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Utilization of the jellyfish occuring in the bycatch for human consumption in the south of Brazil

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Abstract. With the increase in reports of the occurrence of jellyfish and the recent discoveries about their potential use in the areas of healthcare, biotechnology, and nutrition, this work tested a salt processing protocol for jellyfish caught off the Santa Catarina coast, in the south of Brazil, in an attempt to produce a unique product with nutritional value. The jellyfish were captured in bottom trawling artisanal shrimp fishing nets, and a mixed salt process was applied using a mixture of salts in six stages of dehydration. The most frequently occurring and potentially useful species for human consumption in the bycatch were *Rhacostoma atlanticum*, *Chiropsalmus quadrumanus*, and *Lychnorhiza lucerna*. The mean percentage yield values (salted weight/wet weight) of 10.6% for *C. quadrumanus*, 6.6% for *L. lucerna*, and 1.7% for *R. atlanticum*. The results of microbiological tests on the salted material were negative and the percentage of weight gain following rehydration was greater than 95% in all cases. The salting process for the three species was adapted to be started on board and completed in 21 days on land, generating a final product with color and odor characteristics that meet the standards found in the market.

Key words: jellyfish, food, salting, bromatology

Resumo: Utilização de medusas ocorrentes na pesca acidental para consumo humano no sul do Brasil. Com o aumento dos relatos da ocorrência de águas-vivas e as recentes descobertas sobre seu potencial de uso nas áreas de saúde, biotecnologia e nutrição, este trabalho testou um protocolo de processamento de salga para águas-vivas capturadas no litoral catarinense, sul do Brasil, na tentativa de produzir um produto único com valor nutricional. As águas-vivas foram capturadas em redes de pesca de camarão artesanal de arrasto pelo fundo, e um processo de salga mista foi aplicado usando uma mistura de sais em seis estágios de desidratação. As espécies mais frequentes e potencialmente mais úteis para o consumo humano nas capturas acessórias foram *Rhacostoma atlanticum*, *Chiropsalmus quadrumanus* e *Lychnorhiza lucerna*. Os valores médios do percentual de rendimento (peso salgado/peso úmido) foram 10,6% para *C. quadrumanus*, 6,6% para *L. lucerna* e 1,7% para *R. atlanticum*. Os resultados dos testes microbiológicos no material salgado foram negativos e o percentual de ganho de peso após a reidratação foi superior a 95% em todos os casos. O processo de salga das três espécies foi adaptado para ser iniciado a bordo e concluído em 21 dias em terra, gerando um produto final com características de cor e odor que atendem aos padrões encontrados no mercado.

Palavras-chave: Medusa, Alimento, Salga, Bromatologia.

Introduction

Due to the potential for stings, large medusae are avoided by bathers and divers (Haddad *et al*. 2010, Morandini *et al*. 2005, Resgalla Jr *et al*. 2005, 2011, Nogueira Jr. 2006). They are also avoided by fishermen, as they interfere in the fishing (Nagata *et*

al. 2009). On the other hand, it is recognized that these organisms make a significant ecological contribution to the carbon cycle of the oceans (Graham *et al*. 2014), mainly due to the mortality of the organisms after episodes of occurrence in high densities (Sweetman *et al*., 2016).

The occurrence of high densities of gelatinous organisms, known as blooms, have been correlated with favorable conditions in the marine environment or intrinsic biological characteristics of each group (Lucas & Dawson 2014). These phenomena have been occurring frequently, and may be associated with global warming, changes to the marine environment from pollution, and overfishing of their main predators and competitors (Mills 2001, Purcell *et al*. 2007, Condon *et al*. 2012). Recent studies show the occurrence of increasingly intense blooms along the coasts of the countries of Oceania (Richardson *et al*. 2009), East Asia (Dong *et al*. 2010), and in the Mediterranean Sea (Boero, 2013, Purcell *et al*. 2001).

However, in Brazil, little is known about the abundance pattern of these organisms. In a study conducted on the southern coast of Brazil, Schereder *et al*. (2014) measured the density of animals caught as bycatch in the fishing nets of the commercial fleet. The authors identified that the jellyfish with the highest frequency and number, especially in spring and summer, was the hydromedusa *Rhacostoma atlanticum*. Because of it high biomass, organisms of this species have become a problem for fishermen, since in warmer seasons fishing is greatly hampered by the large volume occupied by the jellyfish in the trawling nets, increasing the fishing time of the boats and consequently reducing income. On the other hand, the knowledge of the potential use of these organisms for commercial purposes, and the utilization of the bycatch, is still in its early stages.

