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Chemical, technological and nutritional quality of sausage processed with surimi

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Abstract

Surimi was obtained by washing of mechanical separated meat (MSM) of Argentine anchovy and it was used to produce sausages. Chemical, technological and nutritional quality of product was evaluated. Surimi obtained with sodium bicarbonate (SB) solution showed a lighter color, but the gel strength was higher in the surimi obtained with phosphoric acid (PA) solution. Significant difference between the surimi sausages and the commercial ones in the color and firmness parameters was observed. The sausage produced with surimi PA presented high protein and low fat content comparing with commercial sausage. Furthermore, it presented 5% and 14% of reduction in total energy value and sodium content, respectively, compared to commercial sausage.

Introduction

Sausage is a product widely consumed worldwide and contains basically meat and fat (solid phase) dispersed into ice/water (liquid phase) forming a stable mass that will be submitted to a moderate heat treatment (Mercadante *et al.*, 2009). The addition of fish meat in sausage formulation could improve nutritional quality of the product and can be a way to insert fish meat in human diet. According to FAO (2012) the world consumption per capita of fish was 18.4 kg / year in 2009.

There is a perspective that fish consumption will increase, considering that the supply of products derived from fish and the diversification of products may contribute to the increase of consumption of these foods. Fish sausages can be made from surimi or fish meat produced from different species, adding flavorings and preservatives (Al-Bulushi *et al*., 2013). Products obtained with minced fish and surimi contains important proteins and with a mild fish flavor. Yousefi and Moosavi-Nasab (2014) studied the textural and chemical attributes of minced fish sausages produced from Talang Queenfish *(Scomberoides commersonnianuus)* minced and surimi.

Argentine anchovy *(Engraulis anchoita)* is an important specie in the southwest Atlantic Ocean pelagic ecosystem, and a potentially important fishery resource, characterized as a small pelagic fish found from Vitoria (Brazil) to Gulf San Jorge (Argentina) (Carvalho and Castello, 2013). Among the stocks promising, predictive models of Argentine anchovy estimated a potential capture of 1 million tons per year in the waters of northern Argentina, Uruguay and southern Brazil (Madureira *et al*., 2009).

Mechanically separated meat (MSM) can be used as raw material for a variety of products (Ozkececi *et al*., 2008). Some problems presented by the MSM are low shelf life, high susceptibility to oxidation, dark color and reduced functional properties according to the rigorous process applied in raw material (Souza *et al*., 2009). Undesirable components such as blood, fat, pigment and sarcoplasmic proteins are removed through the washing step (Piyadhammaviboon and Yongsawatdigul, 2010), improving the formation of surimi gel during the cooking process (Han *et al*., 2009).

Previous studies (Gonçalves and Passos, 2003; Ismail *et al*., 2010) reported that water solutions such as sodium chloride, sodium bicarbonate and sodium phosphate buffer are used during washing in surimi elaboration. However, each of these solutions affects product properties such as coloration due to removal of pigments, and the increase in water holding capacity. Clarifying compounds are suggested for some studies, such as phosphoric acid, calcium carbonate, sodium bicarbonate or sodium chloride in order to improve the appearance of surimi. The

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objective of this study was to evaluate the physical, chemical and nutritional properties of sausages produced with Argentine anchovy surimi.

Material and Methods

Material

Argentine anchovy was captured on the South coast of Brazil, removing the head and viscera, washed with sodium chloride 0.3% and deboned in mechanical separated meat (HIGH TECH HT/2500 - Brazil) obtaining the MSM of Argentine anchovy, frozen at -20°C until use.

Ingredients like sausage mix, stabilizer, flavor enhancer, colorant carmine, curing salt, smoke flavoring and antioxidant used in the sausages were donated by the company Duas Rodas Industrial Ltda (Santa Catarina, Brazil). Other ingredients such as salt, garlic powder, soy protein isolate and oil were purchased from local market.

Surimi process

MSM of Argentine anchovy was washed with different solutions in ratio 1:3 (MSM:solution, w/v), following the method described by Ramadhan *et al.* (2014) with adaptations. Two washing procedures were tested, each at three stages: SB treatment (two washes with 0.5% sodium bicarbonate solution and one wash with 0.3% sodium chloride) and PA treatment (one wash with water, one with 0.05% phosphoric acid and one with 0.3% sodium chloride). The MSM was homogenate with solutions at a temperature of 6 ± 1°C for 3 minutes under manual stirring. After each wash the mixture was subjected to the removal of the liquid in a hydro extractor (ANKO FOOD MACHINE YL/15 - Taiwan). Cryoprotectants like sorbitol (3%) and sodium tripolyphosphate (0.25%), related to the washed mass were added. The surimi were packed and frozen at -20°C until use.

