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Effect of different smoking processes on the sensory and chemical attributes of two shrimps native to Brazil

Efeito de diferentes processos de defumação nos atributos sensoriais e químicos de dois camarões nativos do Brasil

Efecto de diferentes procesos de ahumado sobre los atributos químicos y sensoriales de dos camarones nativos de Brasil

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Abstract

The effects of smoking processes on the sensory and proximate components of two species of shrimp were evaluated. Sixty specimens of each species were distributed in a completely randomized design, with two treatments (T1 = hot smoking and T2 = liquid smoking), and fresh shrimps samples were used as control (T3). The sensory characteristics were evaluated using the 9 point hedonic scale and the acceptance index. The centesimal composition was evaluated based on 100 g from each treatment and the fresh samples. The data were submitted to one-way ANOVA and Tukey's test. The results of sensory analysis showed significant variations ($p < 0.05$) for the attributes analyzed among the species, whereas among the smoking processes there was no significance ($p > 0,05$). The acceptance rate was above 70% for amazonian prawn and 80% for white shrimp, regardless of the smoking method. The proximate analysis showed significant differences between the two smoking processes, hot and liquid, with moderet values of lipids, between 0.27% and 1.51%, and high protein values, of 24.61% 24.13%, for white shrimp and amazonian prawn, respectively. The smoking processes altered the sensory and chemical profile of the prawns, causing good acceptance and adequate nutritional constitution for smoked fish.

Keywords: Fishing technology; Crustacean; Acceptability test; Degustation.

Resumo

Foram avaliados os efeitos dos processos de defumação sobre os componentes sensoriais e proximais de duas espécies de camarão. Sessenta espécimes de cada espécie foram distribuídos em delineamento inteiramente casualizado, com dois tratamentos (T1 = fumagem a quente e T2 = fumagem líquida), e amostras frescas de camarão foram utilizadas como controle (T3). As características sensoriais foram avaliadas por meio da escala hedônica de 9 pontos e do índice de aceitação. A composição centesimal foi avaliada com base em 100 g de cada tratamento e nas amostras frescas. Os dados foram submetidos à ANOVA one-way e teste de Tukey. Os resultados da análise sensorial mostraram variações significativas (p <0,05) para os atributos analisados entre as espécies, enquanto entre os processos de tabagismo não houve significância (p> 0,05). A taxa de aceitação ficou acima de 70% para o camarão amazônico e 80% para o camarão branco, independentemente do método de defumação. A análise proximal mostrou diferenças significativas entre os dois processos de defumação, quente e líquido, com valores moderados de lipídios, entre 0,27% e 1,51%, e altos valores de proteína, de 24,61% 24,13%, para camarão branco e camarão amazônico, respectivamente. Os processos de defumação alteraram o perfil sensorial e químico dos camarões, proporcionando boa aceitação e constituição nutricional adequada para pescados defumados.

Palavras-chave: Tecnologia do pescado; Crustáceos; Teste de aceitabilidade; Degustação.

Resumen

Se evaluaron los efectos de los procesos de ahumado sobre los componentes sensoriales y próximos de dos especies de camarón. Se distribuyeron sesenta ejemplares de cada especie en un diseño completamente al azar, con dos tratamientos (T1 = ahumado en caliente y T2 = ahumado líquido), y se utilizaron muestras de camarones frescos como control (T3). Las características sensoriales se evaluaron mediante la escala hedónica de 9 puntos y el índice de aceptación. La composición centesimal se evaluó en base a 100 g de cada tratamiento y las muestras frescas. Los datos se sometieron a ANOVA de una vía y prueba de Tukey. Los resultados del análisis sensorial mostraron variaciones significativas (p <0.05) para los

atributos analizados entre las especies, mientras que entre los procesos de ahumado no hubo significancia (p> 0.05). La tasa de aceptación fue superior al 70% para el camarón amazónico y al 80% para el camarón blanco, independientemente del método de ahumado. El análisis próximo mostró diferencias significativas entre los dos procesos de ahumado, caliente y líquido, con valores moderados de lípidos, entre 0.27% y 1.51%, y altos valores de proteína, de 24.61% 24.13%, para camarón blanco y langostino amazónico, respectivamente. Los procesos de ahumado alteraron el perfil sensorial y químico de las gambas, provocando una buena aceptación y una adecuada constitución nutricional de los ahumados.
Palabras clave: Tecnología pesquera; Crustáceos; Prueba de aceptabilidad; Degustación.

