



Rock-boring urchin roe from Brazilian subtropical coastal zone for human consumption

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ABSTRACT. The portion of food interest of sea urchin is located in the gonads, a dish increasingly appreciated in the international cuisine. The aims of this study were evaluate the process of fresh roes from rock-boring urchin sea *Echinometra lucunter* for human consumption, check the acceptance and preference of the product, and consumer purchase intent. Studies on processing of roes from *E. lucunter* are nonexistent, thus, this study is a pioneer in Brazil. The roes were processed following the steps: wash in a solution of potassium alum, drainage, separation by color, packaging and storage under refrigeration (0-4°C). Following, batches of the roes were characterized by physical, chemical and microbiological analyses, and subjected to sensory analysis to check acceptance and preference of potential consumers. The methodology of potassium alum used was efficient for *E. lucunter* roes and the color attribute was more relevant in the acceptance, preference and purchase intent from processed fresh roes. The extraction process might be improved in order to minimize rupture of the gonads. For managers of fisheries and sea food quality we recommend the implementation of public policies that result in the sustainability of sea-urchin species and food safety for the consumers.

Keywords: *Echinometra lucunter*, adding value, *nama uni*, purchase intent.

Ovas de ouriço-do-mar de zona costeira subtropical brasileira para consumo humano

RESUMO. A porção de interesse alimentar do ouriço-do-mar se concentra nas gônadas, alimento cada vez mais apreciado pela cozinha internacional. Os objetivos deste estudo foram avaliar o processamento de ovas frescas do ouriço *Echinometra lucunter* para consumo humano, verificar a aceitação e a preferência desse produto, bem como a intenção de compra pelo consumidor. Estudos sobre o processamento das ovas de *E. lucunter* são inexistentes; assim, este estudo é pioneiro no Brasil. As ovas foram processadas, seguindo as etapas: lavagem em solução de alúmen de potássio, drenagem, separação por cor, embalagem e armazenamento sob refrigeração (0 a 4°C). Posteriormente, lotes do produto foram caracterizados por análises físicas, químicas e microbiológicas, e submetidos à análise sensorial para verificação da aceitação e da preferência pelos potenciais consumidores. A metodologia com alúmen de potássio utilizada foi eficiente para ovas do *E. lucunter*, e o atributo cor foi mais relevante na aceitação, na preferência e na intenção de compra de ovas frescas processadas. O processo de extração pode ser melhorado, a fim de minimizar ruptura das gônadas. Para os gestores pesqueiros e da qualidade de frutos do mar, recomendamos a implementação de políticas públicas que resultem na sustentabilidade das espécies de ouriço-do-mar e segurança alimentar para o consumidor.

Palavras-chave: *Echinometra lucunter*, agregação de valor, *nama uni*, intenção de compra.

Introduction

The rock-boring urchin (*Echinometra lucunter*) is a regular tropical echinoid characterized by the color of the test (or shell) and spikes ranging from dark tones to black. The species occur in substrates at very high densities along the Brazilian coast, usually in the intertidal zone up to 45 m deep, and adults can reach 150 mm in diameter (Santos & Flammang, 2005, Gondim, Lacouth, Alonso, & Manso, 2008).

The portion of most marine species used for human consumption comprises the muscles or

visceral mass, however, in the case of sea urchin, the portion of interest for consumption is located in the gonads. The gonads, also called roes, have been consumed since ancient times, currently they are consumed both fresh and processed, and quality standards encompass size, color and texture. The market has a trend to evolve into more elaborated products, like canned preserves, semi-preserves, pâtés and frozen foods (Barea et al., 2010). Roes of sea urchin have large demand and high prices in the international market and are considered marine fish

of greatest economic value, after only the caviar, making sea urchin an important economic resource, especially for local communities (Mcconney, Mahon, & Parker, 2003, Vasquez-Martinez et al., 2004).

Because of the increased demand for high-quality roe, the natural stocks of many sea urchins world-wide have been depleted or even collapsed (Gianguzza et al., 2006). The market demand and vulnerability of this animal have led producers from various countries to adopt conservation measures for extraction, develop aquaculture techniques and fish processing technologies. The marketing and export of this echinoid has increased in the last 20 years in countries such as Ireland, United States, and Canada. Currently, Japan is the largest consumer, using techniques that increased the fishing of sea urchin and the processing of its roes (Mcconney et al., 2003, Sloan, 1985).

