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Production, proximate and sensory analysis of canned fish in *tucupi* and *jambu* (*Acmella oleracea*) sauce

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The objective of the study was to develop canned fish with *tucupi* and *jambu* sauce from king weakfish, sardines and white mullet species. The elaborated products were submitted to sensorial, microbiological and centesimal analyses. The experimental design consisted of three treatments and five replications; 15 containers were processed at 121°C for 15 min. For sensory analysis, the 9-point hedonic scale was used. Frequency of consumption, purchase intention, acceptability index (AI%) and global acceptance (GA) were evaluated. Microbiological analyses were coliforms, coagulase positive *Staphylococcus*, *Salmonella* species and *Clostridium*. The proximate analysis followed the AOAC methodology. Data were submitted to ANOVA and Tukey test ($p<0.05$). For sensory analysis, the products had averages above seven, with no significant effect between treatments, except for the color attribute, where sardines stood out with eight points. The frequency of consumption and purchase intention did not show significant variation either. Microbiological analyses were within legal standards, with absence of *Salmonella* spp. and *Clostridium* <10^3 CFU/g. The canned, after thermal processing, present average levels of 17.59% of protein and 5.14% of lipid. The centesimal and microbiological analyses confirmed the nutritional quality and food safety of the developed products.

Key words: Thermal processing, amazon sauce, sardine, white mullet, weakfish, microbiological analysis, amazon food culture.

INTRODUCTION

World fish production in 2016 was 171 million tons, where about 88% (over 151 million tons) was destined for human consumption. The per capita consumption in 2016 was 14.4 kg, it is estimated that by 2020 consumption will exceed the values of 20.3 kg (FAO, 2018). Brazil does not follow this trend where consumption is around 9 kg

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(Lopes et al., 2011). Several factors contribute to the low consumption of fish in the country, such as social, cultural and economic status, as well as the lack of product standardization and diversification (Ostrensky et al., 2008).

In the northern region of Brazil, several fishing modalities capture several species of economic importance for the region (Espírito Santo et al., 2005),with potential for the elaboration of pre-prepared and industrialized products. Among these species, there is the king weakfish, *Macrodon ancylodon* (Bloch and Schneider, 1801), also known as *pescada-foguete*, *pescada gó* or *pescadinha real*. Species belonging to Sciaenidae family, which has an elongated body, silver staining and maximum length of 45 cm. Its distribution occurs from Venezuela to Argentina, in regions of muddy and sandy sediment (Ikeda, 2003).

The sardine *Cetengraulis edentulus* (Cuvier 1828) is known as the yellow-tailed sardine or *manjubas*, belongs to the family Engraulidae, has a wide occurrence in the tropical western Atlantic Ocean, from the Caribbean to the south of Brazil (Figueiredo and Menezes, 1978; Fishbase, 2019), adult individuals of the species are 11 to 17 cm in total length (Franco et al., 2014).

The white mullet, *Mugil curema* (Valenciennes, 1836), also known as *taínha* and *pratiquiera*, is a species of the Mugilidae family, inhabits coastal and estuarine regions with turbid and hypersaline waters, its average catch size is 30 cm (Cervigón et al., 1992). It has a robust and fusiform body with silver tone, which occurs in the Pacific and Atlantic Oceans, from the Western USA to the South of Brazil (Fischer et al., 2011).

Due to several factors, fish is among the most susceptible meats to deterioration processes, such as pH near neutrality, high nutrient content as protein and lipids, and high water activity (Pereira, 2014; Teodoro et al., 2007). Some techniques are used to prevent fish spoilage as well as squeezing, popularly known as canning, giving increased shelf life of these foods by applying pressure and controlled temperatures to the final product container itself (Gava et al., 2008).

Among the many varieties of plants used for food, jambu, Acmella oleracea, which is characteristic of the Amazon region, plays an important role in regional cuisine, usually associated with regional tucupi sauce in various dishes. Studies with medicinal use of jambu have shown a positive effect on several organ dysfunctions, specifically related to spilanthol, an alcamide present in its constitution that gives a unique characteristic of numbness and tingling when ingested (Malosso et al., 2008; Cheng et al., 2015; Barbosa et al., 2016).

Tucupi is produced during the pressing and grinding process of cassava roots, *Manihot esculenta* (Crantz), for flour production, which results in a liquid residue that is called manipueira, this residue can be discarded or turned into *tucupi* (Chisté et al., 2007). The cassava, *M. esculenta*, is a cyanogenic plant containing cyanides in its composition, which is highly toxic and may cause asphyxiation when ingested, but due to its high volatility, the fermentation and boiling process in *tucupi* production are sufficient to lowering cyanide levels to safe values for human health (Amorim et al., 2005;Chisté and Cohen, 2011).

