BIOMETRIC CHARACTERIZATION, PROXIMATE COMPOSITION, AND FILLET YIELD AND WASTE OF SERRA SPANISH MACKAREL (*Scomberomorus brasiliensis*)*

Diomar Augusto de QUADROS[1,2] and Helena Maria Andre BOLINI[2]

ABSTRACT

The present study aimed to determine the biometric and physicochemical characteristics and fillet yields of serra spanish mackerel (*Scomberomorus brasiliensis*) from artisanal fishing in the municipality of Matinhos/PR, Brazil. Six collections were carried out from March 2013 to January 2014. The parameters fish weight, total length, head length, thickness, and height of the body were determined. The fillet whether or not skinned was evaluated for its length and weight. Yield was determined in the fillet with or without skin, viscera, carcass, skin, and non-edible portions. Moisture content, ash, protein, lipid, energy value, and pH of the skinned fillets were also determined. Data were subjected to analysis of variance and comparison of means by Tukey's test (P<0.05). The results showed a significant difference over time of collection. According to the results, it is concluded that Serra Spanish mackerel presents excellent fillet yield, and its composition is influenced by the time of year.

Keywords: chemical composition; filleting waste; artisanal fishing

CARACTERIZAÇÃO BIOMÉTRICA, COMPOSIÇÃO CENTESIMAL E RENDIMENTO DO FILÉ E RESÍDUOS DA SORO ROCA (*Scomberomorus brasiliensis*)

RESUMO

O trabalho teve como objetivo determinar as características biométricas, físico-químicas e os rendimentos da filetagem de sororoca (*Scomberomorus brasiliensis*) proveniente da pesca artesanal do município de Matinhos/PR, Brasil. Seis coletas foram realizadas no período de março de 2013 a janeiro de 2014. Foram determinados o peso, comprimento total, comprimento da cabeça, espessura e altura do corpo da sororoca. O filé com e sem pele foi avaliado pelo comprimento e peso. O rendimento foi determinado no filé com e sem pele, vísceras, carcaça, pele e porção não comestível. Foram determinados, ainda, os teores de umidade, cinzas, proteínas, lipídeos, valor energético total e pH dos filés sem pele. Os dados foram submetidos à análise de variância e ao teste de comparação de médias de Tukey (P<0,05). Os resultados demonstraram que houve diferença significativa ao longo do tempo de coleta do peixe. De acordo com os resultados obtidos é possível concluir que a sororoca apresenta um excelente rendimento na filetagem e a sua composição é influenciada pela época do ano.

Palavras chave: composição química; resíduos da filetagem; pesca artesanal

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[1] *Federal University of Paraná (UFPR), Litoral Sector. R. Jaguariaiva, 512 – Caiobá – CEP: 83260-000 – Matinhos – PR – Brazil. e-mail: diomar@ufpr.br (corresponding author)*

[2] *University of Campinas (UNICAMP), Faculty of Food Engineering, Postgraduate Program in Food and Nutrition. R. Monteiro Lobato, 80 – Barão Geraldo – CEP: 13083-862 – Campinas – SP – Brazil. e-mail: hellini@unicamp.br*

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INTRODUCTION

Serra spanish mackarel *Scomberomorus brasiliensis* (Collette, Russo & Zavala-Camin, 1978) is a marine species of commercial value that inhabits most of the Brazilian coast (XIMENES, 1981; LIMA *et al*., 2005). It is considered migratory, living in the open ocean (ALMEIDA *et al*., 2007), a coastal-pelagic species distributed in the Western Atlantic Ocean along the Yucatan Peninsula and Belize to the South of Tramandaí Lagoon, in Rio Grande de Sul, Brazil (COLLETTE *et al*., 1978; COLLETTE and NAUEN, 1983; ZAVALA-CAMIN, 1983; BATISTA and FAVRÉ, 2001; LIMA *et al*., 2009; GOLD *et al*., 2010), tending to form shoals and get into tidal estuaries (SILVA *et al*., 2005).

The species is known as "sororoca" in the states of Paraná, Santa Catarina, São Paulo and Rio de Janeiro. In Espírito Santo, it is called as "sarda", and in Pará, Maranhão, Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, and Sergipe the species is known as "serra" (BARBOSA, 2011). Other names include: "cararoca", "cavala", "cavala-pintada", "escalda-mar", "serra-pima", "serra-pininga", "serrapinima" and "serrinha" (FROESE and PAULY, on line).

