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Quality of fresh native fish in supermarkets in Cuiabá, Mato Grosso, Brazil

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The objective of this study was to evaluate the quality of native fresh fish sold in the main supermarket chains in the city of Cuiabá, Mato Grosso. Five commercial establishments were sampled by collecting six fish from each, totaling 30 fish, which were evaluated for their sensory, physicochemical, and microbiological properties. The temperature of the samples at the commercial establishment varied between 0.7°C and 7.9°C, reaching inadequate storage values. Sensorially, intermediate quality characteristics were observed. The physicochemical parameters were expressed according to the Brazilian legislation, with pH values ranging from 6.17 to 6.43 and total volatile basic nitrogen values ranging from 5.85 to 14.62 mgN·100g^{-1}. However, there were counts of up to 1.7×10^7 CFU·mL^{-1} for the coagulase-positive Staphylococci, and >1.1×10^3 NPM·mL^{-1} for coliforms at 45°C, which are both higher than the limits tolerated by the current Brazilian legislation and literature. It was concluded that the physicochemical, sensory, and microbiological analyses presented contradictory results, because of the presence of pathogenic microorganisms. Thus, the guarantee of the quality and safety of fish should be the responsibility of commercial establishments, as the consumer does not have adequate tools for this at the time of purchase.

Keywords: Safe food; Microbiological contamination; Chilled fish; Fish commercialization.

Qualidade do pescado fresco nativo em supermercados em Cuiabá, Mato Grosso, Brasil

O objetivo deste trabalho foi avaliar a qualidade do pescado fresco nativo comercializado nas principais redes de supermercados da cidade de Cuiabá, Mato Grosso. Cinco estabelecimentos comerciais foram amostrados por meio da coleta de seis peixes em cada um, totalizando 30 peixes, os quais foram avaliados quanto aos aspectos sensoriais, físico-químicos e microbiológicos. A temperatura das amostras, no local de comercialização, variou de 0,7 a 7,9ºC, atingindo valores inadequados de armazenamento.

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Sensorialmente, características de qualidade intermediária foram observadas. Quanto aos parâmetros físico-químicos, estes foram expressos de acordo com a legislação brasileira, com valores de 6,17 a 6,43 para pH e 5,85 a 14,62 mgN.100g^{-1} para Bases Nitrogenadas Voláteis Totais. No entanto, houve contagens de até $1,7 \times 10^7$ UFC.mL^{-1} para *Staphylococcus* coagulase positivo e $>1,1 \times 10^3$ NPM.mL^{-1} para coliformes a 45ºC, ambos superiores aos limites tolerados pela legislação e literatura brasileira vigentes, respectivamente. Conclui-se que as análises físico-químicas, sensoriais e microbiológicas apresentaram resultados contraditórios, sendo preocupante a presença de microrganismos patogênicos. Assim, a garantia da qualidade e segurança do pescado deve ser responsabilidade dos estabelecimentos comerciais, visto que o consumidor não dispõe de ferramentas adequadas para isso no momento da compra.

Palavras-chave: Segurança alimentar; Contaminação microbiológica; Peixe refrigerado; Comercialização de peixes.

INTRODUCTION

Fish is a protein-rich food with easy digestibility; it contains micronutrients, such as vitamins and minerals, and has a low fat content. Further, certain species are considered rich in omega-3 fatty acids[1,2]. Thus, its consumption has increased considerably, mainly because of its health benefits. However, it is an extremely perishable raw material that is sensitive to microbial growth because of certain inherent characteristics, such as a high water activity, high content of available nutrients beneficial for microorganisms, presence of easily oxidizable unsaturated fats and tissue enzymes, and muscle pH close to neutral[3,4]. In addition, it is known that bacterial growth causes deterioration and production of odors derived from volatile compounds[5], which are typically detected when the total microbial counts are above 10^6 CFU·g^{-1}[6].

The post-mortem alterations of fish follow a typical and characteristic pattern for each species and have a direct relationship with the harvest technique, time, climate, hygienic and conservation conditions, transport, storage, and handling in all stages of the process[7]. Therefore, remarkably, the fish available for commercialization are presented in the phase of alterations where microbial action overcomes chemical reactions, forming compounds that can be identified and quantified, often using sensory, physicochemical, and microbiological methods[8]. Among these, sensory evaluation is the most used in the fish sector and by sanitary inspection services because of its low cost, efficiency, and practicality[8].

