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Mangrove root crab *Goniopsis cruentata* (Latreille, 1803) processed meat quality by artisanal fisherwoman's in Cajazeiras, Sergipe-Brazil

Caranguejo-raiz de mangue Goniopsis cruentata (Latreille, 1803) qualidade da carne processada por pescadoras artesanais em Cajazeiras, Sergipe-Brasil

Cangrejo de raíz de manglar Goniopsis cruentata (Latreille, 1803) calidad de carne procesada por pescadoras artesanales en Cajazeiras, Sergipe-Brasil

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Abstract
In Sergipe, the mangrove root crab (*Goniopsis cruentata*, Latreille), known in Brazil as "aratu" is considered one of the main fishing resources for the artisanal fisherwoman in Cajazeiras, Sergipe-Brazil, since mangrove root crab meat chain process is a culture and traditional work activity passed down *for* generations. So far, no studies assessed the quality of the processing performed by artisanal fishers in Cajazeiras. Therefore, this study aimed to investigate physico-chemical and microbiological characteristics of packaged or unpackaged meat in vacuum of these artisanal fisherwoman's. The results revealed that the packaging process of the vacuum mangrove root crab meat did not favor the development of thermotolerant coliforms microorganisms, different from the results obtained in the mangrove root crab meat sample packed only in polyethylene bags. It was also found that samples of mangrove root crab meat packed in vacuum and in low density polyethylene bags showed no evidence of coagulase positive *Staphylococcus*, as well as the absence of *Salmonella sp*. It should be emphasized that the use of vacuum packaging may be a method that will increase the shelf life of the product, since the intrinsic factors of the sample such as alkaline pH and relatively high humidity are already positive factors for the development of microorganisms.
Keywords: *Goniopsis cruentata*; Crab; Seafood; Meat quality.

Resumo
Em Sergipe, o caranguejo-raiz-do-mangue (Goniopsis cruentata, Latreille), conhecido no Brasil como "aratu", é considerado um dos principais recursos pesqueiros da pescadora artesanal de Cajazeiras, Sergipe-Brasil, uma vez que o processo da cadeia da carne do caranguejo-raiz-do-mangue é uma cultura e a atividade de trabalho tradicional transmitida por gerações. Até o momento, nenhum estudo avaliou a qualidade do processamento realizado por pescadores artesanais em Cajazeiras. Portanto, este estudo teve como objetivo investigar características físico-químicas e microbiológicas de carnes embaladas ou não embaladas a vácuo dessas pescadoras artesanais. Os resultados revelaram que o processo de embalagem da carne de siri a vácuo não favoreceu o desenvolvimento de

microrganismos coliformes termotolerantes, diferentemente dos resultados obtidos na amostra de carne de siri acondicionada apenas em sacos de polietileno. Verificou-se também que amostras de carne de caranguejo-raiz de mangue embaladas a vácuo e em sacos de polietileno de baixa densidade não apresentaram evidência de Staphylococcus coagulase positiva, bem como a ausência de Salmonella sp. Ressalta-se que o uso de embalagem a vácuo pode ser um método que aumentará a vida útil do produto, uma vez que os fatores intrínsecos da amostra como pH alcalino e umidade relativamente alta já são fatores positivos para o desenvolvimento de microrganismos.
Palavras-chave: *Goniopsis cruentata*; Caranguejo; Frutos do mar; Qualidade da carne.

Resumen
En Sergipe, el cangrejo raíz de mangle (*Goniopsis cruentata*, Latreille), conocido en Brasil como "aratu", es considerado uno de los principales recursos pesqueros para la pescadora artesanal de Cajazeiras, Sergipe-Brasil, ya que el proceso de la cadena de carne del cangrejo raíz de mangle es una cultura y la actividad laboral tradicional se transmite de generación en generación. Hasta el momento, ningún estudio evaluó la calidad del procesamiento realizado por los pescadores artesanales en Cajazeiras. Por lo tanto, este estudio tuvo como objetivo investigar las características fisicoquímicas y microbiológicas de la carne envasada o sin envasar al vacío de estas pescadoras artesanales. Los resultados revelaron que el proceso de envasado al vacío de la carne de cangrejo raíz de manglar no favoreció el desarrollo de microorganismos coliformes termotolerantes, a diferencia de los resultados obtenidos en la muestra de carne de cangrejo raíz de manglar envasada únicamente en bolsas de polietileno. También se encontró que las muestras de carne de cangrejo raíz de manglar empacadas al vacío y en bolsas de polietileno de baja densidad no mostraron evidencia de *Staphylococcus* coagulasa positivo, así como la ausencia de Salmonella sp. Cabe recalcar que el uso del envasado al vacío puede ser un método que aumente la vida útil del producto, ya que los factores intrínsecos de la muestra como el pH alcalino y la humedad relativamente alta ya son factores positivos para el desarrollo de microorganismos.
Palabras clave: *Goniopsis cruentata*; Cangrejo; Mariscos; Calidad de la carne.