Three species of sea urchins are commercially explored in Australia: *Heliocidaris erythrogramma*, *Centrostephanus rodgersii* and *Heliocidaris tuberculata* (Blount & Worthington, 2002). The market of sea urchin is particularly popular in countries like France, Ireland, Italy, Spain and Greece because of its distinctive aroma and very good taste (Kelly, 2005). South Korea has successfully tested the powder of sea urchin (*Hemicentrotus pulcherrimus*) shell, collected in local markets and used as a food supplement for broilers (Kim, Chung, Chung, & Choi, 2015).

The processing of roes of sea urchin is extremely delicate and labor-intensive, the test is usually opened manually with the aid of scissors and pliers, and the roes of both sexes are smoothly extracted, washed and packaged. The Japanese market requires a very dry product, which can be easily handled, otherwise changes the features of volume, color and flavor of the roes (Verachia, Niven, & Bremer, 2012). The alum bath increase the roe firmness, leaves the tissue denser and highlights a stronger color and reduces the moisture, as well as removes the excess of gametes (Kato & Schroeter, 1985, Guðmundsson & Þorsteinsson, 1993).

Studies on processing of roes from *E. lucunter* are nonexistent, thus, this study is a pioneer in Brazil. The aims of this study were evaluate the process of fresh roes from rock-boring urchin sea for human consumption, check the acceptance and preference of the product, and consumer purchase intent.

Material and methods

This research was approved by the committee of ethics for research on human beings of the Catholic

University of Santos– Unisantos – (Registration No. 245,106), and is registered into the Sisbio, Authorization System and Information on Biodiversity (Registration No. 5444151).

The Palmas Island, collection site of the rock-boring urchin, is located in the Santos Bay (24° 00' 31"; 046° 19' 28"), in São Paulo State, Brazil. This island has approximately 615 m of perimeter and rocky shores with up to 20° of inclination. In October 2012, approximately 50 specimens of *E. lucunter*, with test diameter of 65 to 75 mm were collected through manual extraction by snorkeling and packed in cooler boxes with ice and seawater (4.0°C/60 min) to promote thermal shock (Figure 1), similar Stamatis and Vafidis (2009), in the Aegean Sea, for *Paracentrotus lividus*.

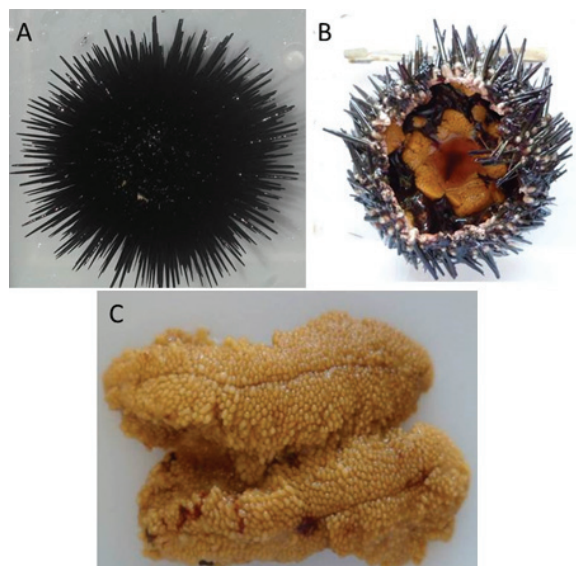


Figure 1. An entire rock-boring urchin (*E. lucunter*) (A), with opened test (B) and the edible fresh roe (*nama uni*) of category B, removed and processed by potassium alum method.

The processing stages, performed in specific laboratory, involved the opening of sea urchins with scissors, removing the roes with a small spoon (dessert spoon) and tongs, avoiding contamination with the digestive tract, and washing the roes in a saline solution (10.0 g NaCl L⁻¹) to remove impurities. In sequence, the roes were immersed for 15-30 min, until the roe stay firm in a solution of 5% (5.0 g L⁻¹) of potassium alum (KAl [SO₄]₂) produced with water in saline (10.0 g NaCl L⁻¹).