Regarding the commercialization of fish for human consumption, globally, the principal form (53%) is live, fresh, or chilled[9]. For fresh fish, according to the Brazilian legislation in force[10], it must be stored at a temperature close to that of melting ice, without any other conservation process and with its original qualities unchanged. However, newly thawed fish are usually sold in large centers[11]. Therefore, it is important and salutary that both the industry and marketing points are aware of the quality of the fish offered to consumers. This is to avoid the spread of problems related to food safety, as well as achieve improved control of the shelf life of these products while minimizing supply problems in retail[12]. In this context, this study aimed to evaluate the quality and freshness characteristics of whole fresh fish sold in the

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main supermarket chains in the city of Cuiabá-MT, Brazil.

MATERIAL AND METHODS

The samples were purchased from five different supermarkets of large retail chains in the city of Cuiabá-MT, Brazil. In total, 30 round fish were acquired: 6 from the tambaqui species *(Colossoma macropomum)* and 24 from the tambacú species *(Colossoma macropomum* x *Piaractus mesopotamicus),* with an average weight of 3.8 kg, marketed fresh (only preserved in ice) and whole. In each establishment, three samplings were conducted on different days of three different weeks, simulating the purchasing habits of a conventional consumer. During each sampling, the temperature of the acquired samples was measured in degrees Celsius (°C) while in the exposed gondolas, using a portable infrared thermometer (SKF brand, model TKTL 10). All samples were transported in isothermal boxes to the Laboratory of Hygiene and Fish Technology, located at the Federal University of Mato Grosso, where they were evaluated based on their sensory, physicochemical, and microbiological characteristics. In each sampling, two fish units were acquired: one for sensory analysis, followed by freshness analysis, and the other for microbiological analysis. Each establishment was denoted by a code, namely A (Supermarket 1), B (Supermarket 2), C (Supermarket 3), D (Supermarket 4), and E (Supermarket 5).

The sensory aspects of freshness were evaluated, considering the peculiarities of the species, according to the parameters established by Decree nº 10,468 of August 18, 2020[10], which provides for the Regulation of Industrial and Sanitary Inspection of Products of Animal Origin (RIISPOA) and Ordinance nº 185 of May 13, 1997[13], which provides for the Technical Regulation of Identity and Quality for Fresh Fish (Whole and Gutted). The following features were evaluated: clean body surface; clear, convex eyes; rosy and red gills, moist and bright gills; uniformly shaped abdomen; shiny scales adhered to the skin; firm texture of the meat; and color and odor of the carcass characteristic to the species. In total, 15 samples were analyzed; however, for the gill parameters, only three samples were analyzed, because this feature was absent in the other samples.

To evaluate the freshness of the samples, the hydrogenionic potential (pH) was determined[14] using a digital potentiometer (DEL LAB brand, DLA model). The total volatile basic nitrogen (TVB-N)[15] was quantified by the distillation method. Regarding the microbiological quality, the total coliform count was determined at 45°C[16], including *Salmonella* spp.[17], coagulase-positive *Staphylococci*[18], and psychrotrophic aerobic bacteria[19].

A descriptive analysis of the distribution of the data obtained, which were compared with the standards or maximum limits established by the current Brazilian legislation and literature for this type of product, was performed.

RESULTS AND DISCUSSION

All the samples evaluated in this study were marketed at temperatures above the melting point of ice, expressing a temperature range variation between 0.7 and 7.9°C, for the samples acquired in the same and different establishments in different weeks (Table 1).

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Table 1. Average temperature of the round fish sold in different supermarkets in the city of Cuiabá-MT, Brazil, with different weeks of sampling

Temperature (ºC)	A	B	C	D	E	SEM[1]
Week 1	1.7	5.3	4.6	7.9	5.9	2.2543
Week 2	1.8	4.1	1.2	1.9	5.4	1.7880
Week 3	1.4	1.3	3.2	0.7	1.7	0.9343
SEM[2]	0.2082	2.0526	1.7088	3.8575	2.2942	

A, B, C, D, E = supermarkets 1, 2, 3, 4, and 5, respectively. N = 15 samples.
SEM = average standard error of samples between ([1]) different supermarkets and ([2]) weeks.

This behavior may indicate the difficulty experienced by these establishments in maintaining a cold-temperature chain suitable for the preservation of the fish quality. Moreover, according to the Brazilian legislation in force[10,13], temperatures significantly different from the melting point of ice are not recommended for marketing this type of product; however, it is emphasized that these laws do not determine the exact limit value of storage and commercialization for fresh fish. Nevertheless, the literature[20] does not recommend the packaging of fresh and chilled fish at temperatures above 5°C, because exceeding this recommendation intensifies the autolytic processes of fish, either by enzymatic or microbial actions, directly influencing the nutritional quality and safety of the fish. Thus, according to these authors, it was verified that 26.7% of the samples evaluated would be at unsuitable temperatures.

