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Lipid profile and nutritional quality of canned fish species in vegetable oil: matrinxã (*Brycon amazonicus*) and freshwater sardine (*Hemiodus unicamculatus*)

Perfil lipídico y calidad nutricional de especies de pescado enlatadas en aceite vegetal: matrinxa (*Brycon amazonicus*) y sardina de agua dulce (*Hemiodus unicamculatus)*

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Abstract

Given the need to satisfy the demand for fish consumption, canned native fish has emerged as a market alternative, but it is necessary to determine the nutritional aspects of this product. The aim of this study was to characterise the lipid profile and evaluate the nutritional quality of matrinxã preserved in vegetable oil and compare these results with freshwater sardines obtained from the same type of processing and canning. Matrinxã species had higher protein content than sardines, but sardines had higher levels of moisture, lipids and total minerals. The predominant fatty acid in the canned fish samples was linoleic acid, followed by oleic acid and palmitic acid. In terms of nutritional quality, matrinxã showed higher indices of atherogenicity and thrombogenicity and lower values of the following ratios: hypocholesterolemic and hypercholesterolemic fatty acids; polyunsaturated/saturated and omega 6/omega 3 ratio in relation to sardines. In view of the results, it can be affirmed that Matrinxã, from a nutritional point of view, presents itself as a good alternative for the canned fish industry.

Keywords: *Brycon amazonicus, Hemiodus unicamculatus*, fatty acids, nutritional quality, native fish.

Resumen

Ante la necesidad de satisfacer la demanda de consumo de pescado, la conserva de pescado nativo se plantea como una alternativa de mercado, pero es necesario determinar los aspectos nutricionales de este producto. El objetivo de este trabajo fue caracterizar el perfil lipídico y evaluar la calidad nutricional de matrinxã conservada en aceite vegetal y comparar estos resultados con sardinas de agua dulce, obtenidas en el mismo tipo de procesamiento y enlatamiento. La especie Matrinxã tuvo mayor contenido de proteína que las sardinas, pero las sardinas presentaron mayores niveles de humedad, lípidos y minerales totales. El ácido graso predominante en las muestras de pescado en conserva fue el ácido linoleico, seguido del ácido oleico y el ácido palmítico. En cuanto a la calidad nutricional, matrinxã mostró mayores índices de aterogenicidad y trombogenicidad y menores valores de las relaciones: ácidos grasos hipocolesterolémicos y hipercolesterolémicos; ratio de ácidos poliinsaturados/saturados y omega 6/omega 3 en relación con las sardinas. En vista de los resultados, se puede afirmar que Matrinxã, desde el punto de vista nutricional, se presenta como una buena alternativa para la industria de conservas de pescado.

Palabras clave: *Brycon amazonicus; Hemiodus unicamculatus*, ácidos grasos; calidad nutricional, pescado nativo.

Introduction

The matrinxã (*Brycon amazonicus*) is a Brazilian fish species found in the Amazon rivers that features rapid growth in captivity, omnivorous feeding habit, easy induced reproduction, and characteristics suitable for sport fishing (Tavares-Dias et al., 1999; Oliveira et al., 2017). These aspects have aroused the interest in rearing fish in captivity with commercial purposes (Tavares-Dias et al., 1999). Nevertheless, when juvenile, this fish has cannibalistic habits, which compromises its production (Leonardo et al., 2008). The species has good intensive farming potential, with rapid growth (700 to 1,000 g of weight in the first year) and "prime" meat (Graef et al., 1987). However, its consumption is restricted due to the high amount of bones (Gomiero et al., 2003).

In 2016, Brazil occupied the 18th position in the world fish production ranking, with 0.86% of the production, corresponding to 1,286t with a forecast of 1,885 t in 2030 (FAO, 2018). The matrinxã accounted for the small fraction of 0.76% of the national fish production from continental aquaculture in 2008; however, production rose by approximately 40% from 2008 to 2010 (Brasil, 2012).

In the Brazilian market, 2013 had the highest number of fish imports, especially from China, Chile, and Vietnam, growing from 383.383t in 2013 to 383.652t in 2017. As a consequence, Brazilian fish exports increased from 31,0251 t in 2013 to 37,853 t in 2017 (FAO, 2020). In contrast, the canned fish was one of the products whose import most increased (Silva et al., 2016).

The industry of canned in Brazil has serious supply problems, because of its raw material, the Brazilian sardine (Sardinella brasiliensis), of extractivist origin, does not meet the demand of the sector, which has led to a high degree of idleness and/or the need for importing fish from other countries like Morocco and Venezuela (Batista, 2005).

