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Yield and Characterization of the Centesimal Composition of Amazonian Estuarine Fish

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Abstract: Fish, as one of the fishery resources, is an important constituent of the diet of the Amazon population, as it is the source of several nutritional components. The present work aimed to characterize the centesimal composition of *Plagioscion squamosissimus* fillet (n = 10) and *Macrobrachium amazonicum* meat (n = 82), species acquired in the estuarine region of the state of Amapá, Brazil. Carcass yield, as well as protein, water content, lipids and ashes was determined according to the methodologies proposed by the Adolf Lutz Institute, as well as carbohydrate and caloric determinations. The analyses were performed in triplicate per sample. After comparing with the literature, it was possible to conclude that *P. squamosissimus* presented a fillet yield of 31.11% ± 0.61%, high protein content (15.99 ± 1.26 g/100 g) and humidity (79.40 ± 1.10 g/100 g), moderate contents of mineral residues (1.10 ± 0.07 g/100 g) and carbohydrates (0.96 ± 0.90 g/100 g), low lipid contents (2.29 ± 0.65 g/100 g), as well as low caloric values (385,018.12 J/100 g) and *M. amazonicum* a meat yield of 44.12% ± 8.34%, high levels of protein (22.81 ± 1.72 g/100 g), carbohydrates (1.92 ± 1.61 g/100 g) and mineral residues (1.76 ± 0.78 g/100 g), moderate water content (73.38 ± 0.78 g/100 g), low lipid levels (0.43 ± 0.08 g/100 g), as well as low caloric values (440,786.3 J/100 g). The results obtained in this work can serve as a subsidy in nutritional diets for humans, thus allowing an adequate dietary use of these species.

Key words: Nutritional assessment, bromatological variables, nutritional value, chemical parameters of food.

1. Introduction

Fishing is one of the oldest activities used by man to meet his food needs. Fish is an important constituent of the human diet because it represents a source of several nutritional components. Although variable, the centesimal composition of fish meat is very close to the composition of poultry, cattle and pigs [1-3].

Plagioscion squamosissimus is commonly known as white hake, corvina, hake and piauí hake. It is a marine species adapted in fresh water, that is distributed by rivers of the Guianas, by the Central Amazon, region of the Low Amazon, by the estuary of the Caeté River, Bay of Marajó, coast of Amapá, reentrances Maranhenses and rivers of the northeast region of Brazil. The individuals of this species feed on small fish, crustaceans (shrimp, copepods) and aquatic insects [4-6].

Macrobrachium amazonicum is commonly known as cinnamon shrimp, regional shrimp or amazon shrimp. It is endemic to South America and has a wide geographical distribution: Brazil, Bolivia, Paraguay and Northern Argentina. This species inhabits environments with different levels of salinity. There is no known information about the eating and feeding habits of *M. amazonicum* in a natural environment [7-10].

There are few data on the processing of fish, and related to the yield of fillet and meat of Amazonian aquatic species. In general, in literature it is common to find results for Nile tilapia, but the anatomy of each species and the slaughter weight directly influence its yield [11-13].

Knowledge about the chemical composition of food is advantageous and necessary for the consumer to

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better meet the demand for macronutrients and other nutritional components, for influencing the increase of their acceptance and providing competition with other sources of nutrients are of paramount importance both nutritionally and economically [11, 14].

Although there is ample data and nutritional tables of fish, the use of this existing information, on centesimal constituents should be made with caution, since the food is produced or captured in different regions and its values vary according to the intrinsic and extrinsic factors, such as age, sex, species, food, seasonality, part of the fish in which the sample was obtained and the place of capture [14]. The aim of this study was to evaluate the yield of fillet and meat, and the centesimal composition of *P. squamosissimus* and *M. amazonicum*, obtained in the estuarine region of the state of Amapá, Brazil.

2. Materials and Methods

Samples of *P. squamosissimus* (*n* = 10) were obtained from the Bailique Archipelago, and *M. amazonicum* (*n* = 82) samples were collected from the city of Santana. Both were donated by artisanal fishermen from the state of Amapá, Eastern Amazonia, Brazil.