The capture and processing of jellyfish for human consumption have been developed in Asian countries for more than 1700 years (Li & Hsieh 2004, Martínez & Tello 2013). Because it is considered to be a delicacy, jellyfish production has already been commercialized in those countries, as is the case of the species *Rhopilema esculentum*, which is farming in China (You *et al*. 2007). Recently, countries of North and South America, particularly the USA and Mexico, have begun to invest in the capture and processing of these products, but this exploration is far more intense in Asian countries (Brotz *et al*., 2016). The processing of medusa jellyfish as food is carried out mainly by salting (Sloan & Gunn 1985, Huang 1988) in basically the same way as for fish, such as sardines and cod. This type of processing promotes the extraction of water from the tissues of the animal, inhibits the growth of microorganisms, and increases shelf-life. At the same time, the characteristics of palatability, such as consistency, a slight crunchiness, and a pleasant color are preserved (Hsieh & Rudloe 1994, Hsieh *et al*. 2001).

Due to the great occurrence of jellyfish in artisanal shrimp fishing along the Santa Catarina coast, in the south of Brazil, the feasibility of the salting protocol technique applied to different jellyfish species was investigated, and the definite nutritional value of the product, as demonstrated by bromatological analyses, indicated an alternative for the use of certain jellyfish species within the fishing production chain.

Material and Methods

Collection: Sampling campaigns for the collection of jellyfish were conducted monthly, from February 2012 to January 2016, on the northern coast of Santa Catarina and in the region around the mouth of the Itajaí-açu River, between the 10 to 20 m isobaths and 25 km off the coast (26°45’ to 27°00’ S) (Fig. 1).

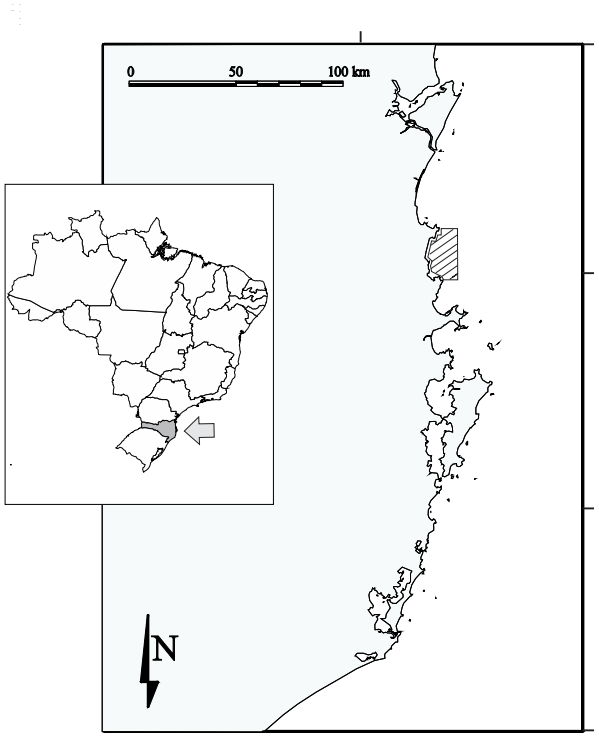

Figure 1 - Coast of Santa Catarina and shrimp artisanal fishing area (marked area) used to obtain macromedusae specimens.

The bottom trawls were performed from a motorized boat, using nets with a mesh size of 50 mm between opposite knots in the body and 30 mm in the bagger, with a length of 14 meters and opening of 5 meters. Surface temperature and salinity data were obtained using a YSI 30 thermo-salinometer. For the salting process, 22 sampling campaigns were conducted to collect organisms during the study period, 9 of which gathered enough organisms to perform the salting process. The jellyfish obtained in the trawls were bagged on board and transported to the laboratory, where they were washed in running water and sent to the salt processing. To estimate the density of the species captured, the data were standardized by number of organisms per 10 minutes of bottom trawling.

Salting: The protocol used for jellyfish processing was that proposed by Sloan & Gunn (1985), with modifications in an attempt to initiate the processing on board, eliminating the problem of having to land immediately after the catch, since jellyfish cannot be kept on ice prior to processing (steps I-VI, Table I). For this reason, the first 24 hours of the protocol were conducted in sea water. In this procedure, a mixture of sodium chloride, potassium alum, and citric acid is used per kilogram of fresh whole jellyfish, without tentacles, and is adjusted as the weight of the jellyfish changes in each step, as shown in Table I for the proportions between jellyfish and salts. During all stages of processing, the pH was measured with a Thermo Orion Star A211 benchtop meter. During the entire process, the odor of the material, and its color, which should be uniform (absence of blotches) with a whitish opaque tonality, were recorded.