In this context, in prospective studies, such as Silva et al. (2016) and Sousa et al. (2019), matrinxã has been proposed as an alternative to be canned by the fish industry, opening a new market niche for fish farmers, benefiting several regions of Brazil. In turn, in the statistics regarding the production of Brazilian aquaculture by species (native x exotic), in 2019, it was found that there is not a single native species that can actually replace the Brazilian sardine (Ciaqui, 2021). However, if research confirms the use of matrinxã or another native species, production may be encouraged. Another aspect that justifies studies in this line of research would be the question of fishing uncertainty regarding the safety of cultivation (Sousa et al., 2019).

In a study of species not yet commercially exploited for industrial canning, Sousa et al. (2019) found that matrinxã and freshwater sardines (*Hemiodus unicamculatus*) are promising native species as an alternative raw material for the fish canning industry. Both species are freshwater, although with different characteristics for canning. When comparing them, it is identified that, in the case of matrinxã, it does not have desirable physical characteristics for whole canning; on the other hand, freshwater sardines have a shape and size similar to real Brazilian sardines. Another point in favor of freshwater sardines is that they are not yet commercially exploited, as it is an invasive species, being more commonly used as bait, canning would be done at a low cost. Therefore, the choice of these two species with different specificities, which have the prospect of being marketed with good market acceptance and the possibility of boosting the canning industry sector by introducing new species and creating new market niches. However, there are no reports in the literature on the nutritional quality of these species. Thus, this study aimed to characterize the lipid profile and to evaluate the nutritional quality of canned matrinxã in vegetable oil and to compare these results with those of freshwater sardine, obtained by the same processing and canning procedures.

Material and Methods

The matrinxã and the freshwater sardine were acquired from a fish farm in the state of Tocantins, Brazil. They were packed in isothermal boxes and sent to a fish canning industry located in Rio the Janeiro State for the canning process. In this process, vegetable oil (soybean) was used to cover both fish, and the cans had net and drained weights of 125 g and 84 g, respectively.

After canning, the samples of canned fish with soybean oil as the liquid covering were stored at room temperature (27°C ±2°C) for 30 days. After this period, physicochemical analyses were conducted. The canned fish samples were blended in a mixer to homogenize all the material, including the fish and the covering oil, in order to simulate the consumption of the entire product without separating its components. Physicochemical analyses were performed on the canned fish in vegetable oil. The moisture of the samples was determined by the gravimetric method using heat, according to the *official methods of the Association of Agricultural Chemists* (AOAC, 2000), while the ethereal extract was measured by extraction with organic solvent (ethyl ether), using a Soxhlet extraction device. The crude protein was analyzed by the nitrogen content, with distillation in Kjedahl equipment, using the factor 6.25 to calculate the crude protein content. The ash fraction was determined by the gravimetric method, evaluating the weight loss of the material subjected to oven-drying at 550 ºC (AOAC, 2000). The energy content was calculated based on the proteins, carbohydrate, and lipid contents of the samples, according to Mahan & Raymond (2018), using the following equation: E (kcal) = (protein × 4.0) + (carbohydrate × 4.0) + (lipid × 9.0).

The fatty acids were extracted from the samples by the methodology proposed by Folch et al. (1957). To determine the fatty acid profile of the lipid fraction, the esterification of fatty acids from the total lipids was performed, according to Metcalfe and Schmitz (1966). Analyses were performed on a gas chromatograph model CG – 17, with a SHIMADZU flame ionization detector (FID). Compounds were separated and identified in a Carbowax capillary column (30 m × 0.25 mm).

The nutritional quality index (NQI) of lipids was assessed on three parameters, based on the fatty acid composition data of each fish, using the following calculations: atherogenicity index (AI) = [(C12:0 + (4 × C14:0) + C16:0)]/(∑MUFA + ∑ω6 + ∑ω3) and thrombogenicity index (TI) = (C14:0 + C16:0 + C18:0)/[(0. 5 × ∑MUFA) + (0. 5×∑ω6 + (3 × ∑ω3) + (∑ω3/∑ω6)], according to Ulbricth & Southgate (1991), and the ratio of hypo/hypercholesterolemic (HH) acids = (C18: 1cis9 + C18:2ω6 + C20:4ω6 + C18:3ω3 + C20:5ω3 + C22:5ω3 + C22:6ω3/(C14:0 + C16:0), according to Santos-Silva et al. (2002).

