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Research Article

Panelist Acceptance, Proximate Characteristics of Amino Acids and Volatile Compounds, and Color Profile of Fermented Cempedak (*Artocarpus champeden*) and Oyster Mushroom (*Pleurotus ostreatus*) Seasoning

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The potential of mandai cempedak (*Artocarpus champeden*) powder to be mixed with other abundant raw materials such as oyster mushroom (*Pleurotus ostreatus*) as a flavoring ingredient is an exciting thing to study as a unique flavor source for the archipelago. This study aims to observe panelist acceptance, proximate characteristics of amino acid, volatile compounds, and color profiles on five mixed formulas of fermented cempedak (*Artocarpus champeden*) and oyster mushroom (*Pleurotus ostreatus*) seasoning. The five seasoning formulas combine 30–70% flavored mushroom powder and 30–70% mandai cempedak powder with control of commercial mushroom powder and pure mandai powder. Hedonic quality assessment on seasoning samples of flavored mushroom powder and mandai cempedak powder played a more critical role in the acceptance of the final product, with a slightly reddish yellow color tendency with a paleness level of around 66–67%. Seasoning samples had a savory taste with dominant amino acid profiles of ileusine (1.46%, w/w), glutamate (1.37%), methionine (0.82%), and aspartic acid (0.72%). All seasoning formulations of flavored mushroom and mandai cempedak powder have a moisture content of 8.4–10.9%, total protein 7.0–9.0%, soluble protein 2.4–3.5%, ash content 4.5–19.2%, fat content 2.3–4.5%, carbohydrates 62.7–79.4%, and the solubility is 31.0–89.4%. The dominant volatile compounds in seasoning are heptanone, dodecoxyethanol, and etradecyloxyethanol with pleasant aroma profiles, pungent fruity, green, citrus, and herbal. In conclusion, mandai cempedak powder to be mixed with other abundant raw materials such as oyster mushroom (*Pleurotus ostreatus*) can be used as a typical Indonesian flavor ingredient with unique characteristics in terms of its amino acid content, volatile compounds, and essential oils.

1. Introduction

Mandai cempedak is a typical product from Kalimantan, and this product utilizes waste from the cempedak fruit (*Artocarpus champeden*). Mandai making is done by spontaneous fermentation and stored at room temperature. The processing steps include peeling the fruit skin, removing the *epidermis*, and soaking it in salt water to preserve and soften the texture. The duration of immersion is from several hours to a month [1]. The process of making mandai cempedak by induction of lactic acid bacteria starter has received a patent number S00201708792.

Mandai cempedak can be used as a source of typical Indonesian flavor, as fruits with a strong and distinctive aroma. Mandai cempedak which has been fermented at 37°C for seven days has characteristics such as valeric acid (46.83% of the GCMS chromatogram area), lactic acid (8.17%), 1-hydroxy-2-propanone (7.86%), 3-isopropoxy-1, 1, 1, 7, 7, 7-hexamethyl-3,5,5-tris (trimethylsiloxy) tetrasiloxane (7.01%), and N-methyl-beta,3,4-tris (trimethylsiloxy) phenethylamine (6.86%). The typical mandai cempedak has been used in ice cream products [2]. One of the best drying results of fermented mandai cempedak is obtained at 45°C, with a total polyphenol content (TPC) of 358.8 ± 55.6 mg gallic acid equivalent (GAE) kg^{-1} dry sample, total hydrolyzed tannin content (HTC) of 143.8 ± 9.3 mg tannic acid equivalent (TAE) kg^{-1} dry sample, total flavonoid content (TFC) of 17.5 ± 1.3 mg catechin equivalent (CAE) kg^{-1} dry sample, and antioxidant activity (IC50) 56.96 g/mL [1]. The taste of mandai cempedak as a plant-derived product fermented by lactic acid bacteria is preferred [1], similar to other fermented products [3]. Lactic acid bacteria as flavor enhancers and seasoning food products have been widely used [4–6].

Oyster mushroom is a popular product widely used as a snack, usually served in dry, crispy fried foods. Oyster mushrooms have a taste readily accepted due to the high content of free amino acids [7]. The composition of umami components detected in mushrooms consisted of 5′-nucleotides groups, namely, inosinic acid (IMP), adenylate monophosphate (AMP), guanylate monophosphate (GMP), xanthosine monophosphate (XMP), and free amino acid groups, namely: aspartic and glutamic acid. The components of 5′-nucleotides and free amino acids are what cause the acceptance of oyster mushrooms to be the best when compared to other mushrooms [8].

The potential of mandai cempedak powder to be mixed with other abundant raw materials such as oyster mushroom (*Pleurotus ostreatus*) as a flavor ingredient is an interesting thing to study. The production process of vegetable seasoning from mandai cempedak and oyster mushrooms has been registered as a patent (no. S00202007443). The success of seasoning products is determined by the ability to improve the taste. Therefore, this study aims to observe the panelist acceptance, proximate characteristics, amino acids, volatile compounds, and color profile on five mixed formulas of fermented cempedak (*Artocarpus champeden*) and oyster mushroom (*Pleurotus ostreatus*) seasoning.

