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Proximate composition, cholesterol and fatty acids profile of canned sardines (*Sardinella brasiliensis*) in soybean oil and tomato sauce

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Abstract

Different brands of sardines canned in soybean oil and tomato sauce, that are commercialized in Brazil, had their proximate composition, cholesterol content and fatty acids composition analyzed. Protein contents were equivalent to the values found for sardines *in natura*, ranging from 19.8 to 24.4%. High variations of the total lipids content (5.30–16.8%) were verified; the highest levels were found for sardines canned in soybean oil. The cholesterol content ranged from 50.4 to 65.1 mg/100 g. The highest levels of essential C18:2$n-6$ and C18:3$n-3$ fatty acids were found in sardines canned in soybean oil. The EPA (C20:5$n-3$) and DHA (C22:6$n-3$) concentrations ranged from 5.39 to 15.1% and from 3.89% to 9.51%, respectively, and the highest levels were observed in sardines canned in tomato sauce.

Keywords: Proximate composition; Cholesterol; Fatty acids; Canned ardines

1. Introduction

Sardine, *Sardinella brasiliensis*, is a short-lived species, inhabiting coastal waters of the southeastern Brasilian Bight. The sardine distribution area includes the coastal region of four states, Rio de Janeiro, São Paulo, Paraná and Santa Catarina (Vasconcellos, 2003). Sardines become mature at approximately 17 cm and 1 year of age (Cergole, 1995). Sardines became the main Brazilian fishery resource in terms of volume, with total annual catches increasing from ca. 38,000t in 1964 to an historical peak of 228,000t in 1973. It is estimated that, between 1977 and 1990, the stocks of biomass declined from ca. 350,000t to less than 80,000t (Vasconcellos, 2000). Catches increased from 1992 to 1997 reaching ca. 118,000t, but decreased again to less than 30,000t in 2000 (Cergole, 2000), accounting for 25% of the total Brazilian marine catch (IBAMA, 1995). The production of 1998 was 350 million sardine cans (IBAMA, 1997). Significant attention has been paid to studies of the fatty acids composition of fish, due to the numerous health benefits attributed to fish oils. In general, the lipids of marine fish are characterized by low concentrations of linoleic (C18:2$n-6$) and linolenic (C18:3$n-3$) acids and by high levels of eicosapentaenoic (EPA, C20:5$n-3$) and docosahexaenoic (DHA, C22:6$n-3$) acids (Steffens, 1997). There are a high concentrations of polyunsaturated EPA and DHA in marine fish because some microalgae can contain up to 27% of EPA (Brown, Jeffrey, Volkman, & Dunstam, 1997). The essential C18:2$n-6$ and C18:3$n-3$ fatty acids are important in the human diet because they affect the fluidity, flexibility and permeability of the membranes, and are precursors of the eicosanoids (prostaglandins, thromboxanes and leukotrienes), that act as messengers of the cell and metabolic regulators (Gil, 2002). However, the overproduction of the eicosanoids can cause health disorders, such as the production of cancerous cells. In this context, the ingestion of polyunsaturated $n-3$ fatty acids, such as C18:3$n-3$, EPA and DHA, can minimize the production

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of the eicosanoids by enzymatic competition between the $n-6$ and $n-3$ fatty acids. Therefore, besides having antiatherosclerotic efficacy, due to the decrease of low density lipoproteins (LDL) and triglycerides, and reduction of blood pressure, the polyunsaturated $n-3$ fatty acids control the synthesis of the eicosanoids, being indispensable to the human health (Muggli, 1997). Nutritionists believe that the $n-6/n-3$ ratio in daily feeding should be 5/1, and that the recommended absolute values of daily ingestion for the long-chain polyunsaturated EPA and DHA fatty acids, should vary between 300 and 400 mg (Simopoulos, 1991). Other additional relevant data, also related to cardiovascular diseases and atherosclerosis, are associated with the daily ingestion of cholesterol, present in the food that is consumed. The maximum amount of cholesterol that can be ingested per day is of 300 mg (Romero, Robert, Masson, Luck, & Buschmann, 1996). Several studies have shown the importance of the inclusion of sardines in the human diet, due to the high concentrations of EPA and DHA (Andrade, Rubira, Matsushita, & Souza, 1995; Asiedu-Steiner, Julshamn, & Lie, 1991; Bandarra, Batista, Nunes, Empis, & Chistie, 1997; Beltrán & Moral, 1991; Ortíz & Bello, 1992). In Brazil, the capturing of sardines for the processing industries is carried out in every season of the year. According to Badolato et al. (1994), the chemical composition of sardines (*Sardinella brasiliensis*) in different seasons does not show significant differences of moisture, ash on protein contents. In the winter, higher lipid levels (3.4%) were observed, while the fatty acids profile does not significantly vary. In the canned sardines produced in Brazil, two different types of coating can be added. One of them is called coating-oil, and an example of this is soybean oil. The other is tomato sauce, which also has soybean oil in its formulation. The amount of coating substance (soybean oil or tomato sauce) can affect the chemical composition of the sardines, and mainly the fatty acids profile, due to the interaction between the lipids of the sardines and those of the coating substances (Caponio, Gomes, & Summo, 2003; Rossi, Colonello, & Alamprese, 2001). The purpose of this work was to investigate the chemical composition, cholesterol and fatty acids in different brands of whole sardines canned in soybean oil and tomato sauce, commercialized in Brazil.

