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Research Article

Study of Seasoning Powder Processing from Gray Abalone Mushroom

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The gray abalone mushroom is a rich source of amino acids and carbohydrate compounds, with some biological activities and antioxidants. Nowadays, the variety of food additives on the market such as sodium glutamate (E621), sodium guanylate (E627), or sodium insonate (E631), could probably cause negative effects for people's health. This study used gray abalone mushrooms to create naturally derived seasoning products without using flavor enhancers and synthetic compounds. The gray abalone mushroom was pretreated and dried at 60°C until attaining the moisture content of <5%, while the biological activity and antioxidant values were kept optimal. The mixture ingredients, including 5% abalone mushroom powder, 2% baby cornstarch, and other seasoning ingredients, were uniformly ground. The based-gray abalone mushroom powder that was packed in PE with the moisture content below 3% displayed stability in terms of quality throughout 90 days. Gray abalone mushroom seasoning powder contributed to creating safe, natural products as well as improving consumers' health.

1. Introduction

Abalone mushroom, also known as gray oyster mushroom, tough mushroom, white mushroom, and white foot shiitake mushroom has the scientific name of *Pleurotus ostreatus*. It is an edible mushroom belonging to the family *Pleurotaceae*. Abalone mushrooms were first grown in Germany. Since 1970, mushrooms have been widely cultivated around the world. Abalone mushrooms commonly grow on dry stems or straw and develop into alternating mushroom ears like a ladder [1].

Mushrooms are considered highly nutritious such as vitamin B, vitamin D, and some other minerals [2, 3]. Furthermore, mushroom protein contains all the essential amino acids, especially lysine and leucine, which contribute a small amount in most grains. Besides, other components such as lucid, vitamins, minerals, fatty acids (mainly unsaturated acids, organic acids...) also contribute to the nutritional values of mushroom content [4]. In terms of energy, abalone mushrooms provide less energy compared to shiitake and are considerably equivalent to straw mushrooms, which are very suitable for dieters. Abalone mushrooms contain about 33–43% protein content, being higher than shiitake mushrooms, in which it is composed of 40–50% of essential amino acids [4]. Therefore, abalone mushrooms are recommended for consumption on a daily basis in many countries [5]. In addition, edible mushrooms also possess many health-beneficial effects such as treating high blood pressure, obesity, and intestinal disorders. Many studies showed that abalone mushrooms and other edible mushrooms exhibited anticancer effects. At the same time, mushrooms also contain more folic acid than meat and vegetables that is essential for people with anemia. Moreover, mushrooms are noted for their low fat and starch

content, which makes them suitable for patients with diabetes and high blood pressure [6].

The addition of abalone mushrooms to many commercial products has been widely employed to increase the nutritional values of the resulting product. Srivastava et al. [7] added 20% of abalone mushroom powder to instant soup products to improve the product's protein content. The result showed that the protein content in the product increased to 11.79 g/100 g. Rosli et al. [8] showed that adding 6% of abalone mushroom powder to the fried chicken meal increased the ash content, moisture content, and carbohydrate content. On the other hand, the powdered cohesion on the chicken was also better while it reduced the fat content but still did not change the adhesion. This study confirmed that the addition of mushroom powder was used as an alternative to functional ingredients to improve the nutritional value of processed food products. In addition, the addition of (15%) abalone mushroom to the baking powder was reported to increase the water absorption (66.4%) compared to the control sample (56.4%). Another result indicated that the maximum viscosity increased from 1595 to 1700 BU when adding from 3% of mushroom powder to 15% of the mushroom powder sample [9]. Previous studies found that the nutrition of gray abalone mushrooms is extensive, but most of them might contain a mixture of fungi and microorganisms, which is not suitable for vegetarians.

On the other hand, the demand for seasoning powder is increasing in Asian countries and Vietnam (statistics from Nielsen Corporation). Achieve an average annual growth of 25–32% in the period 2016-2022. Accordingly, seasoning powder products are consumed daily to meet 30 million liters of soup/day, seasoning for fried dishes on a daily basis. At the end of the week, increase 18 million dishes/day, seasoning in stock dishes 14 million pot/day. The seasoning market is currently dominated by large food groups (Knorr (Unilever), Maggi (Nestlé), Aji-Ngon (Ajinomoto), and Miwon), which account for 33% of the total condiments while supplying the main seasoning from meat and bone and vegetarian seasoning from shiitake Statistics from Nielsen Corporation.

There are several similar products on the market that commonly use flavor enhancers, affecting human health. In this study, we aimed to select the optimal parameters for the production of seasoning powder from gray abalone mushrooms. A process for producing seasoning powder from gray abalone mushrooms was proposed. First, we investigated the blanching condition to evaluate the polyphenol oxidase (PPO) inactivation, followed by a drying process. After the blanching and drying process, the structure of treated mushrooms was found to be difficult to grind. Thereby, the blanching process was skipped. During the drying process, the total polyphenol content (TPC), total flavonoid content (TFC), and antioxidant activities of the resulting product were investigated. The dried mushrooms were then ground into a fine powder to create seasoning powder. The product was packaged in 3 different types of packages and stored at room temperature for a minimum of 90 days. The result was expected to create a product without using flavor enhancers while still promoting the richness and nutrition of the dishes. In particular, the product is considerably used by vegetarians.