The combination of tucupi and jambu as a cover sauce for canned fish is an alternative in offering a product with different characteristics from conventional canned products available on the market. Therefore, the objective of this study was to develop canned fish from different species, sardines (*C. edentulus*), white mullet (*M. curema*) and king weakfish (*M. ancylodon*) with *tucupi* and *jambu* (*A. oleracea*) sauce, besides performing sensory, microbiological and proximate analyses of the product.

MATERIALS AND METHODS

Raw material

Five grams of each species of king weakfish (M. ancylodon), white mullet (M. curema) and sardines (C. endentulus), obtained in the municipal market of Bragança-PA was used. The fish were immediately stored in coolers with ice in the proportion of 1:1 and sent to the Fish Technology Laboratory (LATEP) at the Federal University of Para campus - Bragança. Each species was properly classified following its identification key. Also, 8 L of *tucupi* and three packs of *jambu* (*A. oleracea*), were used referring to the cover sauce, purchased at local shops.

Treatment of raw material and sterilization

The fish processing follows the fish gutting, scaling, heading and removal of fins, according to SDA Normative Instruction nº 22 of 11/07/2011 (IBAMA, 2011). The fish, in the form of a clean stem, were roasted for 15 min in a conventional oven at 250°C to minimize exudate. 200 g of fish were placed in 330 ml cylindrical glass containers. After that, the cover sauce was added at a temperature of about 80°C, performing exhaustion inside the container, and then the manual resealing of the container was made.

To prepare the topping sauce, tucupi was seasoned and boiled for 30 min to reduce free cyanides that might have been left from the fermentation process of its production, and the jambu was dehydrated at 70°C to its constant weight.

Autoclave sterilization time was 15 min at 121°C, applied to 15 containers, five for each treatment, where one container was quarantined for 30 days for microbiological analysis, one container for proximate analysis and three containers for sensory analysis. The thermal sensitivity of the glass did not allow thermal shock after sterilization. The products were stored at room temperature for further analysis.

Sensory analysis

Sensory analysis were performed at the fish technology laboratory campus - bragança, with 40 untrained tasters, using the 9-point hedonic scale test (scale ranging from very much disliked to very much liked), distributed in disposable plates with random markings, with the objective to evaluate the acceptability of the product (Instituto Adolfo Lutz, 2008).

Table 1. Sensory analysis, acceptance test, purchase intention analysis and frequency of canned consumption.

Attribute	Treatments		
	King weakfish	White mullet	Sardine
Appearance	7.50	7.25	7.50
Color	7.23[a]	7.25[a]	8.00[b]
Aroma	7.58	7.53	7.50
Flavor	8.15	8.08	8.03
Texture	7.68	7.65	7.80
A.G	7.73	7.70	7.90
IA (%)	85.83	85.56	87.78
Purchase Intent	3.97	4.02	4.07
Consumption frequency	5.42	5.17	5.42

Different letters on the same line differ from each other by the Tukey test ($p<0.05$). IA = acceptability index; AG = global acceptance.
Source: Authors

A consumption frequency and purchase intent test was applied. The frequency of consumption with seven options, ranging from one (would never eat this) to nine (would eat this always) and the purchase intention test with five options, ranging from one (certainly would not buy) to five (would certainly buy), methodology proposed by the Adolfo Lutz Institute (2008). The acceptability index was obtained by the formula using the average global acceptance (g.a) (Dutcosky, 2015):

Ai (%) = average g.a × 100 / maximum product rating

Microbiological analysis

Microbiological analyses were performed at the Microbiology Laboratory, Faculty of Food Engineering, Federal University of Pará-Belém. Coliforms were analyzed at 45°C coagulase positive *Staphylococcus* and *Salmonella* spp., with added *Clostridium* sulfite reduction analysis at 46°C, the most dangerous canned bacteria, due to its higher resistance to acid pH, superior than 4.6 (Evancho et al., 2009; Gava et al., 2008).

Physicochemical analysis

The centesimal analyses were performed at the Microbiology Laboratory, Faculty of Food Engineering, Federal University of Pará-Belém, according to AOAC methods (AOAC, 1990).

After the quarantine period, the samples were submitted to pH analysis at room temperature (25°C) in bench pH meter. The total titratable acidity of *tucupi* was obtained by the titration methodology with 0.1N NaOH (sodium hydroxide) solution, using phenolphthalein as an indicator (Instituto Adolfo Lutz, 2008).

Statistical analysis

Sensory analysis, frequency of consumption and purchase intention data were submitted to the Shapiro-Wilk and Bartlett test to verify the assumptions of normality and homoscedasticity, respectively. Subsequently, treated by one-way ANOVA, where the values that obtained significant difference were submitted to Tukey's post hoc test, considering the significance level of 5%. Statistical analyzes were performed using Statistica 7.0 software.

