fibrous and tend to weaken myofibrillary bonds (Presenza et al., 2022).

Elasticity was higher in the standard burger and lower in the burger with 3.7% inclusion of sweet passion fruit peel flour ($p \leq 0.05$), emphasizing that even with the addition of peel flour, which contains large amounts of pectin that has the ability to retain water, the removal of starch decreased the elasticity (Gonçalves, 2021). There was a reduction in shear force for burgers with 3.1 and 3.7% of passion fruit peel flour, in relation to the others ($p \leq 0.05$). These parameters may have also been influenced by the moisture content of these burgers, because the higher humidity observed in the 3.7% inclusion treatment may have influenced the lower shear force, as the high water content of the fish burger makes it less resistant to shear force (Bainy et al., 2015). Burgers with mechanically separated Nile tilapia fish showed shear strength ranging from 1.8 to 2.9 N and hardness ranging from 10 to 45.2 N (Costa et al., 2019).

Therefore, the results of the texture profile indicate that burgers with higher levels of sweet passion fruit peel flour were less hard and less elastic and required less chewing to be swallowed.

As for the preparation yield, it was higher in the burgers with 0 and 4.3% inclusion of sweet passion fruit peel flour, while the burger with the addition of 3.1% presented the lowest yield. However, the percentage of shrinkage was the same for all burgers ($p > 0.05$). Higher cooking losses are expected with NaCl reduction (Saavedra et al., 2022) because NaCl can solubilize and hydrate proteins, increasing water retention and fat-binding capacity and favoring product yield (Desmond, 2006). In this study, the increase in the inclusion levels of sweet passion fruit peel flour may have compensated for the cooking losses resulting from the partial removal of salt. In cooked "spam-like" products formulated with tilapia filleting by-product, it was observed that cooking loss, fat, and water exudations increased, and texture parameters decreased by NaCl substitution (Santos et al., 2021).

3.2. Nutritional composition of fish burgers

The consumer and meat industry is alert to the sodium content, and the demand for products with reduced levels of sodium increases continuously year by year (Vidal et al., 2021). Regarding the nutritional composition of the burgers (Table 3), higher moisture content was observed for the burger with a 3.7% inclusion of sweet passion fruit peel flour and lower moisture content in the burger with a 4.3% addition ($p \leq 0.05$). As for protein content, it was higher for standard burgers and with a 3.7% inclusion of sweet passion fruit peel flour. The lipid and carbohydrate contents did not differ between treatments ($p > 0.05$), but a lower ash content can be observed in burgers with 3.1 and 3.7% addition of sweet passion fruit peel flour.

Table 3. Nutritional composition (g/100 g) and sodium content of raw fish burgers.

	Inclusion levels of sweet passion fruit peel flour			
Parameters	0%	3.1%	3.7%	4.3%
Moisture	71.7±0.8^{ab}	72.0±0.4^{ab}	72.7±0.1^{a}	71.7±0.3^{b}
Proteins	15.2±0.5^{a}	12.4±3.7^{ab}	14.8±0.2^{a}	14.1±0.0^{b}
Lipids	5.1±0.7	5.0±0.8	4.6±0.2	4.0±0.5
Carbohydrates	6.4±1.3	9.6±4.8	6.9±0.6	8.9±1.3
Ashes	2.2±0.1^{a}	1.6±0.0^{c}	1.6±0.0^{c}	1.8±0.0^{b}
Sodium (mg)	592.7±25.2^{a}	201.8±28.9^{b}	275.9±31.7^{c}	301.7±13.4^{c}

Standard formulation, without the addition of passion fruit peel flour (0%) and formulations with added sweet passion fruit peel flour of 3.1, 3.7, and 4.3%, respectively, and with a 50% reduction of sodium chloride in relation to the 0% sample. Different letters on the same line indicate a significant difference between the samples by the Tukey's test ($p \leq 0.05$).

The burger formulations developed have a maximum lipid content of maximum fat 23% and a protein content very close to the minimum protein required, which is 15% (Brasil, 2000).

The moisture found in the burgers in this study was similar to that of fish burgers developed by Maciel et al. (2021), with 72%. Fish protein has similar nutritional values to those of bovine protein (Khan et al., 2020; Lee et al., 2019); however, higher values were found in fish burgers when compared to this study (Marconato et al., 2020).

