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MICRONUTRIENTS (Ca, Fe, K, Na, Se, Zn) ASSESSMENT AND FATTY ACIDS PROFILE IN FISH MOST CONSUMED BY CUBATÃO COMMUNITY, SÃO PAULO, BRAZIL

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ABSTRACT

Fish are a healthy source of protein, providing omega-3 (n-3) the fatty acids that reduce cholesterol levels, and reduce the incidence of heart disease and stroke. The purpose of the present study was to assess the concentration of some micronutrients and also fatty acids profile in muscles of the most consumed fish species from Cubatão coastal region. Cubatão carnivorous fish species analyzed were: *Micropogonias furnieri* (Corvina), *Macrodon ancylodon* (*Pescada)* and *Menticirrhus americanus* (Perna-de-Moça), and planktivorous species *Sardinella braziliensis* (Sardinha) and *Mugil liza* (Tainha). Micronutrients (Ca, Fe, K, Na, Se, Zn) in fish muscle were determined by means of instrumental neutron activation analysis (INAA). Fatty acids profiles in these muscle fish samples were performed by gas chromatography. Total saturated fatty acids ranged from 23.0% in *M. ancylodon* to 50.0% in *M. liza*. Total polyunsaturated fatty acid contents varied from 10.9% in *M. liza* 38.4% in *S. braziliensis*. These fish species presented different proportions of polyunsaturated fatty acids of the n-3 family and of the n-6 family. Regarding the n-6 family, *M. furnieri* showed the highest values (13.3%) and *M. ancylodon*, the lowest ones (4.1%). On the other hand, for the n-3 family, *S. braziliensis* presented the highest value (31.8%) and *M. liza* the lowest one (5.7%). Regarding micronutrients content, great concentration variations between individual of the same species and between different species were observed. From the nutritional point of view *S. braziliensis* is the best choice showing highest content of fatty acid n-3 family and micronutrient concentrations.

1. INTRODUCTION

Fish consumption is prevalent throughout the world, due to among other factors, it being and excellent nutritional alternative to meat. Its attractiveness is also due to the presence of polyunsaturated fatty acids, minerals availability, proteins and vitamins contents. [1]. Fish is rich in vitamin A, D, and the B group. In addition, fish represents a good source of micro and micro-elements such as calcium, phosphorus, selenium and manganese. [2] In Brazil, the fish consumption per capita is relatively low when compared to other sources of animal protein.

Minerals are required for normal life processes in all animals, including fish. Fish obtain these minerals in their diet (trophic chain) and also directly from water. Minerals are responsible for skeletal formation, colloidal systems maintenance, regulation of acid-base equilibrium and to make a part of important physiological compounds such as hormones and enzymes. Mineral deficiencies can provoke structural and functional pathologies which depend on several factors, including the duration and degree of mineral deprivation.[3]

Observations on mineral content in various marine and fresh water fish species indicate that there are important variations among different species, and even among individual members of the same species, in function of seasonality, location, habitat, gender, age, etc.[4]

Fatty acids are defined as long chain aliphatic acids found in natural oils and fats. They can be found as saturated and unsaturated fatty acids. [5] Three of polyunsaturated fatty acids: linoleic, linolenic and araquidonic, are essential fatty acids. However, only linoleic and araquidonic are considered essential for human beings. They play important roles in fat transportation and cell membrane integrity maintenance and function.[6]

Lipid composition in fish tissues can be affected by diet quality and environmental factors, such as salinity, temperature, seasonality and geographic location. The amount of polyunsaturated fatty acids from the omega 3 family can be influenced by a great number of factors and vary following species classification.

In spite of Brazil's conditions for fish production there are still few studies regarding identification, fatty acids composition and micronutrients assessment in fish [2,7-9]. Regarding fish from Cubatão there are some reports and papers published but they focus mainly on toxic metal contamination [10, 11].

Instrumental neutron activation analysis (INAA) has been widely used for micronutrient determination in fish and foods [12, 13].