2. Materials and methods

2.1. Collection for sampling

Cans of 132 g of gross weight were purchased from different markets in Parana State – Brazil. Three brands of sardines canned in soybean oil on tomato sauce, and denominated by the letters B, C, G and BT, CT, GT were studied, respectively. The brand P was studied (in the soybean oil formulation). For moisture, ash, crude protein and cholesterol analyses, four different lots, of four cans each (16 cans), were used. The sardines from each can were triturated, homogenized and analyzed in triplicate. For the total lipids and fatty acid analyses, four different lots, of 12 cans each, were divided into four groups (48 cans). In all analyses, the soybean oil and the tomato sauce were separated from the sardines after a drainage for 10 min in a polyethylene sieve.

2.2. Analysis

Moisture, ash and protein contents were determined as described by AOAC methods (Cunniff, 1998). Lipids were extracted from the muscle tissues using the Bligh and Dyer (1959) method, and fatty acid methyl esters (FAME) were prepared by methylation of the the triacylglycerols, as described by method 5509 of ISO (1978). The FAME were analyzed using a Shimadzu 14A (Japan) gas chromatograph equipped with flame ionization detector and fused silica capillary column (50 m $\times$ 0.25 mm and 0.20 mm of Carbowax 20M). The column temperature was programmed at 2 °C/min from 150 to 240 °C. The injection port and detector were maintained at 220 °C and 245 °C, respectively. The carrier gas was hydrogen (1.2 ml/min), the make-up gas was nitrogen (30 ml/min) and the split used was 1:100. The identification of normal fatty acids was done by comparing the relative retention times of FAME peaks from samples with standards from SIGMA and the main fatty acids, in order of abundance, were confirmed using a Shimadzu 14A (Japan) gas chromatograph, coupled to the mass spectrometer (Shimadzu QP2000A), operating with an ionization energy of 70 eV. The separation of FAME was carried out in the fused silica capillary column (50 m, 0.25 mm i.d.) coated with Carbowax 20M (film thickness of 0.20 mm), using the following temperature programme: 150–240 °C, 2 °C /min. Helium was used as the carrier gas (0.7 ml/min). The peak areas were determined by the CG-300 Computing Integrator programme (CG Instruments, Brazil). Data were calculated using the normalized peak area percentages of fatty acids.

The extraction and quantification of cholesterol were carried out by the method published by Al-Hasani, Hlavac, and Carpenter (1993). Sardine samples (10.000 $\pm$ 0.001 g) were transferred to a 250 ml flat-bottom flask. The sample was stirred in an ethanol–methanol–isopropanol (90:5:5, v/v/v) solution, in an amount equivalent to 4 ml/g sample, and 1 ml 60% KOH/g sample. The flask containing the mixture was connected to a water-cooled condenser, and refluxed for 1 h. After cooling the digest to room temperature, 100 ml of hexane was added, and the mixture was stirred for 10 min. Next, 25 ml of deionized water were added and the mixture was stirred for further 15 min. The layers were then separated and the

hexane layer was collected in an Erlenmeyer flask. An aliquot of 25 ml from hexane layer was evaporated in a rotatory evaporator at 37 °C. The residue was dissolved in 2 ml of hexane containing 0.2 mg/ml of 5α-cholestane, as internal standard, and then 3 μl were injected into the gas chromatograph. A Shimadzu (Japan) chromatograph (model 14A), fitted with flame ionization detector (FID, 300 °C) and the a split/splitless injector (260 °C, split 1:150) was used for the cholesterol analysis. Separation was carried out in a fused silica capillary column (25 m; 0.25 mm i.d.), coated with SE-30 (0.25 mm phase thickness), at 300 °C. The carrier gas was hydrogen (1.5 ml/min) and the make-up gas was nitrogen (25 ml/min). Cholesterol identifications were made by comparing the relative retention times of peaks from samples with the standards from SIGMA. For peak integration, a CG-300 Computing Integrator programme (CG Instruments, Brazil) was used.

