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Development of seasoning powder from foam-mat dried *Artemia franciscana* biomass

Nguyen Minh Thuy[1]*, Nguyen Ngoc Huong Anh[1], Nguyen Thi Kim Xuyen[1], Nguyen Hoang Yen Vi[1], Nguyen Hoang Thuy Quyen[1], Tran Ngoc Giau[1], Hong Van Hao[1], Ngo Van Tai[2], Nguyen Van Hoa[3]

[1]Institute of Food and Biotechnology, Can Tho University, Can Tho, Vietnam.
[2]School of Food Industry, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand.
[3]College of Aquaculture and Fisheries, Can Tho University, Can Tho, Vietnam.

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ABSTRACT

Seasoning powder was commonly produced from meat or poultry. In this research, it was produced from foam mat–dried Artemia powder with the addition of various spices. Six mixing formulas were created with Artemia powder ratios ranging from 60% to 35% (from A1 to A6) along with other spice ingredients such as sugar, salt, pepper powder, shallots powder, and monosodium glutamate (MSG) and analyzed for quality and sensory characteristics. The results showed that the highest protein content was achieved in sample A1 (48.3%) and the lowest in sample A6 (28.2%). Sample A5 (ratio of Artemia powder/sugar/salt/pepper powder/onion powder/MSG is 40:26:24:2:3:5) achieved the highest sensory score, followed by sample A4 (ratio of Artemia powder/sugar/salt/pepper/onion powder/MSG is 45:23:22:2:3:5). The remaining samples (A1, A2, A3, and A6) had lower sensory scores. Microstructural image analysis (from scanning electron microscope) of sample A5 showed good uniformity, high nutritional value, especially high protein content (about 3.06–3.48 times) compared to other existing seasoning powder products on the market, and very good water-binding capacity.

1. INTRODUCTION

Artemia (*Artemia franciscana,* family: *Artemiidae*) is a small crustacean that lives in saltwater areas. In Vietnam, particularly in the Mekong Delta, Artemia (*Artemia franciscana*) was discovered as a nutrient-rich food source for aquaculture [1]. This is a small crustacean that lives in salt water. The amount of Artemia biomass obtained in each season is large with high yield and high nutritional content, especially protein [1,2]. Artemia biomass contains about 16/20 types of amino acids, especially 7/8 essential amino acids. They are also rich in highly unsaturated fatty acids [3]. However, Artemia is used only as food for aquatic animals such as shrimp, fish, and mollusks. With such high nutritional value, Artemia biomass can be evaluated as a potential source of raw materials for use as food for animals and humans.

One of the potential uses of Artemia is to convert them into dry form, which is high in nutrition and easy to use. The dry powder form can be added to different types of food such as making seasoning powder using Artemia is also an effective way to use dried Artemia biomass. Food spices, whether natural or artificial, are in high demand in daily meals because they enhance the flavor of common dishes and make them more attractive when added. There are different types of food seasonings sold on the market, but what they have in common is that they are all produced in the laboratory using different ingredient ratios and techniques.

However, most scientific research on Artemia mainly focuses mainly on its use as food source for aquaculture, with limited research on its use as human food, even though it has high nutritional value. Only a recent study conducted by Minh Thuy et al. [4] has used Artemia as food. Therefore, nutritious raw materials such as Artemia biomass with a large annual output also need to be researched. One of the products that can be developed from Artemia powder is a useful seasoning powder, contributing to diversifying the seasoning powder market that includes products made from meat, chicken, shrimp, mushrooms, and other ingredients. The goal of this study is to develop a seasoning powder from Artemia biomass powder prepared using foam mat–drying method. Mixing and heat treatment methods were performed along with sensory evaluation to produce Artemia seasoning powder product with high quality and high acceptability by consumers.

**Corresponding Author:*
Nguyen Minh Thuy,
Institute of Food and Biotechnology,
Can Tho University,
Can Tho, Vietnam.
E-mail: nmthuy@ctu.edu.vn

2. MATERIALS AND METHODS

2.1. Preparation of Ingredients

Artemia biomass (*Artemia franciscana*) was collected in Vinh Chau, Soc Trang, Vietnam. The samples were frozen (≈−28°C), packed, and transported to the laboratory of the Institute of Food and Biotechnology, Can Tho University. Then, the materials were washed with clean water, frozen at −25°C, and used for further research.

