

Addition of powdered shrimp in the formulation of snacks¹

Adição de camarão em pó na formulação de *snacks*

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ABSTRACT - The aim of this study was to evaluate the acceptability of corn snacks containing different concentrations of powdered shrimp. Five snack formulations were prepared: the control (with no powdered shrimp), F1, F2, F3 and F4, with the addition of 2%, 4%, 8% and 16% powdered shrimp respectively. The raw materials were subjected to a process of thermoplastic extrusion in a single-screw extruder with 3 mm radial die. The snacks produced were evaluated for their centesimal composition, the mineral content was quantified and qualified, and the snacks then submitted to sensory analysis. The sensory parameters under evaluation were: flavour, aroma, colour, texture, overall acceptance, ideal shrimp taste and purchase intention, carried out by a panel of 107 untrained judges from the State University of Maringá. According to the results, the addition of powdered shrimp resulted in a greater increase in the protein and mineral value, especially the phosphorus content. From the acceptability of the snacks, it was found that for the sensory attributes under analysis, as well as purchase intention, the preparation of extrudates with added powdered shrimp to obtain products of sensory acceptance is viable. According to the results of the sensory analysis, the addition of 9.65% powdered shrimp to the formulation gives the product an ideal shrimp taste.

Key words: Snack. *Litopenaeus vannamei*. Sensory acceptability.

RESUMO - O objetivo desse estudo foi avaliar a aceitabilidade de *snacks* de milho, contendo diferentes concentrações de camarão em pó. Foram elaboradas cinco formulações de *snacks* sendo: controle (sem camarão em pó), F1, F2, F3 e F4, adicionadas de camarão em pó a 2%, 4%, 8% e 16%, respectivamente. As matérias-primas foram submetidas ao processo de extrusão termoplástica em uma extrusora de rosca simples e matriz radial de 3 mm. Os *snacks* obtidos foram avaliados quanto a sua composição centesimal, quantificação e qualificação de minerais e submetidos à análise sensorial. Os parâmetros sensoriais avaliados foram: sabor, aroma, cor, textura e aceitação global, sabor ideal de camarão e atitude de compra realizada com um painel de 107 julgadores não treinados da Universidade Estadual de Maringá. De acordo com os resultados obtidos, a adição do camarão em pó proporcionou incremento maior no valor proteico e mineral dos *snacks*, com destaque para o teor de fósforo. A partir da aceitabilidade dos *snacks*, observou-se que, dentre os atributos sensoriais analisados, assim como a intenção de compra do produto, a elaboração de extrusados adicionados de camarão em pó é viável, para obtenção de produtos sensorialmente aceitos. A aplicação de 9,65% de camarão em pó à formulação confere o sabor ideal de camarão ao produto, de acordo com os resultados das análises sensoriais realizadas.

Palavras-chave: Salgadinho. *Litopenaeus vannamei*. Aceitabilidade sensorial.

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INTRODUCTION

Fish is much appreciated for its nutritional value, providing the consumer with high-quality protein and essential amino acids, it is a good source of B-complex vitamins and contains a wide variety of minerals (ARIÑO *et al.*, 2013). Shrimp accounts for one of the largest slices in the global fish market, thanks to the relative ease with which it is found, and to its sensory characteristics such as colour, flavour, texture and aroma that make it so appreciated.

Shrimp is a highly perishable food and requires a method of conservation that prolongs its commercial life. In the area of food preservation, dehydration remains one of the most used methods, since it prevents deterioration by microorganisms and by chemical and enzyme reactions, and a loss in commercial value, it further aims to refine the food, resulting in the supply of a new product for the market, with monetary benefits derived from the type of process applied (SOARES *et al.*, 2001; TOPUZ *et al.*, 2017).

In order to meet the demands of consumers, the food industry has been developing increasingly versatile products that are easy to consume and that satisfy the taste of their consumers (BERWIG *et al.*, 2017; DISCHSEN *et al.*, 2013). With the idea of offering the consumer a product that was nutritious, tasty and easy to consume, snacks have been produced with added powdered shrimp, thereby encouraging the population to consume this fish in a novel way. Snacks are extruded products made from starchy, flavoured flour, which use lipids as fixing agents of aroma and flavour, resulting in a high-calorie food with high amounts of lipids, a low protein content and dietary fibre (CAPRILES; SOARES; ARÊAS, 2007). Several approaches have been tested in order to improve the nutritive value of snacks, such as replacing the lipids with a solution containing prebiotic soluble fibre to fix the aroma and flavour of the product (CAPRILES *et al.*, 2009) and incorporating raw materials with added nutritive value in the formulation (CAPRILES; ARÊAS, 2012; SHAVIKLO *et al.*, 2015; TROMBINI; LEONEL; MISCHAN, 2013).