1. Introduction

In Sergipe, the mangrove root crab (*Goniopsis cruentata*, Latreille), known in Brazil as "aratu," is a crustacean that has fluctuating economic value dependent on the demand, reproduces easily, and is available all year round. It can be found in Florida (USA), Bahamas, Mexico, Honduras, Cuba, Jamaica, Puerto Rico, Barbados, Curaçao, Venezuela, Suriname, and Brazil – mainly in the northeast – inhabiting estuarine regions, between the trunks and mangrove roots (Moreira, 1899, Holthuis, 1959; Chace & Hobbs, 1969). Little research talks about this crab. Vedolin, et al., (2020) in study Cardoso and São Vicente Islands on the coast of the State of São Paulo, quantified the accumulation of metals in the Goniopsis cruentata, the levels of metals in muscle tissue were above the maximum permissible limits established for food by Brazilian legislation. Davanso et al. (2013) report in their research that *G. cruentata* to represent a proper species to monitor the quality of tropical estuaries, of Fortaleza Metropolitan Region- Ceará State.

In the northeastern region of Brazil no machine-processed products based on mangrove root crab meat are available. Instead it is being marketed chilled or frozen, and packed in polyethylene bags, in the central market or at fairs. However, this type of product is usually not processed under satisfactory hygienic-sanitary conditions. Most people involved in handling and processing the crab meat lack the knowledge about hygienic-sanitary care that should be observed in the handling and processing, and they may be asymptomatic carriers of microorganisms that can cause contamination of food. In order to comply to food safety standards, it must be free of pathogenic and deteriorating microorganisms, which, if present, could compromise the quality of the product. In order to achieve this, it is necessary to apply conservation and sterilization procedures, guaranteeing the quality and a longer shelf life of this product, taking into account that crustaceans are susceptible to a faster deterioration due to large amounts of free amino acids and nitrogen compounds (Anacleto et al., 2011).

Several reactions after death are triggered in crustaceans, in which endogenous and bacterial enzymes, as well as extrinsic factors such as temperature, result in protein degradation affecting shelf life (Lorentzen et al., 2016). Conservation, therefore, consists in keeping the food as stable as possible with regard to microbiological factors. It is necessary to delay the proliferation of microorganisms by controlling variables such as temperature, pH, and humidity. Among the methods favorable

to the reduction of microbial growth are treatments with salt application, thermal application, acidification, use of modified atmosphere packaging, and irradiation (Forsythe, 2002).

Numerous seafood products are customarily packaged and pasteurized in sealed plastic or metal cans. The packaging in plastic and metal cans is common in the industry and widely accepted commercially. The canning industry is one of the most important sectors of the fishing industry, both by tradition and by the significance it has for the trade balance. The discovery of sterilization by the Frenchman Nicholas Appert and the utilization of the tin can by the Englishman Peter Durand gave rise to the preservation as it is still known today. Generally, the preserved product is a food product packed in a hermetically sealed container and subjected to a heat treatment that destroys or inhibits micro-organisms and their toxins. It guarantees a stable food product with long storage capacity, even under adverse conditions (Gonçalves & Duarte, 2000). There are several methods and materials for packaging mechanically processed foods, generating an area of great growth and innovation at the technological level. These innovations aim to maintain food quality over a longer period of time, while simultaneously seeking to produce a lower environmental impact through new applications of materials obtained from renewable sources (biopolymers), leading to compostable products and / or material reduction. However, despite the innovations, packaging continues to take only into account the four following aspects: i) contain food; ii) protect the product, minimizing loss of quality throughout its useful life; iii) provide information to the consumer and make it function as a marketing tool; (iv) facilitate the use, that is, offer convenience to consumers (Yam et al., 2005). The materials most used in packaging are plastic and, to a lesser extent, metals, glass, and paper. They are economical, versatile, and flexible materials, although some cannot be recycled (Haugaard & Mortensen, 2003).

The use of packaging, such as vacuum packaging, helps in the quality of animal products, preventing the total or partial growth of microorganisms (Silva, 2022). Vacuum packaging has shown potential for seafood preservation (Li et al., 2011). Its packaging material adheres to the product due to the decrease in internal pressure compared to atmospheric pressure and the method can be used for various fish products (Ju et al., 2018), Ultimately, control of oxygen levels in food packages is important in order to limit the rate of spoilage reactions in food (Biji, Ravishankar, Mohan & Gopal, 2015).

This study compare the physical-chemical and microbiological characteristics of vacuum-packed crab meat with that hand-packed by fishermen in Cajazeiras, Sergipe, Brazil.