2. Materials and Methods

2.1. Samples. Gray abalone mushrooms were harvested in Can Tho city (latitudes 10°01′57″N and longitudes 105°47′03″E), Vietnam in October 2020. After harvest, type 2 and type 3 mushrooms were selected with a height of 6–8 cm. The sample was stored at 5°C within 24 h after harvesting.

2.2. Chemicals and Agents. Analytical chemicals such as hydrogen peroxide (H_2O_2), Guaiacol ($C_7H_8O_2$), Folin-Ciocalteu, ABTS (2,2′-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid), and DPPH (2,2–dephenyl–1– picrylhydrazyl) were purchased from Sigma-Aldrich. Other chemicals such as Na_2CO_3 (purity 99.5%) (Natri Carbonat), $AlCl_3$ (Aluminium Cloride), CH_3COOK (Kali Acetate), and $K_2S_2O_8$ (Potassium persulphate) were derived from China.

2.3. Mushroom Seasoning Powder (MSP) Processing. The sample was preliminarily treated by removing the roots at the foot of the fungus and unsatisfactory parts, and by removing dirty particles from the material by using distilled water. Each mushroom was prepared into 5-6 specimens by tearing it apart. The samples were dried at 60–80°C until they had a moisture content of <5%. The dried sample was then ground and sieved using a 0.5 mm mesh. The mixture of seasoning powder was prepared as follows: mushrooms (3–7%), corn (1–3%), malto (8–14%), and some other fixed ingredients. The final product was preserved for 15–90 days by packing it in 3 types of packages (PE/PVC/Aluminum) at room temperature 31°C.

2.4. Determination of PPO. PPO inactivation was performed through blanching, as described by Olivera et al. [10]. The blanching process was carried out at 70°C for 4 min. The treated sample was immediately immersed in cold water for 2 min. The sample was then placed in a test tube containing 10 ml of deionized water. An aliquot mixture of 2 ml of 3 hydrogen peroxide (v/v) and 2 ml of 1% guaiacol (v/v) was added to each test tube. The change in color of the solution in the test tube to a reddish-brown color indicates that PPO remains active, while the unchangeable color reveals the complete inhibition of these enzymes.

2.5. Determination of TPC. Total polyphenol content (TPC) was determined by the Folin-Ciocalteu method based on the description in Dao et al. [11, 12]. For the determination process, the sample was extracted with distilled water and diluted to the appropriate concentration. Then, an aliquot (0.5 ml) of the diluted sample solution was added to the test tube along with 2.5 mL of 10% Folin–Ciocalteu solution and then homogenized uniformly by using a Vortex Apparatus. The mixture was allowed to react for 5 min. Then, 2.0 mL of a 7.5% Na_2CO_3 solution was added to the mixture and kept

for 1 h in the dark at room temperature. The absorbance was read at 765 nm using a UV-Vis spectrophotometer. Gallic acid was used as the standard. The polyphenol content was expressed in milligrams of gallic acid equivalents in 1 g of extract (mgGAE/g of extract).

Standard curve equation for TPC: $y = 0.10165x + 0.01427$ with $R^2 = 0.99966$.

2.6. Determination of TFC. The total flavonoid content (TFC) was determined according to Thaipong et al. [13, 14]. An aliquot of 0.5 mL of the diluted sample solution was added to a test tube along with 0.1 mL of 10% $AlCl_3$ solution. Then, 0.1 mL of 1 M CH_3COOK solution and 4.3 mL of distilled water were added to the test tube. The mixture was kept at room temperature for 30 min. The absorbance of the solution was measured at 415 nm. Quercetin was used as the standard. The total flavonoid content is expressed as milligrams of quercetin equivalent in 1 g of extract (mgQE/g of extract).

Standard curve equation for TFC: $y = 0.009392x - 0.01158$ with $R^2 = 0.99952$.

2.7. Determination of ABTS Reducing Capacity. The ABTS antioxidant test was conducted according to the method of Nhi et al. [15, 16]. The ABTS free radical solution was prepared by adding 10 mL of 7.4 mM ABTS solution to 10 mL of 2.6 mM $K_2S_2O_8$ solution. The mixture was incubated in the dark for 24 h, and then diluted with ethanol to adjust the absorbance of the solution at 734 nm to 1.1 ± 0.02. To a suitable concentration range, and draw 0.5 mL of the diluted sample into a test tube along with 1.5 mL of ABTS solution and allow to react for 30 min in the dark. The absorbance was recorded at 734 nm. Use the equation $y = -0.1266914x + 0.6672952$ (R^2 coefficient = 0.99936) to calculate the percentage of milligram equivalents of ascorbic acid in 1 g of dry matter compared with the original sample for the free radical scavenging capacity by ABTS.