Although in Paraná the exploitation of fish stocks is basically by hand and is still made by fairly simple methods and fishing equipment, the species is well adapted to the local environmental conditions and socio-economic reality. In the municipality of Matinhos (PR), vessels are responsible for the extraction of various species, including serra spanish mackarel (FUNDAÇÃO PROZEE, 2005, 2006), which is mainly captured in purne-seine fishery, besides being an important resource for the artisanal fishing fleet in Brazil (FONTELES-FILHO, 1988; NÓBREGA and LESSA, 2009).

Serra spanish mackarel stands out for providing a large number of direct and indirect jobs, in addition to offering a high amount of animal protein for human consumption (LUCENA *et al*., 2004). It has a huge fishing potential due to its abundance and occurrence throughout the year, especially from April to August (ALMEIDA *et al*., 2007).

Knowledge of fish characteristics is extremely important to open new research areas, and serve as a data source for different technological processes on fish preservation, processing and development of high added value products (JABEEN and CHAUDHRY, 2011). Fish of the family *Scombridae* normally migrate long distances to feed and reproduce, being described as seasonal species abundant in Brazil in the period from May to July (BATISTA and FAVRÉ, 2001).

The biochemical composition of fish is influenced by several factors such as biological variations (species, gender, sexual maturity, size, and age), diet, environmental conditions (temperature, pH, salinity, etc.), and seasonal changes (FALLAH *et al*., 2013).

Despite the high demand, marketability, and wide availability of this species in the municipality of Matinhos/PR/Brazil, accurate information on its characteristics, composition and fillet yield are required, since there are no studies on this geographic area, where fish are the main source of income of artisanal fisheries, and are regularly consumed by the local community. In addition, these data are important tools to understand the industrialization potential of this species. The present study aimed to determine the meat yield and nutritional composition of serra spanish mackarel (*S. brasiliensis*) marketed by artisanal fishermen in Matinhos/PR from March 2013 to January 2014.

MATERIAL AND METHODS

Serra spanish mackerel (*S. brasiliensis*) was acquired from the artisanal fishermen at the Fishing Colony Z-4 in Matinhos/PR/Brazil (25°49'04"S; 48°32'34"W), where the species is captured by mortising and long-line fishing (ANDRIGUETTO FILHO, 2003), with mesh sizes ranging from 9 cm to 12 cm (according to the local artisanal fishermen). Seventy-two fish were sampled every two months, totaling 72 units and six collections. Each collection consisted of three batches of four fish each. The parameters sex, age, and stage of maturity were not observed, representing the reality of marketing and product supply.

The fresh fish was purchased and immediately packed in polystyrene boxes covered with ice and transported to the Laboratory of

Nutrition Education (LEAL) - UFPR Litoral Sector. In the laboratory, fish were washed in chlorinated water and individually weighed using a digital scale Acculab® (VIC-5101 model). Biometric measurements of the total length (cm) measured from the tip of the snout to the end of the caudal fin were made using a measuring tape (BRASIL, 1993). With the aid of a caliper, head size (cm), thickness (cm) and height of the body (cm) of each fish batch (four individuals/batch) were measured (BASTOS, 1966), as shown in Figure 1.

Manual filleting was performed with the aid of a knife by a single operator after fish were decapitated and gutted (SOUZA, 2002). The fillet length (cm) was measured using a measuring tape.

To calculate fillet yield, two fillets with and without skin, viscera, carcass (skeleton with attached flesh, head, and fins) and skin were weighed. The non-edible portion was calculated from the following equation:

Non-edible portion = 100 - % skinned fillet yield.

The skinned fillet was triturated in Lieme® processor (Liemita) and a portion was subjected to pH measurements and moisture determination (IAL, 2008), while the other portion was stored at -18 °C for 62 h, prior to freeze-drying (freeze-drier L202, Liotop®). Then, the product was ground in an electric processor and kept in plastic bottles hermetically sealed under freezing temperature until the time of physicochemical analysis.

