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Study of preparation, composition and moisture sorption isotherm of Amazon River shrimp meal

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ABSTRACT

Amazon River shrimp plays an important role in artisanal fishing in Brazil's Northern region, is common to observe its disposal in commercial fishing over higher economic value fish (bycatch), which is source of environmental drawbacks. The Amazon River shrimp processing is important to extend and add value to a high nutritional product. The shrimp meal production is an alternative to the processing. This work presents a shrimp meal preparation, physicochemical composition, as well as its technological functional properties, sorption isotherm and sensory analysis of a mix of cassava flour (93 g/100 g) and shrimp meal (7 g/100 g). The results showed high content in protein (67.55 g/100 g), besides palmitic fatty acids - 16:0, 13.58 g/100 g; stearic - 18:0, 5.42 g/100 g; oleic - 18:1n-9 16.20 g/100 g and docosenoic - 22:1, 13.12 g/100 g of total fatty acid in the shrimp meal composition. An extruded product was obtained (7 g/100 g of shrimp meal/93 g/100 g of cassava flour) with 78% of acceptance in sensory analysis. The Amazon River shrimp meal is potentially nutritional and it can add up value to nutritionally poorer food.

1. Introduction

Amazon River shrimp (*Macrobrachium amazonicum*) belongs to the Palaemonidae family; it is common in tropical and subtropical regions of South America (Pinto, Lucena, Faleiros, Almeida, McNamara & Leone, 2016). Fresh water shrimp farming (rivers) has shown growth in the last years, despite the difficulties in obtain real statistics to this production, once small rural owners aiming regional consumption usually perform crustacean farming (Dutra, Forneck, Brazão, Freire, & Ballester, 2016).

In the Brazilian North region, the Amazon River shrimp is import to artisanal fishing (Dutra et al., 2016). Its meat has firm consistency and sharp taste (Aragão, Cintra, Silva, & Vieira, 2001; Dutra et al., 2016). In Pará state, the Amazon River shrimp stands out since it has great economic potential and it is one of the most accepted crustacean in the state market (Moraes-Riodades, Valenti, Peralta, & Amorim, 1999, pp. 598–604). Flavor, price and constancy in the grocery stores shelves are contributing factors that make the shrimp one of the most used ingredients in Pará culinary.

In industrial fishing, the Amazon River shrimp is the bycatch of higher economic value fishes and therefore are thrown away in the water, which gradually creates environmental drawbacks (Souza, Ferreira, & Cardoso, 2015). Shrimp is a very rich food; it has high protein content (higher than 60 g/100 g) and contains unsaturated fatty acids, which are good for human health.

Introducing fish products in people's diet is still an obstacle to overcome in order to expand aquaculture around the country (Borghetti & Ostrensky, 1999; Fogaça, Otani, Portella, dos Santos-Filho, & Sant'Ana, 2015). It is known the average consumption of fish in Brazil is 9.0 kg per year (MPA, 2010; Fogaça et al., 2015), which is lower than the 12.0 kg per year recommended by the WHO (World Health Organization).

Fish and crustaceans have high nutritional value, easy digestion and they are source of minerals and vitamins (Ogawa & Maia, 1999; Fogaça et al., 2015). After industrial processing they can still meet to consumers sensory needs, once they have palatable, soft and

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characteristic flavor, in addition to their low price and convenience in cooking (Ferreira et al., 2002; Fogaça et al., 2015).

Fishmeal is obtained from the Fishing Industry byproducts, or from artisanal fishing residues or its excess. These meals are not fit to human feed, once it has high fat content and air contact makes it rancid, which produces unpleasant flavor. For this reason, this meal is usually applied as complement in animal ration. In order to reach stability the meal should be degreased and have the phosphatides removed (Berger, Groth, Verrone, & Gallo, 1968; Martins, 2009).

The Amazon River shrimp has low fat content, which eliminates this degreasing and phosphatides removal process in the meal production process. In Martins (2009) he used the Amazon River shrimp in meal production for use in the thermoplastic extrusion process. For such he mixed it with starchy meal (manioc) and he obtained satisfactory results, as 2.60 g/100 g of lipids content in the shrimp meal.

Tavares (2009) used Amazon River shrimp meal in producing extruded product mixed with rice meal and he obtained 3.2 g/100 g of lipids content in the shrimp meal. Which is much smaller than the tilapia meal, for example, that has lipids content in 25 g/100 g (Petenuci et al., 2010).

The main process for obtaining the shrimp meal is drying. The quality control of most food undergoing drying process depends on its physical, chemical and microbiologic stability conditions, which is, in parts, consequence of the foods equilibrium moisture content (EMC) in relation to is water activity a_w, at given temperature. Adsorption isotherms best describes this relation. They are exclusive to individual food matrix and essential to modeling the process of drying, the project, and the optimization of drying equipment. Which allows the prediction of stability and the useful life period of these foods, in addition to its changes in moisture that may occurs during storage and appropriate material selection (Lago & Noreña, 2015; Yogendrarajah, Samapundo, Devlieghere, De Saeger, & De Meulenaer, 2015).