In general, the sensory profile was expressed in accordance with the Brazilian legislation in more than 50% of the fish samples evaluated in this study for the variables, "body surface" and "skin/scales" and above 80% for the variables, "abdomen", "color", "odor" and "meat consistency". This information is listed in Table 2.

Table 2. Sensory profile of the round fish sold in different supermarkets in the city of Cuiabá-MT, Brazil, with different weeks of sampling

Attributes	Week 1					Week 2					Week 3					Total (%)	
	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	+	-
Body surface	+	+	+	-	+	-	-	+	-	+	-	+	-	+	-	53.3	46.7
Eyes	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	13.3	86.7
Gills	*	*	*	*	-	*	*	*	*	-	*	*	*	*	-	0.00	100
Abdomen format	+	+	+	+	-	+	+	+	+	-	+	+	-	+	+	80.0	20.0
Skin/scales	+	-	-	+	+	+	-	-	+	-	+	-	+	+	-	53.3	46.7
Meat color	+	+	-	+	+	+	+	+	-	+	+	+	+	+	-	80.0	20.0
Carcass odor	+	+	+	+	+	+	+	+	+	+	+	-	+	+	-	86.6	13.4
Meat consistency	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	100	0.00

+ = compliant; - = noncompliant; * = does not apply because the sample did not have the feature during sale.
A, B, C, D, E = supermarkets 1, 2, 3, 4, and 5, respectively. N = 15 samples.

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For the eyes, 86.7% of the samples evaluated presented nonconformity (Table 2). According to the national laws in force[10,13], the eyes of fresh fish must occupy the orbital cavity and be bright and protruding. However, it was observed that the eyes did not fill or occupy the eye sockets, were not transparent, and presented a reddish color indicative of the presence of blood (hemorrhage) or even yellowish coloration.

The scales presented a high rate of non-compliance (46.7%) for the samples evaluated. According to RIISPOA[10], the scales must be shiny, well adhered to the skin and fins, and express some resistance to movements. However, in this study, we observed slight preexisting flaking in the samples; moreover, the scales easily loosened to the touch, indicating their poor resistance to movements.

The only samples where the gills could be evaluated were those acquired in the E establishment. It was observed that the fish samples from this establishment were of the species tambaqui; their gills expressed 100% nonconformity because of their dark brown color and heavy mucus. Therefore, these samples did not present characteristics of a high-quality fish because, according to national legislation[10,13], the gills of a fresh fish should range from pink to red, be moist and bright, and contain little to no mucus.

For the body surface, 46.7% of the samples evaluated showed some type of nonconformity, presenting reddish spots, fractures along the carcasses, dirt (pieces of insects and packaging), and sand. It would be appropriate for the samples to present a clean body surface with a relative metallic luster[10,13]. Such nonconformities may be a determining rejection factor at the time of purchase. In addition, the Resolution of the Collegiate Board (RDC) n° 14, on March 28, 2014[21], determined that this type of noncompliance, defined as foreign matter, may be associated with inadequate conditions or practices in the production, handling, storage, distribution, and poor elaboration practices.

It should be noted that the samples acquired as fresh whole fish should present better characteristics that indicate their freshness in relation to sensory parameters. This is because current consumers are becoming increasingly attentive and demanding regarding the quality of purchased products. According to the literature[22–24], sensory parameters such as odor, texture, color, and hygienic-sanitary qualities at the point of sale are as important as the price of the fish.

However, it was observed that some characteristics, such as the gills, eyes, skin/scales, and body surfaces, could render the samples unfit for consumption, if analyzed in isolation. This can occur because of incorrect fish handling, from the moment of capture to the point of sale.

The samples were selected during the period of the Holy Week and Easter, a period in which the sales and consumption of fish intensify because of religious purposes. For this reason, businesses should adopt measures to ensure that the fish to be marketed are presented more attractively, since these sensory assessments can be conducted at the time of purchase, causing consumers to cancel purchases.

For the physicochemical parameters, the pH and TVB-N results are described in Table 3.

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Table 3. Physicochemical profile of round fish sold in different supermarkets in the city of Cuiabá-MT, Brazil, during different weeks of sampling

pH	A	B	C	D	E	SEM[1]
Week 1	6.17	6.40	6.26	6.43	6.27	0.1074
Week 2	6.21	6.38	6.08	6.13	6.38	0.1394
Week 3	6.18	6.31	6.34	6.42	6.43	0.1011
SEM[2]	0.0208	0.0473	0.1332	0.1704	0.0819	
BNVT (mgN·100⁻¹)	A	B	C	D	E	SEM[1]
Week 1	9.04	8.24	5.85	11.43	10.64	2.1845
Week 2	12.77	11.43	13.30	11.97	10.96	0.9557
Week	12.76	13.30	14.62	13.29	10.90	1.3475
SEM[2]	2.1506	2.5585	4.7286	0.9569	0.1701	

A, B, C, D, E = supermarkets 1, 2, 3, 4, and 5, respectively. N = 15 samples.
SEM = average standard error of samples between (¹) different supermarkets and (²) different weeks.