In pacu (*Piaractus brachypomus*) burgers, an Amazonian freshwater fish, there were no differences in proximal composition except for ash results, in which substitution of 50% NaCl by KCl and $CaCl_2$ increased ash values (Saavedra et al., 2022).

The standard formulation (0%) has a significantly higher ash and sodium content than the others, which can be explained by its much higher sodium content, derived from the higher amount of sodium chloride used in this formulation. In a study conducted by Anjos (2019), the ash value found in fish burgers with added cassava flour, 2.21%, was close to the value found for the standard treatment of this study. Tonet et al. (2019) found 1.16 and 1.32% in standard fish burgers and fish burgers with the addition of yerba mate flour, respectively. The formulation 4.3%, with the highest amount of added peel flour, presented the highest ash content, which can be explained by the fact that sweet passion fruit peel flour, as well as the flours of the peel of other fruits, is considered a food with significant amounts of minerals (Borges et al., 2020).

The formulation 3.1% presented significantly lower sodium content than the other formulations because, despite the same amount of sodium chloride being added as in the formulation 3.7%, it did not contain TSP, which also has sodium in its composition (Unicamp, 2011). The other treatments also presented significantly lower sodium content than 0%, confirming that the addition of sweet passion fruit peel flour does not significantly increase the sodium content of the formulations, as it has only 22.77 mg/100 g of the fruit.

The use of sweet passion fruit peel flour for sodium reduction in fish products was not found in the literature, but in meat products, the use of monosodium glutamate to increase the palatability of low-sodium products was found (Ulusoy et al., 2017). Although sodium is important in food preparation, such as for the making of bread, meat conservation, and increased shelf life of food, its overuse has caused many countries, including Brazil, to take initiatives to reduce sodium consumption in processed and ultra-processed foods.

The World Health Organization (WHO) recommends that sodium intake is 2,000 mg/day, equivalent to 5 g of sodium chloride, for healthy individuals over 2 years of age (Brasil, 2018), but usually, a large part of the population does not follow this guidance, reaching 12 g of sodium chloride per capita (SBC, 2012).

3.3. Sensory analysis

Considering the results of the sensory acceptability of burgers (Figure 3), it was found that the formulations did not differ in relation to the attributes of color and aroma, obtaining a score on the scale used in the evaluation corresponding to "liked slightly" and "liked moderately." As for texture, flavor, and overall impression, the 0% burger obtained a higher acceptance when compared to the other burgers, which did not differ from each other in terms of sensory characteristics (Table 4).

Comments were recorded about the salty taste of the burger formulations with added sweet passion fruit peel flour (7.5% of the time) as "all were good, it is a matter of taste even" and "just put more salt." Replacing salt in meat products is a challenge from both technological and sensorial points of view (Gómez-Salazar et al., 2021; Vidal et al., 2021). The habit of adding sodium chloride to food leads to changes in the perception of salty taste and consequently in food preferences (Li et al., 2017). Palatability is altered due to the increase in the consumption of excessively salty, fatty, and sweet foods. In the study by Tan et al. (2021), it was possible to identify the high intake of sodium chloride, as a dietary habit. In another study, the salty taste was directly related to the habit of adding salt to meals (Dantas, 2020).

In meat products with sodium reduction, as the NaCl decreases in the formulation, the "salty" attribute decreases and a perception of "tasteless" emerges (Lima Filho et al., 2019) because sodium enhances some typical meat tastes, such as meaty and savory notes (Bhat et al., 2020).

As in this study, Cristofel (2014) used functional ingredients (amaranth, chia, and quinoa) for the nutritional enrichment of tilapia fish burgers, and Presenza et al. (2022) used potato starch and oatmeal in burgers with tambaqui fish (*C. macropomum*), with global acceptance similar to that of this study. Other studies use chlorides for partial sodium replacement in meat products. Fieira et al. (2015) studied the partial replacement of sodium chloride by potassium chloride, magnesium chloride, and calcium chloride in Italian salami. This resulted in sodium reduction, but there were sensory changes such as flavor and texture, similar to this study.

Probably, the lower acceptability of the texture of the burgers with added sweet passion fruit peel flour was due to the absence of corn starch because this flour contains high amounts of pectin; this polysaccharide did not provide a sufficient bonding in this meaty product (Freitas et al., 2020). Although no data were found in the literature regarding the use of sweet passion fruit peel flour in fish burgers, in a study by Quadros et al. (2015), the formulation of fish burgers with a lower amount of sodium and no monosodium glutamate was the least accepted compared to the other formulations, similar to the findings in this study, in which the highest acceptance was of the formulation with the highest amount of sodium.

