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Characterization of fillets of Amazon and real hybrid sorubins

Caracterización de filetes de sorubinas híbridas amazónica y real

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Abstract

Background: Many fish hybrids (i.e., obtained by crossing two species) are produced rather than pure species because of their better growth rate and/or acceptance of formulated feed. However, few studies evaluate and compare their meats and acceptance, including, e.g., for the Amazon hybrid sorubim (*Pseudoplatystoma reticulatum* x *Leiarius marmoratus*) and the real hybrid sorubim (*Pseudoplatystoma corruscans* x *L. marmoratus*).
Objective: Thus, this work aimed to evaluate the physical, chemical, microbiological, and sensory characteristics of fillets from the Amazon and real hybrid sorubins.
Method: Proximate composition, instrumental color, water holding capacity, cooking losses, and shear force were measured. Microbiological analyses of the fillets were carried out for *Salmonella* sp. and *Staphylococcus aureus* to ensure food safety during sensory analysis.
Results: Fillets presented excellent quality, classified in category A (lipids below 5% and proteins between 15 and 20%). There was no significant difference (p>0.05) between the evaluated fillets for several parameters: the average water holding capacities were 33.72 and 34.67%, the cooking losses were 14.93 and 13.41%, the shear forces were 2.21 and 1.74 kgf, and the luminosities were 49.61 and 45.04 for the fillets of Amazonian hybrid sorubim and real hybrid sorubim, respectively.
Discussion: There was an evident relationship between water-holding capacities and shear forces. Amazonian hybrid sorubim fillets presented lower intensity of red. However, there was no sensory difference between the hybrids, and both had an acceptance rate above 80%.
Conclusion: The hybridization does not alter the characteristics of the fish fillets.
Keywords: fish product, acceptance, sensory analysis, proximate composition, physical properties, *Pseudoplatystoma reticulatum*, *Leiarius marmoratus*

Resumen

Antecedentes: Muchos híbridos de peces (i.e., obtenidos al cruzar dos especies) se producen en lugar de especies puras debido a su mejor tasa de crecimiento y/o aceptación de alimentos formulados. Sin embargo, pocos estudios evalúan y comparan sus carnes y aceptación, incluyendo, p. ej., para lo surubí híbrido amazónico (*Pseudoplatystoma reticulatum* x *Leiarius marmoratus*) y lo surubí híbrido real (*Pseudoplatystoma corruscans* x *L. marmoratus*).
Objetivo: Así, el objetivo de este trabajo fue evaluar las características físicas, químicas, microbiológicas y sensoriales de filetes sorubines híbridos amazónico y real.
Método: Se midió composición proximal, color instrumental, capacidad de retención de agua, pierdas por cocción y fuerza de corte. Se realizaron análisis microbiológicos de los filetes para *Salmonella* sp. y *Staphylococcus aureus* para garantizar la seguridad alimentaria durante el análisis sensorial.
Resultados: Los filetes presentaron una excelente calidad, siendo clasificados en la categoría A (lípidos por debajo del 5% y proteínas entre 15 y 20%). No hubo diferencia significativa ($p>0.05$) entre los filetes evaluados para varios parámetros: las capacidades de retención de agua fueron 33.72 y 34.67%, las pierdas por cocción fueron 14.93 y 13.41%, las fuerzas de corte fueron 2.21 y 1.74 kgf y las luminosidades fueron 49.61 y 45.04 para los filetes de sorubim híbrido amazónico y sorubim híbrido real, respectivamente.
Discusión: Hubo una relación evidente entre las capacidades de retención de agua y las fuerzas de corte. Los filetes de sorubim híbridos amazónicos presentaron menor intensidad de rojo. Sin embargo, no hubo diferencia sensorial entre los híbridos, y ambos tuvieron una tasa de aceptación superior al 80%.
Conclusión: La hibridación no altera las características de los filetes de pescado.
Palabras clave: producto pesquero, aceptación, análisis sensorial, composición proximal, propiedades físicas, *Pseudoplatystoma reticulatum*; *Leiarius marmoratus.*