In view of the interest in improving the nutritional quality of extruded snacks by combining raw materials of added nutritional value to the formulation, the aim of this study was to produce snacks with added powdered shrimp in different proportions, to evaluate their nutritional value and acceptance by the consumer.

MATERIALS AND METHODS

Obtaining the powdered shrimp

The shrimp were purchased *in natura* from shops in Fortaleza, Ceará, Brazil, and taken to the of Quality

Control Laboratory for Food and Drying of the Federal University of Ceará, where they were cleaned in running water, pre-cooked (3 min at 100 °C) and the cephalothorax removed. The abdomen with the carapace was processed by blender (Britannica Eletronic Filter 800 W) in water at a ratio of 1:2 (w:v). The pulp resulting from this process was passed through a stainless steel sieve with a 0.08 mm mesh to avoid clogging of the equipment nozzle, and then dried in a spray dryer (Labmaq do Brasil, model MSD 1.0) using a pneumatic nozzle of 1.2 mm, an inlet temperature of 120 °C, hot air flow of 3.5 m³/min, pumping rate of 500 ml/h and a pressurised air flow of 30 L/min.

Preparing the snacks

The snacks were prepared in the Cereal Technology Laboratory of the State University of Maringá, in Maringá, Paraná, Brazil, using an extruder (Inbramaq, model IB-50) with a nominal capacity of 50 kg/h, comprising a single screw, 50 mm in diameter and 200 mm in length, and a head with two 3 mm diameter holes. Four formulations, F1, F2, F3 and F4 were prepared including different concentrations of powdered shrimp, 2%, 4%, 8% and 16% respectively; the control formulation was prepared from corn grits only.

Chemical and mineral composition of the powdered shrimp and the snacks

Moisture was determined using a series ID-V1.8 model ID50 scale at 105 °C. The protein content was determined as per the micro-Kjeldahl method, the lipid content by the Soxhlet method, and the ashes quantified following the analytical standards of the Adolfo Lutz Institute (INSTITUTO ADOLFO LUTZ, 2008). The carbohydrates were determined from the difference between 100% and the sum of the percentage moisture, protein, lipids and ashes.

The mineral analysis was carried out in the Laboratory of Agrochemistry and the Environment at the Chemistry Department of the State University of Maringá. The K, Mg, Cu, Fe, Mn, Zn and Na were determined by the atomic absorption spectrometry of a sample digested in nitro-perchloric solution. The phosphorus was quantified by the UV-Vis spectrophotometry of a sample digested in nitro-perchloric solution, and the total nitrogen by the classical Kjeldahl method.

Sensory analysis of the snacks with powdered shrimp

The sensory tests were carried out in the Sensory Analysis Laboratory of the Department of Food Engineering at the State University of Maringá. The experimental protocol was approved by the Research Ethics Committee of the State University of Maringá (record no. CAAE 18718013.3.0000.0104), as it meets

the protection and privacy needs of the volunteers, using terms of free and informed consent.

A total of 107 untrained (volunteer) tasters were recruited, most of whom were female, aged between 18 and 25, who described the frequency with which they consumed shrimp as 'very low' but said that they liked shrimp 'very much'. Samples of approximately 5.0 g were served in randomly encoded disposable plastic cups. Each taster evaluated the four samples, which were individually presented in sequence.

In order to measure the flavour, aroma, colour, texture and overall acceptance of the sample, the nine-point hedonic scale proposed by Peryam and Pilgrim (1957) was used (1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely). To evaluate how ideal the attribute shrimp taste was for the consumers, a relative ideal scale test was carried out using a nine-point scale (+4 = far stronger than ideal and -4 = far less than ideal), with the term 'ideal' in the centre of the scale. The results were expressed as a histogram, using a lower response limit of 70% for the term 'ideal' (INSTITUTO ADOLFO LUTZ, 2008).

To evaluate the purchase intention of the taster, a five-point scale was used (1 = would definitely not buy; 3 = might buy and 5 = would definitely buy).