2.8. Determination of DPPH Reducing Capacity. The DPPH antioxidant test was conducted according to the method of Brand-Williams [17–19]. First, 0.5 mL of the diluted sample was added to the test tube. DPPH solution (1.5 mL) was included to the test tube and allowed to react for 30 min in the dark. The mixture absorbance was recorded at 517 nm. The free radical neutralization capacity by DPPH was calculated as a percentage of the milligram equivalent of ascorbic acid in 1 g of dry matter compared with the original sample according to the equation $y = -0.1239x + 0.991$ (R^2 coefficient = 0.99999).

2.9. Sensory Evaluation. The experiment was carried out on 15 senses, described and practiced according to the provisions of National Standard TCVN 3215-79 (Tables 1 and 2).

2.10. Prediction of Shelf Life Using Thermal Acceleration. The *Q* method assumes that the product quality degrades according to a constant *Qn* when the temperature changes by a certain number [15]. With a temperature change step of usually 10°C, *Qn* is sometimes referred to as Q_{10}. With a known value of Q_{10}, the shelf life was calculated using the formula

$$t_s = t_0.Q_{10}.n. \quad (1)$$

In where: t_s: shelf life under normal storage conditions; t_0: shelf life at thermal acceleration; *n*: thermal acceleration temperature (°C) minus normal storage temperature (°C) divided by 10°C.

2.11. Statistical Analysis. Each experiment was in thrice replicates. The result was expressed as the mean ± standard deviation. One-way analysis of variance (ANOVA) and the Tukey test were used to compare mean values among analyzed groups by using Statgraphics software (Statgraphics Technologies, Inc., The Plains, Virginia) at the significant level of 5%.

3. Result and Discussion

3.1. Basic Physicochemical Composition of Raw Materials. The chemical composition of gray abalone mushroom, baby corn, and white radish is shown in Table 3. The results showed that the moisture content in gray abalone mushrooms fluctuated around 87.23 ± 2.24%, and the protein content was about 3.64 ± 0.02%. These values were consistent with Galoburda's study on the composition of oyster mushrooms *(Pleurotus ostreatus)* [20] and higher than those published by Sing (2012) on the total protein content of oyster mushrooms (*Pleurotus ostreatus*), reaching 0.98–2.71% [21]. On a wet basis, the carbohydrate content in mushrooms reached 9.65 ± 1.45% (equivalent to 87-88% on a dry basis); this value was similar to that of *P. floridanus* [22]. In addition, the total fat content in gray abalone mushrooms reached 0.44 ± 0.04%, which was lower than that of wild oyster mushrooms from the study of Kuda et al. (0.62–0.84%) [23] and encyclopedia Heritage (0.2–8%) [24].

The baby corn used in this study had a bright yellow color. The moisture content in baby corn ranged from 85 to 87%, providing a total protein value of 3.55 ± 0.01. The nutritional and physicochemical value of baby corn depends on the harvest age and the growing conditions. The location of cultivation is also a factor that significantly affects the nutritional and physicochemical value of raw materials. In addition, baby corn (zea mays) contained 5.43 mg/100 g ascorbic acid and 670 μg/100 g β-carotene. The calcium, magnesium, and phosphorus contents of baby corn were 95.00 mg/100 g, 345.00 mg/100 g, and 898.62 mg/100 g, respectively. The content of methionine reached 0.05 μg/g, meanwhile the isoleucine and leucine were 2.85 μg/g and 0.675 μg/g, respectively [24]. Baby corn also provided 1.48 ± 0.05% fiber (both soluble and insoluble on a wet basis,

Table 1: Mixing ratio for seasoning powder.

Ratio (%)	Mushroom powder	Corn powder	Sugar	Salt	Tapioca	Mushroom flavor	Other	Maltodextrin
M1	3	1	20	50	5	7	6	14
M2	3	2	20	50	5	7	6	13
M3	3	3	20	50	5	7	6	12
M4	5	1	20	50	5	7	6	12
M5	5	2	20	50	5	7	6	11
M6	5	3	20	50	5	7	6	10
M7	7	1	20	50	5	7	6	10
M8	7	2	20	50	5	7	6	9
M9	7	3	20	50	5	7	6	8

Table 2: Term describing the sensory evaluation of seasoning powder.

Factor	Influence factor	Score	Description
Color	1.2	5	White, opaque, and slightly ivory, with small brown spots
		4	White with brown fungus stains
		3	Yellow ivory white, with brown stains
		2	Ivory white with many brown stains
		1	Ivory color is less white, with many brown stains
		0	Strange color
Texture	1.2	5	Porous powder, no lumps, fine, and uniform particle size
		4	Porous powder, no lumps, and not smooth size
		3	Porous powder, no lumps, and small particle size
		2	Porous dough, with few small-sized lumps
		1	Porous powder, with lumps, and small size
		0	Nonporous, lumpy dough
Flavor	1.6	5	Fragrant, sweet, and characteristic flavor of mushrooms
		4	Strong aroma, slightly salty taste, less sweet, characteristic flavor of mushrooms
		3	Fragrant, less sweet, less salty, characteristic smell
		2	Less aromatic, mildly sweet, with a slight mushroom taste
		1	Less fragrant, with a pale taste, and very light mushroom smell
		0	Strange taste, hard to recognize
Favorite		5	Like a lot
		4	Like so much
		3	A little like
		2	Like less
		1	Accept
		0	Dislike

Table 3: Chemical composition of raw materials.