2.1 Filleting and Fillet Yield

The fish were previously washed, then weighed separately on a commercial scale to obtain the total weight. The removal of the fillet of *P. squamosissimus* was done using a method described by Souza [15] with some adjustments, where with the whole fish already eviscerated, the fillet was first removed with skin and then the skin of the fillet was separated, with the aid of a knife, and at the end, the respective fillets without skin, of the heavy specimens again. For *M. amazonicum* specimens, they were first weighed to obtain the total weight and then the head and the carapace were removed, obtaining the meat material, which afterwards were weighed again to obtain the weight of this. The quantification of the fillet and meat yield was made through the following mathematical calculation:

$$\%\ \text{Yield of fillet and meat} = \frac{\text{WF}}{\text{WT}} \times 100 \quad (1)$$

where WF = weight of fillets and WT = total weight.

2.2 Water Content Determination

The water content determinations were made through gravimetry and according to analytical methods recommended by the Instituto Adolfo Lutz (IAL) [16], with adaptations. The porcelain crucibles were first dried for 1 h in an oven at 105 °C, after cooling in a desiccator (9478469/300mm, Laborglas, Sao Paulo, Brazil) with silica, these were weighed in analytical balance to obtain the initial weights. The analyses were done in triplicates. A small amount with approximately 5 g of fillet sample was weighed into the respective crucibles. After 24 h in a greenhouse, at 105 °C, the crucibles plus the samples were cooled in a desiccator (9478469/300mm, Laborglas, Sao Paulo, Brazil) for another 24 h and weighed again. The quantification and determination of the humidity values were made through the weight loss ratio through water evaporation and the calculation was described below:

$$\%\text{M} = \frac{(\text{MCI}+\text{MSI})-\text{MTAG}}{\text{MSI}} \times 100 \quad (2)$$

where %M = percentage of water content, MCI = mass of the initial crucible, MSI = mass of the initial sample and MTAG = total mass after oven.

2.3 Mineral Content Determination

The determination of mineral residues was done as described in the analytical methods recommended by IAL [16], with adaptations. With porcelain crucibles previously dried at 105 °C for 1 h and cooled in a desiccator for 24 h, they were weighed to verify initial weight, then approximately 3 g of sample was weighed in analytical balance. After the 24 h oven drying time, the crucibles were transferred to the samples for incineration in muffle at 560 °C for a period of 6 h. The samples were cooled in the

desiccator for 24 h and weighed to verify the final weight and subsequent mathematical calculations, such as:

$$\%WM = \frac{(MTAM - MCI)}{MSI} \times 100 \quad (3)$$

where %WM = percentage of mineral waste, MTAM = total mass after muffle, MCI = mass of the initial crucible and MSI = mass of the initial sample.

2.4 Total Lipids Determination

The total lipids were determined by continuous and direct extraction in a Soxhlet type apparatus, after drying the sample in an oven (402/5N, Nova Ética, Vargem Grande Paulista, Sao Paulo, Brazil), as described by IAL [16], with modifications. A filter paper cartridge containing the sample was analyzed and the whole was weighed on an analytical balance. The extraction was done during 6 h in Soxhlet extractor apparatus with hexane (C_6H_{14}) at approximately 65 °C. At the end of the extraction the cartridges were taken to an oven (402/5N, Nova Ética, Vargem Grande Paulista, Sao Paulo, Brazil) for drying for 1 h and the cooling took place in a desiccator for 24 h until it obtained a constant weight value. The determination of total lipids was done by the calculation described below:

$$\%LT = \frac{(MTCI - MTCF)}{MSI} \times 100 \quad (4)$$

where %LT = percentage of total lipids, MTCI = mass of the initial cartridge, MTCF = mass of the final cartridge and MSI = mass of the initial sample.

2.5 Total Protein Determination

The determination of total proteins was done as described in the analytical methods proposed by IAL [16], with adaptations and in triplicates of samples, in which it was divided into three stages. The first consisted of the digestion of approximately 500 mg of the sample in Kjeldahl tubes in 7 mL of concentrated sulfuric acid (H_2SO_4) with 2.5 g of catalytic mixture (containing 7 g of potassium sulfate (K_2SO_4), 7 g of copper sulfate ($CuSO_4$) and 0.7 g of manganese dioxide (MnO_2)). Digestion occurred in a digester block (SL-25/42, SOLAB, Piracicaba, São Paulo, Brazil) in which the tubes were coupled with the mixture to be digested. This process finally culminated in a blue colored liquid with an apparent precipitate at the bottom of the Kjeldahl tube.

The second stage was carried out in a nitrogen distiller (SL-74, SOLAB, Piracicaba, São Paulo, Brazil), where the samples were neutralized with 25 mL of 50% sodium hydroxide (NaOH), the ammonia (NH_3) released, condensed in a 4% boric acid (H_3BO_3) indicator solution, with three drops of mixed indicator contained in a 250 mL erlenmeyer flask. The distillation was done until the turn of pink color to blue-green occurs for a longer time so that it can be retained in the solution, all the nitrogen contained in the sample.