2.2. Developing a Formula for Making Seasoning Powder From Artemia Biomass Powder

The ingredients and usage ratios in six formulas (A1 to A6) for preparing seasoning powder from Artemia powder (obtained from foam mat drying) are presented in Table 1. The ingredients were weighed according to each formula and mixed with different ratios of Artemia powder, sugar, and salt. Other ingredients such as pepper powder, shallot powder, and MSG were added with the same content in all six formulas.

2.3. Effect of Heat Treatment (Roasting) on the Quality of Artemia Seasoning Powder

Using a food roaster (Guangdong, China—1600 W, 100–250°C), the temperature was adjusted to 160, 170, and 180°C with designed roasting times of 2.5, 5, 7.5, and 10 min. The mixture was ground after roasting, sieved through a sieve hole of about 50–70 µm, and collected as seasoning powder particles. The product was then packaged in PET box with an aluminum lid.

2.4. Analysis of Physical and Chemical Characteristics

Physical characteristics: Water activity (a_w) was measured using a WA-60A device (China); microstructure was observed using a scanning electron microscope (SEM) (JEOL, model J550, Japan); and color (L*, b* value) was measured using a CHN SPEC CS-10 colorimeter (China). Water-binding capacity was analyzed according to Sosulski [5].

Chemical compositions: Moisture (%), protein (%), lipid (%), and ash (%) were determined according to the AOAC standard method [6]. Carbohydrate content was determined using the McCready method [7].

Sensory evaluation method: Sensory evaluation of the samples was conducted with 20 participants. Evaluation of product attributes and acceptability was carried out in random order. The sensory evaluation methods such as quantitative descriptive analysis (QDA) and a 7-point hedonic scale were used (7=like very much, 4=neither like nor dislike, and 1=dislike very much) [8].

2.5. Data Analysis

The Statgraphics Centurion XVI software was applied for statistical analysis and the XLSTAT software was applied for sensory value analysis. The collected data were statistically analyzed by ANOVA and LSD tests to determine significant differences at the 5% level.

Table 1: Design of seasoning powder formulas.

Ingredients	A1	A2	A3	A4	A5	A6
Artemia powder (%)	60	55	50	45	40	35
Sugar (%)	15	18	20	23	26	29
Salt (%)	15	17	20	22	24	26
Pepper powder (%)	2	2	2	2	2	2
Shallot powder (%)	3	3	3	3	3	3
Monosodium glutamate (%)	5	5	5	5	5	5

3. RESULTS AND DISCUSSION

3.1. Nutritional Composition of Artemia Seasoning Powder Products From Mixed Formulas

The macronutrient composition and ash content of Artemia seasoning powder were prepared according to six recipes presented in Table 2. The results showed that the lipids, carbohydrates, and ash of the samples did not have significant differences, with lipids ranging from 0.61% to 1.05%, carbohydrates from 2.48% to 3.91%, and ash from 2.15% to 3.69%, respectively. However, there is a significant difference in protein content in the formulas, in which formula A1 gives the highest protein value (48.30±0.12%) and formula A6 shows the lowest value (28.18±0.11%). This result is due to the Artemia powder having a high protein content (79.9%), so the sample was designed with the highest percentage of Artemia powder, giving the Artemia seasoning product a high protein content. Similarly, the research group of Mahendradatta et al. [9] also showed that the moisture, protein, lipid, carbohydrate, and ash content of seasoning powder made from fermented whole fish were 6.38, 32.52, 4.37, and 20.29%, respectively.

Oo et al. [10] processed seasoning powder from meat, fish, and vegetables. Physico-chemical properties such as moisture (6.8%), protein (42.22%), fat (17.34%), and carbohydrate content (19.62%) were reported. So, like other forms of seasoning powder, the commercialization of this value-added Artemia product can contribute to diversifying the Artemia-processing industry through better utilization of this raw material source.