Composition	Content		
	Mushroom	Corn	Radish
Moisture (%)	87.23 ± 2.24	86.95 ± 1.10	94.75 ± 0.54
Protein (%)	3.64 ± 0.02	3.55 ± 0.01	0.44 ± 0.01
Ash (%)	1.01 ± 0.10	0.46 ± 0.08	1.11 ± 0.03
Fat (%)	0.44 ± 0.04	1.54 ± 0.05	0.38 ± 0.03
Carbohydrates (%)	9.65 ± 1.45	7.47	3.34
Sugar (mg/g dry)	4.14 ± 0.06	4.77 ± 0.03	8.99 ± 0.23
Fiber (%)	1.36 ± 0.02	1.48 ± 0.05	2.88 ± 0.01

equivalent to about 11–12% on a dry basis). According to the announcement of the Japanese Technology Company, in a variety of baby corn used to prepare soup in Taiwan, the fiber content accounted for about 11% [25]. On the other hand, baby corn also provided 8.10 g/100 g cellulose and 5.41 g/100 g of lignin, 13% of potassium, 14% of vitamin B-6, 10% of riboflavin, 17% of the vitamin C that is necessary for adult consumption [25].

Radishes are considered a main source of raw materials for the sugar industry (consisting mainly of beets and

hybrids) [26, 27]. Radish contains many vitamins (including water-soluble and oil-soluble vitamins), about 0.02 mg/100 g of thiamine, 0.2 mg/100 g of niacin, 0.138 mg/100 g of pantothenic acid, and 22.00 mg/100 g of ascorbic acid. In the study, the sugar content in white radish was higher than that of the other two raw materials, reaching $8.99 \pm 0.23\%$ (wet basis) (Table 4). The World Heritage Committee noted that the sugar content of this ingredient was about 2.5 g/100 g (for radish varieties grown in Japan) [28]. Radish was also found to have a certain amount of beneficial trace elements, which were believed to promote a fat-reducing effect in hepatocytes and counteract the proliferation of isothiocyanates (the hydrolyzed form of glucosinolates in various cancers) [29].

3.2. Effect of Conditions During Blanching. Polyphenol oxidase (PPO) is an enzyme that causes browning effect in many fresh fruits, especially mushrooms. Therefore, the inactivation of the PPO enzyme is essential to reduce the possibility of product darkening. On the other hand, some previous studies have shown that the heat treatment contributes to the reduction of PPO enzyme activity, creating an excellent sensory appearance for the product. However, each material needs different blanching conditions to achieve the best product quality. Therefore, we performed heat treatment of gray abalone mushroom material by blanching at a temperature of 60–80°C, for 2–6 min, and 3 different sizes of ingredients.

Figure 1 shows the degree of PPO inactivation in gray abalone at different cutting thicknesses. After blanching at 80°C for 2 min, it was shown that all the whole-forked-tripled samples gave negative results with the guaiacol indicator, and there is no difference in blanching mushroom size at this survey parameter. Gray abalone mushroom is a soft-structured material, which facilitates a rapid heat transfer rate within 2 min. The results were similar to those obtaining when blanching potato slices at 90°C, for 2 min with a thickness of 1 cm [30]. Therefore, the basic structure was selected for the following experimental evaluation.

The efficiency of PPO inactivation in mushrooms at different blanching temperatures of 60–70–80°C for 2 min is shown in Figure 2. Fresh samples gave a (+) indicator with a red color, showing a strong activity of PPO. Test tubes containing blanched samples at 60°C showed red spots, however, a very little percentage showed that PPO still had low content and there was no difference when surveyed at 70 and 80°C. The publication of Hooda et al. [20] indicated that the temperature of 80°C was capable of inactivating the PPO as well as ripening the product cells.

Yılmaz et al. [31] recommend that blanching mushrooms at higher temperatures than 60°C was effective in preventing browning and inactivating the PPO. It is known that PPO includes thermostable and thermostable forms of enzymes, the inactivation of PPO is strongly influenced by temperature and time. In a study by Jittanit et al. [32], it was found that potato slices blanched in 40–50°C water for 60 min were able to partially inactivate the PPO, while Sathivel et al. stated that the PPO could be completely inactivated within 7 min at 90–120°C in apples [33]. Slice thickness, hardness, and permeability, as well as heat transfer between materials, are factors contributing to the discrepancy in the PPO inactivation activity. Thereby, the soft structure of the abalone mushroom helps fasten the blanching process, leading to the PPO inactivation effect in a short time. When blanching at 60°C, the sample showed a red stain, showing the existence of PPO in the sample, whereas PPO was completely inactivated at 80°C but was considerably energy-consuming. Therefore, the blanching temperature of 70°C was selected as the optimal temperature in the blanching process.