The final step consisted of titrating the distillate from the sample with H_2SO_4 (0.05 M) in a 50 mL burette, until the turn from blue-green to pink. The quantification of the protein content was done through the calculations as:

$$\%N = \frac{(Va - Vb) \times N \times F \times 14 \times 100}{(MD)} \quad (5)$$

where %N = percentage of nitrogen, Va = volume of the H_2SO_4 spent on the sample titration, Vb = volume of the H_2SO_4 spent on the titration of the blank, N = normality, F = correction factor of H_2SO_4, the number 14 = milligrams of nitrogen or 1 mEq of nitrogen and MD = mass to be digested.

$$\%PMS = \%NMS \times 6.25 \quad (6)$$

where %PMS = percentage of protein in the dry mass, %NMS = percentage of nitrogen in the dry mass and 6.25 = total nitrogen conversion factor in crude protein for fish.

$$\%PT = \frac{((100 - \%M - \%LT)\%PMS)}{100} \quad (7)$$

where %PT = percentage of total proteins, %M = percentage of water content, %LT = percentage of total lipids and %PMS = percentage of protein in the

dry mass. It is worth mentioning that the normality of the concentrated H_2SO_4 and the correction factor (1.0 mL) was considered.

2.6 Carbohydrate Determination

Carbohydrates were quantified by difference, where %C = (100 – (%water content + %waste mineral + %total lipids + %total proteins)), as described by the Brazilian Table of Food Composition (TACO) [17] and the results were expressed in g/100 g.

2.7 Calorie Determination

The caloric value was calculated as follows:

$$VC = (\%C \times 4 + \%LT \times 9 + \%PT \times 4) \quad (8)$$

where VC = caloric value, %C = percentage of carbohydrates, %LT = percentage of total lipids, %PT = percentage of total proteins and caloric coefficients of macronutrients (4, 9 and 4, respectively). Done as described by Watt and Merrill [18], where results are expressed in J/100 g.

2.8 Statistical Analysis

Descriptive statistics was used and the results were expressed as means and standard deviations.

3. Results and Discussion

The results obtained for the meat yield and the centesimal characterization of the analyzed species are presented in Table 1, followed by means and the standard deviations for each parameter evaluated through the quantitative analyses of the samples.

3.1 Filleting and Fillet Yield

The average result of fillet yield for *P. squamosissimus* was made from specimens with a mean total weight of 200 g and for the meat yield of *M. amazonicum* with an average weight of 3 g. The result of this work is provided for every 100 g of these fish.

The fillet and meat yield depends on the efficiency of the manual method applied by the worker, the anatomical shape of the body, the size of the head and weight of the viscera, fins and skin, the form of removal of skin from fish fillet and the time of slaughter for fish in general [13, 19, 20].

Souza [15], in its analyses with Nile tilapia (*Oreochromis niloticus*), one of the most popular fish raised and marketed in Brazil, obtained a yield of 34.63% for fillet without skin. The percentage of yield found in this study was slightly lower when compared to the analyses made by Souza [15].

3.2 Water Content Determination

The determination and quantification of the water content present in food is one of the most important measurements in the centesimal analysis, since the quality of the product and the adequate use of mechanisms in which it can be used in the process of food preservation are closely linked. Foods with high humidity tend to deteriorate more quickly than those with low humidity. Your percentage may vary by species, time of year, age, sex and nutritional status [2, 14, 21].

Table 1 Yield of fillet of *Plagioscion squamosissimus* (*n* = 10) and meat of *Macrobrachium amazonicum* (*n* = 82), as well as characterization of the centesimal composition of these species, and whitefish (*P. squamosissimus*) from the Bailique Archipelago, and the shrimp (*M. amazonicum*) from the municipality of Santana, in the metropolitan region of Macapá, in the state of Amapá, Northern Brazil. Both were acquired through donations made by artisanal fishermen.

Evaluated parameters	*P. squamosissimus*	*M. amazonicum*
Yield (%)	31.11 ± 0.61	44.12 ± 8.34
Water content (g/100 g)	79.40 ± 1.10	73.38 ± 0.78
Mineral wastes (g/100 g)	1.10 ± 0.07	1.76 ± 0.78
Total lipids (g/100 g)	2.29 ± 0.65	0.43 ± 0.08
Total proteins (g/100 g)	15.99 ± 1.26	22.81 ± 1.72
Carbohydrates (g/100 g)	0.96 ± 0.90	1.92 ± 1.61
Calorific value (J/100 g)	385,018.12 ± 29,558.81	440,786.3 ± 27,884.09

Results were expressed as mean ± standard deviation.