2.3. Statistics

The values of the means were statistically compared by the Tukey's test at 5% with one-way ANOVA. Data were processed using the Statistica 5.1 Software (StatSoft, USA, 1996).

3. Results and discussion

3.1. Proximate composition

The moisture, ash, crude protein, total lipids and cholesterol contents of the four studied brands are shown in Table 1. The moisture content for the different brands ranged from 57.38% to 68.22%. It was verified that sardines canned in tomato sauce presented the highest moisture content. Only the brand P presented a high ash content (5.74%), with significant differences ($P < 0.05$) when compared to the other brands. The protein content ranged from 19.8% to 24.4% and was almost the same as the values found for sardines *in natura*, showing that the manufacturing process does not modify the protein value of the sardines (Badolato et al., 1994). The total lipids content showed high variations (5.30–16.76%), and the highest levels in canned sardines were found for those in soybean oil. The water–fat content has been described in different fish and is highly dependent on the catch season (Luzia, Sampaio, Castellucci, & Torres, 2003; Varela, Perez, & Ruiz Rozo, 1990). The cholesterol concentration varied from 50.4 to 65.1 mg/100 g. These values are close to those found for sardines canned in water (*Sardinops sagax*) that are commercialized in Chile (Romero et al., 1996) and raw sardines commercialized in the city of São Paulo (Luzia et al., 2003).

3.2. Fatty acid composition

The fatty acids compositions of the four brands of canned sardines are presented in Tables 2 and 3. The sequence of the fatty acids are ordered according to their chromatographic retention times and the values are given as weight percentages of the total acid methyl esters. In some brands, it was possible to separate and to identify 48 different fatty acids. However, some fatty acids are present at concentrations that are below 0.13%, and were therefore excluded from Tables 2 and 3. According to Badolato et al. (1994), the main saturated fatty acids found in a typical refined soybean oil are: (i) saturated C16:0 (11.6%) and C18:0 (2.8%); (ii) monounsaturated C18:1$n-9$ (22.1%) and (iii) polyunsaturated C18:2$n-6$ (54.2%) and C18:3$n-3$ (7.5%). The refined soybean oil has higher concentrations of C18:1$n-9$, C18:2$n-6$ and C18:3$n-3$ acids than different species of uncanned sardines (*Sardinops sagax*, *Sardina pilchardus*, *Sardinella achovia* and*Sardinella brasiliensis*) (Andrade et al., 1995; Asiedu-Steiner et al., 1991; Bandarra et al., 1997; Beltrán & Moral, 1991; Ortíz & Bello, 1992; Luzia et al., 2003), especially the C18:2$n-6$ acid. In this way, the exchange between the lipids of the sardines and the coating-oil (Caponio et al., 2003; Rossi et al., 2001) could possibly affect the fatty acid profile of the sardines and therefore their nutritional value. Considering the different brands of sardines

Table 1
Proximate composition and cholesterol content (per 100 g) in canned sardines[1]

Brands	Moisture (g)	Ash (g)	Protein (g)	Total lipids (g)*	Cholesterol (mg)
C	$63.85 \pm 1.56^{2,3}$	2.65 ± 0.44^{2}	$22.0 \pm 2.10^{2,3,4}$	10.96 ± 2.35^{2}	$51.8 \pm 8.75^{2,4}$
CT	$66.19 \pm 5.50^{2,3}$	2.69 ± 0.32^{2}	22.2 ± 1.32^{3}	7.34 ± 3.20^{3}	$59.9 \pm 8.73^{2,3,4}$
B	65.09 ± 1.97^{2}	2.98 ± 0.30^{2}	24.4 ± 0.45^{2}	$7.08 \pm 1.46^{3,6}$	$60.0 \pm 5.78^{2,3,4}$
BT	68.22 ± 1.73^{3}	2.87 ± 0.30^{2}	23.8 ± 0.82^{2}	5.30 ± 1.63^{6}	$62.3 \pm 13.03^{2,3}$
G	$64.36 \pm 1.20^{2,5}$	3.11 ± 0.66^{2}	$22.8 \pm 1.02^{2,3,4}$	$9.84 \pm 3.11^{2,5}$	65.1 ± 8.50^{3}
GT	$66.26 \pm 2.10^{2,3}$	2.94 ± 0.63^{2}	$21.8 \pm 0.72^{4,5}$	$8.86 \pm 1.83^{3,5,6}$	$60.0 \pm 13.89^{2,3,4}$
P	57.38 ± 1.02^{4}	5.74 ± 0.73^{3}	19.8 ± 1.13^{5}	16.76 ± 3.10^{4}	50.4 ± 2.67^{4}