As for the intention to purchase the burgers, most tasters reported that they would probably or certainly buy the formulation 0%, while most doubted whether they would buy the sample with 3.1% added sweet passion fruit peel flour, and that they possibly would not buy the formulations 3.7 and 4.3% (Figure 4).

Table 4. Sensory acceptability of the fish burger.

Features	Inclusion levels of sweet passion fruit peel flour			
	0%	3.1%	3.7%	4.3%
Color	6.4±1.7	7.2±1.8	7.2±1.7	7.1±1.7
Aroma	7.1±1.4	7.1±1.7	6.8±1.9	6.5±1.8
Texture	7.3±1.3^a	6.4±1.9^b	6.1±2.0^b	6.5±1.7^b
Flavor	8.0±1.3^a	5.4±1.9^b	5.0±2.0^b	5.3±2.0^b
Overall impression	7.7±1.2^a	6.3±1.9^b	5.9±1.9^b	5.6±1.7^b

Standard formulation, without the addition of passion fruit peel flour (0%) and formulations with added sweet passion fruit peel flour of 3.1, 3.7, and 4.3%, respectively, and with a 50% reduction of sodium chloride in relation to the 0% sample. Different letters on the same line indicate a significant difference between the samples by the Tukey's test (p≤0.05).

Figure 3. Grilled fish burgers: (A) standard formulation, without the addition of passion fruit peel flour (0%) and formulations with added sweet passion fruit peel flour of (B) 3.1, (C) 3.7, (D) 4.3%, respectively, and with a 50% reduction of sodium chloride compared to the 0% sample.

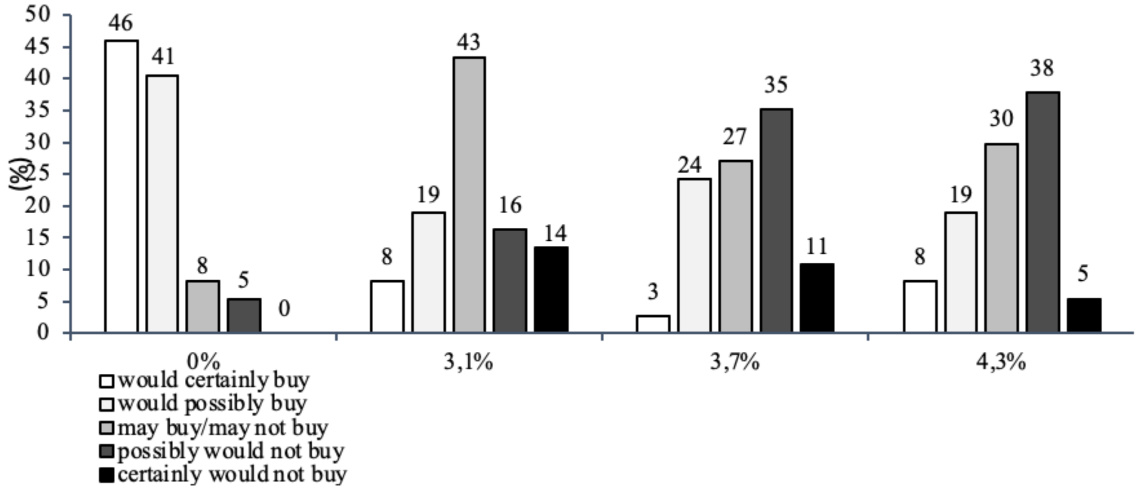

Figure 4. Analysis of intention to purchase formulations, without the addition of passion fruit peel flour (0%) and formulations with added sweet passion fruit peel flour of 3.1, 3.7, and 4.3%, respectively, and with a 50% reduction of sodium chloride compared to the 0% sample.

A very important factor that directly influences purchase intention is the flavor of the product (Nunes et al., 2020); in this study, there was greater acceptance of the formulation with a higher amount of sodium followed by the formulation with a lower amount of peel flour, directly influencing the results for the purchase intention.

4. Conclusion

The use of sweet passion fruit peel flour as a partial substitute for sodium chloride in fish burgers gave good physical and sensory characteristics and reduced sodium content, showing its potential for the development of products with sodium reduction. Sensory results suggest the need for further studies in order to test different proportions of sodium chloride replacement. In addition, it would be interesting to test the use of this flour in the preparation of other commonly consumed meat products.