Subsequently, the roes were drained in sieve and then separated by color according to the hexadecimal code and RGB model for color table. The RGB is an additive color model in which red (R), green (G), and blue (B) light are added together in various ways to reproduce a broad array of colors

(Quevedo, Aguilera, & Pedreschi, 2010). Generally the gonads of sea urchin are divided into three color categories: yellow or bright orange, represents intact and firm texture or otherwise less intense yellow, indicates intact and firm texture also, and brown color, may be ruptured and features smooth and creamy texture (Stamatis & Vafidis, 2009). These roes were packed in trays and stored under refrigeration (0-4°C). Throughout the process, good manufacturing practices were adopted according to Prieto-Montalvo, Barrera-Moreno, and Contreras-Rivas (2000). The operational flow chart of fresh roes of rock-boring urchin (*E. lucunter*) for human consumption is shown in Figure 2.

The yield of roes was calculated by the ratio for wet weight (g) of the roes and the total weight (g) of sea urchins used in the process. The colors with the respective RGB and hexadecimal codes were determined in high-resolution digital images of the processed roes.

The proximate analysis was composed of a homogenized sample in duplicate of processed product. Thus, it was possible to obtain representative values of proximate analysis from the roe of sea urchins, collected with similar size, at the same time and place, remaining enough roe for subsequent sensory analysis. The analyses of moisture, protein and ashes were performed, as described in Brasil (2011). The lipids were determined according to method of Bligh and Dyer (1959). The carbohydrate content was determined by difference: the percentage of moisture, proteins, lipids and ashes, subtracted from 100, according to Anvisa-RDC360/03 (Brasil, 2003). To calculate the calorific value, the coefficients of Atwater were used according to Watt and Merrill (1963), that is, 4 for proteins; 4 carbohydrates, and 9 for lipids, and fibers were determined according to method of Association of Official Analytical Chemists (AOAC, 2010).