Blanching time has a direct effect on the PPO enzyme in abalone mushrooms (Figure 3). During the survey time of 2 min, a small pink spot appeared in the control sample (+), while the other two samples gave the negative result (−). It can be seen that the size and thickness of each individual mushroom ears are different. The difference in the uniformity of each sample after blanching leads to the pale color of the guaiol indicator. The blanching process at 90°C for 60 sec with the help of an ultrasound system at 60°C only partially inactivated the PPO activity [31]. Thus, the results showed a good agreement in selecting a blanching time of 4 min.

3.3. Effect of Drying Process Conditions. With negative changes as shown in Table 5 after blanching and drying (hard structured mushrooms, leading to the difficulty for the grinding process). To obtain better performance from the final mushroom seasoning powder, the blanching process might be skipped and the fresh mushrooms were directly subjected to the drying process.

The change in the content of biologically active substances in mushrooms after the drying process is shown in Figure 4. The study showed that TPC, TFC, DPPH-reducing, and ABTS reducing values decreased sharply when drying at different temperatures 60–70–80°C (with an air velocity of 45 Hz). Specifically, the TPC value decreased from 17.96 ± 1.56 mg·GAE/gDW to 11.37 ± 0.63 mg·GAE/gDW (at 60°C); 9.43 ± 0.42 mgGAE/gDW (at 70°C), and there was no significant difference of the TPC value between 70°C and 80°C of the dried sample ($p > 0.05$). Notably, the DPPH-reducing value reduced during heating, and there was no difference between the dried samples. Bioactive compounds are very sensitive to temperature and light that heating them for a long time will cause negative effects. The results showed that the TFC was reduced by 70% after the drying process, and the ABTS scavenging effect of the sample lost 50% of its activity. About 60% of polyphenols compounds were degraded through the drying process at 60 °C. Singla et al. showed that DPPH and ABTS free radical scavenging activity (about 2.67 mgAA/100 gDW) tended to decrease after drying at 60°C by convectional hot air [33].

The drying process ends when the moisture content is less than 5%, and the change in color and sensory description is shown in Table 6. The results showed that the drying temperature had a significant influence on the product quality. However, according to the statistical results, there was no significant effect on the yield of the product

Table 4: Content of biologically active compounds in gray abalone mushrooms.

Content (mg/g dry matter)		Mushroom ear	Mushroom body
Moisture (%)		86.92 ± 3.07	82.90 ± 0.13
TPC		16.33 ± 0.93	14.65 ± 0.60
TAA		0.26 ± 0.03	0.09 ± 0.02
TFC		15.50 ± 0.36	7.71 ± 0.50
DPPH		10.22 ± 2.31	14.30 ± 3.28
ABTS		5.58 ± 0.03	5.54 ± 0.06
Size (cm)		D: 6.41 ± 1.48	D: 1.37 ± 0.37 L: 6.05 ± 1.30
Color	L^*	64.73 ± 1.12	79.37 ± 0.47
	a*	0.81 ± 0.13	0.12 ± 0.02
	b^*	13.23 ± 0.09	4,35 ± 0.19

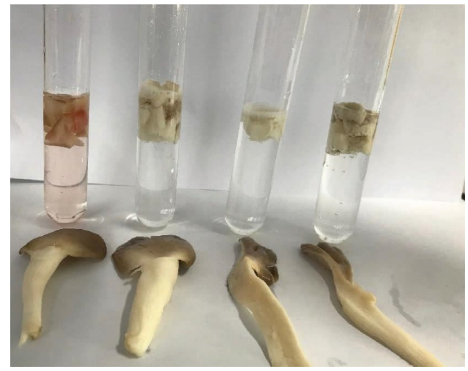

Figure 1: Effect of mushroom size on PPO enzyme inactivation efficiency during blanching (control-whole-split-split 3 of mushroom).

Figure 2: Effect of temperature on inactivation of PPO enzyme during blanching (control -60-70-80°C).

Figure 3: Effect of time on the fruit's inactivation of the PPO enzyme during blanching (2–4–6 min).

Table 5: Description of input materials and after drying to moisture content.

Materials	Image	Description
Radish		After drying, the product has a flexible structure, dark yellow, slightly brown color, Cannot be finely ground for blending After 24 hours, the smell begins to change in a negative direction
Corn		Characteristic yellow color after drying, hard structure, characteristic aroma Easy to grind to a size <0.5 mm
Mushroom		The structure of the mushrooms is blanched and hard after drying, the moisture draining time is long, and the product color greatly affects the quality of the output mushroom seasoning powder Difficult to grind

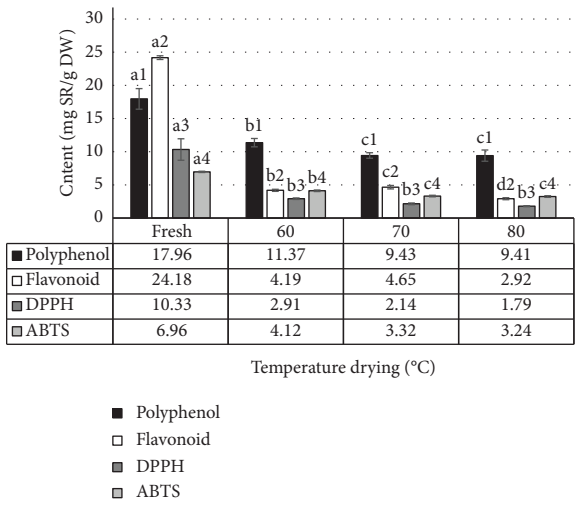

Figure 4: Effect of convection drying temperature on the content of bioactive compounds in gray abalone mushroom.