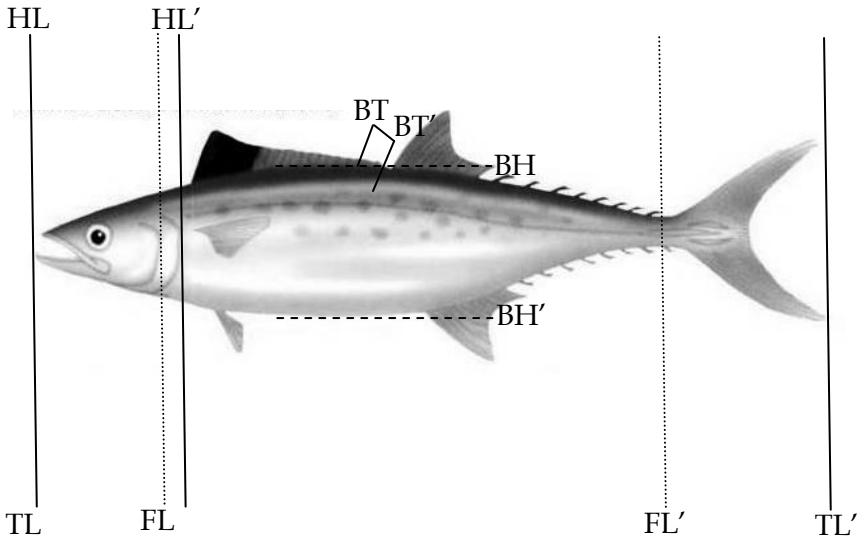

Figure 1. Diagram of the biometric measurements of serra spanish mackarel (*Scomberomorus brasiliensis*) and fillet size. TL - TL' = total length; HL - HL' = head length; BH - BH' = body height; BT - BT' = body thickness; FL - FL' = fillet length.

The physicochemical composition was determined in triplicate according to IAL (2008), as follows: pH was measured in Hanna® digital potentiometer, model pH 21; moisture was determined gravimetrically at 105 °C to constant weight; total lipids were determined by Bligh-Dyer method with modifications, and ash content was determined by incineration at 550 °C. Protein content was calculated from the total nitrogen, using the factor 6.25. Total nitrogen was determined by the Dumas method (SADER *et al*., 2004). The energy value was calculated from protein and total lipids contents and expressed in kcal, according to the Atwater system (NEPA, 2011).

Data were subjected to analysis of variance and means were compared by Tukey's test at 5% significance level, using the SAS software - version 9.4 (SAS INSTITUTE, 2013). Simple linear regression was used to describe the relationship between the variables.

RESULTS

All biometric variables (total weight and length, head length, thickness and height of the

body), mean weight of the fillet whether or not skinned, and fillet length were statistically different (P<0.05) over time (Table 1). The collection performed in July/2013 had the highest values for most variables, differing significantly from the other collections. The lowest values were found in the collection of November/2013, and the variables total weight, body thickness, head length, mean weight of the fillet whether or not skinned, and fillet length showed no significant difference for the collection of January/2014. The total weight observed in November/2013 did not differ statistically from May/2013.

Table 1. Biometric variables (cm), and total weight of serra spanish mackarel (*Scomberomorus brasiliensis*) fillets whether or not skinned (g), from March/2013 to January/2014, Matinhos/PR/Brazil.

Biometric variables*	Month/Year						LSD**
	March/ 2013	May/ 2013	July/ 2013	September/ 2013	November/ 2013	January/ 2013	
Total weight (g)	1111.6 ± 119.5^{c}	1027.3 ± 259.6^{dc}	1900.4 ± 355.5^{a}	1449.5 ± 228.6^{b}	768.1 ± 144.6^{d}	982.4 ± 96.4^{dc}	266.4
Total length (cm)	59.3 ± 2.4^{b}	58.2 ± 5.2^{b}	71.0 ± 3.3^{a}	67.3 ± 3.5^{a}	51.9 ± 3.1^{c}	57.0 ± 1.1^{b}	4.0
Head length (cm)	9.8 ± 0.5^{c}	9.5 ± 0.9^{c}	11.7 ± 0.8^{a}	10.9 ± 0.7^{b}	8.6 ± 0.6^{d}	9.7 ± 0.3^{dc}	0.8
Body thickness (cm)	4.7 ± 0.2^{cb}	4.6 ± 0.5^{cb}	5.8 ± 0.4^{a}	5.1 ± 0.4^{b}	4.2 ± 0.4^{d}	4.4 ± 0.1^{cd}	0.4
Body height (cm)	9.9 ± 0.4^{c}	9.8 ± 0.7^{c}	11.6 ± 0.8^{a}	10.7 ± 0.7^{b}	8.7 ± 0.7^{d}	9.6 ± 0.2^{c}	0.8

**Data represented as mean ± standard deviation; same letters in the same row do not differ statistically by the Tukey's test (p>0.05); ** LSD (Least Significant Difference).*

The average (± standard deviation) results were: total weight of 1206.6 ± 429.3 g; total length of 60.8 ± 7.2 cm; body thickness of 4.8 ± 0.6 cm; body height of 10.0 ± 1.1 cm; head length of 10.0 ± 1.2 cm; skinned fillet weight 838.9 ± 325.2 g; weight of the fillet without skin 740.8 ± 297.7 cm, and fillet length of 38.8 ± 5.4 cm.