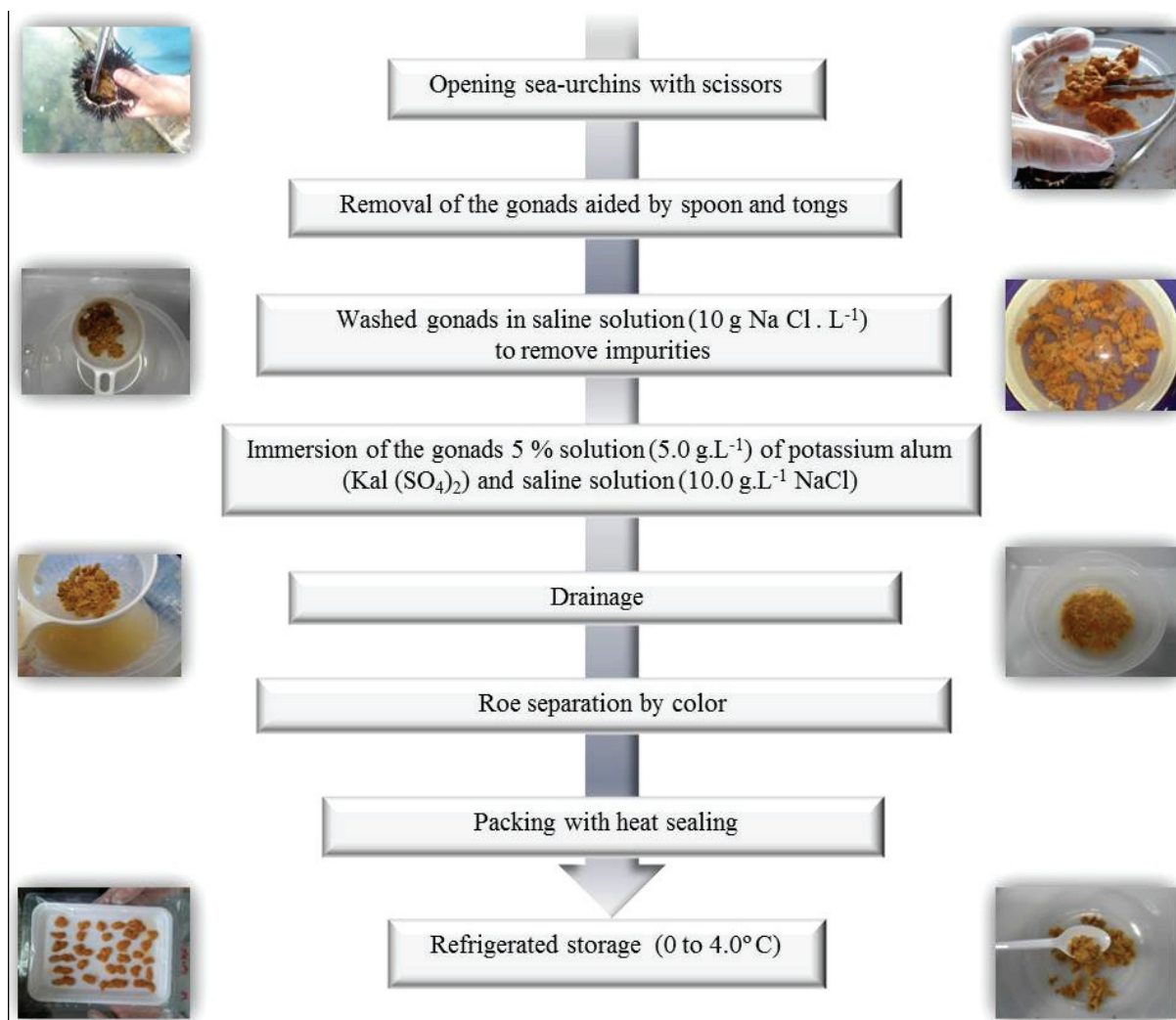


Figure 2. Flow chart of processing fresh roes (*nama uni*) of rock-boring urchin (*E. lucunter*) for human consumption.

The microbiological analyses (count of total coliforms and thermotolerant bacteria, *Staphylococcus aureus* positive coagulase and *Salmonella* spp) were composed of processed roes separated by color in duplicate samples and carried out according to the methods recommended by Downes and Ito (2001), and the results compared to the standards established by Resolution RDC No. 12/2001 of the Ministry of Health (Brasil, 2001). After 10 days of gap for results of microbiological analysis, chilled samples of roes processed, according to limit values of tolerance for microbiological standards established by Resolution RDC 12 (Brasil, 2001), were available to next step, the sensory evaluation panel.

The sensory tests were performed by 17 panelists, comprised of researchers and employees at the Fisheries Institute, Santos City – São Paulo State, Brazil, usual consumers of sea food and often participate in sensory analyzes of different projects conducted in fish technology. We opted for the use of hedonic scale, due to ease of understanding by the panelists and simplicity in data processing.

The 9-point hedonic scale was used to evaluate the parameters between 'liked very much' and 'disliked very much' to check the acceptance indexes (Stone & Sidel, 1993, Meilgaard, Civille, & Carr, 1999, Drake, 2007, Dutcosky, 2009), similar to that performed by Martins, Borges, Deliza, Castro, and Cavalcante (2007). The A, B and C samples were evaluated in the monadic form, in an individual sensory analysis cabin, and the attributes evaluated comprised appearance, color, texture, odor, and flavor, as well as purchase intent. For the preference test, each judge received coded samples to order them in the descending form as their choice (Drake, 2007). The analysis was performed in the monadic form in an individual cabin for the sensory analysis of the A, B and C samples.

For indicate which factors of the sensory analysis were statistically significant for the score from the judges, a generalized linear model (GLM) was tested as: Score = Constant + Attributes + Products + Purchase Intent + Interactions + Error, where the dependent variable was the Score of judges and the factors in the model were the Purchase Intent, the Attributes and evaluated Products.

To check the preference scale for product, considering the gender and age of the judges, the nominal logistic regression was used (Hough & Garitta, 2012). The Index of Product Acceptability the expression $IA (\%) = x \cdot 100/B$ was adopted, where A = mean rate for the product, and B = maximum rate given to the product. An IA with $\geq 70\%$ was

considered of good acceptance (Teixeira, Meinert, & Barbata, 1987).