3.2. Calculate Energy and Energy Distribution From Artemia Seasoning Powder Product

Energy-producing nutrients and the percentage of energy provided from macronutrients (100 g) of Artemia seasoning powder formulas are presented in Table 3. The results showed that the total calorie content of sample A1 was highest (218.27 kcal/100 g), and that of sample A6 was lowest (128.14 kcal/100 g). Compared to AMDR recommendations, the energy distribution of protein ranges from 10% to 35% per serving. In Artemia seasoning powder formulas, the protein energy distribution is 87.95–88.51%, much higher than recommended. However, this product is used in food as a spice/seasoning, so it is promising as a good source of dietary protein supplementation and support when used in prepared dishes.

The energy distribution of carbohydrates and lipids of the formulas ranges from 7.16–7.74% to 4.3–4.33%, respectively, much lower than AMDR recommendations for carbohydrate energy distribution

Table 2: Nutritional composition of Artemia seasoning powder.

Formula	Protein (%)	Lipid (%)	Carbohydrate (%)	Ash (%)
A1	48.30 ± 0.12	1.05 ± 0.08	3.91 ± 0.22	3.69 ± 0.05
A2	44.28 ± 0.1	0.96 ± 0.07	3.62 ± 0.23	3.38 ± 0.07
A3	40.25 ± 0.13	0.88 ± 0.1	3.33 ± 0.18	3.08 ± 0.05
A4	36.23 ± 0.09	0.79 ± 0.12	3.05 ± 0.16	2.77 ± 0.08
A5	32.20 ± 0.11	0.70 ± 0.09	2.76 ± 0.2	2.46 ± 0.1
A6	28.18 ± 0.1	0.61 ± 0.11	2.48 ± 0.11	2.15 ± 0.09

Mean ± STD. The ratio of Artemia powder/sugar/salt (%) →A1 (60:15:15), A2 (55:18:17), A3 (50:20:20), A4 (45:23:22), A5 (40:26:24), and A6 (35:29:26).

Table 3: Energy-producing nutrients and percentage of energy provided from macronutrients (100 g).

Formula	Energy (kcal)			Total Energy (kcal)	Energy Distribution From Macronutrients (%)			Total (%)
	Protein	Carb.	Lipid		Protein	Carb.	Lipid	
A1	193.2	15.62	9.45	218.27	88.51	7.16	4.33	100
A2	177.1	14.49	8.66	200.25	88.44	7.24	4.33	100
A3	161.0	13.32	7.88	182.20	88.37	7.31	4.32	100
A4	144.9	12.19	7.09	164.18	88.26	7.42	4.32	100
A5	128.8	11.06	6.30	146.16	88.13	7.56	4.31	100
A6	112.7	9.92	5.51	128.14	87.95	7.74	4.30	100

The ratio of Artemia powder/sugar/salt (%) →A1 (60:15:15), A2 (55:18:17), A3 (50:20:20), A4 (45:23:22), A5 (40:26:24), and A6 (35:29:26).

(45–65%) and lipids (20–35%). Although the energy distribution of these two ingredients is low, this seasoning powder product is used as a seasoning, so it will be balanced with other ingredients in the meal such as healthy cooking oils (canola, soybean oil), vegetables, and grains.

3.3. Effect of Mixing Ratio on Sensory Quality of Artemia Seasoning Powder Product

Artemia seasoning powder formulations were sensorily evaluated by QDA and data were analyzed by principal component analysis (PCA), with the frequency of occurrence of attributes representing the sensory attributes for Artemia seasoning powder formulations, including yellowish white color, seafood smell, egg smell, strange smell, sweet taste, salty taste, spicy taste, and strange taste. These are the most important attributes that determine the choice of this type of product. The relationship between the sensory attributes and the two main components chosen to represent the collected sensory data is also shown in Figure 1.