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Introduction

The world faces the critical challenge of feeding the growing population with an improved nutritional quality of the food produced, and fish is one of the main candidates (1), as it is one of the most important animal sources of food for a healthy diet. It is rich in amino acids, unsaturated fatty acids, vitamins, and trace metals, beyond easily digested due to lack of connective tissue (2).
The surubim is a group of fish species that belongs to the Family Pimelodidae, the genus Pseudoplatystoma, and the order of Siluriformes, which includes many species of catfish or leather fish that are distributed on all continents (3, 4). This group is highly valued and has great production. In addition, it has high commercial value due to its light color, firm texture, and pleasant taste (5, 6).
For better performance, Brazilian fish farming has increasingly used the hybridization technique, a cross between animals of different species or strains (7). An example of hybridization produced in various regions of the country is the Amazon hybrid sorubim (cachandia, cachadia or jundiara), obtained from the cross between *Pseudoplatystoma reticulatum* (cachara) female and *Leiarius*

marmoratus (Amazon jundia) male (8,9), and the real hybrid sorubim (pintado real), in turn, is the result of the cross between *Pseudoplatystoma corruscans* (pintado) and the *L. marmoratus* (10,11).
The characteristics of the fish, including chemical and physical compositions, depend mainly on the species. However, variations for the same species can be explained due to environmental conditions (water volume, temperature and quality, food availability and/or feeding, system, region, and season of the capture/production), physiological conditions (age, sex, behavior), besides genetic modifications (12, 13, 14).
There are few studies on the evaluation of meat from hybrid sorubins. Thus, this work aimed to evaluate the physical, chemical, microbiological, and sensory characteristics of fillets from the Amazon River and real hybrid sorubins.

Material and methods

Fish fillets

Amazon hybrid sorubim (*Pseudoplatystoma reticulatum* x *Leiarius marmoratus*) and real hybrid sorubim (*Pseudoplatystoma corruscans* x *Leiarius marmoratus*; patent: 850140179843) fishes were supplied from two local fish farms at the municipalities of Itaporã and Dourados, Mato Grosso do Sul (MS), Brazil, respectively. They were transported to the Laboratory of Food Technology from the Federal University of Grande Dourados, Dourados, MS, Brazil, where 15 exemplars with 12 months of age of each hybrid sorubim were slaughtered by thermonarcosis and filleted under refrigerated conditions.

Figure 1. Amazon hybrid sorubim (A) and real hybrid sorubim (B).

Chemical analyzes

Moisture, crude protein, and crude ash contents of the fillets were determined in triplicate according to the methods described elsewhere (15). Moisture was determined by the oven drying method at 105°C until constant weight (method 950.46B), protein by the Kjeldhal method (method 928.08), and ash by using the muffle oven technique (method 920.153). The lipid content was obtained in triplicate by the extraction method with cold organic solvent (16). The carbohydrate content was estimated by difference. Fillets were categorized based on their lipid and protein content using a scale of A (low lipid (<5%), high protein (15-20%)), B (medium lipid (5-15%), high protein (15-20%)), C (high lipid (>15%), low protein(<15%)), D (low lipid (<5%), very high protein (>20%)), and D (low lipid (<5%), low protein (<15%)) (17).

Physical analysis

Instrumental colour

The color [CIE L*(lightness), a* (redness), b* (yellowness)] of the fillets was evaluated using a colorimeter (Minolta Chroma Meter CR 410), with measurements standardized regarding the white calibration plate (18).

Water holding capacity (WHC)

An aliquot of 2 g of fish fillet was weighed and placed in polyvinyl chloride (PVC) with a pre-weighed filter paper. The tube was then subjected to 2.5 kg pressure for 5 min. through a PVC tube filled internally with sand. The weight of the wet filter paper was then taken. The WHC of the fish fillet was calculated as the amount of sample remaining after compressing and expressed as the percentage of retained water in relation to the initial weight of the sample (19).

Cooking losses (CL)

A preheated electric oven at 163°C was used to determine the cooking losses. Samples of fillets were weighed, placed in trays, and taken to the oven until a temperature above 71°C in their geometric center, monitored with an Omron digital thermometer MC-343. Finally, the samples were removed from the oven and allowed to cool (25°C); they were weighed again to calculate the loss percentage (20).

Shear force (SF)

Texture analysis of the cooked fillets was conducted using a texture analyzer Model TA.HDI 25 (Stable Micro Systems, Surrey, England) calibrated with a standard weight of 5 kg. Cylindrical samples of 25 x 30 mm were cut transversely to the direction of the muscle fibers, placed in the texture analyzer, and submitted to a cutting/shearing test (speed of 1.0 mm/s, distance of 30 mm) using a Warner-Bratzler shear blade (1 mm thick) to determine the shear force, which indicated the firmness of the sample. A minimum of 10 replicates of each treatment were analyzed (21).

