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The Nutritional Composition, Sensory Evaluation, and Physical Properties of Cake Patties Made from Shrimp – *Artemia* (*Artemia franciscana*)

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Abstract

This study was conducted to effectively use *Artemia* biomass to create a new product, high-quality shrimp – *Artemia* cake patties. The surveys included the development of 09 formulas that partially replaced shrimp meat with *Artemia* biomass (from 2.5 to 20%) to improve the quality of the finished product. The research results showed that, among the designed formulas, formula A5 (replacement ratio of 12.5% shrimp meat with *Artemia* biomass) produced a product with beautiful color (L* = 60.56), acceptable structure with hardness of 4325.73 gf, springiness of 0.937 and cohesiveness of 0.567. The product from formula A5 also achieved high sensory value (beautiful color, delicious taste) and was accepted by most consumers. The product quality was analyzed with moisture, protein, carbohydrate, lipid, and ash values of 66.88%, 14.19%, 11.94%, 5.30%, and 1.68%, respectively.

Keywords: *Artemia franciscana*, shrimp – *Artemia* cake patties, physicochemical properties, nutritional composition, sensory evaluation

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1. Introduction

In Vietnam, especially in the Mekong Delta, *Artemia* (*Artemia franciscana)* is a nutritious animal and is considered a popular aquaculture food. *Artemia* is a small crustacean that lives in salt water. *Artemia* has a short growth cycle, reaching adulthood after 10 to 15 days and starting to reproduce. During the process of collecting cysts, the amount of biomass discharged due to death during egg collection or after the end of the annual farming season is up to thousands of tons and has not yet received due attention [1]. *Artemia* biomass has a high protein content (50–60%) and is rich in fatty acids and vitamins [1]. Studies on using *Artemia* as food for humans are gradually gaining attention due to its outstanding nutritional properties. Therefore, developing new products from *Artemia* is essential, helping diversify food sources for humans and increasing income for *Artemia* farmers. Research has been conducted on using the foam drying method and processing of *Artemia* seasoning powder [2-4]. However, research on using *Artemia* to make human food has yet to be widely researched. *Artemia* sources are rich in nutritional value and can be processed into human food [5]. The current cake patties on the Vietnamese market all use nutritious raw materials such as pork, squid, beef, shrimp, fish, etc., but they are expensive. In addition, fish/shrimp cake patties in Vietnamese meals are also quite popular due to their convenience and diversity [6]. Shrimp cake patties are also very popular due to their delicious, convenient products that reduce processing time because their formula already contains some spices, making it easier and faster to handle. Nutritious raw materials such as *Artemia* biomass have a high annual output that still needs to be effectively used. This study was conducted to develop a new formula for producing shrimp – *Artemia* cake patties. Successful research will contribute to the effective use of locally available raw materials, reduce the amount of shrimp used, reduce costs, and diversify products from *Artemia* biomass and shrimp. If worked effectively, this activity will increase income for local farmers and improve their quality of life.

2. Materials and methods

2.1 Preparation of materials

Fresh *Artemia* biomass was reared at the Vinh Chau experimental farm of Can Tho University, Vietnam. From 18-20 days after stocking, *Artemia* biomass can be harvested.

Samples were frozen (≈-28ºC), packed, and transported to the laboratories. *Artemia* biomass was washed in cold water (<10ºC) to remove impurities, then drained and put into zip bags weighing 500 g/bag and frozen at -10ºC. Whiteleg shrimp was collected in the College of Aquaculture and Fisheries, Can Tho University, Vietnam. Samples were packed (≈4–5ºC) in an insulated box and transported to the laboratories. Then, the shrimp are peeled, the head is removed, the black thread is separated, and washed in a 0.5% NaCl solution. After preliminary processing, the shrimp meat was washed in cold water (<10ºC), drained, put into zip bags weighing 500 g/bag, and frozen at -10ºC. Lard was purchased at the supermarkets (Can Tho City), washed in clean water, and drained. This material was finely ground, put into zip bags weighing 100 g/bag, and frozen (-10ºC). Duck egg, tapioca starch, konjac flour, seasoning powder, pepper powder, and garlic powder were purchased at supermarkets in Can Tho City.