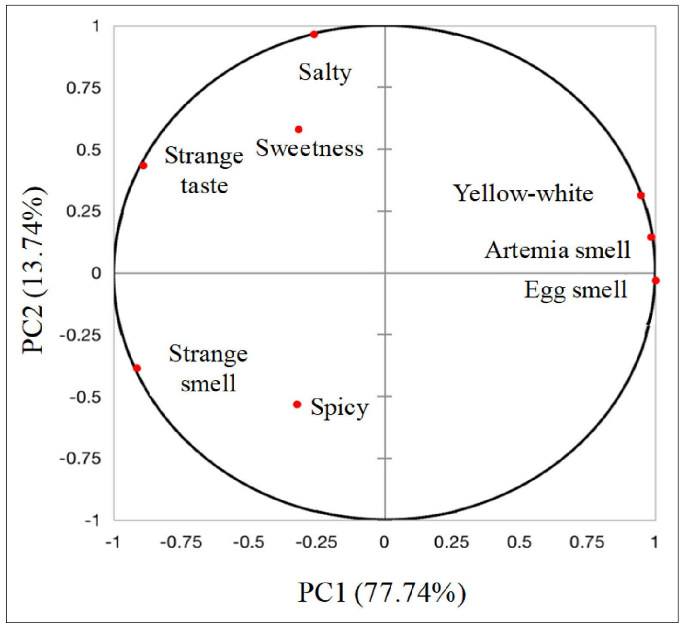

Figure 1: PCA was generated using the sensory data according to the proposed attributes and terms.

Figure 2 shows the dispersion of the samples on the graph when changing the ratio of Artemia powder/sugar/salt (%) greatly affected the sensory feel of the Artemia seasoning powder product. Sample groups A1, A2, and A3 are considered to have strong seafood (Artemia smell) and egg odors due to their proximity to the first principal component axis. However, the strong seafood smell and egg smell are two attributes that consumers do not like about this product. Sample A6 was assessed as having a strange smell, salty taste, sweet taste, spicy taste, and strange taste. Off-flavors are undesirable attributes of this product. Sample A5 is near the second main ingredient axis and is considered to have a beautiful yellowish white color, moderate seafood aroma, not too strong egg smell, and harmonious salty, sweet, and spicy flavors. Besides, sample A4 is also evaluated to have similar sensory characteristics to sample A5. In addition to sensory evaluation using the quantitative description method to determine each sensory attribute of the formulas, six Artemia seasoning powder samples were also evaluated sensorily using the scoring method according to the 7-point hedonic scale [Table 4], including odor, taste, color, and overall acceptability attributes.

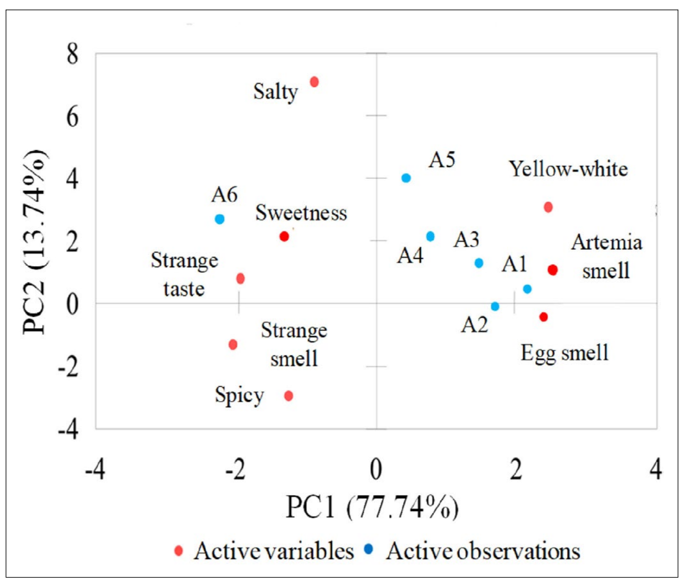

Figure 2: Relationship between six Artemia seasoning powder samples and sensory attributes.

From the sensory attributes (odor, taste, and color) among the Artemia powder formulas, the results showed that the overall acceptability scores of all formulations ranged from 5.0 to 6.7 points. The highest score is shown in sample A5 (6.7±0.3), not significantly different from sample A4 (6.2±0.2). Samples A6 (5.8±0.15), A3 (5.7±0.2), and A2 (5.5±0.15) showed a decreasing trend, and the lowest score was exhibited by sample A1 (5.0±0.2). Samples A3 and A6 are not different from each other, whereas samples A1 and A2 are different from the remaining samples.