Significant differences were observed in the proximate composition, energy value and pH of the serra spanish mackarel fillets during the collection period (Table 2). The proximate composition of the sample expressed on wet basis were (mean ± standard deviation) 75.58 ± 1.23 g/100 g moisture; 1.40 ± 0.18 g/100 g ash; 22.48 ± 1.80 g/100 g protein; 1.76 ± 0.77 g/100 g lipids; energy values of 105.80 ± 5.63 kcal, and pH 6.32 ± 0.14. The moisture content was lower in July/2013, and statistically higher in January/2014. The lowest (19.33 g/100 g) and the highest (24.80 g/ 100 g) protein contents were observed in July/2013 and September/2013, respectively. With respect to the lipids content, the levels found in July/2013 (3.30 g/100 g) were statistically different from the other sampling periods. Thus, the collection in July/2013 exhibited the lowest ash content (1.11 g/100 g), differing from the others. The energy values of March/2013 and January/2014 were statistically lower (100.78 and 98.25 kcal/100 g, respectively) than the others. For pH, the highest values (6.45) were observed in March/2013 to September/2013, with no statistical differences from November/2013 (6.38).

The results of fillet yield and waste were statistically different throughout the collection period (Table 3). The highest yields of the fillets with and without skin (72.5 and 65.5%, respectively) were found in July/2013, and thus smaller carcass (24.7%), and non-edible portions (34.5%) were also observed. The skin percentage obtained in September/2013 (5.3%) did not differ statistically from both the results in July/2013 (5.7%), and November/2013 (5.8%).

Table 2. Proximate composition, energy values (VET) and pH of 100g fillet of fresh serra spanish mackarel (*Scomberomorus brasiliensis*), from March/2013 to January/2014, Matinhos/PR/Brazil.

Month/Year	Variables*					
	Moisture (g/100 g)	Protein (g/100 g)	Fat (g/100 g)	Ash (g/100 g)	Energy (kcal)	pH
March/2013	75.82 ± 0.69^{b}	21.92 ± 0.13^{d}	1.45 ± 0.27^{b}	1.30 ± 0.08^{c}	100.78 ± 2.76^{c}	6.45 ± 0.03^{a}
May/2013	75.79 ± 0.63^{b}	23.84 ± 0.15^{b}	1.42 ± 0.13^{b}	1.56 ± 0.08^{a}	108.13 ± 1.66^{ba}	6.27 ± 0.09^{bc}
July/2013	73.75 ± 0.56^{c}	19.33 ± 0.05^{f}	3.30 ± 0.27^{a}	1.11 ± 0.04^{d}	107.01 ± 2.39^{b}	6.24 ± 0.11^{dc}
September/2013	75.23 ± 1.00^{b}	24.80 ± 0.12^{a}	1.40 ± 0.48^{b}	1.57 ± 0.12^{a}	111.75 ± 4.28^{a}	6.45 ± 0.10^{a}
November/2013	75.80 ± 0.78^{b}	23.36 ± 0.19^{c}	1.72 ± 0.41^{b}	1.47 ± 0.06^{ba}	108.90 ± 4.18^{ba}	6.38 ± 0.03^{ba}
January/2014	77.09 ± 0.77^{a}	21.64 ± 0.18^{e}	1,30 ± 0.30^{b}	1.38 ± 0.03^{bc}	98.25 ± 2.67^{c}	6.14 ± 0.08^{d}
LSD**	1.06	0.21	0.47	0.11	4.47	0.12

** Data represented as mean ± standard deviation; same letters in the same column do not differ statistically by the Tukey's test (p>0.05); ** LSD (Least Significant Difference).*

Table 3. Mean fillet yield and waste of serra spanish mackarel (*Scomberomorus brasiliensis*), from March/2013 to January/2014, Matinhos/PR/Brazil.