Sausage process

Surimi sausage was produced with both surimi treatments (sodium bicarbonate – SB; and phosphoric acid - PA). Soybean protein (4.0%), sunflower oil (12.0%) and water (9.0%) were manually mixed to obtain an emulsion (Furtado *et al.*, 2005), followed by addition of the other ingredients, presented in Table 1.

Surimi and emulsion were mixed in a cutter (METAVISA CUT- 3, Brazil) for one minute. Dry ingredients were added in the mass, and finally the antioxidant and smoke flavoring. The processed paste was stuffed into a cellulose casing previously hydrated in cold distilled water (<10°C). The sausage size was standardized at 10 cm in length, and cooked using the same conditions described by Guerrero (2006). Thus, dry heat was applied in an oven with air circulation (QUIMIS 314-D, Brazil) for 20 minutes at 50°C, and then submitted to cooking in thermostatic bath (QUIMIS Q -215 -1/ 2 - Brazil) at 70°C for 30 minutes and finally increased to 80°C for 30 minutes. The sausages were cooled in ice water (5±1°C) for 20 minutes. The sausages were kept chilled in refrigerator for 18 hours and have been analyzed comparing with a commercial sausage purchased from a local market.

Table 1. Ingredients used to produce surimi sausages

Ingredients	Quantity (%)
Argentine anchovy surimi	75.0
Emulsion	20.0
Starch	2.0
Salt	1.0
Mix for sausage*	0.7
Stabilizer*	0.5
Flavor enhancer *	0.3
Garlic powder	0.3
Carmine colorant *	0.1
Curing salt *	0.045
Smoke flavoring *	0.007
Antioxidant*	0.0005

*Duas Rodas LTDA ingredients

Physical and chemical characterization

Quality of MSM

The freshness of the MSM of Argentine anchovy was determined by pH analysis, and nitrogen total volatile bases (N-TVB), using methods described by AOAC (2000).

Proximal composition

Chemical analysis of MSM, surimi and sausage were performed. Moisture, protein, lipid and ash content were determined according to AOAC (2000), and carbohydrates were calculated by difference from the other components.

Color

Color of the MSM, surimi and sausages was analyzed with a colorimeter (CHROMA METER KONICA MINOLTA CR-400/410 - Japan) using parameters like luminosity *(L^*)* and chromaticity (a^* and b^*). Whiteness (W) was evaluated in the surimi following Equation (1), according to Kristinsson *et al*. (2005).

$$W = 100 - [(100 - L^*)^2 + (a^*)^2 + (b^*)^2]^{\frac{1}{2}} \quad (1)$$

Texture

Penetration analysis of surimi gel and texture of the sausages was carried out with texture analyzer Stable Micro System (TA.XT.plus, United Kingdom). The gel was produced adding 1% (w/w) salt and 4% starch, relating to the surimi weight. After mixing, surimi were embedded around cellulose wrapping (2 cm diameter) and cooked in a water bath at 90 °C for 15 minutes, being cooled and stored under refrigeration for analysis on the next day. The gel strength (g.mm) was performed with a spherical probe of 5 mm P/5S (test speed 1.1 mm/s, force of 10 g and a distance of 15 mm of the sample), according to Yamazawa (1990). The firmness of the sausage (kg) was observed by the force of cross section. The texture analyzer was fitted with HDP/BS Warner-Bratzler blade (pre-test and posttest speeds of 2 mm/s and 10 mm/s, respectively) according to methodology used for texture of hot dogs presented in the program Exponent Stable Micro System Ltd 2003.

Nutritional characteristic of the sausage

Nutritional characteristic such as sodium content and total energy value of the sausage were verified in this work.

Sodium content

The amount of sodium was assessed by analysis of chloride, according to Zenebon and Pascuet (2005) and it was expressed as mg sodium/100 g of sausage.