For the bromatological analyses, the salted jellyfish were desalted and hydrated to remove excess salt that might interfere in the calculations. Three washing cycles of 20 minutes each were performed in drinking water (1:80, weight:volume), changing the water between cycles. The salinity of the washing water was measured with a refractometer. The tissue samples used for crude protein determination were previously dried in a Shimadzu MOC63u moisture analyzer at 105ºC. The percent humidity of the desalted (without excess salt), hydrated jellyfish samples were also measured using the same analyzer.

For the final quality of hydrated jellyfish, the texture (crunchy), color and size were evaluated according to the criteria presented by Schiariti (2008).

Protein, mineral residue, and aluminum content: The chemical analyses were performed according to Horwitz (2000). The total crude protein analysis was performed using an adaptation of the protocol of Galvani & Gaertner (2006). To the procedure was used 50 mg of the dry sample and 500 mg of catalyzer (Na_2SO_4 and $CuSO_4.5H_2O$), which was digested in 2 mL of sulfuric acid in a block digestor at 350 ºC for about 3 hours, until the color change. After digestion, distillation was performed, adding 6 mL of distilled water to the digested sample. The sample was neutralized in the distiller with NaOH at 8 M and the receiver solution was composed of 25 mL of boric acid at 4% and universal coloring. Finally, the receiver solution was titrated with HCl at 0.05 N and the protein content calculated, considering 6.25 as the nitrogen conversion factor for protein. To determine the mineral residue content, the hydrated (desalted) jellyfish samples were dried at a constant weight in a heating chamber at 105°C and incinerated in a muffle oven at 550ºC for 2 hours. The mineral residue content was defined as the difference between the weight of the dry sample before incineration and the weight of the sample after incineration.

To determine the total aluminum content, after desalting, 2.5 g of sample was incubated with 5 mL of concentrated nitric acid (HNO_3) and left to rest for 24 hours. Then, 2 mL of hydrogen peroxide (H_2O_2) was added and left to react for 2 hours. The aluminum concentration was read using a USEPA (2014) atomic absorption spectrophotometer.

Microbiological analyses: The microbiological analyses were performed in salted jellyfish samples and frozen at -20ºC, representing the conditions in which the final product would be obtained in the salting industry. They were thawed at room temperature by adding about 5 g of jellyfish to 90 mL of 0.1% peptone water and homogenized for 30 minutes in a magnetic stirrer. To determine the total coliforms, the methodology proposed by the FDA (2001) was applied and the result expressed as the most probable number (MPN) of total coliforms. For this, two decimal dilutions (10^{-2} and 10^{-3}) were prepared from the salted jellyfish homogenate (10^{-1}), in tubes containing 10 mL of Fluorocult LMX Broth – Modified Lauryl Sulfate Broth with MUG in triplicate. The tubes were kept in a heat chamber at 35°C for 24 hours. After the incubation period, the tubes were examined to verify total coliform growth and the tubes with a change in color of the culture medium to bluish green were classified as positive. The methodology described by Silva (2013) was

Table I. Jellyfish salting protocol (adapted from Sloan & Gunn, 1985).

Step	Per Kg of jellyfish	Time (hours)	Observations
I	Sea water – 1 liter NaCl (50:50% fine and coarse) – 20.0 g Alum – 20.0 g Citric acid – 2.0 g Calcium hypochlorite – 0.7 g	24 to 72 hours	Only the umbrella is used for salting and the jellyfish must be used within 6 hours following capture. This first salting must occur at sea. Solution discarded after use.
II	Fresh water – 1 liter NaCl (50:50% fine and coarse) – 100.0 g Alum – 20.0 g Citric acid – 1.0 g Calcium hypochlorite – 0.4 g	48 hours	Solution discarded after use. The product should be washed with citric acid 1%.
III	Fresh water – 1 liter NaCl (50:50% fine and coarse) – 150.0 g Alum – 10.0 g	96 hours	The solution can be filtered and reused.
IV	Fresh water – 1 liter NaCl (50:50% fine and coarse) – 180.0g Alum – 10.0 g	96 hours	The solution can be filtered and reused.
V	NaCl (50:50% fine and coarse) 100% saline	96 hours	
VI	Drain the jellyfish in piles no more than 30 cm high on a net in a cool place	72 to 96 hours	The product must be completely drained and stored at around 0°C.
	Total procedure time	18 to 21 days	