2.2 Formulation of the shrimp – Artemia cake patties

The ingredients and usage ratios in nine (09) formulas (A0 to A8, previously tested formulas) for preparing cake patties from shrimp meat and *Artemia* (Table 1). The formula A0 is the control sample (using all shrimp meat), while the remaining 08 formulas replaced a part of shrimp meat with *Artemia* in different proportions. In all formulas, in addition to shrimp meat and *Artemia* changing, other ingredients are used in fixed quantities.

2.3 Preparation of the shrimp – Artemia cake patties

Shrimp meat and *Artemia* are pre-treated, washed in cold water (<10ºC), drained, and frozen (≈-10ºC) at least 24 hours before processing (samples stored for no more than 10 days). After freezing, shrimp meat and *Artemia* were thawed at 3 to 5ºC for 12 hours. The thawed *Artemia* sample was steamed for 4 minutes to destroy microorganisms and enzymes and then cooled at normal temperature for about 10 minutes. The raw shrimp meat and *Artemia* are coarsely ground by an electric meat grinder stainless steel (300 W, China) for about 1 minute. After being coarsely ground, shrimp meat and *Artemia* are weighed again with a ratio, mixed with other ingredients, and ground finely, then refrigerated (3–5ºC) for 30 minutes to stabilize the texture. The shrimp – *Artemia* paste was shaped with an aluminum mold (8 cm diameter), steamed at 95ºC for 15 minutes, then cooled to stabilize the texture. The sample was then analyzed.

2.4 Physico-chemical properties of shrimp – Artemia cake patties

2.4.1 Color measurement

The sample's color (L* value) was determined using a Hunter Lab Colorimeter (Color Flex, USA).

2.4.2 Texture Profile Analysis

Texture profile analysis (TPA): The samples were prepared by cutting into 20 mm and 22 mm thickness and diameter slices, respectively. The TA.XT.plusC texture analyzer (Stable Micro Systems Co., England) with a 50 mm cylindrical probe (P/50) was used for structure measurements. The TPA was conducted using two 40% of their original height compression cycles with a 5-second interval between compressions. Force-deformation curves were obtained using a 5–kN load cell applied at a 60 mm/min cross speed. Each sample was measured three times. The results presented are the average values.

2.4.3 Chemical compositions

The moisture, protein, lipid, carbohydrate, and ash content were determined by AOAC [7].

2.5 Sensory evaluation

Quantitative Descriptive Analysis (QDA) sensory evaluation of shrimp – *Artemia* cake patties samples. The sample was described by seven descriptive qualities: brown color, white color, shrimp odor, *Artemia* odor, sweetness, saltiness, and toughness. The sensory evaluation method was carried out according to Thuy, et al. [8].

2.6 Statistical analysis

The experimental values were analyzed using Statgraphics Centurion XV.I (USA) and Excel 2013 software. The results are reported as mean±standard deviation (STD). In addition, sensory analysis was carried out using XLSTAT 2014 for Principal Component Analysis (PCA).

3. Results and discussion

3.1 Proximate composition of shrimp meat – Artemia cake patties from mixed formulas

The nutritional composition of the shrimp–*Artemia* cake patties at different formulas is shown in Table 2. The moisture content represents the water composition of the food, and this water content is responsible for any biochemical reactions of the food. It was observed that the moisture content of the shrimp – *Artemia* cake patties tended to increase from about 63.53% to 68.17% when the ratios of *Artemia* were changed from formula A0 to A8 (Table 2). These results might be explained by the moisture in the *Artemia* being higher than the moisture content in the white-leg shrimp, which could interfere with the protein-water interaction in the gel matrix. This result is higher than the moisture contained in the Thai fish cake (Tod mun pla) fortified with sago palm weevil larvae products (45.05–64.71%) of Kingwascharapong, et al. [9]. However, a moisture content that is too high is not desirable, as when moisture content increases, the gel gets weakened due to a decrease in the breaking force of gels [10].