References

Anjos, E. S. (2019). *Desenvolvimento e aceitação de hambúrguer com resíduos da filetagem do tambaqui (*colossoma macropomum*) e farinha do bagaço de Mandioca (*manihot esculenta crantz*)*. Mestrado em Ciência e Tecnologia de Alimentos, Universidade Federal do Tocantins, Tocantins.

Association of Official Analytical Chemists (AOAC). (1995). Official methods of analysis of the Association of Official Analytical Chemists. AOAC.

Atitallah, A. B., Barkallah, M., Hentati, F., Dammak, M., Hlima, H. B., Fendri, I., Attia H., Michaud P., & Abdelkafi, S. (2019). Physicochemical, textural, antioxidant and sensory characteristics of microalgae-fortified canned fish burgers prepared from minced flesh of common barbel (Barbus barbus). *Food Bioscience*, *30*, 100417. https://doi.org/10.1016/j.fbio.2019.100417

Bainy, E. M., Bertan, L. C., Corazza, M. L., & Lenzi, M. K. (2015). Effect of grilling and baking on physicochemical and textural properties of tilapia (*Oreochromis niloticus*) fish burger. *Journal of Food Science and Technology*, *52*(8), 5111-5119. https://doi.org/10.1007/s13197-014-1604-3

Bhat, Z. F., Morton, J. D., Mason, S. L., & Bekhit, A. E. D. A. (2020). The application of pulsed electric field as a sodium reducing strategy for meat products. *Food Chemistry*, *306*, 125622. https://doi.org/10.1016/j.foodchem.2019.125622

Borges, R. M. A., Alencar, E. R., Costa, A. M., & Junqueira, N. T. V. (2020). Physicochemical aspects of genotypes of Passiflora alata Curtis. *Brazilian Journal of Food Technology*, *23*. https://doi.org/10.1590/1981-6723.18819

Brasil. Ministério da Agricultura e do Abastecimento. Secretaria de Defesa Agropecuária. Departamento de Inspeção de Produtos de Origem Animal (2000). Regulamento técnico de identidade e qualidade de hambúrguer. *Diário Oficial da União*.

Brasil. Ministério da Saúde. Agência Nacional de Vigilância Sanitária (2019). Relatório do monitoramento do teor de sódio em alimentos industrializados. *Diário Oficial da União*.

Brasil. Ministério da Saúde. Secretaria de Atenção à Saúde. Departamento de Atenção Básica (2018). *Monitoramento do plano de redução do sódio macarrão instantâneo, pão de forma e bisnaguinha*. Ministério da Saúde.

Cofrades, S., López-López, I., Solas, M. T., Bravo, L., & Jiménez-Colmenero, F. (2008). Influence of different types and proportions of added edible seaweeds on characteristics of low-salt gel/emulsion meat systems. *Meat Science*, *79*(4), 767-776. https://doi.org/10.1016/j.meatsci.2007.11.010

Costa, D. P. S. D., Gonçalves, T. M. V., & Conti-Silva, A. C. (2019). Potentiality of using mechanically separated meats of nile tilapia in fishburgers: Chemical, physical and sensory characterization. *Brazilian Archives of Biology and Technology*, *62*. https://doi.org/10.1590/1678-4324-2019180436

Cristofel, C. J. (2014). *Elaboração de hambúrguer de tilápia (*Oreochromis niloticus*) enriquecido com ingrediente funcional e resíduo de guabiroba (*Campomanesia xanthocarpa*): caracteristicas físicas, químicas e sensoriais*. (Monografia). Universidade Federal da Fronteira Sul, Laranjeiras do Sul.

Dantas, N. M. (2020). *Avaliação sensorial de alimnetos com redução de sódio: pespectivas de consumidores universitários*. (Monografia). Universidade de São Paulo, São Paulo.

Delgado-Pando, G., Fischer, E., Allen, P., Kerry, J. P., O'Sullivan, M. G., & Hamill, R. M. (2018). Salt content and minimum acceptable levels in whole-muscle cured meat products. *Meat Science*, *139*, 179-186. https://doi.org/10.1016/j.meatsci.2018.01.025

Desmond, E. (2006). Reducing salt: A challenge for the meat industry. *Meat Science*, *74*(1), 188-196. https://doi.org/10.1016/j.meatsci.2006.04.014

Dutcosky, S. D. (2019). *Análise sensorial de alimentos (5. ed.)*. PUCPRess.