Yield variables*	Month/year						LSD***
	March/ 2013	May/ 2013	July/ 2013	September/ 2013	November/ 2013	January/ 2013	
Skinned fillet (g)	372.0 ± 47.4^{c}	366.3 ± 94.1^{c}	688.1 ± 137.0^{a}	506.9 ± 82.4^{b}	257.5 ± 52.6^{d}	326.1 ± 21.5^{dc}	98.8
Skinned fillet (%)	68.0 ± 1.4^{cd}	70.6 ± 0.6^{b}	72.5 ± 1.6^{a}	69.4 ± 1.4^{cb}	66.8 ± 1.6^{d}	66.8 ± 1.8^{d}	1.8
Fillet without skin (g)	329.8 ± 37.5^{c}	312.2 ± 80.3^{dc}	619.9 ± 123.7^{a}	451.1 ± 76.7^{b}	228.4 ± 46.3^{d}	281.1 ± 24.8^{dc}	88.2
Fillet without skin (%)	60.1 ± 1.5^{cbd}	60.8 ± 1.6^{cb}	65.5 ± 1.4^{a}	62.2 ± 1.4^{b}	59.3 ± 1.7^{cd}	58.1 ± 2.7^{d}	2.2
Fillet length (cm)	37.7 ± 2.21^{c}	38.0 ± 3.9^{c}	46.8 ± 2.7^{a}	42.5 ± 3.1^{b}	32.3 ± 1.8^{d}	35.5 ± 1.0^{dc}	3.2
Visceras (%)	4.5 ± 0.6^{b}	4.5 ± 0.4^{b}	4.1 ± 0.5^{b}	4.5 ± 1.3^{b}	6.0 ± 0.8^{a}	5.7 ± 0.9^{a}	0.9
Carcass (%)**	27.3 ± 1.5^{b}	27.5 ± 1.2^{b}	24.7 ± 1.2^{c}	28.0 ± 1.1^{ba}	28.9 ± 1.4^{ba}	29.5 ± 2.3^{a}	1.7
Skin (%)	8.0 ± 1.2^{a}	7.3 ± 1.2^{ba}	5.7 ± 0.7^{dc}	5.3 ± 1.0^{d}	5.8 ± 0.6^{dc}	6.7 ± 0.8^{bc}	1.1
Non edible portion (%)	39.9 ± 1.5^{bac}	39.2 ± 1.6^{bc}	34.5 ± 1.4^{d}	37.8 ± 1.4^{c}	40.7 ± 1.7^{ba}	41.9 ± 2.7^{a}	2.2

** Data represented as mean ± standard deviation; same letters in the same row do not differ statistically by the Tukey's test (p>0.05); ** = carcass skeleton with attached flesh, head, and fins; ***LSD (Least Significant Difference).*

Figures 2, 3, 4 and 5 show the regression analysis of the variables. A linear increase in body height, fillet weight, fillet length and yield was observed and the coefficients of determination (R^2) indicate a high adjustment level of the regression equations.

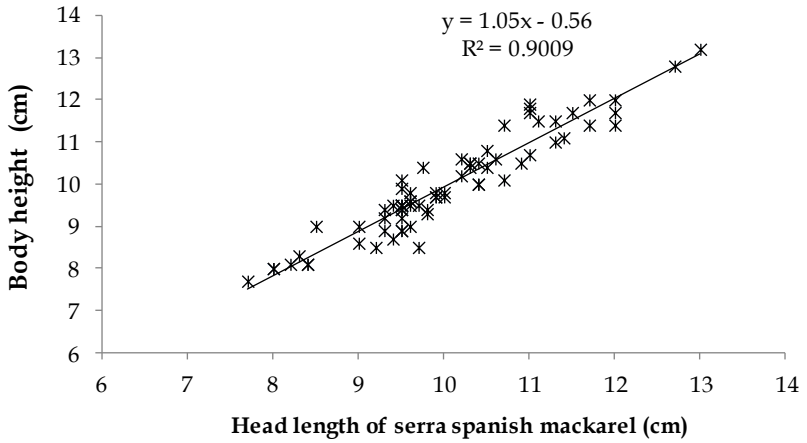

Figure 2. Body height as a function of head length of serra spanish mackarel (*Scomberomorus brasiliensis*), Matinhos/PR/Brazil.