The proximate composition of the cake patties from shrimp meat and *Artemia* prepared according to 09 recipes are presented in Table 2. The results showed that the proteins, lipids, carbohydrates, and ash of the samples had significant differences, with protein ranging from 16.79% to 13.07%, lipids from 5.01% to 5.58%, carbohydrates from 11.61 to 13.45% and ash from 1.56% to 1.79%, respectively. A decreasing trend was observed for protein content in the cake patties samples at a higher level of *Artemia* ($P < 0.05$). In that formula, A0 gave the highest protein value (16.79%); the lowest value was shown in formula A8 (13.07%). This result is due to shrimp meat having a higher protein content (70–77% DW) than *Artemia* (44–52.7% DW). The protein content decreased when a portion of shrimp meat was replaced with Artemia. Therefore, the sample needs to be designed with the highest percentage of *Artemia* (most suitable) to create the product shrimp – *Artemia* cake patties have high enough protein content and low price. The lipid content of cake patties samples increased from formula A0 to A8 (Table 2). The increase in lipid content in the formula was due to the higher lipid content in *Artemia* biomass than that in whiteleg shrimp. *Artemia* is rich in highly unsaturated fatty acids (accounting for 52.31% of total fatty acids) and polyunsaturated fatty acids (accounting for 7.43% of total fatty acids) [11]. These fatty acids have a unique role in preventing cardiovascular disease and some neuropsychiatric disorders, especially depression and dementia, notably Alzheimer's disease [12]. This result is consistent with Zhou, et al. [13] the fat content of surimi fortified with camellia oil increased to 9.13% when those surimi were replaced with camellia oil at 70%. The increase in lipids in patty products had significant nutritional significance for humans. The ash content of all processing formulas of shrimp – *Artemia* cake patties ranged from 1.56–1.79% (Table 2). It can be seen that these values decreased when supplemented ratios of *Artemia* increased ($P < 0.05$).

It was possibly due to the significant components of *Artemia*, which may interfere with the amount of inorganic matter in the cake patties samples. The result was similar to the finding of Kingwascharapong, Petsong, Karnjanapratum, and Pongsetkul [9], who revealed that the ash content of the Thai fish cake (Tod mun pla) fortified with sago palm weevil larvae significantly decreased following an increase in the amount added, due to the significant components of sago palm weevil larvae being lipid, which may interfere with the amount of inorganic matter in the Thai fish cake samples. Similarly, Nasution, Nur Atiqah, Fisal, and Wan Hafiz [10] also showed that the moisture, protein, lipid, carbohydrate, and ash content of surimi–based products made from African catfish were 76.30%, 11.16%, 1.42%, 10.89%, 0.27% respectively. Zhou, Jiang, Zhao, Zhang, Gu, Pan, and Ding [13] processed surimi enhanced with camellia tea oil with physicochemical properties such as moisture (71.81%), protein (11.04%), and fat (7.46%) were reported. Therefore, similar to other surimi products, the commercialization of products combined with *Artemia* could better use this raw material, create diverse products, and reduce the amount of shrimp meat (high cost) used to process cake patties. This activity has the potential to create products with quality equivalent to cake patties from shrimp meat only, bringing high economic efficiency by reducing the cost of raw materials used and investment in production.

3.2 The color and texture profiles of cake made from shrimp meat fortified with Artemia at different formulas

3.2.1 The color (L)*

The color (L*) and texture profiles of cake patties made from shrimp meat fortified with *Artemia* at different formulas are shown in Table 3. Color is an important parameter indicating the customer acceptance [14]. The basic properties of the cake patties made from shrimp – *Artemia* are lightness (L* value). The cake patties made from shrimp meat replaced by *Artemia* at different ratios showed a difference in color from the measured L* values; with increasing replacement level of *Artemia*, then the L* values decreased significantly (Table 3). The L* values in the formulas were clearly shown, with the highest value in formula A0 (74.46±0.02) and the lowest value in the sample prepared from formula A8 (54.71±0.04). Since *Artemia* contains astaxanthin, an orange-red pigment [15], incorporating *Artemia* into the cake patties tended to decrease the L* value, making the cake patties appear darker. As more *Artemia* was used to replace shrimp meat, the darker pigments became more pronounced, and as a result, the L* value of the final product was significantly reduced. The color of protein gel products varies depending on the types and concentrations of added additives or the raw material used [16]. The color formed is probably due to the combination of many ingredients from the diverse ingredients used in the formulas. Kingwascharapong, Petsong, Karnjanapratum, and Pongsetkul [9] reported that the lightness (L*) of the Thai fish cake (Tod mun pla) fortified with sago palm weevil larvae was 40.73 at the 80:20 ratio of fish mince and larvae, respectively. Thus, based on measured L* color values, it can be seen that the color of shrimp – *Artemia* cake patties depends mainly on the level of replacement of the *Artemia* in formula.