[1] The values are means ± S.D. of 16 cans analyzed in triplicate.
[2,3,4,5,6] The means followed by the same superscripts within a column do not present significant differences by Tukey's test at 5%.

Table 2
Fatty acids profile in different brands of sardines canned in soybean oil[1]

Fatty acids	Brands			
	B	C	G	P
C14:0	$5.02 \pm 0.57^{2,3}$	$5.69 \pm 1.20^{2,3}$	6.89 ± 2.49^{2}	2.92 ± 0.68^{3}
iC16:0	0.38 ± 0.07^{2}	0.37 ± 0.05^{2}	$0.44 \pm 0.08^{2,3}$	0.33 ± 0.04^{3}
C16:0	17.45 ± 0.92^{2}	18.4 ± 0.46^{2}	18.4 ± 1.12^{2}	17.14 ± 2.15^{2}
C16:1$n-7$	5.88 ± 0.65^{2}	6.56 ± 0.97^{2}	7.18 ± 2.38^{2}	3.93 ± 1.02^{2}
C16:1$n-5$	$0.17 \pm 0.03^{2,3}$	$0.16 \pm 0.03^{2,3}$	0.26 ± 0.14^{3}	$0.11 \pm 0{,}02^{2}$
iC17:0	$0.280.05^{2,4}$	0.40 ± 0.05^{3}	$0.35 \pm 0.09^{2,3}$	0.21 ± 0.03^{4}
C16:2$n-4$	$0.65 \pm 0.16^{2,3}$	$0.70 \pm 0.13^{2,3}$	$0.72 \pm 0.22^{2,3}$	0.41 ± 0.06^{3}
C16:3$n-6$	0.16 ± 0.04^{2}	0.20 ± 0.09^{2}	0.23 ± 0.08^{2}	$0.14 \pm 0{,}01^{2}$
C17:0	$0.470.05^{2}$	$0.38 \pm 0.08^{2,3}$	0.49 ± 0.07^{2}	0.29 ± 0.02^{3}
C17:1$n-11$	0.95 ± 0.28^{2}	0.99 ± 0.26^{2}	1.02 ± 0.36^{2}	0.54 ± 0.16^{2}
C16:4$n-3$	0.64 ± 0.28^{2}	1.43 ± 0.48^{2}	0.92 ± 0.30^{2}	0.31 ± 0.07^{2}
C18:0	$4.270.22^{2}$	4.22 ± 0.40^{2}	4.07 ± 0.54^{2}	4.10 ± 0.16^{2}
C18:1$n-9$	12.42 ± 2.00^{2}	12.0 ± 1.19^{2}	10.8 ± 1.95^{2}	16.8 ± 1.14^{3}
C18:1$n-7$	$2.67 \pm 0.19^{2,3}$	3.17 ± 0.25^{2}	3.14 ± 0.57^{2}	2.27 ± 0.43^{3}
C18:2$n-6$	$26.2 \pm 4.60^{2,4}$	16.3 ± 3.66^{3}	$19.6 \pm 5.03^{2,3}$	32.9 ± 4.89^{4}
C18:2$n-4$	0.19 ± 0.06^{2}	0.31 ± 0.09^{2}	0.20 ± 0.02^{2}	0.12 ± 0.01^{2}
C18:3$n-6$	$0.24 \pm 0.04^{2,3}$	$0.29 \pm 0.02^{2,3}$	0.35 ± 0.12^{2}	0.13 ± 0.02^{3}
C18:3$n-3$	2.95 ± 0.50^{2}	2.10 ± 0.44^{2}	2.44 ± 0.78^{2}	4.10 ± 0.65^{3}
C18:4$n-3$	$1.08 \pm 0.26^{2,3}$	1.64 ± 0.41^{2}	$1.34 \pm 0.36^{2,3}$	0.84 ± 0.34^{3}
C20:1$n-11$	0.57 ± 0.08^{2}	0.46 ± 0.05^{2}	0.56 ± 0.05^{2}	0.46 ± 0.05^{2}
C20:1$n-9$	0.17 ± 0.04^{2}	1.12 ± 0.52^{2}	0.45 ± 0.31^{2}	0.26 ± 0.07^{2}
C20:4$n-6$	1.07 ± 0.14^{2}	1.21 ± 0.18^{2}	1.30 ± 0.19^{2}	0.55 ± 0.06^{3}
C20:4$n-3$	$0.30 \pm 0.04^{2,4}$	0.53 ± 0.11^{3}	$0.36 \pm 0.02^{2,3,4}$	0.24 ± 0.06^{4}
C20:5$n-3$	8.25 ± 2.06^{2}	10.9 ± 1.96^{2}	9.48 ± 1.59^{2}	5.39 ± 1.04^{3}
C22:1$n-11$	0.30 ± 0.03^{2}	1.55 ± 0.87^{2}	0.46 ± 0.39^{2}	0.38 ± 0.09^{2}
C21:5$n-3$	$0.34 \pm 0.10^{2,3}$	0.47 ± 0.12^{2}	0.42 ± 0.07^{2}	0.21 ± 0.04^{3}
C22:4$n-6$	0.30 ± 0.14^{2}	0.28 ± 0.08^{2}	0.38 ± 0.14^{2}	0.23 ± 0.04^{2}
C22:5$n-3$	0.74 ± 0.04^{2}	1.21 ± 0.23^{2}	0.85 ± 0.11^{2}	0.70 ± 0.16^{2}
C22:6$n-3$	5.72 ± 1.15^{2}	6.64 ± 1.37^{2}	6.64 ± 2.11^{2}	3.89 ± 0.53^{2}
C24:1$n-9$	0.20 ± 0.05^{2}	0.39 ± 0.03^{2}	0.28 ± 0.12^{2}	0.19 ± 0.06^{2}
SFA[5]	27.9 ± 1.10	29.5 ± 1.35	30.6 ± 2.79	25.0 ± 2.26
MUFA[5]	23.2 ± 2.13	25.3 ± 1.87	23.7 ± 3.20	24.7 ± 1.61
PUFA[5]	48.8 ± 5.22	44.2 ± 4.46	45.2 ± 5.76	50.1 ± 5.08
$n-3$[6]	20.0 ± 2.45	24.9 ± 2.53	22.5 ± 2.80	15.7 ± 1.40
$n-6$[7]	27.9 ± 4.60	18.2 ± 3.67	21.8 ± 5.03	34.0 ± 4.89
PUFA/SFA[8]	1.75 ± 0.20	1.50 ± 0.17	1.48 ± 0.23	2.00 ± 0.27
$n-6/n-3$[9]	1.39 ± 0.29	0.73 ± 0.16	0.97 ± 0.25	2.17 ± 0.37