Fieira, C., Marchi, I. J. F., & Alfaro, A. T. (2015). Partial replacement of sodium chloride in Italian salami and the influence on the sensory properties and texture. *Acta Scientiarum. Technology*, *37*(2), 293-299. https://doi.org/10.4025/actascitechnol.v37i2.24912

Fogaça, F. H. S., Otani, F. S., Santarém, P. A., Portella C. G., Santos L. G. A. & Sant'ana, L. S. (2015). Characterization of surimi obtained from the mechanically separated meat of Nile tilapia and elaboration of fishburger. *Semina Ciências e Agrárias*, *36*(2), 765-776. https://doi.org/10.5433/1679-0359.2015v36n2p765

Freitas, C. M. P., Sousa, R. C. S., Dias, M. M. S., & Coimbra, J. S. R. (2020). Extraction of pectin from passion fruit peel. *Food Engineering Reviews*, *12*, 460-472. https://doi.org/10.1007/s12393-020-09254-9

Gao, X., Zhang, W., & Zhou, G. (2014). Effects of glutinous rice flour on the physiochemical and sensory qualities of ground pork patties. *LWT – Food Science and Technology*, *58*(1), 135-141.

Giese, E., Meyer, C., Ostermeyer, U., Lehmann, I., & Fritsche, J. (2019). Sodium reduction in selected fish products through salt substitutes. *European Food Research & Technology*, *245*(8), 1651-1664. https://doi.org/10.1007/s00217-019-03277-1

Gómez-Salazar, J. A., Galván-Navarro, A., Lorenzo, J. M., & Sosa-Morales, M. E. (2021). Ultrasound effect on salt reduction in meat products: a review. *Current Opinion in Food Science*, *38*, 71-78. https://doi.org/10.1016/j.cofs.2020.10.030

Gonçalves, A. A. (2021). *Tecnologia do pescado: Ciência tecnologia, inovação e legislação (2. ed.)*. Atheneu.

Hicks, C. C., Cohen, P. J., Graham, N. A., Nash, K. L., Allison, E. H., D'Lima, C., Mills, D. J., Roscher, M., Thilsted, S. H., Thorne-Lyman, A. L., & MacNeil, M. A. (2019). Harnessing global fisheries to tackle micronutrient deficiencies. *Nature*, *574*(7776), 95-98. https://doi.org/10.1038/s41586-019-1592-6

Jiménez Muñoz, L. M., Sotelo Díaz, I., Salgado Rohner, C., Cáez Ramirez, G., & Filomena Ambrosio, A. (2019). Effectiveness of high power ultrasound for surimi-based preparation of lionfish (Pterois volitans) patties by textural, sensory and shape preference. *Journal of Culinary Science & Technology*, *17*(2), 89-102. https://doi.org/10.1080/15428052.2017.1404538

Khan, S., Rehman, A., Shah, H., Aadil, R. M. A., Shehzad, Q., Ashraf, W., Yang, F., Karim, A., Khaliq, A. & Xia, W. (2020). Fish protein and its derivatives: the novel applications, bioactivities, and their functional significance in food products. *Food Reviews International*, *38*(8), 1607-1634.

Kwasek, K., Thorne-Lyman, A. L., & Phillips, M. (2020). Can human nutrition be improved through better fish feeding practices? a review paper. *Critical Reviews in Food Science and Nutrition*, *60*(22), 3822-3835. https://doi.org/10.1080/10408398.2019.1708698

Lee, S., Jo K., Hur, S. J., Choi, Y. S., Kim, H. J. & Jung, S. (2019). Low protein digestibility of beef puree in infant in vitro digestion model. *Food Science of Animal Resources*, *39*(6), 1000-1007. https://doi.org/10.5851%2Fkosfa.2019.e73

Li, Q., Cui, Y., Jin, R., Lang, H., Yu, H., Sun, F., Presa, S., He, C., Ma, T., Li, Y., Zhou, X., Liu, D., Jia, H. & Zhu, Z. (2017). Enjoyment of spicy taste pleasure increases central salty taste perception and reduces salt intake and blood pressure. *Hypertension*, *70*(6), 1291-1299. https://doi.org/10.1161/hypertensionaha.117.09950