Energy value

Food energy usually is calculated applying a set of energy conversion factors of energy-providing nutrients: protein, carbohydrate and fat (Charrondiere *et al*., 2004). The energy value (EV) of the sausage was obtained according to ANVISA (Agência Nacional de Vigilância Sanitária) (Brasil, 2003) taking into account the values of lipids (%L), proteins (%P) and carbohydrates (%C) obtained by proximal composition, following Equation (2) expressed in kcal/100 g of sausage.

$$EV = (\%L \times 9) + (\%P \times 4) + (\%C \times 4) \qquad (2)$$

Statistical analysis

The data were submitted to variance analysis and comparison of the mean was done by Tukey test ($p<0.05$) using the Statistica 7.0 software.

Results and Discussion

Freshness of MSM of Argentine anchovy

The TVB-N value obtained for the MSM was 4.8 ± 0.9 mg N/100g and pH value was 6.6 ± 0.1. Freshness condition was observed in the raw material, considering the limit established by Germany, Argentina and Australia (Beraquet and Lindo, 1985), should be 30 mg N-TVB /100g. According to Ogawa and Maia (1999), the TVB-N content in fresh fish ranges from 5 to 10 mg N-TVB/100 g of fish.

Another parameter that indicate the quality of food is the pH, and it is affected by reactions occurring in dead animal indicating the microorganism presence through its accumulated metabolic alkaline material, raising the pH value and decreasing the product quality (Martin, 1982). The natural pH of fish muscle is above 7.0 value, but after rigor mortis the pH decreases to 6.0 - 6.8 value due to conversion of glycogen to lactic acid (Rehbein and Oehlenschläger, 2009). Furlan *et al.* (2009) studying the Argentine anchovy muscle obtained a pH value of 6.8, similar to this study.

Table 2. Proximal composition of MSM and surimi of Argentine anchovy obtained by different washes

	g/100 g sample		
	MSM	Surimi SB	Surimi PA
Moisture	81.3±0.1 ^{c}	86.2±0.01 ^{a}	81.9±0.3 ^{b}
Protein*	89.2±3.1 ^{a}	57.1±2.3 ^{b}	63.6±4.7 ^{b}
Fat*	3.1±0.2 ^{a}	0.6±0.1 ^{b}	0.9±0.1 ^{b}
Ash*	7.1±0.3 ^{a}	7.4±0.5 ^{a}	4.0±0.3 ^{b}

* Values on a dry basis. MSM: mechanically separated meat. Surimi SB: surimi obtained by two washes of MSM with sodium bicarbonate 0.5% and one wash with sodium chloride 0.3%; Surimi PA: surimi obtained by MSM washing with water, phosphoric acid 0.05% and sodium chloride 0.3%. Values are mean ± standard deviation. Different letters in the same line indicate significant differences between the samples, with $p <0.05$.

Chemical composition of the MSM, surimi and sausage

Table 2 shows the proximate composition of MSM and surimi of Argentine anchovy. Significantly higher moisture content was observed in surimi compared to the MSM due to washing process, which can be explained by Ismail *et al.* (2010) that related the moisture increase with decreasing amount of protein and lipids in the product . The chemical composition is important for surimi quality. Parvathy and George (2014) also obtained a higher value of surimi moisture compared with the raw material, which was 79.9% to 83.2%, and consequently decrease of the other components (protein, fat and ash). Luo *et al.* (2004) reported that the protein concentration greatly affected the gel properties of Alaska pollack and common carp surimi. Related to

Table 3. Proximal composition of Argentine anchovy and commercial sausages

Components (%)	SSB	SPA	CS
Moisture	70.9±0.2 [a]	63.6 ± 0.1 [c]	64.8 ± 0.2 [b]
Protein	11.2±0.3 [c]	15.5 ± 0.4 [a]	13.0 ± 0.7 [b]
Ash	6.9±0.5 [a]	3.6 ± 0.1 [b]	3.8 ± 0.2 [b]
Fat	10.3±1.3 [c]	12.5 ± 0.6 [b]	15.6 ± 0.4 [a]

SSB: sausage produced with surimi SB; SPA: sausage produced with surimi PA; CS: commercial sausage. Values related to the mean ± standard deviation. Different letters within the same row indicate significant difference between samples ($p < 0.05$)

lipid reduction in surimi, a positive effect on surimi quality is obtained, because the oxidized lipids could interact with proteins causing denaturation, polymerization and changes in functional properties (Jin *et al*., 2007).

Sarcoplasmic proteins are extracted with the washing steps, which would prevent the formation of surimi gel during cooking (Park and Lin 2004). Surimi obtained by washing with a solution of sodium bicarbonate (SB) had lower protein content compared with that obtained with phosphoric acid (PA). This may be due to higher solubilization and loss of MSM proteins at alkaline pH.