RESULTS AND DISCUSSION

Table 1 shows the centesimal composition of the powdered shrimp, the control snack and the snacks formulated with different concentrations of powdered shrimp. A significant difference in moisture was seen between the formulations, however all the values were below 5%, which is enough to maintain quality during storage. Capriles and Arêas (2012) reported moisture values ranging from 8.82 to 8.91% for extruded snacks obtained by combining defatted amaranth flour with corn meal.

When evaluating the protein content, it is important to highlight the percentage of crude protein in the powdered shrimp, which demonstrates the potential of this product as a protein supplement. The addition of powdered shrimp significantly increased the protein content of the snacks, resulting in a higher protein value for formulation F4. For the different prepared formulations, the extrudates showed values between 10.19% and 19.51%, as the minimum value for formulation F1. A lower protein value was found by Shaviklo *et al.* (2015), who reported 6.3 g/100 for a snack with added shrimp. Goes *et al.* (2015) reported a protein index of 11.85% for snacks with 9% tuna meat, which is lower than that seen in the snack from formulation F2. Justen *et al.* (2017) reported 10.28% protein in snacks with 9% smoked tilapia bran.

The lipid content only differed statistically from the control in formulation F4. As the lipid content in the powdered shrimp was low, approximately 2%, the addition of 2%, 4% and 8% powdered shrimp had no effect on the lipid content of the products, however the concentration of 16%, as seen above, provides a significant amount of lipids to the final product, increasing the value. Justen *et al.* (2017) report that including 12% tilapia flour in the formulation of snacks resulted in 8.56% lipids, a higher value than found in this study (4.30%).

The carbohydrate content of the snacks ranged from 70.39% to 80.57%, with this value decreasing as the percentage of powdered shrimp increased. A similar reduction was reported by Justen *et al.* (2017), who added tilapia flour when formulating snacks, since an increase in protein content results in a proportional reduction in carbohydrates. As a result, this substitution gives nutritionally better snacks (MONTEIRO *et al.*, 2016; OLIVEIRA *et al.*, 2013).

The addition of powdered shrimp to the snack formulations had no significant effect ($p > 0.05$) on the ash content of the product, however, from the results shown in Table 2, it can be seen that the addition of the powdered shrimp increased the value of Mg, K, P, Na and Zn, showing the highest increase for phosphorus.

Table 1 - Chemical composition of the powdered shrimp, control snack and snacks with added powdered shrimp

Parameter analysed (%)	Powdered shrimp	Control snack	Snacks with different concentrations of powdered shrimp			
			F1	F2	F3	F4
Moisture	4.33 ± 0.37	2.94 ab ± 0.11	3.12 a ± 0.11	1.97 c ± 0.12	2.75 b ± 0.11	1.90 c ± 0.35
Protein	81.43 ± 0.43	10.19 c ± 2.52	12.52 bc ± 2.20	13.97 b ± 1.51	13.97 b ± 0.87	19.51 a ± 1.33
Lipids	2.12 ± 1.02	3.50 b ± 0.41	3.40 b ± 0.21	3.50 b ± 0.28	3.40 b ± 0.21	4.30 a ± 0.17
Carbohydrates	4.97 ± 0.20	80.76 a ± 0.30	77.68 b ± 0.07	77.06 b ± 0.10	76.18 c ± 0.10	70.39 d ± 0.08
Ash	7.15 ± 0.02	2.61 a ± 0.93	3.28 a ± 1.22	3.50 a ± 0.76	3.70 a ± 0.77	3.90 a ± 1.18

F1 = Formulated with 2% powdered shrimp; F2 = Formulated with 4% powdered shrimp; F3 = Formulated with 8% powdered shrimp; F4 = Formulated with 16% powdered shrimp. Mean values followed by the same lowercase letters on the same row do not differ ($p > 0.05$) by Tukey's test

Table 2 - Mineral composition of the control snack and the snacks with added powdered shrimp