The purpose of the present study was to assess the concentration of the following micronutrients Ca, Fe, K, Na, Se, Zn by INAA and also fatty acid profile in fish muscle in the most commonly consumed fish species available in Cubatão city, an estuarine region. The carnivorous fish species analyzed were: *Micropogonias furnieri* (Corvina), *Macrodon ancylodon* (*Pescada)* and *Menticirrhus americanus* (Perna-de-Moça), and planktivorous species *Sardinella braziliensis* (Sardinha) and *Mugil liza* (Tainha).

2. MATERIAL AND METHODS

2.1. Study area

Cubatão city is near the largest harbor of Latin America located at Santos city. It is also one of the largest industrial complexes in Brazil. This region has been responsible for the extreme contamination and pollution processes of the Santos and São Vicente estuaries and Santos Bay. Sometime ago, Cubatão city had the undesirable reputation of being the most polluted region in the country which obviously affected ecosystem and human health. [10, 14]. Nowadays, the problem has been reduced although not sufficiently to recuperate the natural conditions.

2.2. Fish species choice

Families that took part in another study were questioned to identify which fish species most consumed in the daily diet by Cubatão community. These questions were applied in three public schools where children's hair was also collected for Hg analyses to contribute to bioaccumulation studies. Using the answers, the results were tabulated and the most consumed fish species were identified. The five fish species most common were: *Macrodon ancylodon (*Pescada*), Menticirrhus americanus (*Perna de Moça*) and Micropogonias furnieri (*Corvina*)* three carnivorous species, and *Mugil liza (*Tainha*) and Sardinella braziliensis (*Sardinha*),* two planktivorous species. This study was developed as part of a larger project concerning Hg bioaccumulation in which hair was also analysed.

2.3. Sampling and samples preparation

The fish were acquired directly from local street markets in Cubatão city during March of 2008. All organisms presented quality indicators and external organoleptic characteristics (eyes, gills and scales in good conditions). The fish were identified according to Menezes &Figueiredo [15]. The identified samples were conditioned in thermo boxes with crushed ice. In the laboratory, the biometrical properties were measured: total length, total weight and body weight. After this, muscle tissue samples were separated from 58 individuals and dried at 50^0 C until constant weight. Dried samples were ground, homogenized and submitted to chemical analysis by INAA. These analyses were performed at the Neutron Activation Analysis Laboratory – LAN/IPEN.

For fatty acid profiles, a pool for each fish species was prepared for analysis. The same small amount of muscle was taken from each individual sample of each species. This amount of each individual of the same species was then mixed and homogenized. Each homogenized mixture of the five fish species was then used for analysis to determine the fatty acid profile.

2.4 Micronutrients Determination (Ca, Fe, K, Na, Se and Zn) by INAA

2.4.1 Synthetic standards preparation

Single and multi-element synthetic standards were prepared by pipetting convenient aliquots of standard solutions (SPEX CERTIPREP, USA) onto small sheets of Whatman no 41 filter paper. The following amounts of each element analyzed were used: Ca (962 µg), Fe (481 µg), K (482 µg), Na (481 µg), Se (0.97 µg) and Zn (9.6 µg).

2.4.2 Irradiation and counting

Micronutrients determination was done using Instrumental Neutron Activation Analysis (INAA). For analysis, approximately 200 mg of fish tissue (duplicate) and about 150 mg of reference materials were accurately weighed and sealed in pre-cleaned double polyethylene bags, for irradiation. Fish tissues, reference materials and synthetic standards of the elements analyzed were irradiated for 8 hours, under a thermal neutron flux of 10^{12} cm^{-2} s^{-1} in the IEA-R1 nuclear research reactor at IPEN. Two series of counting were made: i) the first, after one week decay where the ^{47}Ca, ^{42}K and ^{24}Na radioisotopes were determined; ii) the second, after 15-20 days, where the radioisotopes ^{59}Fe, ^{75}Se and ^{65}Zn were quantified. Gamma spectrometry was performed by using an EG & ORTEC hyperpure Ge detector and associated electronics, with a resolution of 0.90keV and 1.90keV for ^{57}Co and ^{60}Co, respectively. Details for the INAA experimental procedure were already described by Favaro *et al.* [16], with some modifications.