used to count the bacterial human pathogen *Staphylococcus aureus*, in which dilutions of the samples were inoculated into two Baird-Parker (BP) agar plates enriched with egg-yolk tellurite emulsion at 0.5% with 0.1 mL for each dilution (10^{-1}, 10^{-2}, and 10^{-3}). The plates were incubated in a heat chamber at 35°C for 24 hours and after this period, the dark colonies (if present) were counted and the result expressed as colony-forming units per milliliter (CFU mL^{-1}).

Results

Between February 2012 and January 2016, the region around the mouth of the Itajaí-açú River showed a ranged of 17.7 ºC (July 2013) to 28ºC (February 2015) in surface water temperature and from 22.2 ºC (August 2014) to 34.1 ºC (March 2013) in salinity, with the occurrence of six species of macromedusa belonging to the classes Hydrozoa, Scyphozoa, and Cubozoa. The Hydromedusae species were the most abundant. *Olindias sambaquiensis* (Müller, 1861) showed the highest densities (average of 7.5 organisms per 10 minutes of trawling) and occurred throughout the year, with the highest densities in the fall and the spring (Fig. 2). The second most important species, also a Hydrozoa, was *Rhacostoma atlanticum* (L. Agassiz, 1850), with the greatest densities (average of 3.9 organisms per 10 minutes of trawling) observed in summer and fall. *Chiropsalmus quadrumanus* (F. Müller, 1859), a Cubozoa, and *Chrysaora lactea* (Eschscholtz, 1829) and *Lychnorhiza lucerna* (Haeckel, 1880), two Scyphozoan, were species that occurred mainly in summer/fall months and in low densities (< 1 organism per 10 minutes of trawling). And finally, *Tamoya haplonema* (F. Müller, 1859) was a rare, irregularly occurring Cubozoan species. In all cases, the production of jellyfish was less than 100 grams per 1000 m^3, which requires fishing in seasons of high occurrence of organisms.

The species destined for the salting process were selected from among the occurring species, considering the criteria of abundance and/or frequency of occurrence, absence of toxicity in the tentacles and/or ease of removing them as a procedure prior to salting, as well as chemical composition, previously determined by De Barba *et al.* (2016). Thus, the species *R. atlanticum*, *C. quadrumanus*, and *L. lucerna* were selected as representatives from each of the occurring classes of Cnidaria.

Salting and Desalting: Five salting procedures were conducted for *R. atlanticum*, 3 for *L. lucerna*, and 4 for *C. quadrumanus*. An adjustment to the protocol proposed by Sloan & Gunn (1985) (Table I) made the use of fresh specimens possible, within 24 hours after capture, with an adaptation for the use of sea water in step I. The pH in the three species tested