[1] Results expressed as percentage of total fatty acid methyl esters. The values are means±S.D. of 48 cans analyzed in triplicate.
[2,3,4]The means followed by the same numbers between the different brands do not present significant differences by Tukey's test at 5%. [5]Saturated, monounsaturated and polyunsaturated fatty acids. [6]$\Sigma n-3$. [7]$\Sigma n-6$. [8]Ratio of polyunsaturated to saturated fatty acids. [9]Ratio of $\Sigma n-6$ to $\Sigma n-3$.

canned in soybean oil, it was observed that most of the saturated fatty acids present were C14:0, C16:0 and C18:0, and especially the C16:0 acid. This observation was typical because palmitic acid is the key metabolite in fish (Andrade et al., 1995). Only the brand P presented significant differences ($P < 0.05$) for the C14:0 fatty acid (2.92%) when compared to the other brands. Significant differences of the C16:0 and C18:0 acids were not observed among the studied brands ($P < 0.05$). The levels of the essential C18:2$n-6$ fatty acid were higher than the levels of C18:3$n-3$, with variations from 16.3% to 32.9% and from 2.10% to 4.10%, respectively. The high concentrations of both fatty acids, when compared to uncanned sardines, show the migration of fatty acids from the coating-oil to the sardines. Significant differences ($P < 0.05$) between the brands P (32.9%), C (16.3%) and G (19.6%), for C18:2$n-6$ were observed, while this did not occur between the brands P and B (26.2%). The values of the C18:3$n-3$ fatty acid did not significantly differ ($P < 0.05$) between the brands, except for the brand P. The arachidonic acid (C20:4$n-6$), an important precursor of prostaglandins, showed variations (0.55–2.31%) among whole brands. Considering the polyunsaturated EPA and DHA fatty acids, all brands showed high levels of EPA, and this is possibly due to retroconversions of DHA to EPA (Aubourg, Sotelo, & Gallardo, 1990). By analyzing only the EPA values of the brand P (5.39%), significant differences ($P < 0.05$) in comparison to the other brands were observed. However, the DHA values, varying from 3.89% to 6.64%, were the same ($P < 0.05$) among the brands. In general, the EPA and DHA values in canned fish are

Table 3