Mineral (mg /100 g)	Control snack	Snacks with different concentrations of powdered shrimp			
		F1	F2	F3	F4
Mg	46.75 ± 3.90	43.10 ± 9.41	56.27 ± 5.00	59.32 ± 4.95	90.78 ± 2.70
K	188.55 ± 2.12	177.48 ± 5.88	246.16 ± 2.98	284.92 ± 8.27	301.92 ± 11.22
P	464.50 ± 37.88	660.66 ± 26.85	942.30 ± 93.96	1.293.23 ± 32.67	2.014.10 ± 26.28
Na	2.187.22 ± 19.40	2.054.45 ± 156.63	2.291.43 ± 162.87	2.631.60 ± 38.22	2.511.07 ± 56.72
Fe	-	0.50 ± 0.06	1.72 ± 0.19	1.64 ± 0.1	4.21 ± 0.03
Zn	0.53 ± 0.06	0.57 ± 0.05	0.78 ± 0.01	0.95 ± 0.03	1.47 ± 0.08

Magnesium (Mg); Calcium (Ca); Potassium (K); Phosphorus (P); Sodium (Na); Iron (Fe); Copper (Cu); Manganese (Mn); Zinc (Zn). F1 = Formulated with 2% powdered shrimp; F2 = Formulated with 4% powdered shrimp; F3 = Formulated with 8% powdered shrimp; F4 = Formulated with 16% powdered shrimp. - values less than 0.1 mg/100 g

Justen *et al.* (2017) reported that the inclusion of 12% tilapia flour in the formulation of snacks gave the product values of 16 mg magnesium/100 g, 440 mg phosphorus/100 g and 1,119 mg iron/100 g, which were lower values than those seen in formulation F3 for both parameters.

Iron was added to the processed products from the powdered shrimp, its concentration increasing as the percentage of powdered shrimp increased, reaching 4.21 mg/100 g in formulation F4. The addition of 2% powdered shrimp to the snack formulation was enough to give the product an iron content greater than that of pork (0.70 mg/100 g), chicken thighs (0.96 mg/100 g) and lean beef (2.47 mg/100 g) (PHILIPPI, 2017).

The results showed that powdered shrimp is an important source of minerals, and the higher the concentration of this product in the snack formulation, the greater its contribution to the mineral enrichment of the product under study, as seen in the formulation with 16% powdered shrimp.

Shaviklo, Kargari Dehkordi and Zangeneh (2014) report that corn extrudates with added fish derivatives

show an increase in the nutritional value of the product in comparison to extrudates already found on the market, and that such additions also provide an alternative for diversifying corn snacks, making this food a healthy and nutritious option, in addition to increasing the consumption of fish protein.

Besides knowledge of the nutritional value, another important factor for evaluation is product acceptance by the consumer, an evaluation which employs sensory techniques. The sensory techniques, applied with the use of scales, involve the use of numbers or words to express the intensity of a given attribute, or reaction to the product, associating numerical values to words in order to allow statistical analysis of the data (CHELLELLATO *et al.*, 2016). With the hedonic-scale test, the taster expresses the degree of like or dislike of a product, either globally or in relation to a specific attribute (BRASIL, 2005). Table 3 shows a comparison of the sensory acceptability of the snacks. It can be seen that for the attribute shrimp taste, the snacks presented mean hedonic values between point 6 (like slightly) and 7 (like moderately).

Observing the responses to the attribute shrimp aroma, it was found that the four formulations had a

Table 3 - Mean values for the hedonic scores of the attributes flavour, aroma, colour, texture and overall acceptance (OA) of shrimp-flavoured snacks

Sample/Attribute	Snacks with different concentrations of powdered shrimp			
	F1	F2	F3	F4
Flavour	6.54 a ± 1.89	6.81 a ± 1.62	6.72 a ± 1.67	6.98 a ± 1.95
Aroma	6.03 a ± 1.77	6.42 a ± 1.48	6.25 a ± 1.69	6.33 a ± 1.63
Colour	6.86 a ± 1.72	6.99 a ± 1.40	6.45 a ± 1.61	6.00 a ± 1.86
Texture	7.14 a ± 1.62	7.13 a ± 1.50	6.15 a ± 1.92	5.60 a ± 2.31
OA	6.91a ± 1.59	7.08 a ± 1.30	6.62 a ± 1.53	6.52 a ± 1.95