3.2.2 Texture Profiles Analysis

Generally, TPA parameters have been widely used to investigate several foods' rheological properties and sensory parameters [17]. *Artemia* replaced part of the shrimp that had decreased the cake patties' hardness, springiness, and cohesiveness (Table 3). Hardness is used to assess the change in food structure during the first bite of the product [17]. The ratio of *Artemia* at higher levels showed a slightly decreasing trend of hardness compared to control, where the formula A0 (control sample) gives the highest hardness value (5636.52±266.13 gf) and the lowest is the formula A8 with a hardness value of 3049.25±165.09 gf. The ratio of *Artemia*, especially at the higher level, might interrupt the formation of the gel network. The high water content of *Artemia* can obstruct protein gelation and negatively impact the gel structure. Similar results were confirmed by Chang, et al. [18], who reported that an emulsion of surimi added with soybean oil at a moisture content of 76% had a higher hardness value than a sample with a moisture content of 80%. Meng, et al. [19] reported that the low moisture content in surimi directly affects the hardness of surimi gel by increasing the hardness of the product. Springiness was initially described as elasticity [17].

The *Artemia* could decrease the springiness values of gels. The results in Table 3 showed a slight difference in gels' springiness values with different *Artemia* ratios from formula A0 (0.967) to A8 (0.907). It can be due to the high water content of *Artemia*, which may affect the texture of cake patties. Cake patties with higher water content are always softer and have a tenderer texture. However, excessive water may prevent the texture from becoming too loose, reducing springiness and producing a mushier product. This is because water disrupts the formation of protein and starch networks that help maintain structural integrity [20]. Cohesiveness is the extent to which an applied force can overcome internal bonding until deformation [21]. The cohesiveness of the cake patties also tended to decrease with increasing *Artemia* replacement ratio. The lowest value (0.517) was measured from formula A8, where the *Artemia* supplementation content was the highest among the formulas (Table 3). The high water content of *Artemia*, which dilutes starch and protein networks, leads to a weaker structure & reduced cohesiveness [22]. Excess water can separate during cooking or storage, causing the patty to become soggy and fall apart [23].