Lima Filho, T., Della Lucia, S. M., Minim, L. A., Gamba, M. M., Lima, R. M., & Minim, V. P. R. (2019). Directional hedonic thresholds for sodium concentration in hamburger. *Food Quality and Preference*, *78*, 103722. https://doi.org/10.1016/j.foodqual.2019.103722

Maciel, C. N., Seller, L. F. F., Souza, A. B. & Almeida, P. F. (2021). Formulation of fishburgers with the addition of different protein sources and taro flour. *Rural Science*, *51*(2). https://doi.org/10.1590/0103-8478cr20200380

Macfie, H. J. N., Bratchell, K., Greenhoff & Vallis, L. V. (1989). Designs to balance the effect of order of presentation and first-order carry-over effects in hall tests. *Journal of Sensory Studies*, *4*(2), 129-148. https://doi.org/10.1111/j.1745-459X.1989.tb00463.x

Maia, J. A. (2017). *Substituição parcial de NaCl por KCl e $CaCl_2$ e inclusão de farinha de maracujá em linguiça defumada de carne ovina*. 100f. (Tese em Nutrição e Produção Animal), Universidade Estadual do Norte Fluminense Darcy Ribeiro.

Marconato, A. M., Hartmann, G. L., Santos, M. M. R., Amaral, L. A., Souza, G. H. O., Santos, E. F., & Novello, D. (2020). Sweet potato peel flour in hamburger: effect on physicochemical, technological and sensorial characteristics. *Brazilian Journal of Food Technology*, *23*, e2019115. https://doi.org/10.1590/1981-6723.11519

Mitterer-Daltoé, M. L., Nogueira, B. A., Rodrigues, D. P., & Breda, L. S. (2017). Sensory perception in the replacement of NaCl by MSG in fish burgers. *Acta Scientiarum. Technology*, *39*(5), 565-572. https://doi.org/10.4025/actascitechnol.v39i5.28660

Muzzolon, E., Biassi, D. C., Konopka, D. N., Oliveira, J., Poliseli-Scopel, F. H., & Bainy, E. M. (2018). Processamento de fishburguer utilizando subprodutos da filetagem de tilápia: Caracterização físico-química, análise do congelamento e avaliação da vida de prateleira. *Brazilian Journal of Food Research*, *9*(1), 154-173. https://doi.org/10.3895/rebrapa.v9n1.5251

Nunes, L. P., Dutra, F. M. & Borges, J. A. S. (2020). Consumo de peixe: uma aplicação da teoria do comportamento planejado. *Revista Brasileira de Administração Científica*, *11*(1), 189-204. https://doi.org/10.6008/CBPC2179-684X.2020.001.0014

Ozarowski, M., Piasecka, A., Paszel-Jaworska, A., Chaves, D. S. A., Romaniuk, A., Rybczynska, M., Gryszczynska, A., Sawikowska, A., Kachlicki, P., Mikolajczak, P. L., Seremak-Mrozikiewicz, A., Klejewski, A. & Thiem, B. (2018). Comparison of bioactive compounds content in leaf extracts of *Passiflora incarnata*, *P. caerulea* and *P. alata* and in vitro cytotoxic potential on leukemia cell lines. *Brasilian Journal of Pharmacognosy*, *28*(2), 179-191. https://doi.org/10.1016/j.bjp.2018.01.006

Presenza, L., Fabrício, L. F. F., Galvão, J. A., & Vieira, T. M. F. S. (2022). Simplex-centroid mixture design as a tool to evaluate the effect of added flours for optimizing the formulation of native Brazilian freshwater fish burger. *LWT*, *156*, 113008. https://doi.org/10.1016/j.lwt.2021.113008

Quadros, D. A., Rocha, I. F. O., Ferreira, S. M. R., & Bolini, H. M. A. (2015). Low-sodium fish burgers: Sensory profile and drivers of liking. *Food Science and Technology*, *63*(1), 236-242. https://doi.org/10.1016/j.lwt.2015.03.083

Saavedra, A. R., Rios-Mera, J. D., Imán, A., Vásquez, J., Saldana, E., Siche, R., & Tello, F. (2022). A sequential approach to reduce sodium chloride in freshwater fish burgers considering chemical, texture, and consumer sensory responses. *LWT*, *167*, 113854. https://doi.org/10.1016/j.lwt.2022.113854