According to Andrade *et al.* [14] and Spitz *et al. Revui* [21], the fish muscle can contain on average 64% to 90% of humidity, being the results found in this work in agreement with the described in the literature.

The results obtained in this study for *P. squamosissimus* were described for the same species by R. O. Sales and A. M. Sales [22] with a value of 78.0 g/100, Sanchez *et al.* [23] with a result of 78.8 g/100 and by TACO [17] which presented a value of 79.2 g/100 of water content.

The results of water content for *M. amazonicum*, when compared with other literatures, were found to be below that reported by Portella *et al.* [24] and above the values reported by Furuya *et al.* [25]. This difference can be explained as follows: the first author used a methodology different from the one used by this study, since the second author used whole amazonicum specimens in his analyses, as well as using another methodology to reach his results.

3.3 Mineral Content Determination

In general, calcium, phosphorus, sodium, potassium, arsenic, manganese, copper, lithium, cobalt, zinc, iron, selenium and iodine are among the essential elements of the human diet. In addition, the fish is still a source of lipids, proteins and carbohydrates [2, 26-29].

In fish a wide variety of mineral residues can be found, and according to TACO [17] and Viana *et al.* [2], the variations of minerals in fish oscillate between 1% and 2%, being in this way the results found by this study according to what the mentioned literature reports.

Lourenço *et al.* [30] in their analyses carried out in the state of Pará, for the same species of fish, found values of 1.1 g/100 g of mineral residues in the natural specimens, results identical to those found in this study. This can be explained because the fish come from the same region. Analyzing the ash content in *P. squamosissimus* from Brazilian northeastern reservoirs, R. O. Sales and A. M. Sales [22] found an average result of 1.5 g/100 g, a result that was above the average of what was determined by this study. However, the results of this study when compared to those found in TACO (2011) expressing values of 1.0 g/100 g, are slightly above the values described by this literature.

Furuya *et al.* [25] using in its analysis *M. amazonicum* integers, originating from the Paraná River, municipality of Santa Helena, Paraná State, Brazil, obtained a value for mineral residues of 1.5 ± 0.1 g/100 g. Already Portella *et al.* [24] after captive breeding of prawns of the same species, for a period of four months using a balanced diet, obtained an average value for mineral residues of 1.3 ± 0.01 g/100 g. The results of this work, using only the meat product (without cephalothorax and carapace) of *M. amazonicum* originated from a natural environment, are above mentioned by the two authors.

3.4 Total Lipids Determination

The amounts of lipids that can be found in fish meat range from 0.6% to 36%. The classification of fish on the fat content is based on the following relation: less than 2% of lipids, is considered as a low fat fish, between 2% and 5%, is a moderate fish in fat content, and values higher than 5%, was considered a fish with high fat content [31, 32]. According to the results obtained in this study for *P. squamosissimus* and for *M. amazonicum*, the first species can be classified as a moderate fish in fat content and the second as low in fat content.

Aguiar [33] in his studies, for the same species of fish (*P. squamosissimus*) acquired in the Central Market of Manaus, in the state of Amazonas, obtained an average value of 1.3 g/100 g, below what is described by the present study. Sanchez *et al.* [23] in their analyses for the same species collected in the Barra Bonita reservoir, in the state of São Paulo, obtained an average value of 2.1 g/100 g. Therefore, the values found by this study are greater than those cited by both authors.

The average values found by this work for *M. amazonicum* are below the values reported by Portella *et al*. [24] and Furuya *et al*. [25]. For Bragagnolo and Rodriguez-Amaya [34], the difference between the results is due to the fact that fat storage in shrimps occurs in the hepatopancreas, located in the cephalothorax and since the part analyzed in this study was only the meat part (without carapace and cephalothorax) the low values are therefore explained by this reason.

According to Ogawa and Maia [32], the difference between the results found in the literature compared to that found in this study is quite variable due to several factors such as sex, age, time of year in which it is captured, diet in which the species is submitted, type of body muscle analyzed, environment in which it is developed and part of the body in which the sample material is removed for analysis.

Usually lipids, is the second largest biochemical element, after protein, present in several fish species. The lipid composition varies among species and among the same species, according to some factors such as environmental conditions, feeding, sex, size, reproductive cycle, diet, nutritional status, location and times of the year in which they develop [28, 35].