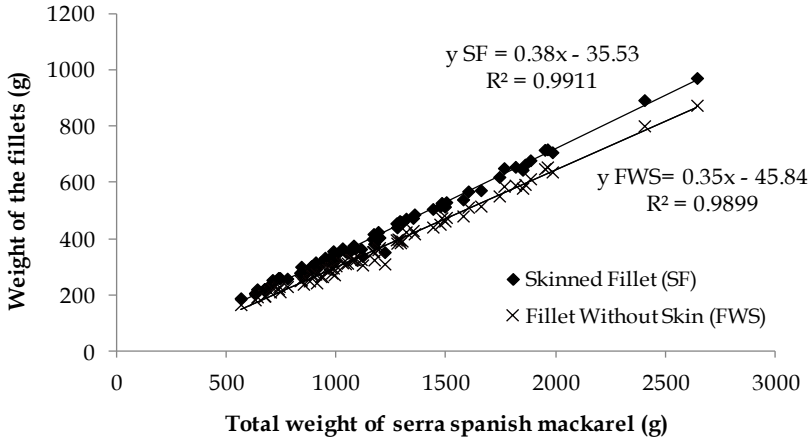

Figure 3. Weight of the fillets whether or not skinned as a function of the total weight of serra spanish mackarel (*Scomberomorus brasiliensis*), Matinhos/PR/Brazil

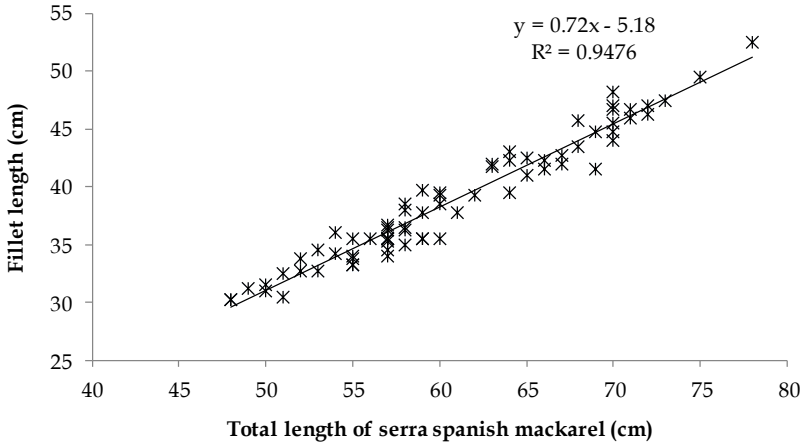

Figure 4. Fillet length as a function of the total length of the serra spanish mackarel (*Scomberomorus brasiliensis*), Matinhos/PR/Brazil

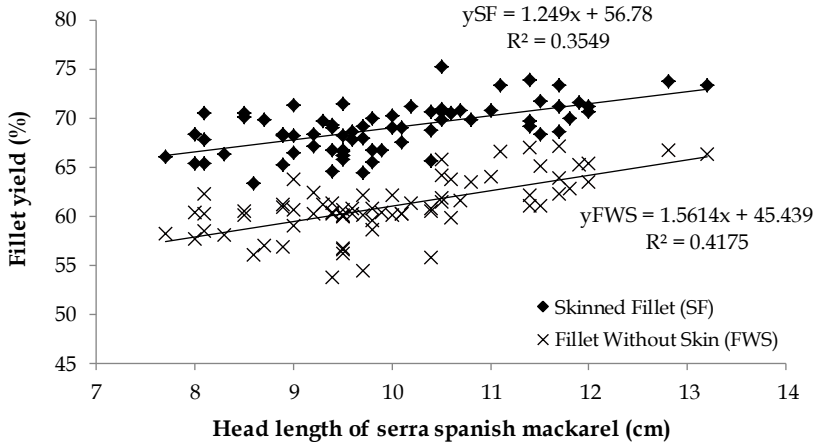

Figure 5. Fillet yield as a function of head length of serra spanish mackarel (*Scomberomorus brasiliensis*), Matinhos/PR/Brazil.

DISCUSSION

Studies on the chemical composition have discussed concentrations of mercury (COSTA and LACERDA, 2009), heavy metals (SINGH *et al*., 1991), and freshness indicators (BALLADIN *et al*., 1998).

The biometric data are in agreement with the literature, since the fish can grow up to 125 cm and weigh 6800 g (SZPILMAN, 2000). LIMA *et al*. (2007), with total length ranging from 13.5 to 80.5 cm in serra spanish mackarel females and from 14.0 to 59.8 cm in males and SINGH *et al*. (1991) found mean total length of 57.1 cm. For the rational extraction, it is necessary that individuals caught with gill nets have fork length greater than 42 cm (NÓBREGA and LESSA, 2009).