1. Introduction

Among the species explored on the coast of Brazil, the white shrimp (*Litopenaues schmitti* Burkenroad, 1936) has significant economic and ecological importance, since this is the only species belonging to the genus *Litopenaeus*, occurring in Brazilian native waters (Maggioni et al., 2003). This species has distribution along the western Atlantic coast, from the Antilles to the State of Rio Grande do Sul in Brazil (Péres-Farfante, 1970; D'Incao, 1995). Another important species native to South America is the Amazonian prawn (*Macrobrachium amazonicum* Heller, 1862), as it has great geospatial importance and wide acceptance by the populations of the Amazon region (Maciel & Valenti, 2009).

Shrimps are highly perishable foods due to the intrinsic characteristics of their meat, such as high water activity, pH close to neutrality, and content of oxidazible unsaturated fatty acids, which compromise the product's shelf life (Franco & Landgraf, 2008; Liu et al., 2013). Thus, seafood is subject to physical-chemical, sensory, and microbiological changes that influence the loss of quality, associated with enzymatic, oxidative, and bacterial factors (Ferreira et al., 2014). For these reasons, the conservation processes and technological transformations of seafood have gained importance aiming at guaranteeing the most extended shelf life of their products and derivatives (Godoy et al., 2010).

As a technology for fish conservation, the smoking process stands out, as it gives the final product optimized sensory characteristics (Ordóñez, 2005). Among the most used methods, hot smoking aims to add sensory qualities to food, such as aroma, texture, and appearance, by the action of the chemical composition of the applied smoke (Souza, 2004). In addition to the benefit of extending the shelf life of the product, through the dehydration process and consequent reduction of water activity in seafood, which inhibits the action of deteriorating bacteria, there is the combined effect of salting, cooking, drying and deposition of bactericidal chemical substances present in smoke such as phenols, aldehydes and organic acids (Miler & Sikorski, 1990; Souza, 2004).

Another process is the application of smoke in its liquid state applied directly to the brine, by spraying or atomization, to provide the permeability of its constituents in the product. This process guarantees a pleasant taste, golden and bright color on the surface, with greater product attractiveness to the consumer (Makawa et al., 2019). Such a methodology can be adopted in order to to guarantee product safety (Nithin et al., 2020). In addition to larger varieties of smoke available in the market, liquid smoking is considered a more sterilizing process with less environmental impact. During this process, antioxidant and antimicrobial substances are released and smaller amounts of carcinogenic ones, such as hydrocarbons and benzopyrenes (Costa et al., 2008).

Because of this, sensory analysis stands out as a practical and effective method in assessing the quality and acceptance of a new food product, where only chemical analysis does not replace the perception of sensory receptors and consumer preferences (Amaral et al., 2016). Besides, knowledge of the chemical composition of fish is essential for the standardization of food products based on nutritional criteria (Simões et al., 2007).

Thus, the present study aimed to evaluate the sensory characteristics, product acceptance and the proximate composition of two native Brazilian shrimp species submitted to traditional smoking processes.

2. Material and Methods

Acquisition of samples

The samples of white shrimp (*Litopenaeus schmitti* Burkenroad, 1936) and shrimp from the amazon prawn (*Macrobrachium amazonicum* Heller, 1862) were purchased at the fish market in Bragança-Pará, Brazil. The specimens were washed in chlorinated water at 5 ppm, separated by species, headed and placed in a sieve to eliminate excess water. Soon after, they were divided into two batches, one for each species and then, the processing of the material was carried out: salting and smoking (hot and liquid).

Salting process

In this step, the prawns were submerged in a 5 ppm chlorine solution for 5 minutes and transferred to drying containers to remove excess solution. Then they were emerged for 5 minutes in hot brine (100°C), with a concentration of 15% NaCl, in the proportion of 1:2 (weight.volume^{-1}). For the sterilization of salt crystals and colonies of pathogenic and deteriorating bacteria (Perry, 2004).

Warm smoking method

For hot smoking, sawdust and pieces of non-resinous wood were used in an artisanal smoker as a smoke source. The fish subjected to this smoking process was placed in the smoker immediately after leaving the brine. The prawns were placed on a metal screen and smoked for 120 minutes at a controlled temperature of 70ºC to 85ºC.

Liquid smoking method

For liquid smoking, a concentration of 1.0% of liquid smoke was used, diluted in water in the proportion 2:1 (volume.weight-1). The prawns were immersed in the smoking solution for 30 minutes. Afterwards they were placed in an oven with forced air circulation at 70°C. Every 30 minutes the temperature was raised by 10°C until it reached a temperature of 90°C, maintained like this for another 30 minutes following the recommendations of the manufacturer SMOKES® (Empresa Adicon - Indústria e Comércio de Adificados Ltda).