RESULTS

The results of the sensory analysis demonstrate that only the color attribute presented significant differences between the treatments, being the sardine, the one that obtained the best result (Table 1).

The average values of all attributes (except for Purchase Intent and Consumption Frequency) were higher than 7, showing good acceptance of the product, with emphasis on the “flavor” attribute, which obtained an average of 8.00 for sardines. For the attributes “G.A” and “AI%” the treatment of canned sardines obtained better average among the others, values that also reflect the purchase intention, where sardines stand out, but not enough to significantly vary from other treatments.

The results related to sensory analysis for king weakfish registered comments regarding the improvement of “appearance” and “color”, with five (12.5%) comments inherent to this attribute. The white mullet obtained three (7.5%) comments on improving bone consistency. There were no significant comments for sardines.

The results of the microbiological analyses were presented in accordance with current legislation, resolution - RDC nº 12, of January 2, 2001, of the National Health Surveillance Agency - ANVISA (ANVISA, 2001) (Table 2).

The pH value obtained was 4.4 and the total titratable acidity was 5 mEq NaOH/100 mL, this value is within the established standard for canning, similar to those found by Chisté et al. (2007).

The values of the proximate analyses of the preserves fit the values for this product with the use of fish, especially carbohydrate, which in the treatment of king weakfish obtained an average of 4.24%, being superior to the other treatments. The averages of proteins, lipids and energy value also had great variation, where the canning of white mullet stood out among the others, with average

Table 2. Microbiological analysis of King Weakfish, White Mullet and Sardine canned.

Analysis	Sample			Legislation (ANVISA, 2001)
	King weakfish	White mullet	Sardine	
Salmonella	Absent	Absent	Absent	Absent
Staphylococcus	< 10 CFU/g*	< 10 CFU/g*	< 10 CFU/g*	Max 10^3 CFU/g*
C*oliforms* at 45°C	< 3 MPN/ml**	< 3 MPN/ml**	< 3 MPN/ml**	Max 10^3 MPN/g*
Clostridium	< 10 CFU/g*	< 10 CFU/g*	< 10 CFU/g*	-

*Colony-Forming Unit. **Most probable number.
Source: Authors

Table 3. Centesimal characterization of King Weakfish, white mullet and sardine canned.

Variable (%)	Sample		
	King weakfish	White mullet	Sardine
Moisture	70.34	71.24	76.73
Protein	16.34	19.07	17.36
Lipids	6.72	7.15	1.55
Ashes	2.36	1.66	3.30
Carbohydrates	4.24	0.88	1.06
Energetic value (Kcal)	142.80	144.15	87.63

Source: Authors

values of 19.07, 7.15 and 144.15 Kcal, respectively (Table 3).

DISCUSSION

The mean values obtained by the sensory analysis were positive, being all attributes higher than seven, showing a good acceptance of the product, considering that values with averages higher than seven fit between "liked moderately" and "liked very much". However, the “flavor” attribute, which stood out with an average of more than eight, was classified as “very liked” and “extremely liked”, higher than those obtained by Hautrive et al. (2008) in themaking of ostrich burgers, *Struthio camelus* (Linnaeus, 1758). The AI value obtained a satisfactory value, all greater than 80%, better averages than all jundiá canned treatments, *Rhamdia quelen* (Quoy and Gaimard, 1824), produced by Cozer et al. (2014), who obtained the average value of AI = 85.20%.

The variation of sardines in AI (87.78%) may possibly be due to the wide commercialization of canned sardines in the Brazilian national market, which may generate a greater familiarity with the organoleptic characteristics of the species in relation to the others. However, the small size of the species having a maximum catch size of 16 cm (Espírito Santo et al., 2005) in the coast of Pará, hinders its processing, being a species very sensitive to physical damage and its seasonality are factors that may make unfeasible its production at the industrial level.

The treatment of king weakfish differed significantly in color, mainly due to the fragility of fish muscle tissue, which has high sensitivity to heat treatment, reducing the resistance of the meat as a function of the heat exposure time (Alfaro et al., 2004).

This muscular fragility allowed fragments of fish musculature to be suspended in the glass container, which affected the visual appearance of the king weakfish conserves, resulting in comments inherent to improvements of these attributes. Such factors may also make their production unfeasible at the industrial level.

The white mullet presented greater resistance of its bones, which could be observed by the comments of the tasters, showing that the heat treatment in autoclave could be extended in time to obtain the best texture of the bones.

Tucupi, as a topping sauce, is part of the Amazonian gastronomy and is closely related to the cultural factors of this region and its indigenous roots; its production is artisanal and without standardization, as evidenced in the work of Chisté et al. (2007). This fact may affect the judgment of the tasters and the values of centesimal analyses, which justify the comments regarding the addition of pepper to the dressing and the variation of carbohydrates between treatments.