A completely randomized design with two fish species and three replicates was adopted. The analysis data were expressed as mean ± standard deviation. To assess the difference between the samples, the Student's t-test with a 95% confidence interval was used, utilizing SISVAR software (Ferreira, 2000).

Results and Discussion

Table 1 shows the mean values for the centesimal composition of canned matrinxã and freshwater sardine.

Table 1: Centesimal composition (g.100 g^{-1}) of samples of canned matrinxã and freshwater sardine in vegetable oil.

Fish	Centesimal composition (g.100 g^{-1})					Source
	Moisture	Lipids	Protein	Fixed mineral	E (kcal)	
Matrinxã	51.67 ± 0.75^b	15.67 ± 0.28^b	28.67± 0.48^a	2.67± 0.30^a	255.71± 2.30^b	Silva et al. (2016)
Sardine	59.33 ± 0.59^a	20.34 ± 0.79^a	18.67± 0.46^b	3.00 ± 0.08^a	258.59± 5.42^a	Survey data

Mean ± standard deviation; common letters in the same column do not differ significantly ($p<0.05$), by Student's t-test.
Source: Adapted from Silva et al. (2016) and survey data.

The canned matrinxã displayed an average moisture value of 51.67%, which is significantly lower than the average 59.33% obtained by the canned freshwater sardine. Evaluating the moisture content of three brands of canned sardine (*Sardinella brasiliensis*) and tuna (*Thunnus tynnus*) in vegetable oil, Loiko (2011) found values between 61.10 and 65.02% for the sardine and 69.75 and 73.75% for the tuna. Colembergue et al. (2011), in turn, found 62.44% moisture in canned sardine in tomato sauce. Ordóñez (2005) stated that water is one of the fish components that varies largely according to the species, time of the year, age, sex, and nutritional status of the fish, ranging from 53 to 80% of the fish centesimal composition.

Concerning the lipid content, the matrinxã showed 15.67%, which is significantly lower than the 20.34% found in the freshwater sardine. Lipid contents in the same range as those observed in the present study were found in three brands of Brazilian sardines canned in vegetable oil (Loiko, 2011). Dantas et al. (2021) found a lipid coverage of 23.70 to 43.99% in tuna canned with vegetable oil. The authors justify that the higher lipid concentrations determined for fish with coating oil can be explained by the absorption of oil by the fish muscle and add that the canning process can affect the composition of the fish in different ways, culminating in variable results for different species.

Bahurmiz et al. (2018) add that even within the same species, other factors such as food and environmental conditions, age, time of capture and fishing location can influence the composition of raw fish, affecting the moisture and lipid contents of the final product.

As regards the protein content, the matrinxã had 28.67%, which is significantly greater than the 18.67% protein found in canned freshwater sardine. This variation in protein contents, however, may be associated with the species, size, sex, time of the year, reproductive stage, among other endogenous and exogenous factors (Luzia et al., 2003; Moreira et al., 2001; Reksten et al., 2020). Evaluating canned Brazilian sardine, Colembergue et al. (2011) found a protein content of 19.35%, whereas Caula et al. (2008) found it to vary between 17.6 (sardine) and 18.7% (curimatã, *Prochilodus lineatus*), while Mandume (2020) found values of approximately 21% for sardinella (*Sardinella aurita*) and Cunene horse mackerel (*Trachurus trecae*), emphasizing that differences in fish protein content may be related to capture sites, temperature of water and year of capture.

There was no difference between the ash content of matrinxã (2.67%) and freshwater sardine (3%). The ash contents found in other studies with canned fish also ranged between 2.53 and 2.95% (Loiko, 2011; Colembergue et al., 2011). Batista (2005), however, found an average ash content of 4.78% in canned tilapia (*Oreochromis niloticus*).

The caloric value of the matrinxã was 153.41 Kcal/60 g, and that of the freshwater sardine was 155.15 Kcal/60 g, corresponding to a caloric density of 2.56 for matrinxã and 2.59 for the freshwater sardine, which are higher than values found for fresh mullet (1.17), yellowtail snapper (0.83) (Andrade et al., 2009), curimatã (*Prochilodus lineatus*, 1.08), Brazilian sardine (1.12) (Caula et al., 2008), and canned tilapia (≈1.00) (Batista, 2005). This difference may be associated with the additional calories provided by the vegetable oil in the canned product. The composition of the fatty acids found in the samples of canned matrinxã and freshwater sardine are expressed in Table 2.