Experimental design

Sensory analyzes were conducted in a completely randomized design with two treatments (T1 = hot smoking; T2 = liquid smoking) and 60 repetitions for each species. For analyzes of the proximate composition, 100g of shrimp from each treatment were used for both species, plus a positive control (T1 = fresh control; T2 = hot smoking; T3 = liquid smoking).

Sensory analysis

The samples of the shrimp smoked by the two processes were sensorially evaluated by 60 untrained employees. The samples were wrapped in aluminum foil, heated in a microwave oven and arranged at random in plates with the identification of two three-digit codes for each sample of each treatment. Between the analysis of one sample and another, employees received water to neutralize the taste and not alter the results of the personal analysis between the shrimp species and the smoking process used.

The samples were served together with a sensory evaluation form, to estimate the appearance, aroma, color, flavor, texture and global acceptance attributes. For this, the hedonic scale of nine points with extremes 1 (I disliked it a lot) to 9 (I liked it a lot) was used, according to Dutcosky (2009). At the same time, the frequency of consumption, also known as the attitude scale, was checked using a nine-point equivalence with extremes 1 (I would only eat this if forced) and 9 (I would eat this whenever I had the chance), according to Minim (2006). To evaluate the purchase intention, a five-point scale test was used, which also showed extremes from 1 (certainly not buy) to 5 (certainly buy), according to Meilgaard et al. (1999). The acceptance index was calculated using the mathematical expression IA% = X.100.N-1, where X represents the average of each sample and N the maximum score of each sample given by the tasters. The cutoff criterion used to consider good acceptance of the index was set at 70% or more (Amaral et al., 2016).

Centesimal composition

For the analysis of the proximate composition, the moisture content was determined gravimetrically, using an oven at 105 °C for 24 hours until constant weight. Total ash was obtained by incinerating the material in a muffle furnace at 550 °C for 6 hours. The lipid was obtained by continuous extraction with ethyl ether in a Soxhlet apparatus. Protein determination was performed using the Kjeldhal method, using factor 6.25 for samples of animal origin. All analyzes were performed in triplicates according to AOAC (2000).

Statistical analysis

The data were previously subjected to tests of the premises of normality (Shapiro-wilk) and homoscedasticity (Levene). Confirmed these premises followed the parametric test

(ANOVA one-way), for data from sensory analysis, purchase intention, frequency of consumption, and proximate composition of the products. When statistical differences were observed (p <0.05), the Tukey test pos hoc test to separate the groups of means. All statistical analyzes were done using the statistical program BIOSTAT 5.0 (Ayres et al., 2007).

3. Results

The results for sensory acceptance, frequency of consumption, intention to buy and acceptability index appeared statistically significant ($p < 0.05$) (Table 1) for the treatments of both shrimp species *M. amazonicum* and white *L. schmitti*.

Table 1. Mean values ± standard deviation of smoking process for liquid and hot smoke for white shrimp *L. schmitti* and amazon shrimp *M. amazonicum* (n = 60) using the 9 - point hedonic scale and the acceptance index.

Characteristics	Treatments of *L. schmitti*		Treatments of *M. amazonicum*	
	T1	T2	T1	T2
Appearance	7.68 ± 1.03 a	7.65 ± 1.16 a	6.17 ± 1.77 b	5.93 ± 1.86 b
Smell	6.90 ± 1.53 a	6.93 ± 1.44 a	6.20 ± 1.49 b	6.15 ± 1.55 b
Color	7.67 ± 1.27 a	7.52 ± 1.26 a	6.03 ± 1.68 b	5.95 ± 1.64 b
Flavor	7.18 ± 1.69 a	7.10 ± 1.37 a	6.08 ± 1.91 b	6.08 ± 1.75 b
Texture	7.53 ± 1.23 a	7.15 ± 1.41 a	6.33 ± 1.56 b	6.15 ± 1.64 b
Global acceptance	7.35 ± 1.35 a	7.37 ± 1.22 a	6.20 ± 1.50 b	5.97 ± 1.50 b
Feeding intake	6.88 ± 1.90 a	6.90 ± 1.72 a	5.70 ± 1.94 b	5.63 ± 2.03 b
Buy intention	3.68 ± 1.27 a	3.65 ± 1.18 a	2.90 ± 1.17 b	2.90 ± 1.15 b
Acceptance Index	81.67	81.85	71.11	70.33

Note: T1: Hot smokin; T2: liquid smoking; Different letters in the same row mean statistical difference by Tukey test ($p<0.05$). Source: Authors.