($p > 0.05$). Specifically, the dried mushrooms to its crispy structure and dark brown color; the recovery efficiency was about 7.71 to 8.74% by weight. The L^* value reached 64.64 ± 2.43 at the drying temperature of 60°C, the a^* value reached 8.06 ± 0.27 at 60°C, and there was no difference with samples dried at 70°C. In general, after the drying process, the browning effect was directly proportional to the drying temperature. High drying temperatures for an extended time also increased the taste of mushrooms. This could be ascribed to the browning reaction, the breakdown of volatile compounds in mushrooms [35, 36]. Lee et al. showed that temperature affected the color value and browning reaction rate. The study [36] showed that the L^* value reached 39.73 when drying at 50°C, a^* values were similar to our experimental results, ranging from 6.99 to 8.87, and b^* values were from 12.28 to 19.89.

The total color difference (TCD) at 60°C (14.93 ± 2.20) for the dried sample was the lowest. On the other hand, the bioactive compounds were found to be degraded at this drying temperature. The sensory evaluation result showed that samples dried at 60°C had a suitable structure for fine grinding. Besides, the drying process at 60°C required minimal consuming energy, which highly feasible for industrial applications. Therefore, drying at 60°C was considered a suitable process parameter for the drying process.

3.4. Effect of Mixing Ratio. The effects of the mixing ratio of mushroom and cornstarch (with maltodextrin filler adjusted) on dispersion time and solubility are shown in Figures 5 and 6. The results showed no significant difference in time dispersed at the same water temperature. However, using water with a temperature of 94 ± 2°C, reduced the dispersion time compared to using water at an average temperature; this value ranged from 11 to 15 seconds. Notably, in samples M2, M3, and M4, there was a significant difference in the statistical results, and the distribution time of particles was faster. The content of maltodextrin that influenced the M8 and M9 samples also gave similar results, possibly due to the influence of mushroom and cornstarch. The high insoluble fiber content in mushrooms and cornstarch induced a low solubility in the final product, increasing dispersion time. On the other hand, the solubility also showed that the mushroom seasoning powder in the mixing formulas from M1 to M9 ranged from 48.13 to 66.77%. M6–M9 samples had low solubility (48.13–54.33%), and M1–M5 samples had high solubility (61.93–66.77%). This was ascribed to the high ratio of mushrooms and cornstarch, resulting in a high content of insoluble carbohydrates. Solubility is one of the most important physicochemical and functional properties of a power product. The results of mushroom seasoning powder had lower solubility than tuna powder reported by Kanpairo et al. [37], ranging from 60.87 to 70.12% (with maltodextrin concentration greater than 30%). Solubility tends to increase with increasing maltodextrin to 24% of total soluble solids. This result was similar to that reported by Sarochawitkasit et al. [38]. The solubility of pineapple powder was 93–96% when adding 37–43% maltodextrin by the spray-drying method. Increasing the concentration of maltodextrin was found to increase the solubility of the powder [39].

The ratio of 2.5 g mushroom powder/150 mL was used to develop the seasoning powder for the evaluation sample, presented in Table 7. The characteristics of the sample were mostly similar, with a characteristic salty taste. Light, sweet, insoluble seeds, clear water, fragrant with mushrooms. However, a few members of the panelist could not detect the flavor of baby corn, typically in samples such as M1, M2, and M4.

From the abovementioned results, samples from M5 to M9 had better sensory descriptions than the others. At the same time, in terms of solubility, these samples tended to have reduced solubility and a fast dispersion time, in which the M5 sample with suitable solubility (ratio of 5% mushroom powder and 2% cornstarch) was selected for the mixing formula. A preliminary description of the mixing process of mushroom powder and other spices is presented in Table 8.

3.5. Effect of Storage Conditions. The effect of packaging on moisture content in gray abalone mushroom seasoning powder is presented in Table 9. Packaging had a significant effect ($p < 0.05$) on moisture content. In general, the moisture value ranged from 2.04 to 4.38%. However, a moisture content of more than 3% was out of the threshold according to the quality standard TCVN 7396: 2004. Specifically, PVC packaging showed that it had a negative effect on the moisture content of the product. After 90 days of storage, the moisture value increased from $2.40 \pm 0.40\%$ to $4.27 \pm 0.20\%$. The use of aluminum and PE/VC packaging was not found to significantly affect the moisture content, indicating the effectiveness and tightness of the packaging.

The total number of yeasts and molds in the gray abalone mushroom seasoning powder gave ND (nondetected) results. The total aerobic microorganisms, result of each sample is shown in Table 10. The results showed that aerobic

Table 6: Effect of convection drying temperature on the yield, color, and structure of gray abalone mushroom.