Microbiological analysis

To assess the microbiological analysis of the fillets, duplicate 25 g samples were aseptically transferred into a stomacher bag containing 100 ml of sterile distilled water containing 0.1% peptone (1% for *Salmonella* sp. determination). Samples were homogenized for 1 min. Ten-fold serial dilutions were prepared using sterile 0.1 peptone solution (9 ml) and spread plated (0.1 ml) in duplicate onto broths and/or agars for detection of typical colonies, biochemical confirmation, and identification, and plate counting for *Salmonella* sp. and *Staphylococcus aureus*, to ensure the food safety of the judges during the sensory analysis, according to the methodology described elsewhere (22).

Sensory analysis

Sensory analyses of the fillets were conducted by 30 untrained panelists aged 18 to 55 years. A vertically structured nine-point hedonic scale of a mixed category (9= extremely like; 1= extremely dislike) was used to evaluate attributes such as color, odor, texture, taste, and overall acceptance. Fillets were immersed in water without added salt and cooked in a microwave oven at maximum power until the product reached an internal temperature of 60°C for 5-6 min. Then they were cut with edges of approx. 10 x 10 x 20 mm, stored in a styrofoam box coated with aluminum foil for temperature maintenance, and presented in monadic form, randomly coded with three digits. The consumption frequency was rated on the same sheet, using a 5-point scale (5 = weekly; 4 = 2 to 4 times a week; 3 = fortnightly; 2 = monthly; and 1 = rarely) (23). The acceptance index (AI) was calculated using the following equation: AI = (average of the attributed grades/maximum attributed grade) x 100. The sample was considered accepted if the value was greater than 70% (24).

Statistical analysis

Results were evaluated by analysis of variance (ANOVA), and the Tukey test was utilized to compare means at a 5% significance level. The presence of significant correlations was performed by Pearson's correlation test. All analyses were conducted using the Statistica 7.0 software

(StatSoft, Tulsa, USA) from data obtained at least in triplicates, and the results were presented by the mean ± standard deviation. Sensory characteristics and the frequency of consumption results were expressed as percentages.

Results

Microbiological analyses of the fillets indicated *Staphylococcus aureus* at 1.5 x 10^1 CFU g^{-1} for Amazon hybrid sorubim and 1.5 x 10^1 CFU g^{-1} for real hybrid sorubim. *Salmonella* sp. was absent for both fish fillets. Both fillets were classified in category A (lipids below 5% and proteins between 15 and 20%).

Table 1 shows the results of the proximate composition analysis carried out for the fillets. There was no significant difference between any of the parameters of the proximate composition. There was also no significant difference ($p>0.05$) between them for average water holding capacity (WHC), cooking losses (CL), and shear force (SF) (Table 1). A correlation between these parameters was calculated from data obtained for moisture WHC and CL (Table 1). The obtained value of 0.997 indicates that WHC, CL, and moisture are closely correlated.

Table 2 presents the results for the instrumental color. For the luminosity (L), there was no significant difference ($p>0.05$) between the Amazonian hybrid sorubim and the real hybrid sorubim. In relation to the parameter a* (redness), the Amazon hybrid sorubim differed significantly ($p<0.05$) from the real hybrid sorubim. Regarding the parameter b* (yellowness), the fillets studied also differed significantly ($p<0.05$) from each other (Table 2).

Table 2 also presents the average scores for the acceptance test, acceptance indexes (color, taste, texture, and odor sensory attributes), and the overall acceptance of the hybrid sorubim fillets. No significant difference was observed ($p>0.05$) between the Amazonian and real hybrid sorubim fillets for any of the sensorial attributes evaluated. The average values obtained ranged from 7 (moderately like) to 8 (very much like). In addition, no undesirable tastes and odors were detected by the judges.

Table 1. Proximate composition, and physical properties of the fillets of Amazon (*Pseudoplatystoma reticulatum*) x *Leiarius marmoratus*) and real (*Pseudoplatystoma spp.* x *Leiarius marmoratus*) hybrid sorubins.