F1 = Formulated with 2% powdered shrimp; F2 = Formulated with 4% powdered shrimp; F3 = Formulated with 8% powdered shrimp; F4 = Formulated with 16% powdered shrimp. OA = Overall Acceptance. Mean values followed by the same lowercase letters on the same row do not differ ($p > 0.05$) by Tukey's test

good level of acceptance, considering that the mean hedonic values were all greater than 6 (like slightly), the same observation registered for the attribute colour. The responses relative to the attribute texture showed a greater distribution between the levels of the hedonic scale and a greater divergence between the results of each formulation. Formulations F1 and F2 presented the highest hedonic mean values, 7.14 and 7.13 respectively, followed by formulation F3 with 6.15 and F4 with 5.60. Overall acceptance, like the other attributes, showed no statistical difference between the hedonic mean values for the different formulations, indicating that variations in the percentage concentration of the shrimp does not affect overall product acceptance. Justen *et al.* (2017) reported that the addition of up to 12% tilapia flour had no effect on the sensory parameters of the snacks (aroma, taste, appearance, texture, colour and overall acceptance), obtaining scores of between 6.92 and 8.15 for each attribute.

Another sensory test that assists the development of new products is the relative ideal scale test, which quantifies the intensity of a given attribute against the 'ideal' considered by the consumer and makes it possible to identify which changes should be made in the product to achieve the maximum sensory acceptance. As a general rule, to conclude that an attribute is at an optimum level, a minimum of 70% of responses must be at the 'ideal' level, and, to conclude that an attribute is not at the optimum level, it is generally necessary for a minimum of 20% of consumers to include their evaluation in the 'more than ideal' or "less than ideal" categories (DUTCOSKY, 2013).

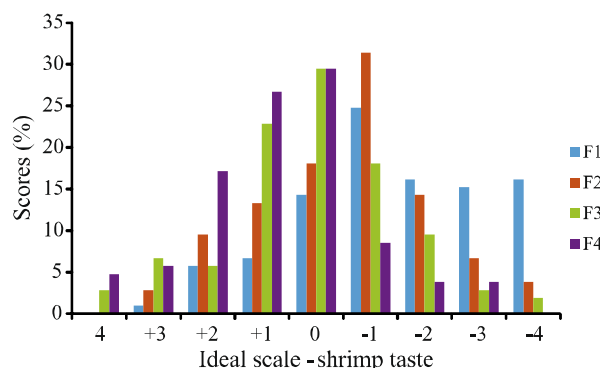
Figure 1 shows the distribution of scores obtained with the relative ideal scale test in evaluating the intensity of shrimp taste for the four snack formulations. According to the results, none of the formulations reached the ideal level for shrimp taste.

The percentage of consumers who considered the shrimp taste of the formulations to be 'ideal' was less than 30%, with this value increasing for formulations F1 to F4. For each formulation, with the exception of formulation F1, responses in the 'less than ideal' or 'more than ideal' categories were greater than 20%.

Formulation F1 obtained a greater percentage of the responses (24.76%) in category -1 of the scale, corresponding to 'slightly weaker than ideal', and had a total of 13.32% of responses in the 'more than ideal' category and 72.37% in the 'less than ideal' category, showing that 2% powdered shrimp does not give the product the ideal flavour.

With formulation F2, the greatest percentage of responses (31.43%) also occurred in category -1 of the

Figure 1 - Histogram of score frequency for the attribute shrimp taste. F1 = Formulated with 2% powdered shrimp; F2 = Formulated with 4% powdered shrimp; F3 = Formulated with 8% powdered shrimp; F4 = Formulated with 16% powdered shrimp. Scale: +4 = extremely stronger than ideal; 0 = ideal; -4 = extremely weaker than ideal



scale; the percentage total of responses in the 'more than ideal' category was 25.71%, while in the 'less than ideal' category it was 56.17% with 18.09% 'ideal'. Such a result suggests that adding 4% shrimp to the snack formulation was also not enough to give the product an ideal shrimp flavour.

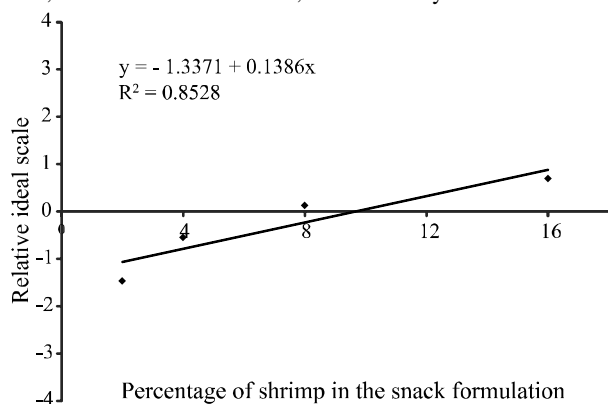
Formulation F3 showed more balanced results between the categories of the relative ideal scale for the attribute shrimp taste. The greatest percentage of responses occurred in category 0 of the scale, corresponding to 'ideal', with 29.52% of the responses. However, this percentage was lower than the sum of the percentages in the 'more than ideal' category (+4 to +1) (38.10%) and the 'less than ideal' category (-1 to -4) (32, 38%).