Drying temperature (°C)		Tươi	60	70	80
Image					
Moisture content (%)		85.56 ± 0.96	4.41 ± 0.43	4.74 ± 0.20	4.05 ± 0.10
Drying time		0	4 h 10′	3 h 20′	1 h 20′
Yield (%)		100	7.71 ± 1.24	8.74 ± 0.74	8.43 ± 1.27
Color	L^*	78.73 ± 0.55^{a1}	64.64 ± 2.43^{b1}	60.83 ± 2.31^{c1}	59.91 ± 1.89^{d1}
	a^*	0.82 ± 0.11^{c2}	$8{,}06 \pm 0.27^{b2}$	10.18 ± 1.75^{b2}	14.61 ± 2.85^{a2}
	b^*	7.33 ± 0.09^{a3}	3.84 ± 0.24^{b3}	$3.30 \pm 1.08c^{d3}$	2.41 ± 0.26^{d3}
	TCD	0^{d4}	14.93 ± 2.20^{c4}	23.38 ± 2.03^{b4}	29.50 ± 2.07^{a4}
Description		Soft, tough, brittle structure, characteristic gray-white color	Crispy structure, light brown color, characteristic aroma of mushrooms	Crispy structure, dark brownish yellow color, characteristic aroma of mushrooms	Crispy structure, dark brown with golden luster, characteristic aroma of mushrooms

[a–d]: statistically significant difference.

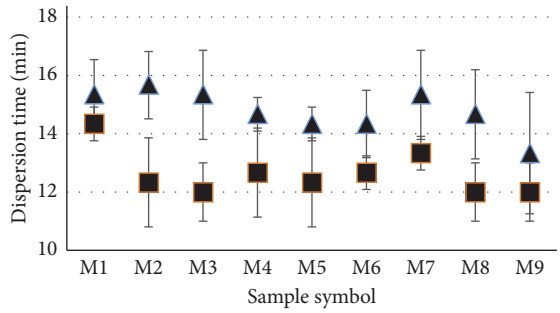

Figure 5: Effect of mixing ratio on dispersion time (s).

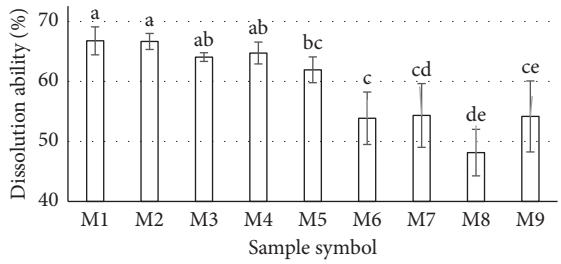

Figure 6: Effect of mixing ratio on the solubility of mushroom seasoning powder.

Table 7: Visual description of seasoning powder after mixing.

Code	Taste	Odor	Status	Characteristics of seasoning powder after brewing
M1	3.00 ± 0.67	2.80 ± 0.79	3.60 ± 0.70	Lightly salty, slightly sweet, insoluble seeds are large and small, clear water, fragrant, sometimes users do not smell corn
M2	3.00 ± 0.47	3.20 ± 0.92	3.00 ± 0.84	Lightly salty, less sweet, small insoluble seeds, clear water, mushroom aroma, sometimes users can't smell corn
M3	3.4 ± 0.84	3.50 ± 0.97	3.20 ± 0.92	Light salty taste, sweet bar, small insoluble seeds, clear water, light mushroom smell, corn smell
M4	3.10 ± 0.57	2.90 ± 0.57	3.10 ± 0.88	Light salty taste, little sweetness, small insoluble seeds, clear water, mushroom aroma, no corn smell
M5	3.90 ± 0.88	4.50 ± 0.53	3.20 ± 0.79	Light salty, sweet, insoluble seeds, clear water, fragrant mushrooms, light corn
M6	3.70 ± 0.48	4.50 ± 0.71	3.90 ± 0.88	Light salty taste, sweet bar, few insoluble seeds, clear water, mushroom smell, corn smell
M7	3.80 ± 0.63	4.00 ± 0.94	3.70 ± 0.48	Light salty taste, sweet bar, few insoluble seeds, clear water, light mushroom smell, corn smell
M8	3.40 ± 0.70	3.90 ± 1.20	3.70 ± 0.48	Light salty taste, little sweetness, few insoluble seeds, clear water, slight mushroom aroma, corn smell
M9	3.70 ± 0.67	4.40 ± 1.07	3.70 ± 0.67	Light salty taste, sweet bar, few insoluble seeds, clear water, mushroom smell, corn smell

microorganisms after 90 days in all three types of packaging (at room temperature) were below the allowable threshold ($<10^4$ CFU/g product). Specifically, during the 15-day storage period, this value was less than 10^2 CFU/g of product in all three types of packaging. However, after 45 days, the population of microorganisms increased exponentially, and there was a significant difference ($p < 0.05$) in aluminum packaging (7.7×10^1), vacuum PE (4.3×10^1), and PVC (1.2×10^2 CFU/g) after 75 days and 90 days. PVC packaging had a high thickness which was difficult to seal, less flexible, and easier to absorb water than aluminum packaging and vacuum PE packaging, noticeably affecting product quality. In Table 11, after 90 days of storage with PVC packaging, total aerobic microorganisms gave a high value of 4.6×10^2 CFU/g of product, which was not suitable if this packaging was used.