The The results of the proximate composition of the treatments T1 (hot smoking), T2 (liquid smoke) and T3 (fresh shrimp), for both species, showed significant differences (p < 0. 05) for all constituents, moisture, ash, lipids and proteins (Table 2).

Table 2. Average values of centesimal analysis of fresh and processed prawns by two smoking processes.

Treatment	*Litopenaeus schmitti*			
	Moisture (%)	Ashes (%)	Lipid (%)	C. Protein (%)
T1	76.71 ± 0.05 a	3.85 ± 0.11 c	0.12 ± 0.09 b	16.97 ± 0.09 c
T2	56.04 ± 0.04 c	8.24 ± 0.13 a	0.36 ± 0.11 a	30.24 ± 0.12 a
T3	61.92 ± 0.07 b	6.40 ± 0.14 b	0.33 ± 0.07 a	26.64 ± 0.17 b
	Macrobrachium amazonicum			
T1	77.14 ± 0.14 a	3.09 ± 0.01 c	0.9 ± 0.01 c	15.45 ± 0.07 c
T2	54.24 ± 0.15 c	7.95 ± 0.03 a	1.98 ± 0.05 a	29.84 ± 0.04 a
T3	59.96 ± 0.08 b	6.23 ± 0.01 b	1.67 ± 0.02 b	27.12 ± 0.07 b

Note: T1 – Shrimp in nature as control, T2 – Warm smoking process, T3 – Liquid smoking process, Different letters in the row mean statistical difference by Tukey test ($p<0.05$). Source: Authors.

4. Discussion

The Appearance is one of the essential sensory attributes for the acceptance of smoked products since it has a direct relationship with color, followed by aroma, flavor and texture. In this sense, the phenolic compounds and aldehydes adhered to the surface of the product during its processing enhance and intensify the color with golden-red tones making it more attractive (Santana et al., 2010).

Processing at temperatures above 35ºC triggers muscle fat, intensifying aspects of appearance, color and shine, in addition to the retention of aromatic substances from smoke by fat droplets, giving better flavors and pleasant odors to the final product (Galvão & Oetter 2014; Dias et al., 2018). Results above 4 on the scale of appearance, color and texture were evidenced for the pink shrimp (*Farfantepenaeus brasiliensis*), smoked with and without shell, below the observed results in the present study for both species Silva et al. (2017).

The acceptance rate of a given food must be higher than 70%, considering its sensory quality characteristics in a global perception (Queiroz & Treptow 2006). Thus, the results of the present study, the average acceptance index, for white shrimp, were 81.67% and 81.85%, and for amazonian prawn it was 71.11% and 70.33%, smoked hot and liquid smoke, respectively. Knowledge of consumer acceptability is important in creating an image of attractiveness, which is a sustained demand for a particular product if introduced to the market (Makawa et al., 2019).

In the evaluation of the frequency of consumption, the shrimp *L. schmitti* smoked by the cold method with liquid smoke showed the best result for this index, with an average of 6.90 and and the concept "I would eat this often" being highlighted . For *M. amazonicum*, the results for both smoking methods were similar, with 6.13. In this case, the concept attributed by the tasters was "I like this and would eat from time to time". The increase in sensory acceptability of products processed at temperatures between 30 to 50 °C in liquid smoke is desirable; however, elevated temperatures may lead a higher exposure to phenolic compounds and other flavoring compounds, which produces a bitter taste in the product (Nithin et al., 2020). In this case, liquid smoke stands out, as its use occurs at lower temperatures.

Thus, it should be noted that the liquid smoking method performed better than the traditional method for both species, since the smoke properties may have added better aromas, aspects of appearance and even flavor, making the product more attractive for the consumer. These results corroborate those found by Defaveri et al. (2016), who found values of 6.61, being among the concepts “I like this and would eat from time to time” and “I would eat this often”, for tilapia smoked ham.

Buy intentions, together with the acceptability test, are complementary to sensory analysis. Thus, the results pointed to purchase intention values of 3.68 and 3.65 for the species *L. schmitti* and 3.25 and 3.20 for the species *M. amazonicum* smoked hot and liquid, respectively. This data falls between the concepts ‘‘possibly buy’’ and ‘‘maybe buy / maybe don’t buy’’. Observed similar results in the sensorial and proximate characterization of fishburgers, from mechanically separated tilapia meat (Marengoni et al., 2009). The consumer's purchase intention is related to a complex decision-making process, influenced by several factors including price, convenience and marketing, constituting, along with sensory analysis, the determining characteristics in the product purchase decision (Guerrero et al., 2000).