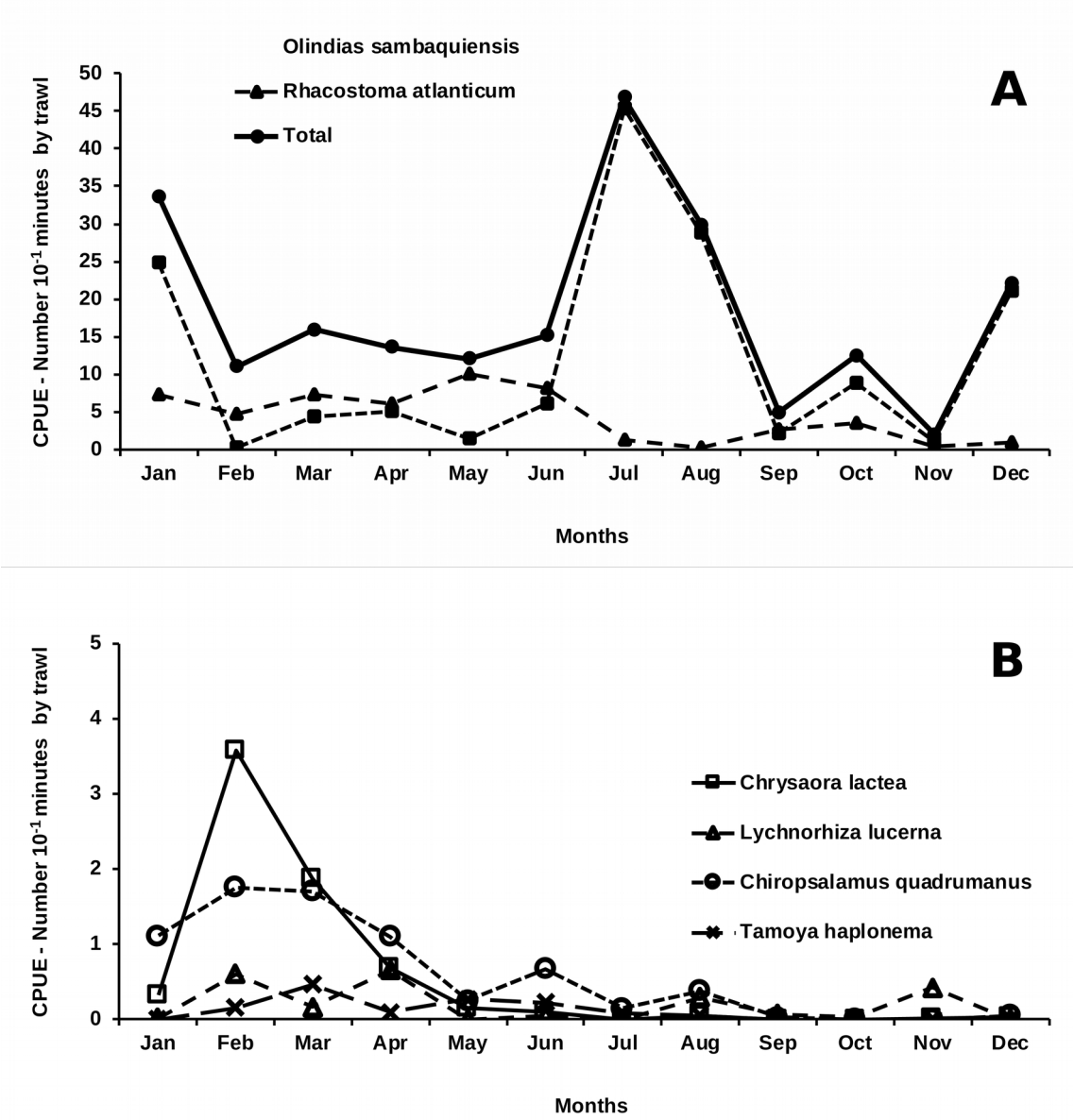

Figure 2 – Mean monthly catch per unit of effort values (Number of organisms per 10 minutes of trawl) of the jellyfish species sampled in the region around the mouth of the Rio Itajaí-açu (northern coast of Santa Catarina, Brazil) for the period February 2012 to January 2016 (4 years of sampling). A - Catch per unit of effort for the total jellyfish and for the two most abundant species *Olindias sambaquiensis* and *Rhacostoma atlanticum*. B - Catch per unit of effort of low density jellyfish species, being *Chrysaora lactea*, *Lychnorhiza lucerna*, *Chiropsalmus quadrumanus* and *Tamoya haplonema*.

was maintained in acid medium, as recommended by the protocol, and ensured successful salting. The pH was between 2.3 and 2.4 for steps I and II and between 3.3 and 3.5 in steps III and IV. No changes in odor or formation of blotches were observed in the salted jellyfish, but all with a clear reduction in size and weight. Processing was performed in six steps with no significant variation in time among the different lots (collections in the different months). Besides that, with the modification in the step I, the total processing time was reduced from 21 days (Sloan & Gunn, 1985) to 18 days.

The final product yield varied among the species, being lower for *R. atlanticum* (average of 1.7±1.5%) and higher for *L. lucerna* (average of 6.6±1.1%) and *C. quadrumanus* (average of 10.6±4.2%) (Table II).