However, the preservation results of gray abalone mushroom seasoning powder showed that aluminum packaging had the same effect as PE/vacuum packaging. However, aluminum packaging was difficult to pack and seal, on the other hand, the cost of this packaging was considerably expensive. Thereby, PE packaging was flexible,

Table 8: The process of mixing mushroom powder and other spices.

Type	Image	Description
Mushroom powder		Mushrooms are crushed with a cutter and sieved through a sieve with a hole size of 0.5 mm, the particles on the sieve are returned to the grinding process to continue to be chopped
Cornstarch		Postdried corn has a crispy structure, light spongy, crushed to the same size as mushroom powder (this process is done independently)
Mixing		The process of mixing ingredients is calculated according to the formula with reference to the product on the market The mixing process is done in the order of adding each ingredient to avoid clumping Support heating temperature during mixing: 45°C, with stirring speed at 60 rpm until the mixture is visually homogeneous

Table 9: Effect of packaging on moisture content.

Packaging type	Aluminum (Al)	Vacuum sealed (PE/VC)	PVC
Control	2.40 ± 0.40	2.40 ± 0.40	2.40 ± 0.40
15 days	2.72 ± 0.53	2.48 ± 0.39	2.72 ± 0.56
30 days	2.98 ± 0.26	2.67 ± 0.44	3.91 ± 0.75
45 days	2.04 ± 0.81	2.76 ± 1.08	4.38 ± 0.52
60 days	2.82 ± 0.62	2.63 ± 1.66	4.03 ± 0.72
75 days	2.83 ± 1.47	2.94 ± 0.55	4.18 ± 1.22
90 days	2.89 ± 0.38	2.86 ± 0.52	4.27 ± 0,0.0

Table 10: Effect of packaging type on total aerobic microorganisms.

Packaging type	Aluminum (Al)	Vacuum sealed (PE/VC)	PVC
Control	KHP**	KHP	KPH
15 ngày	$^{b}1.3 \times 10^{1}$	$^{b}1.3 \times 10^{1}$	$^{a}2.3 \times 10^{1}$
30 ngày	$^{a}7.0 \times 10^{1}$	$^{b}4.0 \times 10^{1}$	$^{a}7.3 \times 10^{1}$
45 ngày	$^{b}7.7 \times 10^{1}$	$^{c}4.3 \times 10^{1}$	$^{a}1.2 \times 10^{2}$
60 ngày	$^{b}1.4 \times 10^{2}$	$^{c}7.7 \times 10^{1}$	$^{a}1.9 \times 10^{2}$
75 ngày	$^{b}1.7 \times 10^{2}$	$^{c}1.4 \times 10^{2}$	$^{a}3.3 \times 10^{2}$
90 ngày	$^{b}1.8 \times 10^{2}$	$^{b}1.9 \times 10^{2}$	$^{a}4.6 \times 10^{2}$

*LOD's minimum detection threshold value is 10 CFU/g. $^{a-c}$Statistically significant differences between columns (repetition calculated on plates).

Table 11: Predicting the shelf life of abalone mushroom seasoning powder.

Color coefficient	L^*	a^*	b^*	TCD	Q_{10}	Expiry date (days)
Control	88.27 ± 2.71	1.30 ± 0.09	1.41 ± 0.60	0	6	540.44
Thermal acceleration	78.05 ± 5.20	6.14 ± 0.63	17.18 ± 1.69	19.88 ± 1.59	6	90

easy to seal (can be vacuum sealed), and there was no significant difference in the preservation efficiency compared to aluminum packaging. Therefore, PE was chosen to pack and preserved the mushroom seasoning powder.

The quality indicators of moisture content and total aerobic microorganisms did not show any quality deterioration when exceeding the allowable threshold. Therefore, the color criterion was selected to evaluate the change in the product's properties by the method of thermal acceleration at 40°C.

By carrying out the method of thermal acceleration at a temperature of 40 ± 2°C compared to room conditions for sealed PE packaging to preserve the product for 90 days. The predicted storage time of gray abalone mushroom seasoning powder at room temperature was 540.44 days with Q_{10} estimated to be approximately 6.

4. Conclusion

In this study, the abalone mushroom seasoning powder was successfully developed. The final product was formulated with 5% abalone mushroom powder and 2% baby cornstarch, which was mostly preferred by the sensory panelists. The PE packaging was selected to preserve the final product with the moisture content below 3% stabilized for 90 days. The result showed the feasibility of this product for commercialization. This product is expected to be an alternative to synthetic seasoning powder due to its safety, naturally derived source, and enriched nutrient content.

Data Availability

The data used to support the findings of this study are included within this article.

Ethical Approval

This study does not involve any human or animal testing.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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