Results and discussion

The rock-boring urchin gathered from rocky shore of the Palmas Island ranged the test diameter of 65 to 75 mm and mean of total weight of 152.7 g (SD = 40.83 g). The mean of gonads weight of 9.9 g (SD = 6.8 g), totaling 500 g for 50 echinoids.

The Figure 3 show the positive linear correlation between weight of gonads and total weight and the regression analysis indicated statistical significance (ANOVA: $p = 0.001$) at an a-level of 0.05 and the estimated coefficient of weight of gonads ($p = 0.001$; r^2 adjusted = 0.25; $N = 50$). According to Arana (2005), the mean yield among 14 and 16 g of roes from specimens of *Loxechinus albus*, gathering in Chile, was related to the seasonality and biological characteristics of the animal. These same factors might have influenced the individual yield of roes from sea-urchin *E. lucunter* used in this study.

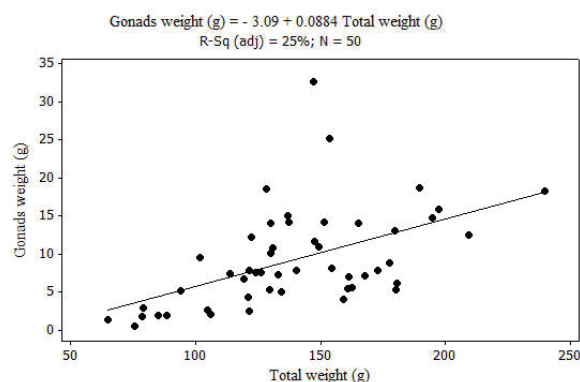


Figure 3. The scatter plot show the linear relationship between the total weight (g) and the weight of the gonads (g) of sea urchins *E. lucunter* used in the processing of fresh roe (*nama uni*).

The method with potassium alum was efficient for reduce the moisture, improved firmness and yielded 500 g of fresh roe for human consumption. Verachia et al. (2012) conducted a study on sea urchin *Evechinus chloroticus* on Stewart Island in New Zealand and observed that the behavior of sea urchins before processing and the processing stages have significant effect on roe quality, such as the percentage variation in weight, height, and width of the roes. The author adds that the deterioration of the gonads is minimized by implementing a washing with brine and potassium alum, after its immediate removal from living sea urchins, the same in this study was performed also and effectively contributed to the microbiological quality of the roes.

The gonads extract of sea urchin were divided into three categories in terms of size, appearance,

color, and texture: A (yellow or bright orange, intact and firm texture), B (less intense yellow, intact and firm texture), and C (brown color, may be ruptured and features smooth and creamy texture). The higher the degree of the parameters, the greater is the price of roes in the market (Barea et al., 2010). This study the three categories separated by colors received respective RGB and hexadecimal codes: 'A' Dark Orange B26924 (RGB 178, 105, 36), 'B' Strong Orange C26400 (RGB 194, 100, 0), and 'C' Moderate Dark Orange 856333 (RGB 133, 99, 51). The amount of each category was: A = 227, B = 161 and C = 112 g, but during the extraction phase some gonads were broken, suggesting the extraction process of the roes might be improved throughout suitable instruments for different types of gonads.

The proximate analysis of fresh processed roes of *E. lucunter* collected in Santos Bay showed: Energy value (Kcal) - 92.23; Protein (%) - 11.47; Lipids (%) - 4.19; Ashes (%) - 1.75; Moisture (%) - 78.5; Carbohydrate (%) - 2.16 and Fibers (%) - 1.93. The results showed values similar to those found by Barea et al. (2010) conducted in Spain on sea urchin *Paracentrotus lividus*, except for lipids and energy value (Table 1).

Table 1. Comparative proximate analysis of gonads of sea urchin *Paracentrotus lividus* and *E. lucunter*.