With respect to fish weight (FONTELES-FILHO, 1988) found that the mean weight of serra spanish mackarel in the period from 1963 to 1986, in the State of Ceará/Brazil was 1208 g, and LIMA *et al*. (2007) found an average weight of 1700 g in the coast of Ponta Negra beach in Natal/RN/Brazil, which is consistent with the values found in this study.

Thus, the differences in the biometric variables and weight may be due to the type of fishing and equipment used. The wide variation in the mesh sizes provided fish of different weights and size; hence fish have different head length, thickness and height of the body.

Another factor that may have contributed to these results is the period of capture. Statistical data of the Fisheries Institute of the State of São Paulo have shown that the period of greatest production is from May to August (INSTITUTO DE PESCA, 2012). As there is wide fish availability, larger and heavier fish may have been caught. In the month of November/2013, smaller biometric values were observed, probably due to climatic conditions, once in this period there was the occurrence of rains accompanied by strong winds and heavy seas, hindering driftnet fishing by artisanal fisherman.

The proximate composition of fish is influenced by several factors including the species, age, environment, type of food, time of capture (climate, season), weight, abundance, among others (ANDRADE *et al.* (2009); MACEDO-VIEGAS *et al*., 2000).

The different chemical composition between serra spanish mackarel and other Scombridae species can be observed with the Atlantic mackerel (*Scomber scombrus*), which has 61.99 g/100 g to 71.59 g/100 g moisture; 8.14 g/100 g to 18.55 g/100 g lipids; 1.27 g/100 g to 2.03 g/100 g ash, and 16.80 g/100 g to 19.07 g/100 g protein (SIGFUSSON *et al*., 2001). BEAULIEU *et al*. (2009) studied this species and found approximately 84 g/100 g moisture content, 6.8 g/100 g protein, 3.1 g/100 g lipids, and 0.2 g/100 g ash. For spanish mackerel (*Scomberomorus commersoni*), moisture values from 73.32 to 75.05 g/100 g, and lipids from 3.89 to 6.35 g/100 g were observed (NAZEMROAYA *et al*., 2009, 2011). FERNANDES *et al*. (2014) studied the nutritional and lipid

profiles in marine fish species from Brazil, and noted that king mackerel (*Scomberomorus cavalla*) presented moisture, protein, total lipids, ash, and total energy value of 76.37 g/100 g; 19.87 g/ 100 g; 1.96 g/100 g; 1.14 g/100 g; and 99.74 kcal, respectively.

With respect to the intrinsic factors, fish composition is influenced by genetic, morphological (size and shape), and physiological factors (migration and gonadal development) (MACEDO-VIEGAS *et al.*, 2000).

Serra spanish mackarel presents breeding conditions throughout the year, and has a more intense spawning season from September to March (NÓBREGA and LESSA, 2009), with peak spawning in December (LIMA *et al.*, 2007). Changes in the chemical composition occur during fish breeding period, since a decrease in protein content is observed during the gonadal development as the spawning approaches, due to greater deposition of fat into the gonads and viscera for future mobilization for the reproduction (SOUZA, 2001). The variation in feeding activity suggests that serra spanish mackarel females have more favorable food supply in the months before and after the breeding season (March to June), while for serra spanish mackarel males this period is in September, December, and April (SILVA *et al.*, 2005).

According to the lipid content, fish can be classified as thin (< 2 g/100 g fat); low fat (2-4 g/ 100 g fat); medium fat (4-8 g/100 g fat); and high fat (> 8 g/100 g fat) (MORADI *et al.*, 2011). Thus, the samples collected in March/2013, May/2013, September/2013, November/2013, and January/2014 can be considered as lean fish, while the sample from July/2013 exhibited low fat content.

Higher lipid contents in serra spanish mackarel (6.62 ± 1.05 g/100 g) were reported by BALLADIN *et al.* (1998). According to NAZEMROAYA *et al.* (2011), lipid levels vary with sex, diet, seasonality, and tissue. MENEZES *et al.* (2009) reported that fish from tropical waters have lower lipids levels when compared to fish from cold regions.

The pH of all samples are in accordance with the Brazilian legislation that establishes the pH of the outer flesh and inner flesh should be lower than 6.8 and 6.5, respectively (BRASIL, 1962). As reported by OETTERER (2002), the decrease in muscle pH to 6.0 to 6.5 is due to the various biochemical changes occurring after *rigor mortis*. Thus, the pH of the muscle can be influenced by fish species, methods of capture, handling, and storage period (RODRIGUES *et al.*, 2012).