Table 3 shows the proximate composition of the sausages produced with Argentine anchovy surimi, and the commercial sausage. Significant difference for moisture and protein values between the sausages was observed. The product obtained with surimi BS (washed with sodium bicarbonate) presented high moisture, explained for the high moisture of the surimi (Table 2). Jin *et al.* (2007) developed sausage including meat from spent laying hen surimi that presented moisture ranged from 60 to 63.5% and protein from 13.5 to 15.5%. Gonçalves *et al.* (2009) obtained sausage with piramutaba surimi adding shrimp flavor or shrimp meat with similar moisture and protein values, ranging to 63.4-70.7% and 12.6-13.8%, respectively.

Furtado *et al*. (2005) produced sausages with frog meat, which also used an emulsion of soy protein isolate, water and vegetable oil, obtaining 14.0% of fat. The smallest value of sausage produced with Argentine anchovy surimi was due the amount of lipids reduced in surimi, which were removed in the washing process. Ferreira *et al.,* (2003) replaced lard by sunflower oil to produce Vienna sausages and obtained a product with higher levels of fat, ranging from 24.30 to 31.63 %. Huda *et al.* (2012) with sausages added of fish surimi showed similar moisture and lower amounts of protein and lipids. In general, the research showed that different raw materials and formulations of the sausages presented moisture and fat content variations.

MSM, surimi and sausage colors

Table 3 shows color parameters of MSM, surimi and sausage, such as luminosity L^*, which ranges from 0 (black) to 100 (white), and chromaticity a^*, from -60 (green) to +60 (red), and b^*, from -60 (blue) to +60 (yellow), and whiteness (W) of surimi. The Argentine anchovy meat was dark and had shades of red and yellow, verified by the values of L^*, a^* and b^*. The minced washed with sodium bicarbonate 0.5% and sodium chloride 0.3% (BS) was significantly lighter than MSM and surimi (PA) obtained by washing with water, 0.05% phosphoric acid and 0.3% sodium chloride ($p < 0.05$).

Washing process has been considered important for some authors to reduce some water-soluble components (heme pigments), improving the texture quality (Tenuta and Jesus, 2003). Jafarpour and Gocczyca (2008), working with surimi from Cyprinus carpio achieved luminosity values in the range of 40-60, close to that presented by the Argentine anchovy surimi. Chen *et al.* (1997) with seahorse minced washed for 15 minutes with sodium bicarbonate 0.5%, presented a value below 40. Values close to 50 with the same washing solution were obtained by these researchers after 90 minutes of washing.

Chromaticity parameters evidenced a significant difference between the samples. Chroma a^* presenting negative values for minced washed with sodium bicarbonate showing a greenish tone, agreeing with Chen *et al.* (1997) that used sodium bicarbonate 0.5% solution in seahorse meat. Chroma b^* of Argentine anchovy surimi showed positive values verifying that the samples had a yellowish tone.

Whiteness is an important factor for choosing surimi because of the industries preferences for white fish meat (Navarro, 2007). However, when dark meat fish are used such as Argentine anchovy, washing methods with chemical solutions are effective for the clarification of MSM, as was observed in surimi (SB) washed with 0.5 % sodium bicarbonate and sodium chloride 0.3 %. Jafarpour and Gocczyca (2008) obtained whiteness value between 40 and 70, similar to this study, as well as Panpipat *et al.* (2010) with surimi from Croaker mackerel with results in the range of 50-58.

According to Hultin and Kelleher (2000), adding alkalis solutions improves the product quality compared to surimi washed only with water. Furthermore, sodium chloride solutions and different concentrations of sodium bicarbonate could also

Table 4. Color parameters of MSM, surimi and sausages of Argentine anchovy and commercial sausage

		L*	a*	b*	W
Raw material	MSM	44.25 ±1.06 c	3.30 ±0.23 a	8.64 ±0.39 a	43.49 ±1.10 c
	Surimi SB	50.43 ±1.87 a	-1.08 ±0.06 c	4.23 ±0.60 c	50.23 ±1.82 a
	Surimi PA	46.43 ±0.36 b	0.98 ±0.12 b	6.72 ±0.21 b	46.00 ±0.33 b
Product	SSB	70.17 ± 0.20 a	6.93 ± 0.07 b	8.52 ± 0.15 c	-
	SPA	65.64 ± 0.10 b	4.63 ± 0.10 c	11.46 ± 0.37 b	-
	CS	61.03 ± 0.97 c	21.75 ± 0.32 a	12.91 ± 0.15 a	-