Parameters	Barea et al. (2010) <i>Paracentrotus lividus</i>	Current study <i>Echinometra lucunter</i>
Energy value (Kcal)	68.70	92.23
Protein (%)	10.32	11.47
Lipids (%)	2.79	4.19
Ashes (%)	2.26	1.75
Moisture (%)	80	78.5
Carbohydrate (%)	-	2.16
Fibers (%)	-	1.93

Pigott and Tucker (1990) report the change of chemical composition of fish roes, mainly due seasonality of species. In the case of the sea urchin, differences are also observed according to the stage of gonadal maturation and diet of the animal. The fiber content in the samples can be related to contamination of the gonads by digestive tract of sea urchin, probably due to the disruption of gonads during their extraction.

The microbiological analysis samples were in accordance with the standards recommended by the RDC 12 (Brasil, 2001) as the absence of *Salmonella* sp in 25 g of the product, population of *Staphylococcus aureus* positive coagulase below 5×10^2 g⁻¹ and population total coliforms at 45°C below 10^2 g⁻¹.

The three categories A, B and C of fresh roes were scored by sensory judges composed of 18 men

and 82% women, aged between 18 and 63 yrs. The Figure 4 shows the variability of scores given by the judges to the three categories of fresh roe among the attributes evaluated. Product 'A' obtained the highest scores in all attributes except for flavor, which was obtained by product 'C', but with the lowest scores for the other attributes. Product 'B' showed intermediate scores in all attributes evaluated.

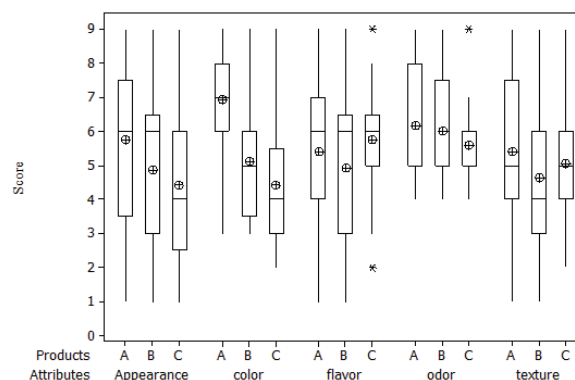


Figure 4. Boxplots of scores given by the judges for the products, considering the attributes in the sensory analysis of fresh roes of rock-boring urchin (*E. lucunter*). The circles represent the means and the asterisks the extreme values.

Roes of female sea urchins are commonly associated with sulphur odor and a metallic bitter taste, while the roes of male sea urchins are associated with a sweet taste. Studies on *Evechinus chloroticus* conducted in New Zealand showed that the sweet taste of roes of male sea urchins is related to the concentration of glycine in the testicles (Phillips et al., 2010a, 2010b). According Kato and Schroeter (1985), in California, the orange color of roes come from male sea-urchin, yellow color of females, and Bernard (1977) and Kramer and Nordin (1975) found the same correlation for red sea-urchins in Columbia British. This study confirmed the similar results for sample 'C' Moderate Dark Orange, although not more attractive with regard to color, texture and appearance, has achieved the highest score for flavor and probably come from males of sea-urchin specimens, more delicate and sweet taste.

The astringent potassium alum prolongs the shelf life of processed roes and is efficient in the removal of impurities from the product; however, it can change the sweet taste of the roes (Kato & Schroeter, 1985). The sea urchins used in the current study were collected in the austral spring and immersed in a potassium alum solution, factors that, along with the lack of consumption habit, may have contributed to the low scores, mainly for flavor.

The multi-varied chart in Figure 5 show the means of scores of the attributes, products and buying intend (yes or no) and also show that between the attributes and products interactions exists. The products A, B and C have the means of the attributes within a same rank, with or without purchase interest. However, the means were slightly higher when there was purchase interest. For judges who had intended to buy the product A obtained the highest scores for almost all attributes, except for appearance and flavor, that were for products B and C respectively.

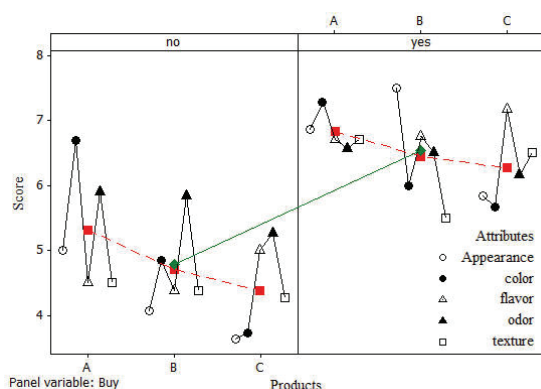


Figure 5. The black lines connect the means of the scores of each attribute, the red lines connect the means reached for each product and the green line connects the means of the scores of purchase intend (yes or no).