3.5 Total Protein Determination

Proteins are one of the main reasons why fish and shrimp are eaten, taking into account their nutritional value. The criterion adopted which justifies the consumption of proteins is their importance as they are essential for life.

The fish muscle may contain approximately 12% to 25% protein and in addition to high nutritional value and high digestibility, they also have good functional properties [28, 35, 36]. The values found in this analysis are in accordance with those reported in the literature.

According to Sartori and Amancio [28], fish are considered low value protein when presented values less than 15% and high protein value when presented with values above this percentage. Therefore, the species analyzed in this study present a protein with high protein value, mainly *M. amazonicum*.

In TACO [17] a value is expressed with 18.9% of proteins for *P. squamosissimus* and in the work of Aguiar [33] 19.4%, thus the data found by the analyses described in this work are therefore in disagreement and below when compared to the last two literatures. For *M. amazonicum* when compared to the literature, this result is below wthat is reported by Furuya *et al.* [25] for *M. amazonicum*. This differential can be explained, since the cited author used in his analyses whole shrimp and this can be a factor that will influence the results of this variable.

Proteins have various biological functions and metabolic processes essential for human survival, being also one of the main constituents of the cells, are composed of chains of amino acids, some of which are not synthesized by the body, meaning that their supply must be from the food. Animal products are good sources of protein, and the essential amino acids found in fish are considered complete and balanced. From the nutritional point of view, fish proteins are of high biological value and have the particularity of having an excellent digestibility [28, 29, 37, 38].

3.6 Carbohydrate Determination

Of the carbohydrates present in fish, glycogen and mucopolysaccharides can be found, there are still free sugars and phosphosaccharides, which is found in low amounts. The fish muscle has a low caloric value when compared to other protein foods, influenced by the amount of lipids [28, 32, 39].

The carbohydrate content present in fish can vary from 0.3% to 1.0% on average, depending on the species contributing to the characteristic sweetish taste of this nutritional component. Glycogen is one of the polysaccharides belonging to the carbohydrate group, that is, an energy reserve component for fish [28, 32, 38].

During the process of “rigor mortis”, the fish tend

to seek energy reserves for the biochemical reactions that result from their slaughter, where adenosine triphosphate (ATP) decomposition initially occurs, and glycogen when used as an energy source in the form of ATP, is broken and their units are removed one by one, until their total exhaustion [28, 40].

Both R. O. Sales and A. M. Sales [22] and Lourenço *et al.* [30] do not mention carbohydrate values for *P. squamosissimus* in their studies. In Refs. [17, 33] the results for *P. squamosissimus* were 0%, being therefore the values found in this present study in disagreement with the cited literature. Portella *et al.* [24] and Furuya *et al.* [25] with whole *M. amazonicum* do not mention the percentage of carbohydrates found in their analyses.

3.7 Calorie Determination

This work presented caloric values close to those found by R. O. Sales and A. M. Sales [22] and described in Ref. [17] for *P. squamosissimus*, as well as values below the results found by Aguiar [33] for *Plagioscion* spp. acquired in the state of Amazonas.

Furuya *et al.* [25] in their analyses with whole *M. amazonicum* captured in the Paraná River, in Paraná, Brazil, obtained values of 483,795.92 J/100 g, so it can be said that the values of the cited literature are above that found by this work, because their analyses used whole *M. amazonicum*, in which it directly influences the value of the collies since the majority of fats present in the species are located in the cephalothorax region, according to Bragagnolo and Rodriguez-Amaya [34].

4. Conclusions

It could be concluded that the skinless fillet of *P. squamosissimus* presented high levels of protein, water content and carbohydrates, moderate contents of mineral residues, low lipid contents, as well as low caloric values and *M. amazonicum* without head and carapace, presented high levels of proteins and carbohydrates, moderate levels of mineral residues and humidity, low levels of lipids and calories. In spite of the great commercial consumption of the studied fish, this work presents the first centesimal determination of the meat material (without head and carapace) of *M. amazonicum* from the Amazonian estuarine region, an important producing center of this species.

Therefore, from a nutritional point of view, the analyzed species are considered to have good dietary patterns because: they have nutritional components that can be used in diets in which they require high protein content and low fat content, the species may further serve as a basis for nutritional diets of humans, allowing through the results found to be suitably used dietetically, and may also serve as a subsidy for subsequent researches that offer products elaborated from the analyzed species, thus allowing a greater insertion of the fish in daily life and in human food.

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