Sorubim	Proximate composition (%)					Physical properties		
	Moisture	**Protein**	**Lipids**	**Ash**	**Carbohydrates**	**WHC (%)**	**CL (%)**	**SF (kgf)**
Amazon	74.80[a] ± 1.63	18.50[a] ± 0.30	2.61[a] ± 0.18	1.03[a] ± 0.07	3.06[a] ± 0.42	33.72[a] ± 6.14	14.93[a] ± 1.72	2.21[a] ± 1.76
Real	76.42[a] ± 1.78	17.59[a] ± 0.90	3.57[a] ± 0.04	1.26[a] ± 0.01	1.16[a] ± 0.37	34.67[a] ± 2.04	13.41[a] ± 1.32	1.74[a] ± 0.95

WHC: water holding capacity; CL: cooking losses; SF: shear force. Means with the same letter in the same column do not differ statistically at 5% ($p>0.05$).

Table 2. Instrumental color, and sensory analysis of the fillets of Amazon (*Pseudoplatystoma reticulatum*) x *Leiarius marmoratus*) and real (*Pseudoplatystoma spp.* x *Leiarius marmoratus*) hybrid sorubins.

Sorubim	Instrumental color			Sensory analysis				
	L*	a*	b*	**Color**	**Taste**	**Texture**	**Odor**	**Overall acceptance**
Amazon	49.61[a] ± 1.10	0.21[b] ± 0.30	6.34[a] ± 0.81	7.26[a] ± 1.22 (80.67)	7.81[a] ± 0.91 (86.78)	7.77[a] ± 0.90 (86.33)	7.53[a] ± 1.62 (83.67)	7.79[a] ± 0.74 (86.56)
Real	45.04[a] ± 4.43	6.29[a] ± 0.27	1.72[b] ± 0.75	7.49[a] ± 1.24 (83.22)	7.86[a] ± 1.01 (87.33)	7.86[a] ± 0.99 (87.33)	7.49[a] ± 1.37 (83.22)	7.84[a] ± 0.90 (87.11)

L*: lightness); a*: redness, b*: yellowness. Means with the same letter in the same column do not differ statistically at 5% ($p>0.05$). Values in parenthesis are referred to the acceptance index (%).

The correlation between the shear force (SF, Table 1) and the texture attribute (Table 2) was 0.96 for the real hybrid sorubim fillets and 0.99 for the Amazonian hybrid sorubim fillets. All the sensory attributes of the fillets of both hybrids sorubins were accepted regarding the acceptance index. The frequencies ranged from 87.33% for real hybrid sorubim fillets in the "flavor" and "texture" attributes and 80.67% for the Amazonian hybrid sorubim in the "color" attribute. The judges were also asked to respond on the frequencies of fish consumption (Figure 2A) and sorubim consumption (Figure 2B).

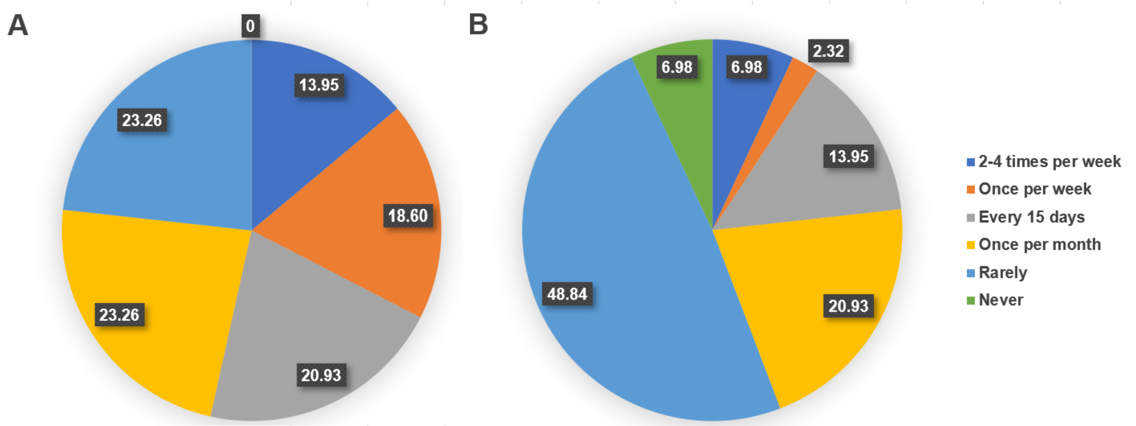

Figure 2. Frequency of consumption (%) of fish (A) and hybrid sorubins (B).