The desalting process resulted in a rehydration and duplication of initial dry mass that represented an increase in wet mass of 133% for *R. atlanticum*,

Table II. Period and yield for the three jellyfish species submitted to the salting protocol

Species	Series	Start	End	Start Weight (g)	End Weight (g)	Product yield (%)
Rhacostoma atlanticum	SR1	01/29/2015	02/18/2015	492.05	7.78	1.6
	SR2	05/20/2015	06/09/2015	127.81	0.31	0.2
	SR3	07/03/2015	08/13/2015	71.40	0.39	0.5
	SR4	09/03/2015	09/25/2015	559.43	21.24	3.8
	SR5	09/08/2015	09/02/2015	302.16	7.37	2.4
Lychnorhiza lucerna	SL1	07/01/2015	07/21/2015	897.81	56.27	6.3
	SL2	07/08/2015	07/27/2015	955.68	54.32	5.7
	SL3	08/06/2015	08/27/2015	645.73	50.42	7.8
Chiropsalmus quadrumanus	SC1	03/16/2015	04/06/2015	968.50	50.52	5.2
	SC2	07/08/2015	07/27/2015	421.47	63.55	15.1
	SC3	08/06/2015	08/27/2015	1219.48	122.57	10.1
	SC4	09/03/2015	09/25/2015	235.17	28.50	12.1

97% for *C. quadrumanus*, and 129% for *L. lucerna* (Fig. 3).

After desalting, *R. atlanticum* was the species with minor alteration of the coloration, remaining transparent while *L. lucerna* and *C. quadrumanus* became whitish. All species have a crunchy texture.

Protein, mineral residue, and aluminum content: The average crude protein values indicated higher content for *R. atlanticum* (> 80% of the dry weight) than the other species (Table III). Variations in mineral residue content were not observed among the species, with low percentages (0.86 to 1.02%) of the dry weight measured after desalting (Table III).

The limit of detection of the method for determining the aluminum content was 4.7 mg Kg^{-1}. The species *R. atlanticum* and *C. quadrumanus* had concentrations below the limit of detection of the method and the species *L. lucerna* showed residual presence of aluminum (Table III). The aluminum standard presented 94.3% recovery in the analysis.

Microbiological Analyses: Regarding the microbiological tests for total coliforms, the results indicated contamination lower than 0.3 MPN (most probable number according to ABNT, 1991) for all samples. The results for S. aureus observed in the species *R. atlanticum*, *C. quadrumanus*, and *L. lucerna* indicated the absence of growth of these bacteria in all the tested samples.

Discussion

The impact of jellyfish on fishing activities on the coast of Santa Catarina has already attracted attention. Schroeder *et al*. (2014) and Rutkowski *et al*. (2018) point out that the bycatch of macrozooplankton by the commercial fleet is composed mainly of the species *R. atlanticum.* This species occurs all year round, but with peaks of abundance in the autumn and spring and with high variability between years, as already highlighted by similar studies conducted by Mianzan & Guerrero (2000) and Nogueira Jr. *et al.* (2010).

Due to its sporadic occurrence and high-density variability, the cubozoan *C. quadrumanus* has not been investigated; therefore, there is no ecological data available for this species. On the other hand, *L. lucerna* is one of the most widely studied species in South America, due to its wide distribution in this region (Schiariti *et al*. 2008). In Brazil, Morandini *et al.* (2005) observed the presence of this species throughout the year, peaking in summer, without a defined seasonality.

Regarding the use of jellyfish as food, China was the first country to introduce it as a food, with the earliest records dating back to the Tsin dynasty (Omori & Nakano 2001, Hsieh *et al*. 2001), but since the 1970s, demand has grown in other countries, such as Japan, where they began to market the product. Today, China, Japan and Korea are the countries with the highest consumption of jellyfish (Kitamura & Omori, 2010). To meet the demand, they import it from other countries, such as Australia, Mexico, and the United States, which have developed the Asian salting technique.

Among the species of jellyfish heavily exploited commercially for consumption, the majority belong to the class Scyphozoa, Rhizostomeae order. Species such as *Rhopilema hispidum*, *Rhopilema esculentum*, and *Nemopilema nomurai* are among the most widely used (Morishige *et al*. 2011, Kawahara *et al.* 2006). This preference is associated with the fact that these animals are large, with firmer bodies, resulting in higher yields after salting (Morishige *et al.* 2011), and because their