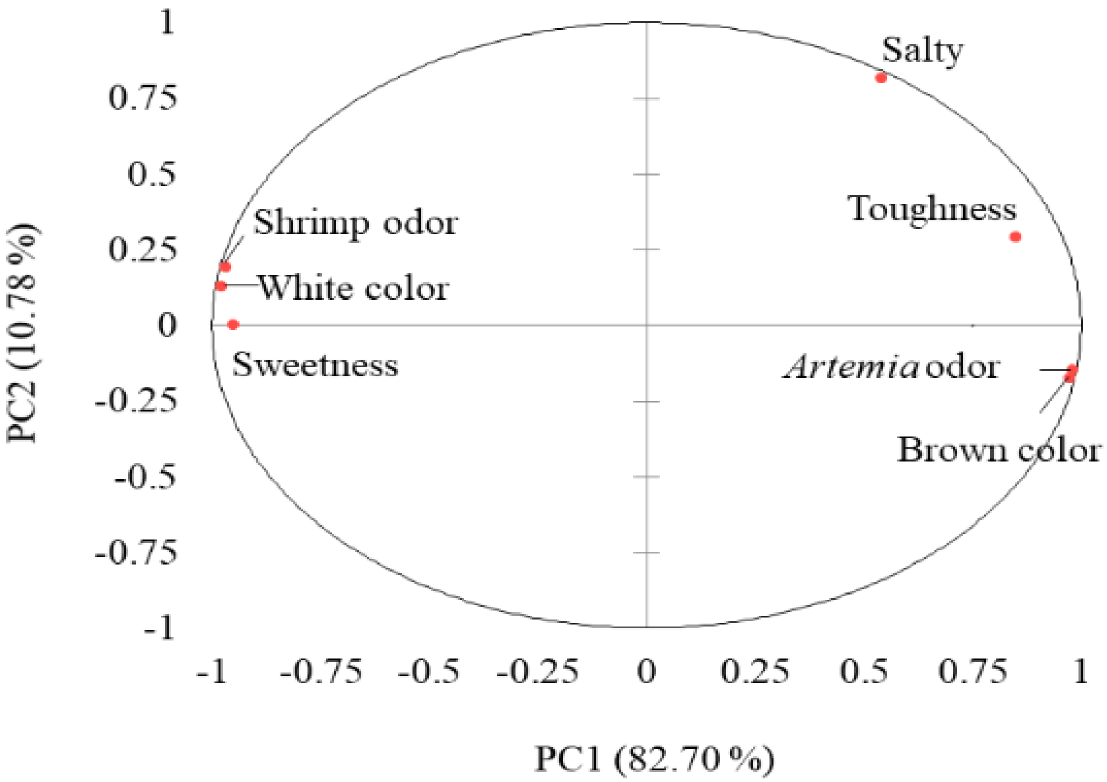

Figure 1: Distribution of sensory attributes as assessed by the panelists

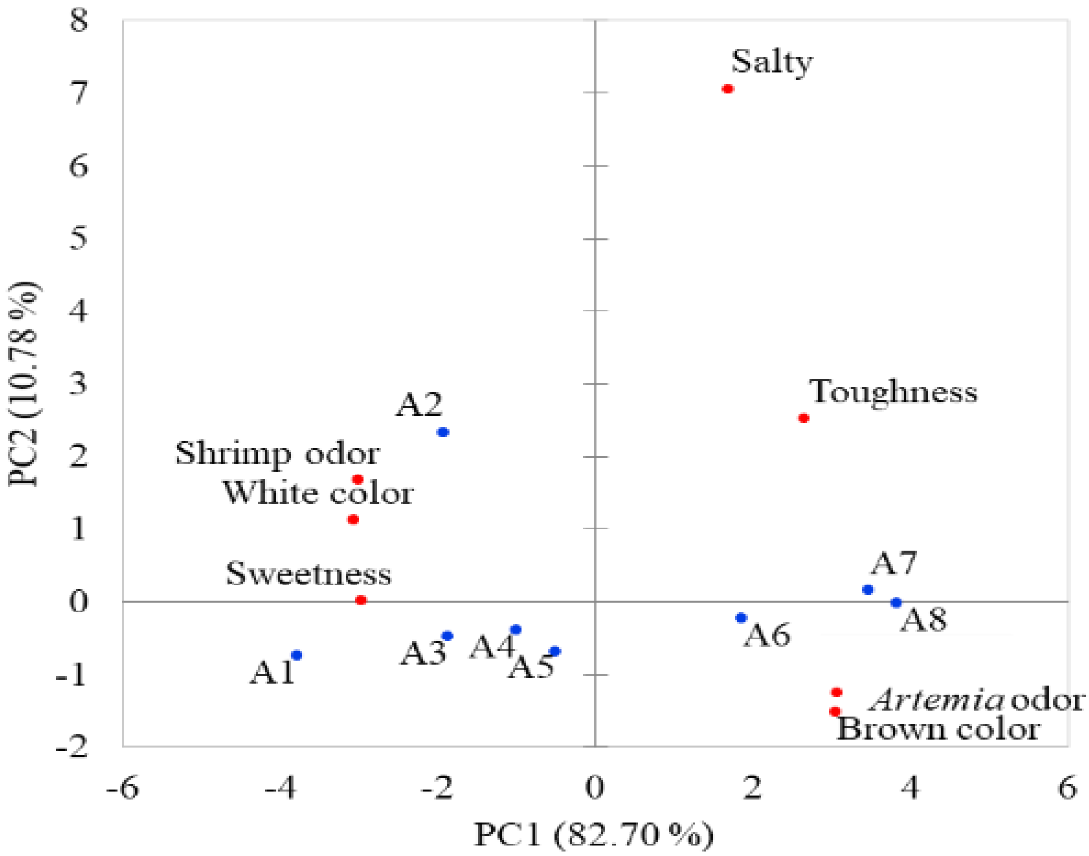

Figure 2: Correlation of sensory properties with shrimp – *Artemia* cake patties formulas