2. Methodology

Crab meat samples were collected in Cajazeiras, Sergipe-Brazil. The local artisanal fisherwomen processed the aratu's legs by placing them in a sodium chloride solution at a temperature above 60°C for 35 minutes. After cooking, manual extraction of the meat began. Part of the meat was packed in low-density polyethylene bags and the other in vacuum packs. After collection at the processing site, the samples were identified and packed in isothermal boxes, then transported to the Food Microbiology Laboratory of the Department of Nutrition at the Federal University of Sergipe, Brazil, where the physicochemical and chemical analyzes were carried out. microbiological.

2.1 Physico-chemical evaluation

The following analytical parameters were adopted: Humidity – Determined by constant weight after oven drying at 105 ° C; Proteins – Determined by way of the evaluation of the total nitrogen in the sample via the Kjeldahl method executed at the semimicro level – it uses the nitrogen conversion factor for protein of 6.25; Lipids - Determined in Soxhlet with solvent, petroleum ether; Ashes - Determined in muffle at 550ºC; pH – were weighed 10 g of crab meat in a beaker and diluted with the aid of 100 mL of water and determined with the device previously calibrated (Brasil, 2008). All analyzes were performed in triplicates.

2.2 Microbiological evaluation

The following microbiological analyzes were performed: enumeration of *Staphylococcus aureus*, enumeration of coliforms at 35 ° C, enumeration of coliforms at 45 ° C, research of *E. coli* and research of *Salmonella sp*. (Silva et al., 2017).

2.3 Statistical analysis

With the aid of the IBM SPSS Statistics® software, version 21 (2012), the chemical composition data were submitted to analysis of variance (ANOVA) for repeated measures to verify the homogeneity. The homogeneous averages ($p>0.05$) were submitted to the Tukey and Bonferroni parametric test. The variables that presented $p<0.05$ were submitted to the Kruscal-Wallis non-parametric test to check for differences between treatments. The p-values were considered significant when smaller than 0.05.

3. Results and Discussion

3.1 Physical-chemical evaluation

Table 1 shows that the two samples did not present significant differences ($p> 0.05$), but they display high values for moisture that could accelerate the development of pathogens. Therefore, the packaging of mangrove root crab meat under the vacuum system could contribute to the decrease of growth of aerobic microorganisms. The value obtained above are those mentioned by Santos Reis, Souza & Nunes (2010) when analyzing the moisture content of the meat of mangrove root crab after cooking, namely, the value of 69.75% of moisture. But, according to Gonçalves (2011) the humidity can vary in crustaceans (60 to 85%) dependent on the species, time of year, age, sex, and nutrition. Anacleto et al. (2011) investigated the shelf life of cooked meat crab (*C. paguros*) vacuum-spacked during refrigeration, and the results indicated 76.9±0.2% of moisture – this result corroborate with those found in this research, although the research was carried out on another species.

Table 1 - Physical-chemical composition of mangrove root crab meat (Goniopsis cruentata) submitted or not to the vacuum preservation process.

Parameters analyzed	A	AF
Moisture (g/100g)	**74.67 ± 0.10[a]**	**74.56 ± 0.28[a]**
Protein (g/100g)	**21.44 ± 0.31[b]**	**22.38 ± 0.42[a]**
Fat (g/100g)	**1.02 ± 0.26[a]**	**1.11 ± 0.13[a]**
Ash (g/100g)	**1.85 ± 0.08[a]**	**1.00 ± 0.05[b]**
pH	**8.04 ± 0.09[a]**	**8.13 ± 0.01[a]**

The results are averages ± standard deviation. The same lowercase letters in the same line indicate the absence of significant differences ($p > 0.05$). A (Mangrove root crab meat packed in vacuum); AF (Mangrove root crab meat packed in polyethylene bags). Source: Authors (2022).

The percentage of proteins differed statistically between the samples in the present study (Table 1), but this parameter may change according to species, size, sex, time of year, among other factors (Gonçalves, 2011). A number of studies have been carried out to investigate the effects of vacuum packaging on crab meat of the *Maja brachydactyla* and *C. paguros* species as demonstrated by Marques et al. (2010) and Anacleto et al. (2011) respectively. This research obtained higher content of proteins for the meat of mangrove root crab in the two types of packaging compared with *Maja brachydactyla* and *C. paguros* species.

In relation to the lipid contents, it was observed that there were no significant differences between the samples ($p> 0.05$) and this corroborates with the data obtained by Santos et. al. (2010) for the meat of mangrove root crab and crab meat of

Cancer pagurus after cooking (Maulvault et al., 2012). Lipids play an important role as an energy source in fish and their quantity can easily vary due to diet and composition of the plankton (Sinanoglou, Meimaroglou & Miniadis-Meimaroglou, 2008).