According to RIISPOA[10], fresh, cold, or frozen fish should have a pH value equal to or lower than 7.0. Thus, it was verified that the results obtained in the fish samples in this study were 100% compliant. However, it is known that factors such as resistance to capture, decomposition of amino acids and urea, fish species, type of microorganisms and microbial load, methods of capture, handling, storage, and excessive use of polyphosphates can influence pH variation in fish products[25]. Thus, these factors may justify the variation observed in the results (6.08–6.43).

The chemical analysis of the TVB-N showed that 100% of the samples evaluated were in accordance with the current Brazilian legislation, since they expressed values lower than 30 mgN·100g⁻¹[10]. However, some authors have established other limits for classifying the freshness of fish[7]; these papers state that the TVB-N content of fish in an excellent state of freshness ranges from 5 to 10 mgN·100g⁻¹; in fish with reasonable freshness, the value can reach up to 15–25 mgN·100g⁻¹. At the beginning of putrefaction, this value can reach up to 30–40 mgN·100g⁻¹, and when greatly deteriorated, the value should be above 50 mgN·100g⁻¹. Considering these limits, all the samples analyzed in this study can be classified in the excellent or reasonable freshness stage.

The results of the microbiological analyses in this study are shown in Table 4.

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Table 4. Microbiological profile of round fish sold in different supermarkets in the city of Cuiabá-MT, Brazil, during different weeks of sampling

Coliform at 45 ºC (NPM·mL^{-1})		B	C	D	E
Week 1	$>1.1 \times 10^3$	$>1.1 \times 10^3$	$>1.1 \times 10^3$	$>1.1 \times 10^3$	$>1.1 \times 10^3$
Week 2	$>1.1 \times 10^3$	$>1.1 \times 10^3$	$>1.1 \times 10^3$	$>1.1 \times 10^3$	$>1.1 \times 10^3$
Week 3	$>1.1 \times 10^3$	$>1.1 \times 10^3$	$>1.1 \times 10^3$	$>1.1 \times 10^3$	$>1.1 \times 10^3$
S. coagulase + (CFU·mL^{-1})	A	B	C	D	E
Week 1	1.5×10^5	1.3×10^7	1.3×10^7	1.4×10^4	8.3×10^4
Week 2	1.2×10^5	2.5×10^5	1.2×10^5	1.2×10^5	1.1×10^4
Week 3	7.3×10^4	2.8×10^4	4.0×10^4	6.3×10^4	1.1×10^4
Psychrotrophic (CFU·mL^{-1})	A	B	C	D	E
Week 1	<10	<10	<10	<10	<10
Week 2	6.5×10^5	6.5×10^5	6.5×10^5	6.5×10^5	6.5×10^5
Week 3	<10	<10	<10	<10	<10
Salmonella sp. (25 mL^{-1})	A	B	C	D	E
Week 1	Absent	Absent	Absent	Absent	Absent
Week 2	Absent	Absent	Absent	Absent	Absent
Week 3	Absent	Absent	Absent	Absent	Absent

A, B, C, D, E = supermarkets 1, 2, 3, 4, and 5, respectively. N = 15 samples.

The results for counting the most probable number of coliforms at 45 °C were higher than those established as a limit for this group of microorganisms, which, as suggested in the literature, is 10^3 NPM·mL^{-1}[26]. This indicates 100% nonconformity in the samples analyzed in this study. Although Brazilian legislation does not establish a specific standard for the coliform count at 45 °C in fresh fish, these can be considered microorganism indicators of quality, because their presence is commonly associated with pathogenic bacteria[27], and is therefore considered a risk to the health of consumers.

A 100% rate of non-compliance was expressed for *Staphylococcus* coagulase-positive, as its presence was detected in all samples evaluated and in amounts higher than those tolerated by the current Brazilian legislation[28], which is 10^3 CFU·mL^{-1}, particularly the results obtained in supermarkets B and C (Table 4), where values up to 1.3×10^7 CFU·mL^{-1} were observed. This can be considered an indication of poor hygiene of the operators of the evaluated establishments, because the *S. aureus* reservoirs include the nasal passage, throat, skin, and hair of approximately 50% of healthy human individuals[29]. When this microorganism is detected in food, it is evidence of inadequate manufacturing practices in the evaluated establishments; thus, there may be a possibility of food poisoning when consuming the food from these establishments.