According to Ogawa (1999), fresh seafood has average humidity values of 60 to 85%, corroborating the average values observed in the present study in T1 treatment with an amount of around 75%. Thus, moisture content registered a sharp drop for treatments using the two smoking processes compared to the control. This variation is related to dehydration caused by heat exchange during the process of hot smoking, and osmotic regulation observed during liquid smoking. However, the brine process is an additional factor in reducing the moisture content by dehydrating the osmotic process, in removing free water from the fish tissue (Sigurgisladottir et al. 2000; Gonçalves & Cezarini 2008).

Similar results were obtained by Lira et al. (2013), where they observed moisture content of the seven-bearded shrimp (*Xiphopenaeus kroyeri*) in natura of 77.87% and smoked of 40.32%. Silva et al. (2010), state that the decrease in humidity is due to the absorption of sodium chloride in the salting process and, consequently, an increase in the ash content in the hot smoking process. Thus, the T1 prawns showed results close to 3.5% and, for the T2 prawns close to 8% and T3 close to 6% for the ash constituent for both species. Kirschnik et al. (2006), reported similar results with a value of 1.35% for ashes, in the study with the same species, the shrimp seven beards in natura. However, Lira et al. (2013), observed lower values of ash for the species of seven-bearded shrimp (*X. kroyeri*) in natura of 1.73% and higher values for smoked shrimp with a value of 14.03%.

The increase in the lipid content observed in the T2 and T3 treatments is associated with dehydration due to the processing of salting and smoking. However, the process of hot smoking, caused a more significant dehydration due to the heat of the smoke and, consequently, a higher concentration of lipids and proteins in the proximate composition for both species. Furuya et al. (2006) reported a higher value of 1.5% of lipids in freshwater prawn *M. amazonicum* in the fresh form, however, they analyzed whole shrimp, justifying the high content of lipids, since most crustaceans store their energy reserves (hepatropancreas) in the cephalothorax. The species of Amazonian prawn *M. amazonicum* and white shrimp *L. schmitti*, can be considered fish with low fat content (<5%) (Contreras-Guzmán 1994). High values were found by Akintola (2015) with the species of southern pink shrimp Penaeus notialis, with amounts of 5.06% for fresh fish and 6.41% for the hot smoking process.

The lipid content is crucial for the smoking process. In general, the fatty fish, with the constitution above 10% of lipids are more indicated for this process, mainly for the fact that the fat content in the muscles interferes with the aroma and flavor of the smoked product (Nunes, 1999). The fat content of the fish acts as an absorbent of the aromatic substances present in the smoke (Geromel & Forster 1982).

Besides, burning wood releases substances such as volatile compounds, alcohols, carbonyls and hydrocarbons, which are considered bactericidal, inactivating pathogenic and deteriorating microorganisms (Sampels, 2015). Other compounds such as phenols, aldehydes and organic acids, components of smoke and the consequent combination of salting, cooking and dehydration of fish can extend the shelf life of the product (Assis et al., 2009).

The smoking process also changed the protein content, where the highest values were found for the T2 treatment for both species, indicating that the hot smoking process increases the content of these two important macronutrients in food. The variation in the values of proteins observed for fresh and processed products can be influenced by the eating habits of the species, freshwater and saltwater environments, sexual maturation, food quality and environmental seasonality, in addition to size and between species (Contreras-Guzmán, 1994).

As seen in the study with the southern pink shrimp (*P. notialis*), based on dry weight, where they presented values above 60% of proteins, effect of osmotic dehydration by the action of smoke (Akintola, 2015). Phenomenon also evidenced by Silva et al. (2017), with the pink shrimp (F. brasiliensis) that obtained average values of 28% of proteins after the use of the smoke. The consequent excessive loss of moisture resulting from the process of dehydration and leaching of muscle lipids during smoking, favor the increase in high protein levels (Gonçalves & Prentice-Hernández, 1998; Sigurgisladottir et al., 2000).

Results corroborate those observed by Kirschnik et al. (2006), with the species of freshwater shrimp (*M. rosenbergii*) with 18.59% crude protein for fresh shrimp. Likewise, Silva et al. (2010) observed similar values for the species *M. rosenbergii* in natura (16.80%), with a significant increase in protein contents (44.72%), after the salting and smoking processes.

5. Conclusion

Smoked prawns showed satisfactory results in terms of frequency of consumption, purchase intention and acceptance of products; however, white prawns were the species with the best sensory results, regardless of the smoking process. The smoking processes, hot and liquid, affected the chemical composition of the final smoked products, with a significant decrease in the moisture content and a relative increase in the content of macronutrients, lipids and proteins, for both species.

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Conflict of interest

The authors have no conflict of interest to declare.

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