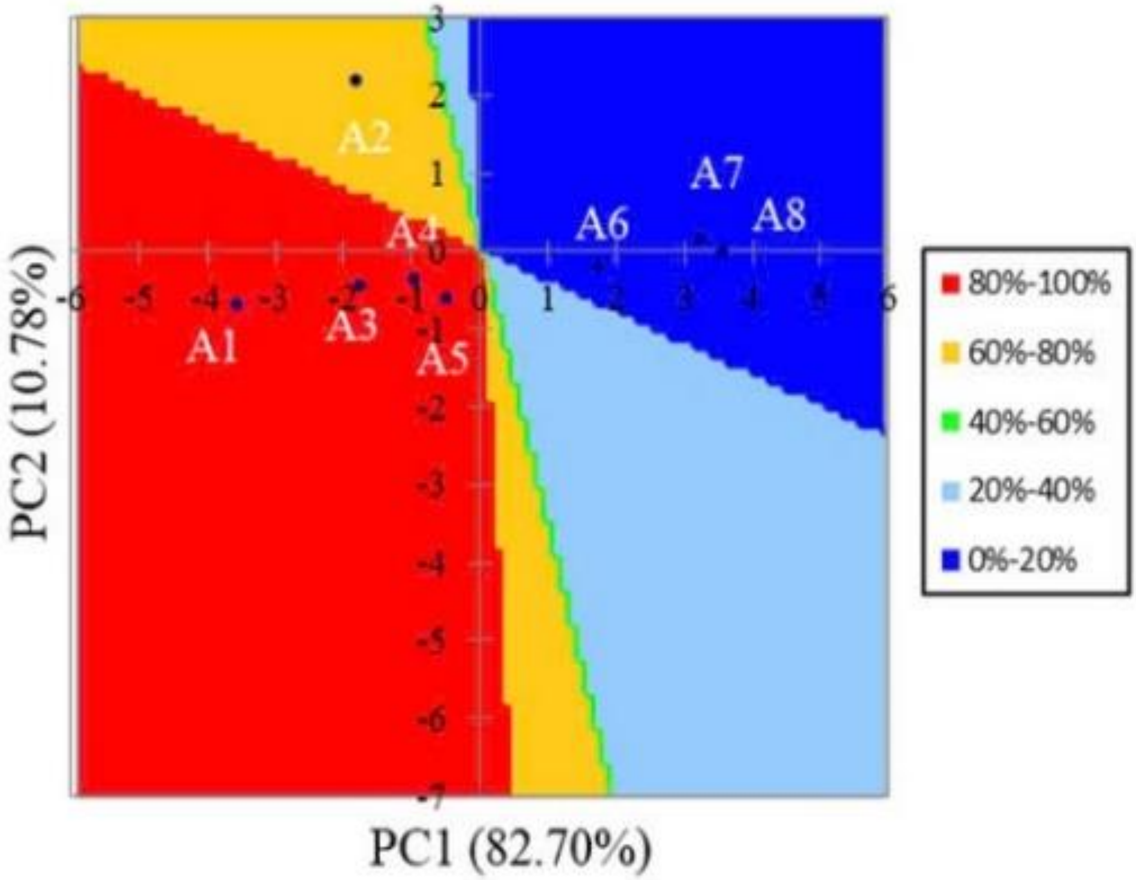

Figure 3: Visualization of the consumer's preferences with preference map for all shrimp – *Artemia* cake patties formulas

Table 1: Shrimp – *Artemia* cake patties formulas

Ingredients (%)	**A0**	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**
Shrimp meat	75	72.5	70	67.5	65	62.5	60	57.5	55
Artemia	0	2.5	5	7.5	10	12.5	15	17.5	20
Lard	6	6	6	6	6	6	6	6	6
Duck egg	6	6	6	6	6	6	6	6	6
Tapioca starch	7	7	7	7	7	7	7	7	7
Konjac flour	4	4	4	4	4	4	4	4	4
Seasoning powder	1	1	1	1	1	1	1	1	1
Pepper powder	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Garlic powder	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Table 2: Nutritional composition of shrimp meat – *Artemia* cake patties