Ash analyzes are performed to verify the content of minerals in food. This minerals may be from the meat itself but also from the addition of salt to the cooking water. Table 2 shows that there are significant differences between the samples, in which the values are higher for the aratu meat packed in vacuum. However, these values are lower than those reported by Santos et al. (2010), which states that the ashes content of cooked mangrove root crab meat is 2.55% and of the processed products develop in the work 3.01 and 2.76%, resulted from the addition of salt and seasoning. Results higher than those found in this research were also reported for crab meat of *Cancer paguros* (Marques et al., 2010; Maulvault et al., 2012).

In the pH parameter the samples displayed the same statistic behavior ($p > 0.05$), hence presenting higher values than the one recommended for crustaceans in the Regulation of the Industrial and Sanitary Inspection of Products of Animal Origin (Brasil, 2017), stating that the pH of the meat should be less than 7.85 in crustaceans. But, according to Santos et al. (2010) these values are normal for crab meat due to the higher content of non-protein nitrogenous compounds in crustaceans (Anacleto et al., 2011). Similar values were found in the crab meat of Chioneocetes opilio stored at 0 and 4ºC (Lorentzen et al., 2016).

It should be emphasized that the use of vacuum packaging may be a method that will increase the shelf life of the product, since intrinsic factors such as alkaline pH and relatively high humidity are contributing to the development of microorganisms.

3.2 Microbiological evaluation

Table 2 shows that the vacuum-packed samples presented results within the standard limits established for total and thermotolerant coliforms, according to the standards in force at the time of the research (Brasil, 2001), which recommends a maximum value of 5x10 MPN. g^{-1} for this group of microorganisms. From these results, it could be concluded that the packaging process of the vacuum mangrove root crab meat did not favor the development of these microorganisms. It differs from the results obtained in the mangrove root crab meat sample packed only in polyethylene bags, which, despite demonstrating a low total coliforms and thermotolerant, indicates that there were sanitary defects in the processing of the meat, such as recontamination after cooking. However, the presence of oxygen in the packaging probably favored the development of these microorganisms. Fresh ready-to-eat crab meat is potentially dangerous (Senkel Jr, 2005), so the use of vacuum packaging for marketing would reduce the possibility of contamination and avoid health problems for consumers.

Table 2 - Means ± standard deviations of total and thermotolerant coliforms in Probable Number (MPN.g^{-1}) in mangrove root crab meat (Goniopsis cruentata) submitted or not to the vacuum preservation process.

Samples	Total coliforms (MPN.g^{-1})	*E.coli* (MPN.g^{1})
A	<3.0 ± 0.0	<3.0 ± 0.0
AF	6.5 ± 3.5	<3.0 ± 0.0

<3.0 Indicates absence of total and thermotolerant coliforms. A (Mangrove root crab meat packed in vacuum) AF (Mangrove root crab meat packed in polyethylene bags). Source: Authors (2022).

It was also found that samples of mangrove root crab meat packed in vacuum and in low density polyethylene bags showed no evidence of coagulase positive *Staphylococcus*, as well as the absence of *Salmonella* sp. The Brazilian legislation

imposes microbiological criteria of coagulase positive *Staphylococcus* to a maximum of 10^3 CFU.g^{-1} and the absence of *Salmonella sp*. in 25g of meat obtained from boiled, cooled, or frozen crustaceans (Brasil, 2001).

It is suggested that the absence of *Salmonella sp.* in all samples is due to the cooking process of the crab (above 60°C and duration of approximately 30 minutes), as well as to the non-occurrence of contamination by this microorganism during the process of meat extraction.

Salmonella, E. coli and Staphylococcus aureus are recognized as etiological agents among seafood-borne diseases, so the prevention and control of bacterial contamination is dependent on the appropriate hygienic conditions in the processing of raw and cooked seafood (Elbashir et al., 2018).

4. Conclusion

The present study demonstrated that the packaging process of the vacuum mangrove root crab meat did not favor the development of these microorganisms, different from the results obtained in the mangrove root crab meat sample packed only in polyethylene bags, which, despite demonstrating a low total coliforms and thermotolerant, indicates that there were sanitary defects in the process of obtaining meat, which entailed recontamination after cooking, assuming also that the presence of oxygen in the packaging favored the development of these microorganisms. It was also found that samples of mangrove root crab meat packed in vacuum and in low density polyethylene bags showed no evidence of coagulase positive Staphylococcus, as well as the absence of Salmonella sp. It is suggested that the absence of *Salmonella sp.* in all samples is due to the cooking process of the crab (above 60°C and duration of approximately 30 minutes), as well as to he non-occurrence of contamination by this microorganism during the process of meat extraction. It should be emphasized that the use of vacuum packaging may be a method that will increase the shelf life of the product, since the intrinsic factors of the sample such as alkaline pH and relatively high humidity are already positive factors for the development of microorganisms.

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