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Assessing the use of arabic gum as a drying adjuvant for powdered shrimp obtained using a spray dryer

Avaliação do uso de goma arabica como adjuvante de secagem para camarão em pó obtido por spray-dryer

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Abstract

The aim of this study was to find a new method to improve shrimp availability in the culinary and food industry, especially for products in which the flavour of shrimp must be preserved, such as sauces, seasonings, dehydrated soups, and snacks. The approach involved the use of arabic gum as a drying adjuvant on powdered shrimp obtained by spray drying. The effects of the arabic gum on the physicochemical characteristics of the powdered shrimp were then evaluated. The fresh shrimp was processed using the following steps: washing, pre-baking, cephalothorax elimination, and grinding of the abdomen in a blender. Arabic gum was added to the shrimp paste at concentrations of 2%, 4%, and 8% and dehydrated in a spray dryer with input temperatures of 120 ˚C and 150 ˚C. The chemical, physical, and physicochemical characteristics of the powder were evaluated. When compared to the case of the control treatment, the addition of arabic gum did not cause any significant alterations to the chemical, physical, and physicochemical characteristics. The temperature increase from 120 ˚C to 150 ˚C in the control samples had no significant effect ($p \leq 0.05$) on the moisture of the product. The input temperature of 120 ˚C was found to be the most efficient for drying the shrimp, given that the final product had a high protein content.
Keywords: Powder; Spray dryer; *Litopenaeus vannamei*.

Resumo

O presente trabalho trata de uma nova forma de disponibilizar o camarão, visando sua aplicação na indústria alimentícia ou na culinária, em que se deseje agregar o sabor de camarão, como molhos, temperos, patês, sopas desidratadas, salgadinhos, entre outros. Este trabalho teve como objetivo avaliar os efeitos do uso da goma arábica como adjuvante de secagem nas características físicas e químicas do pó de camarão obtido pelo processo de secagem por atomização. O camarão fresco foi submetido às etapas: lavagem, pré-aquecimento, eliminação do cefalotórax e trituração do abdômen em liquidificador. À pasta de camarão resultante foi adicionada goma arábica nas concentrações de 2, 4 e 8% e desidratada em spray de aquecimento utilizando as temperaturas de

entrada de 120 e 150 ° C. O pó obtido foi avaliado quanto às suas características químicas, físicas e físico-químicas. A adição de goma arábica não alterou significativamente as características químicas, físicas e físico-químicas em relação à amostra controle. O aumento da temperatura de 120 para 150°C, amostras controle, não teve efeito significativo ($p \leq 0.05$) sobre a umidade do produto. O uso da temperatura de entrada de 120 ° C no spray-dryer foi mais indicado para a secagem do camarão, apresentando um produto final de alto valor proteico.
Palavras-chave: Pó, Spray dryer; *Litopenaeus vannamei*.

Introduction

Among all meat products, those obtained from fisheries are the most sensitive to degradation, oxidation, fat hydrolysis, and attack from microorganisms. This is due to their biological composition, high moisture content, water activity, and low collagen content in their muscle tissue. As with other animals, when shrimp die, they go through harsh chemical, physical, and microbiological alterations, which leads to complete deterioration. Thus, shrimp must be stored under strictly controlled conditions to maintain its quality and lengthen its lifespan.

With regard to nutritional value, shrimp meat is rich in proteins, lacks saturated fats, are low in calories, and has a neutral taste(1). Furthermore, it is a good source of vitamin B12, selenium, omega-3 fatty acids, highly unsaturated fatty acids (HUFA), and astaxanthin – a powerful natural antioxidant(2).

Dehydration of biological products, such as those obtained from fisheries, is used as a conservation method to improve product quality and decrease the rate of deterioration during storage(3). This process makes it easier to handle, transport, stock, and prepare these foods.