Formula	**Moisture content (%)**	**Protein (%)**	**Lipid (%)**	**Carbohydrate (%)**	**Ash (%)**
A0	63.53 ± 0.41^{a}	16.79 ± 0.29^{f}	5.01 ± 0.02^{a}	12.87 ± 0.42^{bc}	1.79 ± 0.02^{f}
A1	63.79 ± 0.46^{ab}	16.53 ± 0.28^{f}	5.06 ± 0.02^{b}	12.84 ± 0.41^{bc}	1.78 ± 0.04^{ef}
A2	64.08 ± 0.42^{abc}	16.02 ± 0.24^{e}	5.14 ± 0.02^{c}	12.99 ± 0.57^{c}	1.77 ± 0.02^{ef}
A3	64.37 ± 0.45^{bc}	15.43 ± 0.27^{d}	5.18 ± 0.01^{d}	13.28 ± 0.60^{c}	1.74 ± 0.02^{de}
A4	64.75 ± 0.42^{c}	14.85 ± 0.26^{c}	5.23 ± 0.02^{e}	13.45 ± 0.25^{c}	1.72 ± 0.03^{cd}
A5	66.88 ± 0.40^{d}	14.19 ± 0.23^{b}	5.30 ± 0.01^{f}	11.94 ± 0.26^{a}	1.68 ± 0.05^{bc}
A6	67.02 ± 0.44^{d}	14.02 ± 0.26^{b}	5.35 ± 0.02^{g}	11.96 ± 0.65^{a}	1.65 ± 0.04^{b}
A7	67.55 ± 0.46^{de}	13.31 ± 0.22^{a}	5.42 ± 0.02^{h}	12.13 ± 0.42^{ab}	1.59 ± 0.02^{a}
A8	68.17 ± 0.41^{e}	13.07 ± 0.22^{a}	5.58 ± 0.03^{i}	11.61 ± 0.41^{a}	1.56 ± 0.04^{a}

Mean±STD. The ratio of shrimp: Artemia (%) → A0 (75:0), A1 (72.5:2.5), A2 (70:5), A3 (67.5:7.5), A4 (65:10), A5 (62.5:12.5), A6 (60:15), A7 (57.5:17.5), A8 (55:20). Different superscripts following treatments in the same column indicate significant differences (P < 0.05).

Table 3: The color (L*) and texture profiles of cake patties made from shrimp meat fortified with *Artemia* at different formulas

Formula	Color	Texture profiles		
	L*	Hardness (gf)	Springiness	Cohesiveness
A0	74.46±0.02[j]	5636.52±266.13[e]	0.967±0.02[e]	0.643±0.03[e]
A1	72.68±0.04[h]	5552.13±230.22[e]	0.963±0.01[de]	0.630±0.02[e]
A2	70.65±0.23[g]	5342.16±199.32[e]	0.957±0.02[de]	0.610±0.05[de]
A3	65.89±0.03[f]	4777.39±144.20[d]	0.953±0.02[cde]	0.603±0.02[cde]
A4	62.52±0.03[e]	4747.63±143.63[d]	0.947±0.02[cde]	0.587±0.02[bcde]
A5	60.56±0.08[d]	4325.73±243.18[cd]	0.937±0.03[bcd]	0.567±0.03[abcd]
A6	56.72±0.03[c]	4493.26±196.97[c]	0.927±0.02[abc]	0.537±0.02[abc]
A7	55.74±0.04[b]	3790.27±258.55[b]	0.913±0.02[ab]	0.533±0.03[ab]
A8	54.71±0.04[a]	3049.25±165.09[a]	0.907±0.01[a]	0.517±0.02[a]

Mean±STD. The ratio of shrimp: Artemia (%) → A0 (75:0), A1 (72.5:2.5), A2 (70:5), A3 (67.5:7.5), A4 (65:10), A5 (62.5:12.5), A6 (60:15), A7 (57.5:17.5), A8 (55:20). Different superscripts following treatments in the same column indicate significant differences (P < 0.05).