MSM: mechanically separated meat. Surimi SB: surimi obtained by two washes of MSM with sodium bicarbonate 0.5% and one wash with sodium chloride 0.3%; Surimi PA: surimi obtained by MSM washing with water, phosphoric acid 0.05% and sodium chloride 0.3%. SSB: sausage produced with surimi SB; SPA: sausage produced with surimi PA; CS: commercial sausage. Values are mean ± standard deviation. Different letters in the same column indicate significant differences between each separated samples (raw materials and product), with p <0.05.

be used. The color characteristics (luminosity L^*, chromaticity a^* and b^*) of sausages produced with surimi, and the commercial sausage presented significant difference in all colors parameters ($p < 0.05$). The luminosity of SSB sausage was higher compared with SPA sausage, and both compared with commercial sausage (CS). Sausages produced in this work contain emulsion (water, sunflower oil and protein isolated), which mixed with surimi conferred a lighter color. Furthermore, the absence of blood pigments in surimi due to extraction in the washing process prevented the formation of reddish color as occurs in the commercial sausage (CS). This can be verified by chroma a^* of the commercial sausage, which was 21.75 ± 0.32, higher than the sausages with Argentine anchovy surimi.

Oliveira-Filho *et al.* (2010) produced sausages with Nile tilapia minced and fillet obtained the luminosity values ranged to 65-68, chroma a^* to 2.3-2.9, and chroma b^* to 12-17, color parameters similar to this study. Al-Bulushi *et al.* (2013), with *Argyrosomus heinii* sausages had a lower chroma a^* (2.4 ± 0.02) and luminosity (60.9 ± 0.42). Thus, it can be considered that sausage produced with fish presents itself a lighter color compared to the same product made with other meat species.

Texture of surimi gel and sausage

The gel strength of the surimi and firmness of sausage are presented in Figure 1. The gel strength (Figure 1.A) was significantly higher in surimi PA (1154.25 ± 4.37 g.mm), obtained from washing of MSM with water, phosphoric acid 0.05% and sodium chloride 0.3%. Moisture of the surimi can influence the gel strength, since the surimi PA has lower moisture than the surimi SB (Table 2), that presented a low gel strength value.

Jafarpour and Gorczyca (2008) produced Cyprinus carpio surimi by the conventional method, obtaining 1,073.56 g.mm of gel strength, a lower value than that obtained with surimi PA. But a surimi

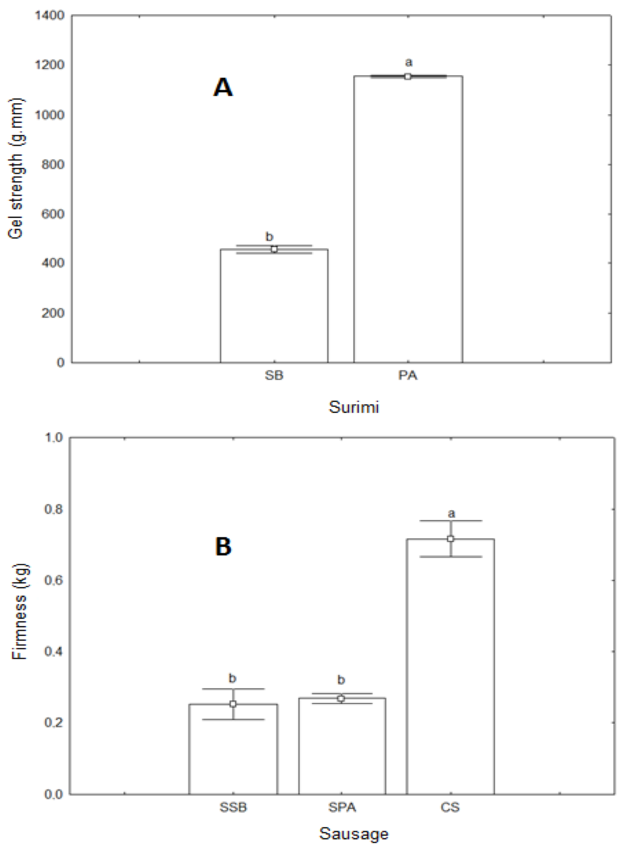

Figure 1. Surimi gel strength (A) and firmness of sausages produced with Argentine anchovy surimi and of commercial sausage (B).
SB: surimi obtained by two washes of MSM of Argentine anchovy with sodium bicarbonate 0.5% and one wash with sodium chloride 0.3%; PA: surimi obtained by MSM of Argentine anchovy washing with water, phosphoric acid 0.05% and sodium chloride 0.3%. SSB: sausage produced with surimi SB; SPA: sausage produced with surimi PA; CS: commercial sausage. Values related to the mean ± standard deviation. Different letters indicate significant difference between samples (p< 0.05).