Regarding the count of psychrotrophic bacteria, it was observed that the mean values for all samples were in accordance with the maximum limits suggested by the literature[26], which is 10^7 CFU·g^{-1}. This is desirable because, as the literature shows[30], this group of microorganisms can produce proteolytic and lipolytic enzymes; therefore, its low concentration maintains the sensory quality and safety of the fish. However, high values were observed in the samples acquired during the second week in all the establishments evaluated (Table 4).

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In the results observed for *Salmonella* sp., it was verified that this microorganism was absent in all evaluated samples; this is compliant with Brazilian legislation[28], which recommends the absence of the microorganism in 25 g food samples. This is because the presence of this pathogen in food can cause serious consequences to the health of consumers, mainly for those who have compromised immune systems, and can be fatal in severe cases[29]. The results obtained in the present study can be justified because of its low capacity for competition. This is because such bacteria have limited growth when there is high contamination in the product by other microorganisms, which in this experiment was verified with the high counts observed for coliforms at 45°C, and *Staphylococcus* coagulase-positive which may have hindered the survival and multiplication of *Salmonella sp.* in the evaluated samples.

The behavior of the fish freshness parameters should be coherent, because these parameters form the basis for the evaluation of fish quality and safety. However, the literature states that when the freshness of different fish species was evaluated, the variation of the results was expressed for the following examples: Tilapia (*Oreochromis* spp.)[31], Catfish (*Bagre marinus*), Golden Dorado (*Salminus brasiliensis*), Goldfish (*Carassius auratus*), Sea Bass (*Centropomus* sp.), Hake Weakfish (*Cynoscion* sp.), Chub Mackerel (*Scomber japonicus*), Freshwater Stingray (*Brycon* sp.) and Mullet (*Mugil* sp.)[32], Acoupa Weakfish (*Cynoscion acoupa*) and Atlantic Sierra (*Scomberomorus brasiliensis*) [33], Herring Hake (*Merluccius merluccius*), Nile Tilapia (*Oreochromis niloticus*), Broadband Anchovy (*Anchoviella lepidentostole*), Silver Croaker (*Plagioscion squamosissimus*), and Moonfish (*Selene setapinnis*)[12].

In this study, there were inconsistencies in the results when some parameters were evaluated individually. The products could be condemned sensorially and microbiologically, according to current legislation and literature; however, there are physicochemical indexes that could qualify the evaluated samples as adequate for consumption. However, the literature[12,34,35] states that, when analyzed separately, the pH and TVB-N are not safe indexes to evaluate the freshness of the fish, and therefore its use should generally be restricted and carefully evaluated, because the responses may vary among samples, depending on the method used, species, capture, and slaughter conditions, among other factors. Thus, for a safer evaluation, it is necessary to associate these analyses with microbiological and sensorial analyses[12,36], to ensure one of the basic criteria for food security.

Estimates by the World Health Organization (WHO) state that by June 2019, 600,000 people in the world had been affected by foodborne diseases (FBD), and of this total, approximately 420,000 died[37]. Nevertheless, the occurrence of food infections and toxicities associated with food marketing is generally associated with inadequate hygienic-sanitary conditions, and low levels of knowledge regarding good food handling practices on the part of the employees of these establishments. These rates can be even higher, since most FBDs are sporadic and often unreported.

Moreover, the Brazilian and international legislation present little to no distinction in relation to the different species of fish and the acceptable levels of these parameters for each of them. They do not take into account the intrinsic characteristics of each species[12].

Therefore, it is recommended that more efficient standards of analysis be established for the evaluation of fresh fish, and the parameters of the current legislation updated. Furthermore, better practices of good manufacturing should be adopted in the entire fish production chain, taking into consideration, according to the literature[12], the maintenance of the storage temperature and conservation of the fish during its storage and commercialization.

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There is also a need to monitor, inspect, and penalize fish marketing sites that do not meet the standards set by legislation. This puts the health of the final consumer at risk, since the guarantee of the quality of fresh fish must be the responsibility of the marketing establishments, as the consumers do not have the required tools to ensure this at the time of purchase.

CONCLUSION

It was concluded that the fish analyzed presented freshness and microbiological results in accordance with the Brazilian legislation for marketing fresh fish. However, high counts of pathogenic microorganisms and undesirable sensory attributes were noted, as well as high variation in the temperature of the product offered for sale. Such factors increase the possibility of the consumer acquiring a product already in the process of deterioration, rendering it a source of disease.

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