From the results of sensory evaluation according to the QDA method and the hedonic scale, it was confirmed that sample A5 was highly appreciated by the panelists because of its beautiful bright whitish yellow color, harmonious taste, and moderate aroma. From the analysis results of nutritional values, energy, and energy distribution of different Artemia seasoning powder formulas, along with sensory evaluation, formula A5 with Artemia powder/sugar/salt ratio (%) of 40:26:24 was selected as the best among six designed formulas.

3.4. Effect of Temperature and Roasting Time on the Quality of Artemia Seasoning Powder

3.4.1. Color, a_w, and water-binding capacity

The effects of different roasting times on color, a_w, and water-binding capacity (WBC) are presented in Table 5.

3.4.2. Color and a_w

The important changes during roasting are the loss of moisture, the reduction of bonds in the grain, and the caramelization of sugars and other components that change color. Color is one of the main quality attributes of soup powder and is considered to directly influence consumer acceptance and selectivity. The color change of Artemia seasoning powder may be due to lipid and protein oxidation during roasting. The L* value [Table 5] of the sample roasted at 160°C for 10 min (66.65) decreased significantly compared to the sample roasted at 2.5 min (85.14). The longer the roasting time, the darker the Artemia seasoning powder. Browning in roasted foods is mainly due to the development of non-enzymatic reactions such as the Maillard reaction and sugar caramelization [11]. Şahin et al. [12] stated that the Maillard reaction, part of the non-enzymatic browning reaction system, prevails when components such as reducing sugars and amines (amino acids, peptides, or proteins) react with each other during thermal treatment in food processing. The b* value increased significantly (from 10.25 to 20.38) when the roasting time was extended.

Table 4: Sensory evaluation scores of sensory attributes for different Artemia seasoning powder formulations.

Formula	Odor	Taste	Color	Overall Acceptability
A1	4.8 ± 0.26	5.0 ± 0.2	4.3 ± 0.2	5.0 ± 0.2
A2	5.2 ± 0.2	5.3 ± 0.1	4.6 ± 0.3	5.5 ± 0.15
A3	5.6 ± 0.15	5.7 ± 0.2	5.2 ± 0.2	5.7 ± 0.2
A4	6.1 ± 0.2	5.8 ± 0.15	5.7 ± 0.1	6.2 ± 0.2
A5	6.5 ± 0.22	6.2 ± 0.2	6.0 ± 0.15	6.7 ± 0.30
A6	5.7 ± 0.15	5.5 ± 0.1	4.9 ± 0.12	5.8 ± 0.15

Mean ± Std. The ratio of Artemia powder/sugar/salt (%) →A1 (60:15:15), A2 (55:18:17), A3 (50:20:20), A4 (45:23:22), A5 (40:26:24), and A6 (35:29:26).

Similar to the research results of Kahyaoglu et al. [13], it was observed that the whiteness of sesame seeds initially increased and then decreased during roasting. An increase in the redness and yellowness of sesame seeds was observed with increasing temperature and time. When fixing the roasting time to 5 min, the L* value decreased significantly and the b* value increased significantly when increasing the roasting temperature. It should also be noted that the Maillard reaction rate at high temperatures increases and L* decreases, which is another cause of this phenomenon [14]. Therefore, thermally processed foods often contain varying levels of Maillard reaction products, which are ideal temperature–time indicators for determining the extent of heat treatment. Water activity did not differ significantly across roasting times, fluctuating in the range of 0.201–0.227. With this range, the product can be preserved for a long time while still maintaining quality [15].

3.4.3. Water-binding capacity

WBC refers to the amount of water that a dry food is capable of absorbing and is directly related to its hydration capacity [16]. WBC of Artemia seasoning powder decreased with increasing roasting temperature and roasting time (also presented in Table 5), and the highest WBC of Artemia seasoning powder was 375.12 and the lowest was 248.02 when roasted at 160°C for 2.5 min and 180°C for 10 min, respectively. The decrease in WBC with increasing temperature and roasting time may be due to the denaturation of the protein. As a results, the hydrophobic groups move to the surface of the protein and the amount of hydrogen bonding is reduced [17]. If denaturation is too extensive, causing aggregation and coagulation of protein molecules, the protein's ability to absorb water will decrease because the surface area of the protein that can be exposed to water is reduced [18].