In the analysis of the total lipids, the unsaturated fatty acids (UFA) prevailed over the saturated fatty acids (SFA) in the two types of fish evaluated. In the matrinxã, the total percentage of UFA was 82.87%, and, of this total, 30.51% consisted of monounsaturated fatty acids (MUFA) and 52.36% of polyunsaturated fatty acids (PUFA). The freshwater sardine showed an UFA content of 81.70%, of which 26.58% consisted of MUFA and 55.12% of PUFA. The fatty acids found in largest amount in the matrinxã and in the freshwater sardine were, in descending order, linoleic C18:2ω-6), oleic (C18:1ω-9), and palmitic acids (C16:0), with contents ranging from 47.29 to 49.38, 26.25 to 26.58, and 10.78 to 11.14 g.100^{-1} g respectively.

As linoleic acid is commonly found in vegetable oils, such as soybean oil, its high content in canned fish covered with this oil promotes an alteration in the lipid profile of the samples (Li et al., 2016).

Dantas et al. (2021) also identified that the main fatty acid found in tuna covered with vegetable oil was linoleic acid, ranging from 39.03 to 49.61%, followed by oleic acid (18.94 to 25.96%). The authors observed that PUFA had the highest levels, followed by MUFA and SFA, respectively, corroborating the results obtained in the present study (Dantas et al., 2021).

However, some studies indicate that variations in the fatty acid profile of fish can vary according to diet, metabolic differences, size, reproductive status, sexual maturity, geographic location and season of the year (Chaguaceda et al., 2020; Petenuci et al., 2020; al., 2016).

Table 2: Fatty acid composition of canned matrinxã and freshwater sardine, expressed in % of area relative to the total fatty acids in g of fatty acid.100 g–1 muscle tissue.

Fatty acid		Matrinxã		Sardine	
		%	g.100 g^{-1}	%	g.100 g^{-1}
Tridecylic	C13:0	0.17±0.00	0.03±0.00	0.00±0.00	0.00±0.00
Myristic	C14:0	2.93±0.05	0.50±0.05	0.00±0.00	0.00±0.00
Myristoleic	C14:1	0.09±0.00	0.01±0.00	0.00±0.00	0.00±0.00
Palmitic	C16:0	$10.78±0.15^{b}$	$2.64±0.15^{β}$	$11.14±0.02^{a}$	$2.73±0.02^{α}$
Palmitoleic	C16:1	0.27±0.02	0.05±0.02	0.00±0.00	0.00±0.00
Heptadecanoic	C17:0	0.12±0.01	0.01±0.01	0.00±0.00	0.00±0.00
Cis-10-heptadecenoic	C17:1	3.90±0.10	0.48±0.10	0.00±0.00	0.00±0.00
Stearic	C18:0	0.00±0.00	0.00±0.00	3.93±0.02	0.49±0.02
Oleic	C18:1 ω9c	$26.25±0.00^{b}$	3.28±0.00 β	$26.58±0.02^{a}$	$4.33±0.02^{α}$
Linoleic	C18:2 ω6c	$47.29±0.07^{b}$	5.87±0.07β	$49.38±0.02^{a}$	$8.01±0.02^{α}$
Eicosanoic	C20:0	$0.32±0.01^{a}$	0.05±0.01α	$0.33±0.02^{a}$	$0.05±0.02^{α}$
γ-linolenic	C18:3 ω6	0.00±0.00	0.00±0.00	0.37±0.02	0.05±0.02
α-Linolenic	C18:3 ω3	$4.62±0.01^{b}$	$1.02±0.01^{β}$	$5.08±0.02^{a}$	$1.12±0.02^{α}$
Cis-11,14-ecosadienoic	C20:2	$0.45±0.01^{a}$	$0.03±0.01^{α}$	$0.29±0.02^{b}$	$0.02±0.02^{α}$
∑ saturated		$14.32±0.16^{b}$	$3.23±0.16^{α}$	$15.40±0.04^{a}$	$3.27±0.04^{α}$
∑ of monounsaturated (MUFA)		$30.51±0.10^{a}$	$3.82±0.10^{β}$	$26.58±0.02^{b}$	$4.33±0.02^{α}$
∑ polyunsaturated (PUFA)		$52.36±0.12^{b}$	$6.92±0.02^{β}$	$55.12±0.02^{a}$	$9.20±0.02^{α}$
∑ ω-6		$47.29±0.13^{b}$	$5.87±0.02^{β}$	$49.75±0.02^{a}$	$8.06±0.02^{α}$
∑ ω-3		$4.62±0.01^{b}$	$1.02±0.01^{β}$	$5.08±0.02^{a}$	$1.12±0.02^{α}$

Mean ± standard deviation; values expressed in %, in the same row, followed by common letters, do not differ, ($p < 0.05$); values expressed in g.100 g^{-1}, in the same row, followed by common Greek letters, do not differ ($p < 0.05$) by Student's t-test. MUFA = monounsaturated fatty acids; and PUFA = polyunsaturated fatty acids.