Spray drying is widely used in the food industry. Because of its versatility, it can be extended to the laboratory or industrial scale, with sample sizes ranging from a few millilitres to several tons per hour; the samples spend a relatively short time in the drying chamber. Spray drying is one of the most important tools for drying heat-sensitive biologic materials like food products.

Microencapsulation is a technique that aims to protect encapsulated material from factors that may cause deterioration. The most commonly employed microencapsulation agents are plant gum hydrocolloids (primarily arabic gum), jelly, modified starch, dextrin, lipids, emulsifiers, and carbohydrates. Arabic gum has been largely used in spray-drying microencapsulation due to its good emulsification capacity and reduced viscosity in water solutions. Arabic gum also provides protection from oxidation, retains volatile compounds, has emulsifying properties, and good solubility(4,5). Hence, arabic gum was adopted as an encapsulating agent for this study.

Microencapsulation has been used to reduce hygroscopicity in dehydrated products(6), as well as to protect sensitive compounds such as vitamin C(7), antioxidants(8), and volatile compounds. It has also been used to increase product stability[9] and improve oxidative conservation[10].

Powdered shrimp is advantageous for the consumer since it maintains the characteristics of fresh shrimp, and allows the food industry to use a high-quality product with considerable nutritional value and avoid the use of artificial flavouring. Therefore, it is crucial to evaluate the drying parameters of the spray dryer, especially the drying temperature, as it has a strong influence on the characteristics of the product. Another parameter that needs to be evaluated is the use of a drying aid, such as arabic gum. Therefore, the aim of this study was to assess the effects of arabic gum on spray-dried shrimp, with the ultimate goal of increasing the availability of shrimp in the food and culinary industries.

Material and methods

Fresh shrimp (*Litopenaeus vannamei*) was obtained from a shrimp farm located in the city of Itaiçaba, CE, and transported under refrigeration to the Laboratory of Food Quality Control and Drying (LACONSA) at the Federal University of Ceará, where they were subjected to rinsing, pre-cooking, and cephalothorax elimination. The abdomen was triturated in a blender (Britânia electronic filter, 800w), with a filter attached, at a 1:2 ratio of water (w/v), resulting in a homogeneous and slightly viscous paste. Arabic gum was added to the paste at different concentrations (2, 4, and 8% w/w) in relation to the total shrimp paste mass. A sample without the arabic gum adjuvant was also dried, which represented the control sample.

The shrimp was dried using an spray drying (Labmaq do Brasil, MSD 1.0) equipped with a 1.2 mm pneumatic beak. The following conditions were used in the process: a hot air output of 3.5 m^3/min, input temperatures of 120 ºC and 150 ºC, pumping output of 500 mL/h, and a pressurized air output of 30 L/min. The input temperatures of 120 and 150 ºC resulted in an output temperature of 75 ºC and 95 ºC, respectively. The powder obtained from this dehydration process was stored in 100 g batches in laminated packages (ESA 038) composed of aluminium and polyethylene materials, for further analyses.

Analytical determination of the paste and powdered shrimp was carried out in triplicate. The following parameters were evaluated: moisture (determined by a moisture determining scale, series ID-V1.8, model ID50, at 105 ºC, with 0.05% significance, according to the manufacturer's recommendations), water activity (determined by using an AQUALAB, Decagon Devices, model 4TE at 25 ºC, according to the manufacturer's recommendations), protein[11], lipids[11], ashes[11], and hygroscopicity[12], with modifications. The method for the determination of hygroscopicity involved the addition of 1 g of the sample to a hermetic recipient containing a saturated solution of NaCl (with a relative humidity of 75% at 25 ºC). After a week, the samples were weighed, and the hygroscopicity was expressed in grams of moisture adsorbed by 100 g of dry mass (g.100g^{-1}). The yield was determined by dividing the mass of solids in the powder collected at the end of the drying process by the mass of solids present before the drying process.