3.5. Nutritional Composition, Microstructure (SEM), and Total Aerobic Microorganisms of Finished Artemia Seasoning Powder Product

3.5.1. Nutritional ingredients

From the analysis results of color, a_w, and water-binding ability, roasting Artemia seasoning powder for 5 min showed that the product has a

Table 5: Effects of different roasting temperatures and times on color, a_w, and water-binding capacity (WBC).

Roasting Temperature (°C)	Roasting Time (min)	Color		a_w	WBC
		L*	b*		
160	2.5	85.14 ± 0.61	10.25 ± 0.15	0.227 ± 0.002	375.12 ± 4.62
	5	83.21 ± 0.45	12.98 ± 0.31	0.22 ± 0.0016	351.01 ± 4.38
	7.5	72.54 ± 0.25	16.68 ± 0.11	0.220 ± 0.003	338.42 ± 5.12
	10	66.65 ± 0.23	20.38 ± 0.26	0.213 ± 0.005	306.57 ± 6.11
170	2.5	80.12 ± 0.30	17.14 ± 0.19	0.22 ± 0.003	324.48 ± 2.19
	5	77.59 ± 0.33	19.56 ± 0.24	0.217 ± 0.0015	315.35 ± 5.23
	7.5	60.01 ± 0.25	25.68 ± 0.35	0.212 ± 0.004	298.81 ± 4.89
	10	42.15 ± 0.17	29.38 ± 0.20	0.204 ± 0.004	276.14 ± 5.72
180	2.5	65.57 ± 21	21.26 ± 0.18	0.211 ± 0.003	287.25 ± 3.15
	5	56.12 ± 0.35	27.68 ± 0.26	0.207 ± 0.002	279.15 ± 6.14
	7.5	41.24 ± 0.56	33.11 ± 0.24	0.204 ± 0.005	266.45 ± 5.63
	10	28.27 ± 0.45	39.35 ± 0.19	0.201 ± 0.0019	248.02 ± 7.02

Mean ± Std.

beautiful bright whitish yellow color and good water-binding ability. The nutritional composition of the product increased slightly after roasting at 170°C temperature for 5 min with protein, lipid, carbohydrate, and ash content of 33.54, 0.74, 2.82, and 2.51%, respectively. The increase in the proportion of protein, fat, carbohydrate, and ash content can be mainly due to the decrease in moisture content, due to dripping or evaporation under roasting conditions [19]. Similar to the report of Hu et al. [20], the protein, lipid, and ash content of roasted scallops increased with increasing roasting temperature and time. Previous studies have also reported significant water loss and increased protein, fat, and ash content in silver catfish (*Rhamdia quelen*) and mussels (*Mytilus galloprovincialis*) after oven roasting [19,21].

Comparing the macronutrient composition of Artemia seasoning powder products with seasoning products processed from other animal sources currently on the market, the results showed that the protein content of our product is 35.54 g/100 g, about 3.06–3.48 times higher than seasoning powder products on the market (10.2–11.6 g/100 g), the lipid content of this product (0.74 g/100 g) is equivalent to 0.1–4.1 g/100 g, and the carbohydrate content (2.82 g/100 g) is lower by about 12.59–19.65 times the carbohydrate content of existing seasoning products on the market. Artemia seasoning powder contains a high protein content, and when used as a spice, it can provide good nutrition for human health, as it contains 7–8 essential amino acids and highly polyunsaturated fatty acids [3].