Therefore, cake patties made from shrimp meat fortified with *Artemia*, with a progressively variable content from formulas A1 to A8, were likely to hinder gel structure improvement, as indicated by decreasing hardness, springiness, and cohesiveness. It might be explained by moistures, which are the main components in *Artemia*, which are higher than the moisture content in whiteleg shrimp. Hashemi and Jafarpour [24] found that water content affected sausage gel properties and that the hardness, elasticity, and cohesiveness of smoked sausage decreased with increased water content. However, replacing shrimp with *Artemia* at the highest rate is to reduce costs and diversify products from *Artemia* and cake form. All formulas to create products with moderate hardness, good elasticity and high adhesion.

3.3 Sensory evaluation of cake patties products made from shrimp and Artemia

PCA method was used to describe the sensory properties of different formulations and the correlation between the formulation and the sensory properties was recorded. The formulation which is closer to the sensory properties, that formulation shows the highest sensory properties [25]. The sensory quality of the product is analyzed by 15 members trained to evaluate. The frequency of attributes indicating organoleptic characteristics of significant interest to shrimp – *Artemia* cake patties, including brown color, white color, shrimp odor, *Artemia* odor, sweetness, salt, and toughness. These are the essential attributes that determine this type of product choice. The relationship between sensory characteristics and the two principle components (PC) selected to represent collected sensory data (Figure 1). These attributes are divided into three distinct regions based on the distribution of sensory characteristics. Region 1 includes 2 attributes such as salty taste and toughness, while Zone 2 consists of 2 attributes: brown color and *Artemia* odor. Area 3 includes the three attributes: white color, shrimp odor, and sweetness. The salty taste attribute is far from the PC1 axis (first PC), so this attribute has little effect on PC1. On the other hand, sweetness, *Artemia* odor, and brown color attributes are next to the PC2 axis (second PC), so the PC2 depends strongly on sweetness, *Artemia* odor, and brown color attributes.

In addition, attributes such as *Artemia* odor, brown color, sweetness, and white color are located near the F1 axis. Thus, the PC1 is most influenced by these attributes. The distribution of cake patties formula on graph (Figure 2) showed that design formulas greatly influence cake patties's sensory properties. Formula groups A1 and A2 with *Artemia* substitution ratios of 2.5% and 5% shrimp meat evaluated as having a characteristic shrimp odor, bright white color, only sweet taste without salty taste, and moderate toughness. Formula groups A3, A4, and A5 with *Artemia* substitution ratios of 7.5%, 10%, and 12.5% shrimp meat, respectively, were evaluated as having a shrimp, *Artemia* odor harmoniously characterizes product, light brown color, harmonious sweetness – salty taste, well toughness. This is a product group that is favored by testers. Formula groups A6, A7, and A8 had low sensory scores due to their dark brown color, strong *Artemia* odor, and poor toughness. The preference mapping also showed similar results (Figure 3) when different formulas were evaluated according to preference. The chart again confirmed that formulas A1, A3, A4, and A5 were most preferred by consumers (80-100%). This is because products possess delicious and characteristic tastes. Meanwhile, formulas A2 (60-80%) also have relatively high consumer acceptability, and A6, A7 & A8 (0-20%) have low consumer acceptability.

4. Conclusions

This study has established a formula for processing shrimp – *Artemia* cake patties with good quality and high consumer acceptance from sensory evaluation. From the research results, the A5 cake patties formula with a shrimp: *Artemia* ratio of 62.5:12.5 (%) was selected from 9 established recipes. With this recipe, the cake patties product has an acceptable texture (hardness 4325.73 gf, springiness 0.937, cohesiveness 0.567) and has the best sensory value with a beautiful color noted (L* value of 60.56). The shrimp – *Artemia* cake patties are a safe instant product, meeting consumers' nutrition and health requirements. Further research can support consumer confidence and develop products at different production scales according to local shrimp and *Artemia* production. Ultimately, it can increase income and improve people's lives, cultivating this valuable source of nutritional ingredients in localities nationwide.

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