The *jambu* retained, in part, its consistency and texture, but the dormancy characteristic of the species was reduced, which was reported by only one taster (2.5%). It is necessary to apply a more suitable method for the pre- treatment of *jambu*, which maintains the

maximum of its characteristics, since, in previous tests for canning production, it was noted that jambu in natura had undesirable organoleptic characteristics in relation to dehydrated *jambu*, as texture and taste. Using bleached *jambu* is an alternative to be tested.

The purchase intention value of the three preserves produced in the present study was higher than the two values recovered for conservation of jundiá in steak and vegetable oil (3.47) and conservation of jundiá fillet with vegetable oil (3.40). The frequency of consumption values was close to the preserved values of jundiá in steak in tomato sauce (4.43), which was the treatment that showed the best recovery in his experiment (Cozer et al., 2014).

The products based of meat, fish, egg and cooked similar must have a maximum microbial count for coagulase positive Staphylococcus and Sulfite-Reducing Clostridium up to 10^3 CFU/g and absence of Salmonella spp., according to the Resolution RDC nº 12/2001, of the National Health Surveillance Agency (ANVISA, 2001). Therefore, the canned fish evaluated are in accordance with current legislation, with a standard product safe for human consumption. Similar studies evaluated the microbiological quality of canned anchoita (*Engraulis anchoita*) in tomato sauce and found absence of *Salmonella* spp., coagulase positive *Staphylococcus* ($<1\times10^3$ CFU/g) and sulfite-reducing Clostridium ($<1\times10^3$ CFU/g) (Carvalho et al., 2013). Similar results were evidenced for canned jundiá (R. quelen) (Cozer et al., 2014). For tilapia, *Oreochromis niloticus* (linnaeus, 1758), heat treatment at 121°C proved to be effective in inactivating microorganisms (Pizato et al., 2012). The processing steps used were adequate and within hygienic-sanitary standards to avoid contamination of the final product, in this way the topping sauce can be applied to these fish species.

The moisture content of all elaborated products was lower than the raw material, mainly due to the preprocessing step in the oven, the same was evidenced by Nhavoto et al. (2018) in the canning process of tambaqui, *Colossoma macropomum* (Cuvier, 1918), to *tucupi* sauce, with the application of three distinct temperatures, finding an average of 71.29% of humidity. In general, fish moisture ranges from 70.34 to 76.73, described by Ogawa and Maia (1999).

The protein levels found in the present study were high in relation to canned tilapia, with oil as a cover sauce, which obtained a protein content of 12.20% (Pizato et al., 2012); this effect is not related to the cover sauce content, but to the processed species and factors such as habitat, diet, sex and ontogeny of the processed individuals. Some authors have reported that *tucupi* used as a cover sauce in the canning of tambaqui did not influence the increase in protein values up to 20.98% (Nhavoto et al., 2018), since this sauce contains low protein, between 0.33 and 0.66% (Chisté et al., 2007).

The canned of king weakfish and white mullet, with lipid content of 6.72 and 7.15, respectively, are considered semi-fatty fish (between 2.5 and 10%) while sardines, with lipid content of 1.55, is considered a lean fish (up to 2.5%), according to the classification of Contreras- Guzmán (1994). These values were below the 24.75% found for canned jundiá; such values may come from the composition of the vegetable oil present in this sauce (Cozer et al., 2014). High lipid concentrations may influence product shelf life, impair its value and reduce consumer market acceptance (Bombardelli et al., 2008; Soares et al., 2012).

Regarding the ash content, the values obtained in this work are compatible with those reported for canning of tambaqui, with values from 0.72 to 2.52% (Nhavoto et al., 2018). For jundiá canning, there is a record of 0.24 to 2.00% of ash (Cozer et al., 2014), where such variations are related to the presence of bones contained in the samples.

Regarding to carbohydrate values, they are commonly very low in fish, ranging from 0.3 to 1% (*Ogawa* and Maia, 1999). However, the presence of tucupi and jambu in canning topping sauce validated the relevance of this nutritional factor. The cover sauce had a direct influence on the carbohydrate concentration in the product, considering that only the treatment with the white mullet was within the estimated standard for fish, with a value of 0.88. Such variations in carbohydrate values occur mainly due to the lack of standardization in *tucupis* commercialized in the region - as evidenced by Chisté et al. (2007) and the carbohydrate-rich composition of *jambu* (Favoreto and Gilbert, 2010; Barbosa et al., 2016).

Conclusion

The conserves prepared with the target species of fishing in the northern region (king weakfish, white mullet and sardine) with tucupi and jambu sauce showed good values of global acceptance and acceptability index higher than 87%. The thermal method was effective in inactivation of microorganisms, because the results of microbiological analysis are in accordance with the standards required by legislation, ensuring safety and food safety. The proximate analysis, with average content of 17.59% protein and 5.14% lipid, confirms the nutritional quality of the elaborated product.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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