For this experiment, a fully randomized design was used with three concentrations of arabic gum (2, 4, and 8% w/w) and two temperatures (120 ºC and 150 ºC), resulting in eight assays (including the controls). All results were statistically analysed through ANOVA, and when significant differences occurred, they were submitted to a Tukey test with 5% significance. For these analyses, Statistica version 7.0[13] was used.

Results and discussion

Table 1 shows the results of the evaluated parameters of spray-dried shrimp with the addition of arabic gum. The results show that in the samples with an input temperature of 120 ºC, the concentration of arabic gum did not have any effect on the moisture levels. However, with an input temperature of 150 °C, it was observed that the control and the 4% arabic gum samples had reduced moisture levels, with no linear correlation to the arabic gum concentration.

Table 1 – Results obtained from the experimental design for shrimp dehydration by spray drying at 120 ˚C and 150 ˚C

Samples		Analyses (% d.b)			
		Moisture	Protein	Hygroscopicity	Yield
Control 120 °C		4.531 ± 0.336^{bc}	84.040 ± 0.741^{b}	15.288 ± 0.138^{ab}	33.617 ± 0.010^{g}
Control 150 °C		3.739 ± 0.225^{ab}	86.414 ± 0.401^{a}	15.132 ± 0.754^{ab}	31.500 ± 0.350^{h}
120 °C	2% AG	4.709 ± 0.226^{c}	64.324 ± 0.482^{d}	14.917 ± 0.541^{abc}	35.995 ± 0.090^{e}
	4% AG	4.619 ± 0.397^{bc}	53.469 ± 0.281^{g}	16.262 ± 0.136^{ab}	47.146 ± 0.230^{b}
	8% AG	4.796 ± 0.117^{c}	43.959 ± 0.260^{f}	14.004 ± 0.041^{c}	51.166 ± 0.006^{a}
150 °C	2% AG	5.435 ± 0.377^{c}	71.166 ± 0.368^{c}	14.433 ± 1.089^{bc}	35.731 ± 0.100^{f}
	4% AG	3.424 ± 0.223^{a}	53.411 ± 0.338^{g}	16.853 ± 0.832^{a}	38.949 ± 0.040^{d}
	8% AG	5.215 ± 0.165^{c}	46.964 ± 0.722^{e}	15.903 ± 0.734^{ab}	42.080 ± 0.500^{c}

d.b = dry basis. AG = arabic gum. Rates in the same row followed by the same letter are not significantly different by Tukey's test at 5% probability ($p \leq 0.05$).

Water content in food is the principal factor that influences microorganism degradation, and it can change through chemical and enzymatic reactions. The reduction of water content is a widely used food conservation method[14].

The results show that the increase in the amount of drying adjuvant greatly influenced the sample's protein content, with the protein content decreasing as the arabic gum percentage increased. The lower protein content in the samples with higher arabic gum concentration can be attributed to the increase in the solids content of the product due to the addition of the drying adjuvant. This resulted in each test having less shrimp per gram in the final product with the increase of the adjuvant percentage, which led to the reduction of the total protein content.

The protein percentage in the control samples demonstrates that this product has the potential to be used as a protein supplement in soups, instant noodles, and sauces, or in the preparation of more elaborate dishes. The biological value of the proteins can be categorised according to the protein digestibility-corrected amino acid score (PDCAAS), where proteins with a score above 0.8 have a high biological value. Shrimp presents a score of 1.0, which is superior to the scores of soybean (0.91) and beef (0.92), and equal to the scores of cow milk and egg[15,16].

It was observed that neither the addition of arabic gum nor the temperature levels had any effect on the hygroscopicity of the product, except for the 8% sample (120 °C), which showed a significant difference. Hygroscopicity can be defined as the tendency of a material to absorb or adsorb water from the environment, an important characteristic in food products, since it may influence the handling, processing, storage and consumption processes. It is an essential parameter to evaluate since it is associated with physical, chemical, and microbiological stability[17]. The hygroscopicity of a product is directly related to its moisture levels, with higher drying temperatures resulting in powders with lower moisture levels[8].