The fillet yield is related to several factors including the efficiency of filleting machines, manual dexterity of the workman, method used, or fish characteristics, i.e., the anatomical body shape, head size and weight of the waste including viscera, skin and fins. It can vary between species and within species, also according to weight on slaughter, sex, size, or age (BASSO and FERREIRA, 2011; MACHADO and FORESTI, 2009; SOUZA *et al.*, 1999). The fillet yield of serra spanish mackarel is in agreement with the data reported by QUADROS and BOLINI (2012).

In the present study, higher fillet yield and lower visceral percentages were observed when compared to other species. ADAMES *et al.* (2014) studied the body morphometric characteristics and cuts yielding of barbados (*Pinirampus pirinampu*), and found fillet yields ranging from 38.33 to 42.27% and visceral percentage from 8.67 to 10. 04%. For jaraqui (*Semaprochilodus* spp.) with coarse scale and fine scale, the skinned fillet yield ranged from 30.96 to 32.29%, and fillet yield with skin ranged from 40.29 to 41.20%, respectively, and waste yield from 67.62% to 69.15% of body weight for jaraqui of coarse scale and fine scale, respectively (COSTA *et al.*, 2014). CORRÊA *et al.* (2013) compared the fillet yield of river and sea fat snook (*Centropomus parallelus*), and found a yield of 43.88 ± 2.47%; and BASSO and FERREIRA (2011) studied the processing yield of pacu (*Piaractus mesopotamicus*) as a function of the weight at slaughter, and found fillet yield ranging from 28.50 to 32.65% and visceral percentage from 12.70 to 15.45%; MACEDO-VIEGAS *et al.* (2000), evaluated the processing yield and body composition of matrinxã (*Brycon cephalus*) in three weight classes, and observed that the skinned fillet yield ranged from 38.57 to 39.99% and visceral percentage from 8.38 to 9.48%; surubim (*Pseudoplatystoma corruscans*) raised in different aquaculture systems exhibited fillet yield from 33.19 to 36.34%, visceral percentage from 6.31 to 7.33%, and skin from 2.10 to 6.84% (FRASCÁ-

SCORVO *et al*., 2008). The fillet yield of armado (*Pterodoras granulosus*) ranged from 28.48 to 26.90% and the visceral percentage from 16.12 to 17.74% (BOMBARDELLI and SANCHES, 2008).

The results of the present study are in accordance with KUBITZA and CAMPOS (2006), who reported that in general, fish waste can vary as follows: viscera, 8 to 16%; clean skin, 2 to 6%; head, 12 to 25%; skeleton with attached flesh, 30 to 35%.

The results of the linear regression are in agreement with those found by BASTOS (1966), who reported that several measurements were dependent on the fork length of serra spanish mackarel. According to ADAMES *et al*. (2014), fish with lower body height exhibited smaller fillet width and lower carcass yield. The authors have also reported that the morphometric relationships body length and head height are quite important, once they relate the head size to a little utilization. As the head is not used in edible form, high ratios can lead to lower meat yield.

The correlation between body weight/length and fillet weight is generally high, and fish with small head relative to the body present higher fillet yield, when compared to fish with large head (COSTA *et al*., 2014; FRASCÁ-SCORVO *et al*., 2008). Furthermore, the shape of species influences the fillet length and is important in view of its potential for industrialization (SOUZA, 2001).

CONCLUSIONS

Studies on biometric characteristics, composition, and fillet yield of serra spanish mackarel throughout the year are important to understand the behavior of this species in the natural environment, particularly in the city of Matinhos/PR/Brazil.

It was observed that the time of year influenced the biometric data and hence the chemical composition and fillet yield. Fish composition is influenced by genetic, morphological (size and shape), and physiological factors. The collection of July stood out over the others, with higher biometric values, lipids content, and yield of the fillets whether or not skinned. Consequently, lower moisture content, protein, and non-edible portions were observed in this month.

Therefore, it can be concluded that serra spanish mackarel can be found throughout the year in the city of Matinhos, and is considered a lean fish with high protein content and high fillet yield, regardless of the time of capture. These data are important as they allow characterizing the final product, evidencing that serra spanish mackarel has great potential for industrialization and may be a source of income for small scale fishing.

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