In the GLM model ($r^2 = 0.23$; $n = 51$) significant differences among products (ANOVA: $F = 5.78$; $p = 0.004$) and purchase intent (ANOVA: $F = 34.72$; $p = 0.0001$) was observed, however, among the attributes evaluated significant differences do not exist (ANOVA: $F = 1.42$; $p = 0.238$), as well as in the interactions (ANOVA: $p > 0.05$). The multiple comparison of Tuckey indicated significant differences ($p < 0.05$) of the score for product 'A' in relation of the other products.

On the scale of preference, product 'A' obtained the best score (20 points), followed by 'C' (17 points) and 'B' (14 points), and the ordinal logistic regression model did not show enough evidence ($G = 0.393$, $GL = 2$, $p = 0.822$) on consumer preference with regard to age and gender of the judge. The values of acceptance index (AI) for evaluated attributes are shown in Table 2 and indicate the highest value for color of product 'A'.

The index of acceptance (IA) for the attributes evaluated indicating that only the attribute color of product 'A' was within $\geq 70\%$, so we agree with Leon, Mery, Pedreschi, and Leon (2006), that report the color as the first quality parameter evaluated by

consumers, and it is fundamental for product acceptance. Phillips et al. (2010a) concluded that there is influence of season, sex and reproductive maturity on the sensory properties of the roes (appearance, odor, flavor, aroma, texture). These same authors indicate that during the southern fall, roes of female sea urchins show sensory quality similar to those of male sea urchins (less bitter and sweeter), and although the relative size of the roe is smaller in the fall, it seems to be the ideal season for harvesting high quality roes. Possibly the capture period of sea-urchin, in this study (early spring), may have influenced the sensory quality and acceptability of roes, especially in flavor of roe from females.

Table 2. Index of acceptance (IA) for attributes appearance, color, odor, texture and flavor of roes of rock-boring urchin (*E. lucunter*).

Category	IA appearance (%)	IA color (%)	IA odor (%)	IA texture (%)	IA flavor (%)
A	64.0	77.1	68.5	60.1	60.1
B	54.2	56.7	66.7	51.5	54.9
C	49.0	49.0	62.0	56.1	64.0

In northeastern Brazil, coastal communities use roes of species *E. lucunter* as food and as a means of subsistence (Carneiro & Cerqueira, 2008). Communities in southern Brazil, market roes of *E. lucunter* and *Lytechinus variegatus* to large Japanese restaurants in São Paulo and Rio de Janeiro cities in Brazil, however, sea urchin is not considered a fishing resource. The fish requires a lot of care with respect to its handling during the process of capture, storage, processing and distribution, as it is highly perishable (Mukundan, Antony, & Nair, 1986). The adoption of health measures is of fundamental importance to ensure the quality and increase the reliability of sea food (Vieira, 2004). The fresh consumption of sea urchin roes and sales of entire animal, directly to the consumer, in major markets in Brazil exist, and is required the adoption of hygiene and sanitary actions for the handling and consumption of roes, keep cold during exposure for sale, besides the origin and quality of the product.

The scenario of increasing trend of roes consumption of *E. lucunter* due the great impulse of the gourmet market of seafood in Brazil, justifies the development of public policy programs for the sustainability of the species and sufficient sanitary conditions to ensure quality and food safety for consumers.

Conclusion

The methodology of potassium alum used was efficient to prepare *nama uni* from roes of *E. lucunter*.

The color attribute was more relevant in the acceptance, preference and purchase intent from processed fresh roes. The extraction process might be improved in order to minimize occasional rupture of the gonads, so we recommend further studies on the reproductive biology of rock-boring urchin *E. lucunter*, for evaluation of suitable harvest period. The implementation of public policies through fisheries management and the research and development of sea-urchin commercial culture, addressed to sustainability of species and food safety for consumers.

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Received on November 18, 2015.

Accepted on June 1, 2016.

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