This was not the case in this study since the temperature variation did not affect the product's moisture levels. Thus hygroscopicity, which is directly related to moisture, did not significantly change with the variation of temperature or arabic gum concentration.

The results show a yield variation that differs significantly between all assays, from 31.50% (control) to 51.16% (8% of arabic gum – 120 ºC). The yield increased with the increase in the arabic gum percentage. This can be explained by the fact that the arabic gum increases the solids concentration, thus raising the yield, so a higher yield in a sample with the arabic gum does not mean that the product has a higher amount of shrimp per gram. What is important for the consumer is that the product is as cheap and as natural as possible.

The results reported in Table 1 showed that arabic gum is technologically dispensable in shrimp dehydration. Thus, the control samples were considered adequate within the experimental approach of this study. As seen in Table 1, the 150 °C control test did not present much higher moisture and yield values as compared to the 120 °C control test, suggesting that the temperature of 120 °C is the most suitable for shrimp dehydration.

In Table 2, shrimp dried at 120 ºC was compared to fresh shrimp, with regards to their physical, chemical, and physicochemical properties. During the drying process, the shrimp suffered alterations in water activity, moisture content, raw proteins, total lipids, and ashes, as a consequence of nutrient concentration. The powdered shrimp showed water activity values that inhibit the development of any microorganism. The drying process also decreased the moisture content in 94% and conferred a longer shelf life to the final product. The dried shrimp's final moisture content was lower than 5%, which is the maximum limit established by the Law on Industrial and Sanitary Inspection of Animal Products – RIISPO[18] for dehydrated fishery products.

Table 2 – Characterization of fresh shrimp and powdered shrimp dehydrated by spray drying at an input temperature of 120 ˚C

Analysis (% w.b)	Fresh shrimp	Powdered shrimp
Water activity	0.98 ± 0.06^a	0.12 ± 0.20^b
Moisture	73.73 ± 0.40^a	4.33 ± 0.37^b
Proteins	19.11 ± 0.45^b	81.43 ± 0.43^a
Lipids	0.62 ± 0.11^b	2.12 ± 1.02^a
Ashes	1.42 ± 0.26^b	7.15 ± 0.02^a

w.b = wet basis. Mean values followed by the same lowercase letters on the same row do not differ ($p > 0.05$) by Tukey's test.

As moisture was removed, the powdered shrimp protein content was concentrated. The increase was from 19.114% to 81.431%. This increase is very favourable, due to the biological nature of these proteins, which are classified as highly valuable.

Shrimp meat, in general, has a low amount of lipids since the shrimp fat deposits are located in the hepatopancreas, in the head area. After drying, these values increased threefold, which is excellent because lipids from fishery products are rich in essential polyunsaturated fatty acids, of the omega family, as opposed to lipids in red meat, which contain a high amount of saturated fats. Ackman[19] divided fishery products into four categories related to their lipid content: lean (less than 2% of fat), low-fat (2 – 4% of fat), semi-fat (4 – 8% of fat), and high-fat (more than 8% of fat). Based on this, the shrimp powder obtained was classified as a low-fat content food (2.12 ± 1.02%), which reinforces its nutritional value.

The ash content of the spray-dried shrimp increased considerably compared to that of the in natura shrimp (503.52%). However, it was smaller than the values found by Castro et al.,[20] 11.34 ± 0.09%, who analysed cooked shrimp. In shrimps, most ashes are found in the skin. Since this part of the body cannot be processed through our dehydration process, it results in a lower ash content as compared to that reported by Castro et al., where the whole shrimps were dried.

Conclusion

The use of arabic gum at different concentrations and under different process conditions did not improve the physical (hygroscopicity) and physicochemical (moisture and protein content) characteristics of shrimp dehydrated by spray drying. The drying air input temperature caused significant differences ($p \leq 0.05$) in the moisture and protein content of the product. Spray drying of shrimp resulted in a product with water activities and moisture contents that are ideal for storage, according to the legislation[18].

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