2.4.3 Methodology validation

INAA was validated for precision and accuracy by means of reference material analyses with certified values for the elements determined: Dogfish muscle (DORM-1, NRCC), Oyster Tissue (SRM 1566^b, NIST) and Peach Leaves (SRM 1647, NIST).

2.5 Fatty acid determination

2.5.1 Lipid extraction according to Bligh & Dyer methodology [17]

The wet tissue was homogenized with a mixture of chloroform and methanol in such proportions that a miscible system is formed with the water in the tissue. Dilution with chloroform and water separates the homogenate into two layers, the chloroform layer containing all the lipids and the methanolic layer containing all the non-lipids. A purified lipid extract is obtained merely by isolating the chloroform layer [17]. This procedure was undertaken at LAN, the lipid extracts were frozen and then sent to Institute of Food Technology (ITAL) for fatty acid determination.

2.5.2 Fatty acid determination

The analyses were performed at the Center for Food Science and Quality from ITAL, Campinas, São Paulo, Brazil. For fatty acid determination, one aliquot of lipid extract containing approximately 400 mg for each pool of fish species analyzed was taken and dried in a rotatory evaporator. The transmetilation was done according to Hartman & Lago methodology [18], using ammonium chloride solution and sulfuric acid in methanol as an estirificant agent. The gas chromatography was performed using a gas chromatography, (Varian, model 3900, Palo Alto, California, USA) equipped with an auto sampler; injector split, ratio 1/75; fused silica capillary column (100 m x 0.25 mm i.d., 0.20 μm film thickness) (CP-SIL 88, Chrompack, Middelburg, The Netherlands) and flame ionization detector. The initial column temperature was 120 °C for 5 minutes and then programmed to increase at 5°C/min to 235 °C; the injector temperature was set at 270 ^{0}C; the detector temperature at 300 °C; injection volume was 1 μL. The carrier gas was hydrogen at a flow rate of 1 mL/min and nitrogen was used as the make-up gas at 30 mL/min. The fatty acids were identified by comparison of the retention times of the sample with those of the standards and by spiking. To verify the identity and accuracy of the method a total of 37 saturated, monounsaturated and polyunsaturated fatty acid standards (37 FAME Mix 47885-U, Sulpeco$_{TM}$, Bellefonte, PA, USA) were used. Quantification was done as area percentages and the results were expressed in % of area.

3. RESULTS AND DISCUSSION

Table 1 shows the results obtained for the reference materials analyses by INAA. The relative standard deviation ranged from 6.8 % to 12.3% and the relative error ranged from 0.09 % to 9.5%, showing good precision and accuracy, respectively.

Table1. Results of reference materials analyses by INAA (mg kg^{-1}) (n = 6).

	Oyster Tissue (OT)				Dorm -1 (DM)				Peach Leaves (PL)			
Elements	**Certified Values**	**Obtained Values**	**RSD (%)**	**RE (%)**	**Certified Values**	**Obtained Values**	**RSD (%)**	**RE (%)**	**Certified Values**	**Obtained Values**	**RSD (%)**	**RE (%)**
Ca									15600 ± 200	14769 ± 1775	12.0	-5.3
Fe	205.8 ± 6.8	217 ± 20	9.2	5.4	63.6 ± 5.3	68 ± 7	10.3	-6.9	218 ± 14	207 ± 14	6.8	-5.0
K	6520 ± 90	7137 ± 692	9.7	9.5	15900 ± 000	15656 ± 1326	8.5	-1.5	24300 ± 300	24278 ± 2159	8.9	0.09
Na	3297 ± 53	3226 ± 331	10.3	2.2	8000 ± 600	7778 ± 849	10.9	-2.8				
Se (µg kg^{-1})	2060 ± 150	2090 ± 231	11.1	1.5	1620 ± 120	1606 ± 194	12.1	-0.9	120 ± 9	127 ± 9	7.1	5.5
Zn	1423 ± 46	1349 ± 166	12.3	-5.2	21.3 ± 1.1	20.6 ± 1.8	8.7	-3.3	17.9 ± 0.3	18.9 ± 1.2	6.3	5.6

n – number of determinations RSD – relative standard deviation RE – Relative error