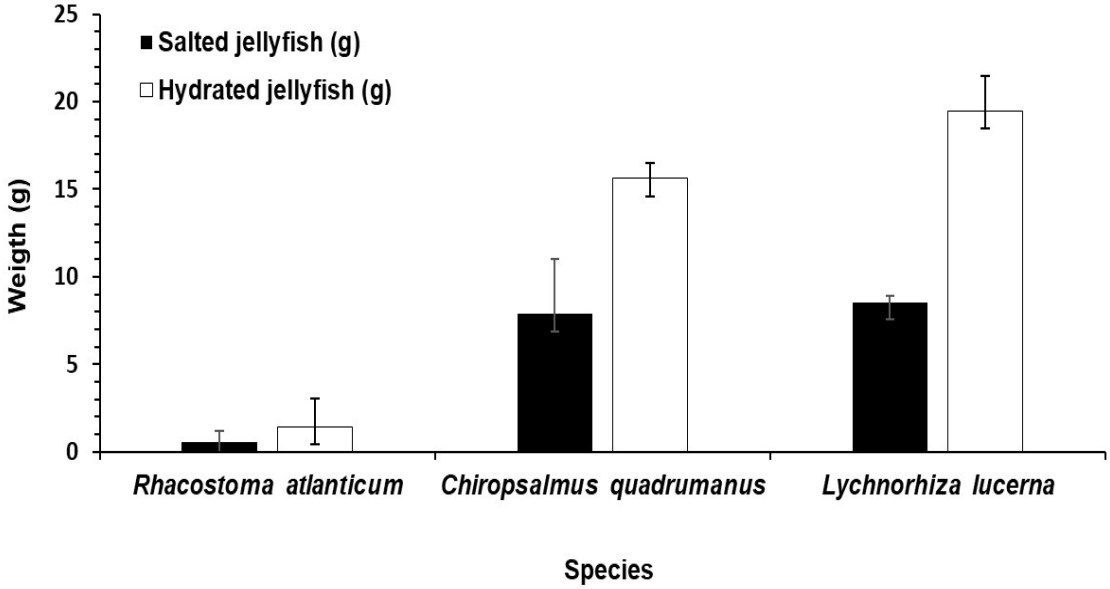

Figure 3. Mean and standard deviation of the variation in mass (g) of the three jellyfish species between salting (dehydrated) and after desalting (hydrated).

Table III – Protein content (over dry and wet weights), ashes (over dry weight), and aluminum (over wet weight) in the tissues for each jellyfish species.

Species	Proteins (%)		Ashes (%)	Aluminum (mg Kg^{-1})
	(dry weight)	(wet weight)		
Rhacostoma. atlanticum	83.7±1.30	3.9	0.71±0.83	nd
Chiropsalmus quadrumanus	62.9±0.38	1.1	0.71±0.89	nd
Lychnorhiza lucerna	66.9±0.66	1.9	1.42±0.02	10.1

nd = not detected

toxins pose a low hazard for humans (Kawahara *et al*. 2006).

Wet salting, although low in cost, requires a long development cycle (Xu 2013, Hsieh *et al*.2001), which is a disadvantage of this technique, since it requires space and containers for the processing of large quantities of jellyfish. However, the technique ensures firmed-textured flesh due to the use of potassium alum, which contributes to the precipitation of proteins and, together with citric acid, to the reduction in pH (Hsieh & Rudloe 1994). The reduction in the pH is critically important for the prevention of microbial growth in the tissue and the conservation of the product. Salted jellyfish has a durability of approximately 6 months to a year at room temperature (Xu 2013) and up to 2 years under refrigeration (Hsieh *et al.* 2001). On the other hand, the yields obtained from the species used in this study (salted weight/crude weight) are at the lower limits of those reported in the review by Brotz *et al.* (2016) from 7% to 25%.

After the salting process, and to prepare the product for consumption, desalting is recommended. Ready-to-eat products, which have already been desalted, can be found on the market. This process may vary from a few hours to overnight, whether in room-temperature or hot water, and basically involves removing excess salt, diluting the alum, and preparing the food for ingestion by rehydrating the tissue (Xu 2013). The volume of water reabsorbed varies according to the protein composition of each species.

Desalting time and water temperature are factors that can alter the texture of the final product. In this study, approximately 60 minutes immersed in room temperature water was sufficient to double the initial weight of each of the three species. According to Xu (2013), the retention of tissue moisture after the salting process is related to the capacity of the myofibrillar proteins to retain water. These collagenous proteins are present in all types of tissue. In fish, for example, when the muscular tissue

is frozen, these proteins double, acquiring a new format that allows the exposure of non-polar amino acids. This exposure makes these amino acids available for hydrophobic interactions with other close protein groups, forming a three-dimensional network that facilitates the aggregation of water molecules and kicks off a process of water retention, textural change, and gel formation (Carvajal *et al*. 1999, Kuhn & Soares 2001). In jellyfish tissues, the factor that can collaborate towards changes in the conformation of these proteins is the immersion of the tissue in salts, which bind the structural proteins of the tissue and denature them, maintaining a firmer texture (Hsieh *et al.* 2001). For this reason, the desalting immersion time is also very important, because the absorption of too much water can impair the characteristic crunchiness of the product.