Moreira et al. (2003) evaluated the fatty acid composition of matrinxã head and also found predominance of UFA over SFA, with largest presence of oleic, followed by palmitic acid, both in the matrinxã reared in weirs (40.21% and 27.04%, respectively) and cages (44.41% and 23.29%, respectively). Analyzing four types of freshwater fish, Ramos Filho et al. (2008) found predominance of unsaturated fatty acids in relation to the total lipids, with greater concentration of monounsaturated fatty acids, varying from 33.81 to 47.53%.

The freshwater sardine showed a higher total SFA content (15.40%) as compared with the matrinxã (14.32%), and palmitic acid predominated in both (11.14% and 10.78%, respectively). Andrade et al. (2009) found an SFA sum between 32.19% and 40.62% in the five most largely produced fish in Bahia state. Other studies have also highlighted palmitic acid (C16:0) as the SFA present in largest quantity in fish (Tonial et al., 2010; Ramos Filho et al., 2008; Moreira et al., 2003; Bentes et al., 2009; Andrade et al., 2009, Mandume, 2020, Dantas, 2021). The other SFA that predominated in the samples were, in descending order: myristic acid (C14:0), at 2.93%, and eicosanoic acid (C20:0), at 0.32%, for matrinxã; and stearic acid (C18:0), at 3.93%, and eicosanoic acid (C20:0), at 0.33%, for freshwater sardine.

Matos et al. (2019), when evaluating the nutritional quality of five species of freshwater fish cultivated in the western region of Santa Catarina, observed that in all species, the most abundant saturated fatty acid (SFA) was palmitic acid (90-1740 mg / 100 g), followed by stearic acid (50-230 mg / 100 g) and myristic acid (10-240 mg / 100 g).

The average amounts of ω6 and ω3 found in the canned freshwater sardine were 49.75% and 5.08%, respectively, which are significantly higher values than those found in the matrinxã (ω6 - 47.29% and ω3 - 4.62%). Loiko (2011) analyzed canned Brazilian sardine and tuna and found ω6 values between 1.53 and 48.7%, and ω3 between 6.28 and 17.73%. This marked variation might have been due to a greater increase in the lipid fraction of the vegetable oil in the samples at the time of homogenization, given that linoleic acid (ω-6) is mostly found in corn, sunflower, and soybean oils; whereas the alpha-linolenic acid is found in linseed, canola, and fish oils (Loiko, 2011). Linoleic acid was the predominating essential fatty acid in the cachara (*Pseudoplatystoma fasciatum*), pacu (*Piaractus mesopotamicus*) and dourado (*Salminus maxillosus*) species (Ramos Filho et al., 2008), corroborating the results obtained in the present study. The nutritional quality of the lipid profile evaluated by different indicators is described in Table 3.

Table 3: Nutritional quality indices of the lipid fractions in canned matrinxã and freshwater sardine

Fish	HH	AI	TI	P/S	ω6/ω3
Matrinxã	3.23±0.03b	0.43±0.02a	0.57±0.01a	2.14±0.02b	5.75±0.01b
Sardine	4,86±0.02a	0.20±0.02b	0.47±0.02b	2.75±0.02a	8.76±0.02a

Mean ± standard deviation; values expressed in g, in the same column, followed by common letters, do not differ, ($p < 0.05$) by Student's t-test; P/S = Polyunsaturated/saturated; ω6/ω3 = Σ of the omega-6 series/Σ of the omega-3 series; HH = Σ hypocholesterolemic/Σ hypercholesterolemic; AI = atherogenicity index; and TI = thrombogenicity index. (Based on: Ulbricht; Southgate, 1991).