Table 2 presents the mean, maximum and minumum concentration values for the micronutrients analysed by INAA in wet weight. Table 2 also shows the detection limits (LD) for the elements analysed in the conditions of the present study. The LD was calculated according to Currie [19] and is very similar to the values presented in the literature [20, 21]. The Brazilian legislation for inorganic contaminants in fish and fish products establish a limit of 50 mg kg^{-1} for Zn [22]. For the other elements analysed there is no limit cited in the legislation.

Ca

There was a great variation in concentration of this element observing inter-specific means data and intra-specific data as verified in Table 2. *Micropogonias furnieri* (1073 mg kg^{-1}) and *Sardinella braziliensis* (923 mg kg^{-1}) were the species that presented the highest mean concentration values. The lowest ones were found for *Mugil liza* (279 mg kg^{-1}) and *Menticirhus americanus* (244 mg kg^{-1}) species. It is necessary to remark that for *Mugil liza* only one result was obtained. The other values were probably below or near the LD for Ca by INAA (100 mg kg^{-1}) and could not be measured.

Fe

There was again a great concentration variation considering the fish species analysed and *Sardinella braziliensis* continuous to show the highest concentration mean value (17.2 mg kg^{-1}). The lowest mean concentration value was presented by *Macrodon ancylodon* (3.1 mg kg^{-1}).

K

The concentration values for K presented important variation between individual data from the same species and from different species. The highest mean concentration value was found for *S. braziliensis* (3889 mg kg^{-1}) and the lowest one *M. ancylodon* (2791 mg kg^{-1}).

Na

There was a great variation concentration between the individual data in same species and between different considered species, being the highest mean concentration value presented once more by *S. braziliensis* (2345 mg kg^{-1}) and the lowest, for *M. liza* (622 mg kg^{-1}).

Se

The highest mean concentration value was found in *S. braziliensis* (Sardinha) (862 mg kg^{-1}) followed by *M. furnieri* (Corvina) and the lowest one in *M. liza* (Tainha) (292 mg kg^{-1}). An accentuated inter and intra specific variations were also observed.

Zn

The variation of means values (inter-specific) diminished except for *S. braziliensis* that presented the highest mean concentration value for Zn (12.5 mg kg^{-1}). In this case, *M. ancylodon* mean value presented the lowest one (3.1 mg kg^{-1}). An important variation of concentration was observed considering the same species individuals. All the fish species analysed did not show concentration values higher than the limit set by ANVISA (50 mg kg^{-1}) for fish and fish products [22]. Results for Zn in fish collected from the Santos and São Vicente estuaries in 1999 published in the CETESB 2001 report [10] were 8.0 ± 8.5 mg kg^{-1} and 10.4 ± 16.0 mg kg^{-1}, respectively. These results were much higher than the results obtained in the present study, except for *S. braziliensis* (Table 2).

For the other elements analyzed in the present study no values were found for comparison in the literature. All the results found are related to As and metals (Cd, Cu, Cr, Hg, Ni, Pb and Zn) levels in fish and aquatic organisms [11, 21].

Table 3 presents the biometric data obtained for the fish samples analysed. Total lenght (LT), standard length (SL), total weight (TW) and body weight (BW) (without visceral parts) were measured.

Table 3 shows a variation of the biometric data between the individuals from the same fish species and also from the different fish species analysed. The *M. furnieri* (Corvina) and *M. liza* (Tainha) constitute the bigger exemplars obtained, but they are seasonal species not available all the time and their economic values are different from the other species that have popular consume. The *S. braziliensis*, came from out of the estuarine system and has also seasonal abundance. The *M. ancylodon* and the *M. americanus* represent important species for the popular feed in this region.

By means of statistical analysis, no important correlation was observed between standard length and total weight with micronutrients concentration in the fish species analysed.