Sampaio, R. F., Lima, V. C., Bungart, G. A. M., Correia L. D. B., & Tobal T. M. (2022). Flour of winged-stm passion fruit peel: Nutritional composition, incorporation in cookies, and sensory acceptability. *Brazilian Archives of Biology and Technology*, *65*, 22200776. https://doi.org/10.1590/1678-4324-2022200776

Santos, E. A., Ribeiro, A. E. C., Oliveira, A. R., Monteiro, M. L. G., Marsico, E. T., Morgano, M., Caliari, M., & Soares Júnior, M. S. (2021). Sodium reduction in "spam-like" product elaborated with mechanically separated tilapia meat. *LWT*, *148*, 111676. https://doi.org/10.1016/j.lwt.2021.111676

Santos, M., Triviño, A. P. R., Barros, J. C., Cruz, A. G., & Pollonio, M. A. R. (2023). Strategies for the reduction of salt in food products. In M. Cerqueira & L. P. Castro (eds.), *Food Structure Engineering and Design for Improved Nutrition, Health and Well-Being* (pp. 187-218). Academic Press.

Santos, Y. C. F., & André, M. F. (2021). Development and sensory analysis of biscuit enriched with passion fruit peel flour (Passiflora Edulis). *Brazilian Journal of Development*, *7*(1), 6932-6938. https://doi.org/10.34117/bjdv7n1-468

Sociedade Brasileira de Cardiologia (SBC). (2012). *Atualização da Diretriz Brasileira de Insuficiência Cardíaca Crônica*. SBC, 33 p.

Steele, C. M., Alsanei, W. A., Ayanikalath, S., Barbon, C. E., Chen, J., Cichero, J. A., Coutts, K., Dantas, R. O., Duivestein, J., Giosa, L., Hanson, B., Lam, P., Lecko, C., Leigh, C., Nagy, A., Namasivayam, A. M., Nascimento, W. V., Odendaal, I., & Wang, H. (2015). The influence of food texture and liquid consistency modification on swallowing physiology and function: a systematic review. *Dysphagia*, *30*(1), 2-26. https://doi.org/10.1007/s00455-014-9578-x

Tan, S.-Y., Sotirelis, E., Bojeh, R., Maan, L., Medalle, M., Chik, X. S. F., Keast, R. & Tucker, R. M. (2021). Is dietary intake associated with salt taste function and perception in adults? A systematic review. *Food Quality and Preference*, *92*, 104174. https://doi.org/10.1016/j.foodqual.2021.104174

Tonet, A., Zara, R. F., & Tiuman, T. S. (2019). Biological activity and quantification of bioactive compounds in yerba mate extract and its application in fish burger. *Brazilian Journal of Food Technology*, *22*(8). https://doi.org/10.1590/1981-6723.05418

Tribuna de Ituverava (2020). Pesquisa feita pelo IBGE divulga hábitos alimentares do brasileiro. Tribuna de Ituverava. Retrieved from https://www.tribunadeituverava.com.br/pesquisa-feita-pelo-ibge-divulga-habitos-alimentares-do-brasileiro/

Ulusoy, Ş., Doğruyol, H., Alakavuk, D. Ü., & Tosun, Ş. Y. (2017). Effect of monosodium glutamate on the sensory properties of fish soup and fish ball. *GIDA - Journal of Food*, *42*(4), 339-347. https://doi.org/10.15237/gida.GD16091

Universidade Estadual de Campinas (Unicamp) (2011). *Tabela Brasileira de Composição de Alimentos (4. ed.)*. NEPA – Unicamp.

Vasconcellos, M. A. S., Savazak, I. E. T., Filho, H. G., Busquet, R. N. B., & Mosca, J. L. (2001). Physical characterization and amount of nutrients in sweet passion fruit. *Revista Brasileira de Fruticultura*, *23*(3), 690-694. https://doi.org/10.1590/S0100-29452001000300049

Vidal, V. A., Paglarini, C. S., Lorenzo, J. M., Munekata, P. E., & Pollonio, M. A. (2021). Salted meat products: nutritional characteristics, processing and strategies for sodium reduction. *Food Reviews International*, 39(4), 2183-2202. https://doi.org/10.1080/87559129.2021.1949342

Wasicky, A., Hernandes, L.S., Vetore-Neto, A., Moreno, P. R.H., Bacchi, E. M., Kato, E. T. M., & Yoshida, M. M. (2015). Evaluation of gastroprotective activity of Passiflora alata]. *Revista Brasileira de Farmacognosia*, *25*(4), 407-412.