The calculation of the ∑ hypocholesterolemic/∑ hypercholesterolemic fatty acids ratio (HH) resulted in 3.23 for matrinxã and 4.86 for freshwater sardine. High values are desirable, from the nutritional perspective, because they indicate high quality of hypocholesterolemic in relation to hypercholesterolemic acids (Cortegano et al., 2017; (Rincón-Cervera et al., 2020). Mandume (2020) found HH ratio values of approximately 0.74 for sardinella (Sardinella aurita) and 2.46 for Cunene horse mackerel (Trachurus trecae), the species and with other factors that interfere with the lipid composition. Ramos Filho et al. (2008) found a HH ratio of 1.75 for cachara (*Pseudoplatystoma fasciatum*); 1.84 for Spotted sorubim (*Pseudoplatystoma corruscans*); 1.66 for pacu (*Piaractus mesopotamicus*) and 1.49 for dorado (*Salminus maxillosus*). Mato et al. (2019) found a lower HH ratio for common carp, Nile tilapia and herbivorous carp (2.15 to 2.94).

The atherogenicity index, which relates the pro- and anti-atherogenic acids in matrinxã and sardine, was 0.43 and 0.20, respectively. Unlike HH, lower values for AI are desirable. In this case, the freshwater sardine showed more desirable results than the matrinxã. Higher results, between 0.59 and 0.86, were found in fresh fish analyzed by Bentes et al. (2009), Ramos Filho et al. (2008), and Tonial et al. (2010).

The thrombogenicity index also displayed low values: 0.57 in matrinxã, and 0.47 in sardine. Similar values were found by Bentes et al. (2009), who analyzed three species of Amazon fish (gurijuba, *Arius parkeri*; piramutaba, *Brachyplatystoma vaillantii*; and dorado, *Salminus maxillosus*), and by Ramos Filho et al. (2008), who evaluated the nutritional quality of dorado (0.35)

According to Chen & Liu (2020), AI and TI indicate the potential of stimulus to platelet aggregation, i.e., as the IA and TI values decrease, the amount of anti-atherogenic fatty acids present in a certain oil/fat is increased, and thus the potential of prevention against the appearance of coronary disease is also increased; however, no organisation has set recommended values for AI and IT.

Foods with a polyunsaturated/saturated fatty acid ratio (P/S) below 0.45 have been considered undesirable in the diet for inducing increased blood cholesterol (Department Of Health And Social Security, 1984). The studied fish showed P/S ratios of 2.14 (matrinxã) and 2.75 (freshwater sardine), which are higher values than the 0.17 to 1.89 found in canned Brazilian sardine (Loiko, 2011) and the 0.99 to 1.07 found by Bentes et al. (2009), evaluating gurijuba (*Arius parkeri*), piramutaba (*Brachyplatystoma vaillantii*), and dorado (*Salminus maxillosus*). Mato et al. (2019) found P/S ratios between 0.5 and 0.6 for carp and between 0.10 and 0.44 for Nile tilapia; however, they state that the P/S ratio alone is not sufficient to determine the nutritional quality of lipids, as the metabolic effect of MUFAs is not considered.

Many health agencies and authors recommend various ω6/ω3 ratios, but a convergence is observed towards the interval from 4 to 5:1 (Martin et al., 2006). Clinical studies show greater benefits to human health when this ratio between ω6 and ω3 is lower (Sahari et al., 2013; Rhee et al., 2017). An unbalanced ω6/ω3 ratio leads to a pro-inflammatory, pro-thrombotic and pro-aggregatory physiological state, increasing blood viscosity, vasoconstriction and cell proliferation; however, the balance of this ratio has been important for the prevention of cardiovascular and degenerative diseases (Simopoulos, 2016).

The ω6/ω3 ratios found in this study (Table 3) in matrinxã and freshwater sardine were 5.75 and 8.76, respectively. Lower values were observed by Tonial et al. (2010), evaluating the ω6/ω3 ratio in fresh salmon, and by Loiko (2011), analyzing three brands of canned Brazilian sardine in soybean oil. Rincón-Cervera et al. (2020) evaluated the fatty acid profile of eight fish species, finding variations in the ω3/ω6 ratio between 4.5 (Seriolella violacea) and 12.5 (Seriola lalandi). Large variations were also found by Mato et al. (2019) for Nile tilapia (cage) (8.16) and for common carp (5.40).

Conclusions

In terms of nutrition, both fish samples canned with soybean oil as the covering liquid appear to be good sources of protein and lipids, in which the polyunsaturated fatty acids predominate. In the assessment of the nutritional quality of the lipids, the matrinxã and freshwater sardine samples with soybean oil as a coating liquid showed favourable AI, IT, P/S and HH for human consumption. However, the ω6/ω3 found is above recommended values, with the sardine showing even higher values than the matrinxã, suggesting that both should be consumed moderately.

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