Table 2. Mean, minimum, maximum concentration values (wet weight) for the elements analysed by INAA

Fish species	Popular Name	Ca (mg kg^{-1})	Fe (mg kg^{-1})	K (mg kg^{-1})	Na (mg kg^{-1})	Se (µg kg^{-1})	Zn (mg kg^{-1})
Micropogonias furnieri **(12)**	**Corvina**	**1073** (541-2511)	**7.8** (3.9-13.8)	**3186** (2364-4412)	**1156** (872-1450)	**793** (441-1066)	**4.6** (3.8-6.6)
Menticirrhus americanus **(12)**	**Perna-de-moça**	**244** (108-414)	**4.3** (1.5-8.5)	**3045** (2367-3612)	**885** (658-1025)	**457** (290-625)	**4.1** (2.6-5.2)
Macrodon ancylodon **(13)**	**Pescada**	**443** (382-575)	**3.1** (1.3-6.3)	**2791** (2249-3601)	**1312** (871-1911)	**370** (299-448)	**3.1** (1.6-4.1)
Sardinella braziliensis **(16)**	**Sardinha**	**923** (426-1446)	**17.2** (12.9-24.4)	**3889** (2823-4436)	**2345** (1436-3039)	**862** (659-1253)	**12.5** (10.2-17.9)
Mugil liza **(5)**	**Tainha**	***279**	**10** (6.1-15)	**2852** (1754-3839)	**622** (256-1005)	**292** (156-426)	**4.8** (3.8-6.4)
Detection limit (LD)		100	1.0	1000	10	76	0.5
Brazilian legislation limit							50

(n) – number of individuals analysed *only one value was obtained

Table 3. Biometric data (mean, minimum, maximum) for the fish species analysed, commercially available in Cubatão city.

Fish species	TL (mm) ± dp	SL (mm) ± dp	TW (g) ± dp	BW (g) ± dp
Micropogonias furnieri (n=12)	**420 ± 29** (365-455)	**327 ± 20** (283-345)	**731 ± 103** (607-909)	**699 ± 88** (602-861)
Menticirrhus americanus (n=12)	**257 ± 12** (239-282)	**199 ± 12** (185-230)	**176 ± 19** (147-217)	**162 ± 17** (136-203)
Macrodon ancylodon (n=13)	**327 ± 17** (301-368)	**242 ± 13** (222-272)	**313 ± 39** (234-374)	**290 ± 35** (230-348)
Sardella braziliensis (n=16)	**225 ± 6** (215-235)	**162 ± 13** (136-175)	**104 ± 8** (92-120)	**93 ± 7** **(83-110)**
Mugil liza (n=5)	**544 ± 14** (520-555)	**397 ± 20** (372-420)	**1440 ± 159** (1303-1710)	**1259 ± 91** (1154-1382)

Total lenght (TL), standard lenght (SL), total weight (TW), body weight (BW), number of individuals analysed (n)

Table 4 presents the fatty acids profile for the five fish species analysed in the present study.

Lipid composition in fish tissues can be affected by diet and environmental factors such as salinity, temperature, seasons and geographic location. Although several marine fish species are rich in polyunsaturated fatty acids n-3 family, their levels can vary according to different species. Eicosapentaenoic (EPA) (C20:5 n-3) and docosahexaenoic (DHA) (C22:6 n-3) fatty acids of the n-3 family are abundant in various marine fish species, specifically those that feed on polyunsaturated fatty acid n-3 family rich-plankton. Both fatty acids have been the subject of several studies, being important for their various benefits to human health, including lowering the risk of cardiovascular diseases [23,24] anti-inflammatory and antithrombotic effects [25], reduction of blood cholesterol levels and cancer prevention [26].

Omega-3 and 6 fatty acids are essential for human beings, but they are not synthesized by the body. Their deficiency can provoke adverse health effects. These fatty acids are constituents of cellular structure and are needed for membrane formation [27]. Omega-6 deficiency can provoke dermatological symptoms, while n-3 deficiency is related to neurological and visual disturbances [28].