For formulation F4, it was found that 29.52% of the scores fell into category 0 ('ideal'), however, summing the percentages found for the categories 'more than ideal' and 'less than ideal', 54.27% and 16.19% of the responses were obtained respectively. This result suggests that the formulation with 16% powdered shrimp has a more than ideal shrimp taste.

Considering the results, the ideal concentration of powdered shrimp is between 8% and 16%, being closer to 8%. The exact percentage value of powdered shrimp to give the product an ideal shrimp taste was found by linear regression of the graph plotted from the mean values of the results obtained for each formulation. Equating y to zero in the equation for the line shown in Figure 2, the point where the line intersects the x axis was found, which represents the ideal percentage of powdered shrimp.

The opinion of the testers, verified in the relative ideal scale test, was transformed into mean values, which range from -4 to +4, with the ideal taste corresponding to

Figure 2 - Determining the exact percentage of powdered shrimp for the ideal shrimp taste by means of linear regression. Scale: 4 = extremely stronger than ideal; 3 = far stronger than ideal; 2 = moderately stronger than ideal; 1 = slightly stronger than ideal; 0 = ideal; -1 = slightly weaker than ideal; -2 = moderately weaker than ideal; -3 = far weaker than ideal; -4 = extremely weaker than ideal

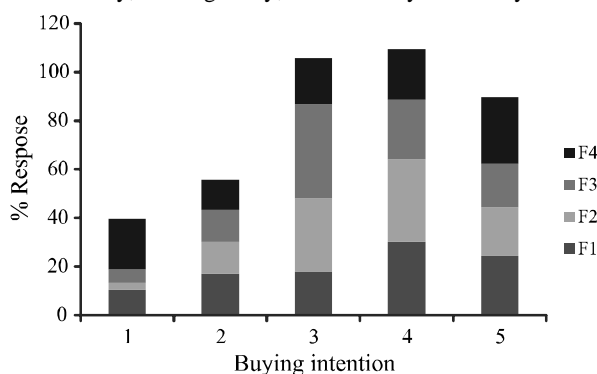


a value of 0 (zero). From the equation for the resulting line, the ideal percentage of powdered shrimp to be added to the formulation was calculated, which reached a value of 9.65%.

By means of the scale for purchase intention, the individual can express their will to consume, acquire or buy the product. The percentage responses of the tasters for purchase intention for shrimp-flavoured snacks are shown in Figure 3.

The responses for purchase intention of the consumers for formulations with different concentrations of powdered shrimp showed that the formulations with 2% and 4% shrimp received the highest percentage response in category 4, corresponding to 'probably would buy', with 30.19% and 33.96% respectively. However, the formulation with 8% shrimp obtained a greater percentage response (38.68%) in category 3, equivalent to 'might

Figure 3 - Percentage responses of the tasters for purchase intention for shrimp-flavoured snacks. Scale: 1 = definitely would not buy; 3 = might buy; 5 = definitely would buy



buy'; the greatest percentage response (27.35%) for the formulation with 16% shrimp was in category 5, equivalent to 'definitely would buy'.

Analysing the percentage responses for purchase intention, it was found that the snacks formulated with 2% and 4% powdered shrimp showed greater intention to purchase, of 54.71% and 53.77% respectively, whereas the formulations with 8% and 16% powdered shrimp achieved values of 42.45% and 48.11% respectively.

CONCLUSIONS

1. The addition of powdered shrimp in the formulation of snacks has proved effective in enriching the product with protein and minerals (magnesium, potassium, phosphorus, iron and zinc);
2. Development of the products proved that the addition of 2%, 4%, 8% and 16% powdered shrimp did not differ statistically in hedonic score for the attributes flavour, aroma, colour, texture and overall acceptance. The percentage to be added to the product to obtain the ideal shrimp taste was calculated to be 9.65%.

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