Fatty acids profile in different brands of sardines canned in tomato sauce[1]

Fatty acids	Brands		
	BT	CT	GT
C14:0	9.17 ± 1.26^{2}	8.51 ± 1.04^{2}	9.99 ± 2.32^{2}
iC16:0	0.48 ± 0.05^{2}	0.47 ± 0.03^{2}	0.53 ± 0.08^{2}
C16:0	21.0 ± 0.24^{2}	20.0 ± 1.44^{2}	21.3 ± 0.89^{2}
C16:1$n-7$	9.30 ± 1.07^{2}	8.68 ± 0.79^{2}	10.5 ± 1.99^{2}
C16:1$n-5$	0.24 ± 0.02^{2}	0.20 ± 0.02^{2}	0.25 ± 0.05^{2}
iC17:0	0.37 ± 0.04^{2}	0.39 ± 0.03^{2}	0.44 ± 0.04^{2}
C16:2$n-4$	0.85 ± 0.14^{2}	0.90 ± 0.05^{2}	1.12 ± 0.15^{2}
C16:3$n-6$	0.17 ± 0.02^{2}	0.19 ± 0.02^{2}	0.26 ± 0.06^{2}
C17:0	0.66 ± 0.08^{2}	0.53 ± 0.07^{2}	0.58 ± 0.09^{2}
C17:1$n-11$	1.18 ± 0.28^{2}	1.30 ± 0.13^{2}	1.59 ± 0.23^{2}
C16:4$n-3$	0.74 ± 0.20^{2}	$1.13 \pm 0.26^{2,3}$	1.53 ± 0.28^{2}
C18:0	4.37 ± 0.16^{2}	4.20 ± 0.18^{2}	4.19 ± 0.43^{2}
C18:1$n-9$	7.22 ± 0.56^{2}	8.91 ± 0.23^{2}	6.17 ± 1.10^{2}
C18:1$n-7$	3.71 ± 0.19^{2}	3.59 ± 0.18^{2}	3.72 ± 0.31^{2}
C18:2$n-6$	$9.78 \pm 2.80^{2,3}$	11.4 ± 3.12^{2}	2.42 ± 0.31^{4}
C18:2$n-4$	0.26 ± 0.04^{2}	0.28 ± 0.02^{2}	0.34 ± 0.04^{2}
C18:3$n-6$	0.36 ± 0.08^{2}	0.36 ± 0.05^{2}	0.43 ± 0.12^{2}
C18:3$n-3$	1.05 ± 0.24^{2}	$1.52 \pm 0.37^{2,3}$	$0.57 \pm 0.10^{2,3}$
C18:4$n-3$	1.37 ± 0.43^{2}	1.83 ± 0.13^{2}	1.97 ± 0.25^{2}
C20:1$n-11$	0.56 ± 0.08^{2}	0.45 ± 0.01^{2}	0.57 ± 0.15^{2}
C20:1$n-9$	0.18 ± 0.02^{2}	0.40 ± 0.33^{2}	1.33 ± 1.28^{2}
C20:4$n-6$	2.31 ± 0.31^{2}	1.68 ± 0.13^{3}	1.81 ± 0.28^{3}
C20:4$n-3$	0.45 ± 0.08^{2}	$0.47 \pm 0.05^{2,3}$	0.55 ± 0.14^{3}
C20:5$n-3$	12.3 ± 1.42^{2}	11.9 ± 0.50^{2}	15.1 ± 0.73^{2}
C22:1$n-11$	0.22 ± 0.02^{2}	0.56 ± 0.35^{2}	1.74 ± 1.32^{2}
C21:5$n-3$	0.41 ± 0.06^{2}	$0.45 \pm 0.03^{2,3}$	0.62 ± 0.05^{3}
C22:4$n-6$	0.26 ± 0.19^{2}	0.44 ± 0.08^{2}	0.45 ± 0.12^{2}
C22:5$n-3$	1.21 ± 0.06^{2}	1.04 ± 0.13^{2}	1.53 ± 0.51^{2}
C22:6$n-3$	9.51 ± 1.65^{2}	7.92 ± 0.58^{2}	8.11 ± 1.05^{2}
C24:1$n-9$	0.36 ± 0.07^{2}	0.38 ± 0.06^{2}	0.35 ± 0.20^{2}
SFA[5]	36.0 ± 1.30	34.1 ± 1.79	37.0 ± 2.53
MUFA[5]	22.8 ± 1.26	24.1 ± 0.98	24.9 ± 2.96
PUFA[5]	41.0 ± 3.66	41.5 ± 3.26	36.8 ± 1.51
$n-3$[6]	27.0 ± 2.2	26.24 ± 0.91	30.0 ± 1.44
$n-6$[7]	12.9 ± 2.89	14.1 ± 3.13	5.38 ± 0.45
PUFA/SFA[8]	1.14 ± 0.11	1.22 ± 0.12	1.00 ± 0.08
$n-6/n-3$[11]	0.48 ± 0.11	0.54 ± 0.12	0.18 ± 0.02