Biomaterials often have problem with moisture content and humidity, once they behave as hygroscopic materials and change its moisture content according to humidity and temperature (Silva, Faria, & Costa, 2015).

Besides that, the spice quality depends on color and flavor retention, which is essential to preserve its quality when drying it to critical values, in order to avoid essential oils oxidation, enzymatic degradation, and microbial deterioration (Lago & Noreña, 2015; Yogendrarajah et al., 2015). The aim of this work was to propose the elaboration of Amazon River shrimp meal to human consumption by analyzing its physical and chemical composition, such as its technological functional properties, moisture sorption isotherm and sensory analysis in a snack formulation.

2. Materials and methods

2.1. Feedstock

The shrimp was obtained from Amasa-Amazonas Indústrias Alimentícias S.A, Belém, PA, Brazil. The shrimp was washed in sodium hypochlorite in concentration of 0.025 $g.L^{-1}$ to avoid microbial growth.

2.2. Microbiological analysis

The microbiological analyses were carried out for both the raw shrimp and the shrimp meal, it was carried out microbiological analysis of *Salmonella* detection, *Staphylococcus* coagulase positive count, and coliforms at 45 °C, according to Vanderzant and Splittstoesser (1992) methodology, and following the FDA (Food and Drug Administration) resolution.

2.3. Physical and chemical composition

Moisture content (nº 925.09), ashes (nº 923.03), crude protein (Nx6.25) (nº 920.87), lipids (nº 31.4.02), dietary fiber (total, soluble and insoluble) (nº 985.29) were measured both the raw shrimp and the meal according to AOAC (1997), in addition to measuring chlorides according to the Mohr method (Brasil, 1981). Water activity was additionally measured using the electronic hygrometer AQUALAB, 3TE (DECAGON DEVICES INC., USA). The 2-thiobarbituric Acid index or TBARS analysis was performed according to Vincke (1970) methodology.

2.4. Fatty acids profile

This analysis was conducted according to the Lepage and Roy (1984) methodology, to determined Fatty acid methyl ester (FAME). Using a gas chromatograph CP-3380 (VARIAN, USA) performed the FAME separation, it was equipped with a fused-silica capillary column CP-SIL88 (60 mm × 0.21 mm i.d) and flame ionization detector (FID), it used Helium as the carrier gas (1 ml/min flux of H_2) with Split module injection. Injector's temperature was 250 °C and the detector's temperature was 280 °C. The column temperature was 175 °C for 8 min, and raised in two steps, the first to 180 °C, at a 2 °C/min rate, and the second to 205 °C, also at a 2 °C/min rate. The run total time was 61 min and the total injected volume was 1 μL. In order to identify and quantify the FAME the acquired retention times from the FAME standard sample (NU − Check USA) was compared with the ones in the shrimp sample, using *Software Star* WS 6.0 version (VARIAN, EUA).

2.5. Obtainment of regional shrimp meal

The Ogawa and Maia (1999, p. 430) methodology was carried out to obtain the regional shrimp meal. Initially, the raw Amazon River shrimp was weighted and seasoned with 3 g/100 g of a mix of garlic and sodium chloride. Then it was boiled in an oven for 5 min at 100 °C. The cooked shrimp was peeled (only cephalothorax removed) and was weighted, after this procedure the cooked shrimp was grinded in a multiprocessor for 1 min and weight again.

The convective drying of the samples was performed in a discontinuous dryer tray, with a flow of rising air, perpendicular to the particle bed, which was projected in built in the UFPA, as showed in Fig. 1.

The yield was obtained calculating the relation between raw shrimp and its meal, after all processing steps according to Sebben, Beirão, Meinert, Teixeira, and Damian (2000).

The flowchart to processing Amazon River shrimp into meal is showed on Fig. 2.

2.6. Moisture sorption isotherm

In the Moisture sorption isotherm the Assunção and Pena (2007), methodology was used to construct absorption and desorption moisture isotherms at 25 °C, in which the product moisture is related to water activity.

In predicting the sorption isotherm to the regional shrimp meal was tested eight mathematical models, three of them bi-parametric (Table 3) and five tri-parametric (Table 3). The models were based the in the studies Assunção and Pena (2007); Lago and Noreña (2015) and Yogendrarajah et al. (2015).

The software *Statistica*® 7.0 was used to the regression analysis, according to the Levenberg-Marquardt estimative methodology and 10^{-6} as convergence criterion. The following parameters to evaluate the adjustments were used: determination coefficient (R^2), relative medium deviation (P) and correlation between