The structure of jellyfish is made up mostly of water and proteins, presenting low levels of sugars and calories (Ding *et al.* 2011, De Barba *et al.* 2016). However, the less than 4% crude protein content in the moistened, ready-to-eat product was lower than the values observed in similar products made from different species. Hsieh *et al*. (2001) analyzed desalted, ready-to-eat jellyfish and reported values of 4.7% for the umbrella and 5.6% for the tentacles. Huang *et al.* (1988) reported values of 5.5% and 6.8% for products produced in Malaysia and China, respectively.

These structural proteins, collagen among them, can represent up to 60% of the protein composition of these organisms (Nagai *et al.* 1999) and are essential components in the construction of cell tissues, cartilage, bones and teeth (Hsieh & Rudloe 1994). According to Hsieh & Rudloe (1994) and Kimura & Miura (1983), much of the collagen found in these organisms is formed from the amino acids glycine, hydroxyproline and hydroxylysine. These proteins began to generate interest and were already extracted, and isolated from the species *Stomolophus nomurai* (Miura & Kimura 1985), *Rhopilema asamushi* (Nagai *et al.* 2000), and *Rhizostoma pulmo* (Addad *et al*. 2011). Furthermore, studies continue on the bioactive activity of this protein and its peptides against health problems like arthritis, hypertension, back pain (Hsieh *et al.* 2001), as anti-fatigue and anti-oxidant agents (Ding *et al*. 2011). The structure of the collagen extracted from jellyfish is very similar to that of the collagen found in vertebrates, and this product can be used in cosmetics, as food, and for therapeutic purposes (Hsieh & Rudloe 1994, Xu 2013).

In relation to the inorganic components found in unprocessed jellyfish, these organisms are rich in minerals such as Ca, Na, K, Mg, and Fe (Xu 2013, De Barba *et al*. 2016). Using the results obtained by De Barba *et al.* (2016) for a comparison with the same species *in natura*, salted jellyfish has lower mineral residue levels, indicating that the salting process can remove soluble minerals from the tissue (Hsieh *et al.* 1996).

In addition to sodium chloride, the excess of potassium alum also requires attention. Consumption of this product can cause exposure to high levels of dietary aluminum, which can be toxic to the central nervous, skeletal and hematopoietic systems (Xu 2013). According to Xu (2013), high levels of aluminum occur due to the binding to the collagen structure, facilitating the precipitation of these proteins and preserving the firm texture of the tissue. However, preliminary analyses performed on samples of hydrated jellyfish did not report aluminum concentrations above the recommendation of the China National Center for Food Safety Risk Assessment, which establishes the safe weekly aluminum consumption limit at 2 mg Kg^{-1} of body weight. In this context, the concentrations obtained in this study are considered safe. Recently, Pedersen *et al.* (2017) presented new techniques for preserving jellyfish without the use of metal salts, but these techniques still need to be tested for consumer market acceptance.

Likewise, the microbiological tests for total coliforms and *S. aureus* did not show growth of microorganisms, and conformed to the parameters proposed by Resolution no. 12, of 02 January 2001 (ANVISA, 2001), which certifies the microbiological procedures of products of animal and plant origin for human consumption. All samples tested showed no microbial growth. This was due to the hypersaline environment and the acid pH in which the jellyfish were placed during the entire process, and to the removal of excess water, hindering the proliferation of microorganisms. This type of processing allows for greater product durability, favoring the long-distance transport of these products. In Brazil, the market is little exploited and the sale of these products occurs, mainly, in the southeastern region. In the city of São Paulo, these products can be found in stores with imported products and in Asian restaurants. Various brands with different prices are sold for an average of 4 USD per kilogram. However, little is known about the origin of the products and the labels,

besides being poorly mistranslated, offer little information about the species being sold.

Based on the data collected and analyzed, this work applied the jellyfish salting process protocol and performed bromatological analyses of the finished product in three jellyfish species occurring along the Brazilian coast. It also offered a viable alternative for the optimization of this natural resource that is frequently discarded by fishing vessels. In this study, we observed that the processing, in addition to being faster than reported in the literature, made the production of this type of delicacy possible using the species most frequently captured along the Santa Catarina coast. However, further studies are needed on palatability and acceptance in the national market, as well as on the use of other jellyfish species for this same protocol or other adaptations.

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