In the five fish species analyzed, the higher concentration of monounsaturated fatty acids ranged from 15.4 % in *Micropogonias furnieri* (Corvina) to 43.1% in *Macrodon ancylodon* (Pescada) (Table 4). The fatty acid composition revealed that the most abundant were palmitic acid (C16:0) and oleic acid (C18:1 n9); palmitoleic acid (C16:1 n7) and estearic acid (C18:0) in lower proportions in the five fish species analyzed with levels ranging from 7.4 to 35.9%, from 9.6 to 28.5%, 2.7 to 19.1% and from 4.1 to 13.5%, respectively of the total fatty acids. Among the fish species analyzed *Mugil liza* (Tainha) presented the highest proportion of palmitic acid (35.9%) and *Macrodon ancylodon*, the highest proportion of oleic (28.5 %) and estearic acids (13.5%). *Mugil liza* presented the highest value of palmitoleic acid (19.1%). The (EPA + DHA) fatty acid levels were higher for *Sardinella braziliensis braziliensis* (Sardinha) (24.6%) and lower for *Mugil liza* (4.2%).

Ramos Filho et al. [7] studied the lipid profile of four fresh water fish species from Pantanal region, MS. They verified that the PUFA levels ranged from 5.24% for *Piaractus mesopotamicus* (Pacú) to 17.3% for *Pseudoplatystoma sp* (Pintado) and the total saturated fatty acids ranged from 32.9 to 38.9%.

Gutierrez & Silva [29] studied the lipid profile from seven (7) fresh water fish species and nine (9) marine species commercially important in Brazil. They concluded that the fish species from fresh water are not a good source of EPA and DHA for the human feed. The marine fish species considered by the authors, only *Sardinella braziliensis* (Sardinha) and *Anchoviella* sp (Manjuba) can be recommended as an adequate source of fatty acid from n-3 family.

It is necessary to remember that fish chemical composition can vary in function due to several endogenous and exogenous factors such as: genetics, size, gender, reproductive age, feeding habits, environmental factors, temperature and seasons [8, 30].

According to published literature, consumption of n-6/n-3 ratio ranging from 2 to 5.1 is recommended for adults in many countries [31, 32]. Even though in the present study n-6/n-3 ratio ranged from 0.17(*Macrodon ancylodon*) to 0.91 (*Mugil liza*), it must not be forgotten that fish is only a small part of a whole diet. Therefore it could be an important contribution in reaching the recommended ratio.

Table 4. Fish species (muscle pool) fatty acid composition, expressed in area (%) of the relative area concerning the total lipids.

Fatty acids	*Micropogonias furnieri* (Corvina)	*Menticirrhus americanus* (Perna-de-Moça)	*Macrodon ancylodon* (Pescada)	*Sardinella braziliensis* (Sardinha)	*Mugil liza* (Tainha)
C 14:0	0.5	1.5	0.4	6.7	7.8
C 15:0	0.4	1.1	0.1	0.9	1.3
C 15:1	nd	Nd	nd	nd	0.1
C 16:0	21.7	27.7	7.4	22.7	35.9
C 16:1n7	2.7	4.9	12.6	4.9	19.1
C 17:0	0.8	1.2	0.5	0.7	0.3
C 17:1	1.1	1.4	0.3	0.1	0.4
C 18:0	10.7	8.2	13.5	5.1	4.1
C 18:1n9*t*	0.3	0.4	0.3	0.1	0.1
C 18:1n 9	11.3	17.6	28.5	9.6	15.9
C 18:2n6*t*	nd	0.6	1.0	0.3	0.4
C 18:2n6	1.0	2.1	nd	2.4	2.5
C 20:0	0.3	0.3	0.6	0.4	0.4
C 18:3n3*t*	0.3	0.1	0.5	0.2	0.6
C 20:1n11	nd	0.8	0.8	2.4	0.3
C 18:3n3	0.3	0.6	0.5	1.8	0.6
C 20:2n6	0.2	0.3	0.5	2.1	1.9
C 22:0	nd	0.5	0.3	0.2	0.1
C 20:3n6	0.2	0.2	0.1	0.1	nd
C 20:3n3	0.2	0.1	0.1	4.1	nd
C 22:1	nd	0.1	0.2	0.3	0.1
C 20:4n6	11.9	5.7	2.2	1.5	0.7
C 22:2n6	nd	0.1	0.3	0.5	0.1
C 24:0	nd	0.3	0.2	1.0	0.1
C 20:5n3 (EPA)	6.2	1.9	4.4	9.0	1.4
C 24:1	nd	0.2	0.7	1.0	0.1
C 22:5n3	3.2	2.6	2.4	1.3	0.9
C 22:6n3 (DHA)	13.7	11.8	16.1	15.6	2.8
Σ Saturated	**34.4**	**40.8**	**23.0**	**36.8**	**50.0**
Σ Monounsaturated (MUFA)	**15.4**	**25.0**	**43.1**	**18.3**	**36.1**
Σ Polyunsaturated (PUFA)	**36.9**	**25.4**	**27.6**	**38.4**	**10.9**
Σ omega 6	**13.3**	**8.4**	**4.1**	**6.6**	**5.2**
Σ omega 3	**23.6**	**17.0**	**23.5**	**31.8**	**5.7**
Trans	**0.3**	**1.1**	**0.3**	**0.6**	**0.5**
NI	**13**	**7.7**	**6.0**	**5.9**	**2.5**
Σ (MUFA+PUFA)	**52.3**	**50.4**	**70.7**	**56.7**	**47.0**
n-6/ n-3	**0.56**	**0.49**	**0.17**	**0.21**	**0.91**
Σ (EPA+DHA)	**19.9**	**13.7**	**20.5**	**24.6**	**4.2**