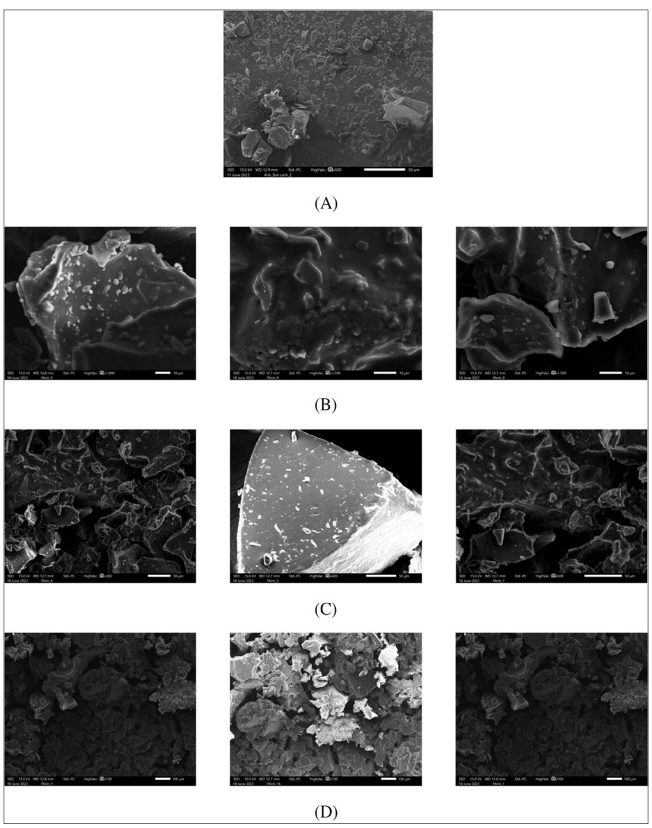

Figure 3: Scanning electron microscope images of Artemia seasoning powder samples with different sizes and magnifications. **(A)** Artemia seasoning powder after roasting and not grinding (particle size 50 μm, 550×). **(B)** Artemia seasoning powder after roasting and grinding, particle size 10 μm (1000×, 1500×, and 2000×). **(C)** Artemia seasoning powder after roasting and grinding, particle size 50 μm (300, 400×, and 500×). **(D)** Artemia seasoning powder after roasting and grinding, particle size 100 μm (100× and 250×).

Figure 4: Artemia seasoning powder product.

3.5.2. Microstructural (SEM) image of the product

The results of SEM imaging of seasoning samples are presented in Figure 3. The addition of different ingredients in the seasoning powder recipe has a great influence on the texture of the product. The sample after mixing clearly shows that the particle size is not uniform [Figure 3A], so the sample needs to be mechanically ground to increase product uniformity. Powder particles from various components have different sizes and have an angular polygonal structure, with several indentations and many holes of different depths observed. Powder particles of smaller size are connected and packed tightly together [Figures 3B and 3C] to form a cluster and show better particle uniformity. With small particles, the interaction force increases leading to the agglomeration of molecules and dense distribution phenomenon [22]. Larger seasoning powder particles are often incomplete, irregular in shape, and form more voids [Figure 3D]. The reason may be that due to the grinding process, different components in the powder mixture with different structural characteristics often have different degrees of mechanical damage [23]. However, after grinding, the uniformity of the sample was significantly improved [Figure 4].

4. CONCLUSION

Technology for producing nutritional seasoning powder from Artemia combined with other ingredients has been developed. The seasoning powder product uses 40% foam mat–dried Artemia powder in a formula that has been selected as the best formula with a good combination of other ingredients. This product has a higher protein content than seasoning powder made from other sources, so it is very suitable for people with protein needs and can be used to replace part of seasoning powder from meat/fish/shrimp. The product structure is also well-evaluated and highly accepted by consumers. Based on complete research on the nutritional value of Artemia, using foam-mat dried Artemia powder to make seasoning powder and taking advantage of Artemia sources with high nutritional value will bring good prospects every year in the Mekong Delta of Vietnam. However, there also needs to be technological improvements applied and tested on a larger production scale to develop this new product for the food technology industry with the goal of serving the community more.

5. AUTHOR CONTRIBUTIONS

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agreed to be accountable for all aspects of the work. All the authors are eligible to be an author as per the International Committee of Medical Journal Editors (ICMJE) requirements/guidelines.

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7. CONFLICTS OF INTEREST

The authors report no financial or any other conflicts of interest in this work.

8. ETHICAL APPROVALS

This study does not involve experiments on animals or human subjects.

9. DATA AVAILABILITY

All the data is available with the authors and shall be provided upon request.

10. USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

11. PUBLISHER'S NOTE

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