[1] Results expressed as percentage of total fatty acid methyl esters. The values are means ± S.D. of 48 cans analyzed in triplicate.
[2,3,4]The means followed by the same numbers between the different brands do not present significant differences by Tukey's test at 5%. [5]Saturated, monounsaturated and polyunsaturated fatty acids. [6]$\Sigma n-3$. [7]$\Sigma n-6$. [8]Ratio of polyunsaturated to saturated fatty acids. [9]Ratio of $\Sigma n-6$ to $\Sigma n-3$.

lower than in fish *in natura*, possibly due to the incorporation of the C18:2$n-6$ and C18:3$n-3$ fatty acids in the fish lipids (Badolato et al., 1994).

The fatty acid composition of sardines canned in tomato sauce is shown in Table 3. There are no significant differences ($P < 0.05$) between saturated C14:0, C16:0 and C18:0 fatty acids among the different studied brands. Comparing these results to the levels of these fatty acids obtained for the brands in soybean oil (Table 2), lower values were observed for the sardines canned in soybean oil. The levels of C18:2$n-6$ in sardines canned in tomato sauce showed great variations, especially for the GT brand (2.42%), with significant differences ($P < 0.05$) in comparison to the other brands. All brands of sardines canned in tomato sauce showed low concentrations of C18:2$n-6$ when compared to the respective brands in soybean oil (Table 2). This effect was also verified for C18:3$n-3$. The values of the polyunsaturated EPA and DHA fatty acids in the sardines canned in tomato sauce were higher than the others canned in soybean oil (Table 2); however, significant differences ($P < 0.05$) do not exist between the different brands. Analyzing the total $n-3$ fatty acids, it was observed that the sardines canned in tomato sauce showed higher values than the same canned brands in soybean oil and, consequently, presented the lowest values for the $n-6/n-3$ ratio. The great variation found in the $n-6/n-3$ ratios for the sardines canned in soybean oil (0.73–2.17) and in tomato sauce (0.18–0.54) can possibly be related to the amounts of coating oil used during the

processing. Considering the studied components, the brand P showed the greatest differences, illustrating the different canning processes of the brands. Some freshwater fish from the south of Brazil, such as Carpa (*Cyprinus carpio*), Pacu (*Colossoma mitrei*) and Tilápia (*Oreochromis niloticus*), present $n-6/n-3$ ratio values of 4.54, 4.35 and 2.38, respectively, which are higher found in this work (Andrade et al., 1995).

4. Conclusions

Regarding the total lipids and percentages of DHA and EPA, we can postulate that sardines canned in tomato sauce are a good source of DHA and EPA. Not withstanding a lower nutritional value, (in relation to long-chain polyunsaturated $n-3$ fatty acids) of sardines canned in soybean oil, they too can be considered a good source of EPA and DHA.

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