nd = not detected (detection limit ≤ 0.1%); N.I. = not identified

4. CONCLUSION

Instrumental neutron activation analysis proved to be a good analytical technique for the determination of some micronutrients such as Ca, K, Na, Se and Zn in fish muscle samples showing good precision and accuracy.

The micronutrient showed great variations of Ca, Fe and Na concentrations considering intra and inter-specific fish data. The K and Se data showed a slight decrease of the variation in intra and inter specific values. The Zn average values for species were very homogeneous discounted the maximum values observed for S*ardinella braziliensis* and the minimum for *Macrodon ancylodon*. In general, *Sardinella brasilienzes* was the fish species that presented the highest concentration values for all micronutrients analyse. *Mugil liza* presented the lowest values for Ca, Na and Se concentrations and *Macrodon ancylodon*, for K and Zn.

Concerning lipid profile obtained in this study, total saturated fatty acids ranged from 23% in *Macrodon ancylodon* to 50.0% in *Mugil liza*. Total polyunsaturated fatty acid contents varied from 10.9% in *Mugil liza* to 38.4% in *Sardinella braziliensis*. The fish species analysed presented different proportions of polyunsaturated fatty acids of the n-3 family and of the n-6 family. Regarding the n-6 family *Micropogonias furnieri* showed the highest values (13.3%) and *Macrodon ancylodon*, the lowest ones (4.1%). On the other hand, for the n-3 family, *Sardinella braziliensis* presented the highest value (31.8%) and *Mugil liza* the lowest one (5.7%). The (EPA + DHA) fatty acid levels were higher for *Sardinella braziliensis* (24.6%) and lower for *Mugil liza* (4.2%). The levels for *Micropogonias furnieri* (19.9%) and *Macrodon ancylodon* (20.5%) were similar.

It is important to observe that in relation to the species studied, *Sardinella braziliensis* is taken in the seawater, relatively far from the continental margin and estuarine system and it appears that from nutritional point of view this species is the best choice showing highest content of fatty acid n-3 family and micronutrient concentrations. Considering estuarine species, *Micropogonias furnieri* and *Macrodon ancylodon* represent a considerable source, in function of availability and price, mainly for the last one.

Finally, the studied region is an industrial coastal pole, near an estuarine and coastal pollution problems and the fish available to the human consume showed a good quality observed by nutritional values and microelement composition, mainly in function of distinct commercial sources of its. For the best nutritional quality, it is necessary to give stimulus for human fish consume in the diet, which is possible with a price reduction of the product, whose is relatively high in Brazil.

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