studied by Dondero *et al.* (2002), produced with the *Trachurus murphyi* species with moisture of 76 %, obtained values between 5,000 and 10,000 g.mm. These values are higher than those obtained in this study, demonstrating that the water contents and the species used ,can influence the surimi gel strength.

Rupsankar (2010) reported that moisture reduction in the surimi improved the gel formation capacity. A certain amount of water is required for adequate protein solubilization and the formation of the gel network, which should be above 74%, considering the critical moisture value (Lanier and Lee, 2000). Though, Ogawa and Maia (1999) reported that moisture value below 80 % are decisive for a good quality of gel formation, with proper restructuring of the fibers, improving the texture in the final product. Uddin *et al*. (2006) suggested that the standard water content of surimi should be 78%. Thus, the gel strength has been influenced by the moisture of surimi when the values were above 80%.

The surimi was applied in sausage formulation, evaluating some aspects compared to the commercial sausage, considering the chemical, physical and nutritional properties of products. The firmness values of the commercial sausage (Figure 1.B) showed higher firmness (0.72 kg) compared to Argentine anchovy surimi sausages (SSB = 0.25 kg, SPA = 0.27 kg), that presented no significant difference between each other ($p < 0.05$). This difference may be due to the type of raw material used to make the sausages and its properties such as water holding capacity, because the higher quantity of retained water the lower hardness of the sausage. Furthermore, the amount of starch used in the formulation may have a positive influence on the texture of the product, because the more starch in product the higher the hardness values (Huda *et al.,* 2012).

Huda *et al.* (2012) evaluated the characteristics of different fish sausages, where one of the formulations possessed fish filet, surimi, vegetable oil and soy protein, getting a value of 0.54 kg of firmness. The lack of data on the type of ingredients and their amounts added in the formulation makes it impossible to explain the difference in results, but this type of product with fish can be regarded with lower firmness compared with commercial sausages. The sausage obtained with surimi PA presented some technological characteristics similar to commercial sausage and nutritional characteristic like energy value and sodium content were analyzed.

Nutritional value of sausages

Energy requirements are based on the concept of metabolizable food energy, considering the energy available to the human body for maintenance, physical activity, pregnancy, lactation and growth (WHO, 1985). Metabolizable food energy values are based on energy conversion factors, either the general Atwater factors (Charrondiere *et al.*, 2004). The Argentine anchovy surimi sausage presented 193.7 kcal/100 g, being lower than the commercial sausage (203.6 kcal/100 g). Furtado *et al.* (2005) with frog sausages presented 180 Kcal/100 g, considering the fat content of sausages as an influential factor for the difference in results.

Surimi sausage presented 520 mg/100 g sodium value. Following the label of the commercial product, the amount of sodium was 604 mg/100 g, greater than surimi sausage. Foods sodium content is very important, and the excess can cause future problems of hypertension, when combined with other factors such as sedentary lifestyle, stress, smoking and alcohol (Molina *et al*., 2003).

Sausage is a low cost product consumed in worldwide, and in this study show that replace other species of meat for fish surimi gives difference regarding the technological characteristics, but would be admissible since it has lower energy and sodium content compared to the commercial sausage. Following European Commission (2014) in regulation (EC) N° 1924/2006 products considered “high protein” may only be made where at least 20 % of the energy value of the food is provided by protein. The surimi sausages presented more than 30 % of the energy provided by protein, and can be considered a high protein food. Furthermore, it is important to note that the quantity of fat in surimi sausage was significantly lower than the fat content of the commercial one.

Conclusion

Positive effects of the washing of the MSM Argentine anchovy were verified on technological characteristics of surimi, such as higher brightness and whiteness of SB surimi and higher value of gel strength in PA surimi, therefore they were included in sausage formulation. Color characteristics was influenced for the type of surimi added in the sausage, but not in texture, except when compared with the commercial sausage. Sausage SPA showed some close features to the commercial sausage, and was considered healthier due to the lower sodium content and lower energy value, considering the high protein value and reduced fat content.

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