Discussion

Chemical analysis

The proximate composition of the fillets was in good agreement with the literature for fillets of, *e.g.*, *Pseudoplatystoma corruscans* (74.06% moisture, 19.28% proteins, 4.85% lipids, 1.22% ash) (4) or (77.26% moisture, 17.90% proteins, 3.30% lipids, 1.01% ash) (25), *Pseudoplatystoma fascinatum* (70.58% moisture, 18.50% proteins, 10.03% lipids, 0.76% ash) (25), *Pseudoplatystoma* sp. (64.83% moisture, 20.63% proteins, 1.64% lipids, 1.81% ash) (26), *Leiarius marmoratus* (at flood station) (74.71% moisture, 17.69% proteins, 4.86% lipids, 1.03% ash) (14).

Physical analyses

Literature reports 61.46 and 63.59% of WHC for fillets of *Pseudoplatystoma* spp. reared in cages and fishponds, respectively (27), 59.95 and 60.62% after 0 and 24h of resting time before slaughter in a holding pound, respectively (28), and proximately 68% for fillets of *Pseudoplatystoma* sp. obtained from the local commerce (29). Thus, genetic and nutritional characteristics may be the main responsible for these differences (30), more than factors such as stress and manipulation during fish capture and slaughter (28).
The literature reports an average of 24.5% of CL for fillets of *Pseudoplatystoma* sp., which was related to the loss of succulence (29). It means that the samples lose more water (due to the greater CL), and the structure becomes more rigid and harder. The greater the

water immobilized by the meat structure, the higher the water retained, which influences the tenderness (succulence) of the sample. This can occur due to differences in heating time and temperature for the same species during processing. However, different isoelectric points and differentiated exposure of active sites in hydrophilic domains of muscle proteins during heating might explain differences in CL between species at the same process conditions (31), as evaluated here. It occurs because at the isoelectric point, the net charge of the protein is zero and protein-protein interactions are dominant. Thus, the closer to this point, the lower the WHC. Consequently, the increase in the WHC would promote a reduction in the CL of the product (32). So, the similarity in the results can be explained by the close relationship between the parental species of the hybrids (all catfish species) (7-11).

The SF values were a little higher than the results reported elsewhere for fillets of *Pseudoplatystoma* spp. reared in cages (1.06 kgf) and fishponds (0.78 kgf) (24) and fillets of *Pseudoplatystoma* sp. obtained from the local commerce (approx. 0.66 kgf) (29). Analyzing all these results, it also becomes evident that there is a relation between WHC and SF, as the fillets of Amazonian hybrid sorubim and the real hybrid sorubim presented lower WHC and higher SF compared to the fillets of *Pseudoplatystoma* spp. (27). In agreement, the fillets of *Pseudoplatystoma* sp. presented the highest WHC and the lowest SF values (29). In this case, it can also be justified by the genetic similarity of hybrids.

The values of L were closely related to that reported for fillets of *Pseudoplatystoma* spp. reared in cages (48.73) and fishponds (49.09) (27). However, the luminosity of fillets of *Pseudoplatystoma* sp. obtained from the local commerce was superior (approximately 60), which is highly appreciated by consumers (29). The observed differences for a* and b* were a feature that has called attention since both hybrids presented similar values for all other parameters.

Microbiological and sensory analyses

The fillets for considered safe for the sensory analyses because the results followed the international standards, which determine that these products must be free of *Salmonella* sp. and the levels of positive coagulase staphylococci $< 1.0 \times 10^2$ CFU g^{-1} (33).

The correlation value obtained between the shear force and the texture attribute indicated a high correlation between these parameters. These data are important because the meat texture is an extremely important quality attribute for the consumer as it defines the commercial value of the product (34).

The obtained acceptance indexes (AI), above 70%, indicated that products were considered sensorially accepted (24).

The frequencies of fish consumption observed were in accordance with the estimative of the Brazilian Ministry of Fisheries and Aquaculture, which indicate consumption of fish in Brazil below that recommended by the World Health Organization (35).

Conclusions

In general, the proximate composition and physical analysis showed the fillets of hybrids as of excellent quality, classified in category A. Amazonian hybrid sorubim fillets presented lower intensity of red and higher intensity of yellow. However, there was no statistical difference for the evaluated chemical and sensory attributes, including the overall acceptance, which means that the hybridization does not alter the characteristics of the fish fillets and that both hybrids are suitable for commercialization.

Conflicts of interest

The authors declare no conflict of interest in the present investigation.

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Author contributions

Adriane Macedo and Andressa Piccoli Chaves carried out the experiments. Angela Dulce Cavenaghi-Altemio supervised the conduction of the research. Gustavo Graciano Fonseca wrote the manuscript. All authors contributed to the discussions.

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