2. Method

2.1. Mandai Cempedak Powder. The mandai cempedak fermentation process follows patent no S00201708792 regarding the suboptimal temperature slow fermentation process with starter culture for mandai cempedak production. Fermented mandai cempedak powder followed the previously published method [1]. The fermented mandai cempedak was separated from the liquid, and the solid was taken. The solid was dried at 55°C for 18 hours in a 300 W electric dryer.

2.2. Flavored Mushroom Powder. Fresh wet oyster mushrooms added with spices such as pepper (2.5%, w/w), shallot (10%, w/w), garlic (8%, w/w), sugar (2%, w/w), and salt (6%, w/w). Furthermore, the new oyster mushroom formula and seasonings mixture was dried at 55°C for 18 hours in a 300 W electric dryer. Mandai cempedak powder and mushroom and spice powder were mixed with specific formulations (6 combinations), as shown in Table 1. Details of the vegetable seasoning production process from mandai cempedak (*Artocarpus champeden*) and oyster mushroom (*Pleurotus ostreatus*) had been protected by patents in the territory of the Republic of Indonesia with registration number S00202007443.

2.3. Hedonic and Hedonic Quality Tests. There are 30 panelists, ranging in age from 18 to 40 years, with a minimum education of a bachelor's degree and having attended lectures on spice and seasoning technology. the term of Hedonic quality tests can be interchangeable with Acceptance quality tests and are carried out in a room designated for organoleptic tests. There is a separate tasting booth for each panelist. The table and partitions are white in color and are made of wood and have no odor. Room temperature ranges from 20 to 27°C with a humidity of 65–75%. The light source is a neutral LED lamp (3000°K). Tests were carried out simultaneously for six people. The panelist who carried out the test was in good health and gave a written statement to participate in the test. Testing time is around 10.00 and 16.00 Central Indonesia Time. The hedonic test uses 5 rating scales, namely, (5) very much like, (4) like, (3) somewhat like, (2) do not like, and (1) do not like it at all. The six formulas were tested for the quality of organoleptic acceptance consisting of taste, color, aroma, texture, and overall acceptance of the six treatments of the samples presented (Table 2). The control product used was 0.5 g of commercial mushroom seasoning dissolved in 750 mL of boiling water (100°C). This formula refers to the product usage rules listed on the packaging. Sample and control were presented by dissolving seasoning at 100°C and served at 40°C. Then, as much as 30 mL of each sample was given to the panelists according to the minimum number of servings for organoleptic testing [9].

The assessment results obtained from all panelists were then analyzed by the nonparametric ANOVA method using the Kruskal–Wallis method with GraphPad Prism software version 8.0. If there is a significant difference at 5%, the differences between formulas are analyzed further with Dunn's Test.

2.4. Proximate, Dissolved Protein, and Solubility Analysis. For samples of all treatments except control mandai cempedak powder 100% (sample F), solubility, water content, ash, protein, and fat were analyzed using the Sudarmadji method [10]. Carbohydrate content is calculated based on the difference between water, ash, protein, and fat content. The dissolved protein test was analyzed by the Rohman and Sumantri [11] method.

Table 1: Composition of flavored mushroom powder and mandai cempedak powder.

Code	Flavored mushroom powder (%)	Mandai cempedak powder (%)
A	40	60
B	70	30
C	30	70
D	50	50
E	60	40
F*	Mandai cempedak powder (100%)	
G	Commercial mushroom powder (100%)	

*Sample F is only used as a comparison for sensory tests and will not be continued with further tests.

2.5. Amino Acid Analysis. Amino acid analysis (AAA) was performed using the standard fluorescence orthophthalaldehyde (OPA) method from the Laboratory Unit for Testing, Calibration and Certification Services, Bogor Agricultural University, procedure number IK.LP-04.7-LT-1.0. Conditions for HPLC (Shimadzu) were as follows: Thermo Scientific ODS-2 Hypersil column, buffers A and B, the gradient flow rate of mobile phase at 1 mL/min, and fluorescence detector (Shimadzu). Buffer A consisted of Na-acetate (pH 6.5; 0.02% w/v), Na-EDTA (0.005% w/v), methanol (9.00% v/v), and tetrahydrofuran (THF) (1, 50% v/v) dissolved in 1 liter of ultrapure water (Merck-Millipore). This buffer was filtered through 0.45 m Millipore paper and used for five days at room temperature (28 ± 2°C), stored in dark bottles, and filled with He or Nitrogen gas. Buffer B consists of 95% methanol and ultrapure water (Merck-Millipore). 0.45-micron Millipore paper was used for filtration.

2.6. Volatile Component Analysis (GCMS). Seasoning powder analysis with GCMS was carried out using the modified method of Misnawi and Ariza [12]. Identification and determination of the volatile component content obtained using the GCMS instrument with the stages of work including (1) extraction with SPME (solid phase microextraction), (2) sample injection into the GCMS device, and (3) qualitative determination of volatile components.

The volatile compound extraction phase with SPME (solid phase microextraction) begins with the sample weighing process. Seasoning powder weighed as much as 5 g placed in a vial with a capacity of 40 ml. Next, the vial containing the powder was heated with a water bath at 60°C. During the heating process in a water bath, the volatile components of the powder were extracted with SPME. The absorber used was polydimethylsyloxane/divinylbenzene (PDMS/DVB) polymer at 1 cm in length (Supelco, USA).

Analysis of volatile component composition by GCMS: the GCMS instrument used is the GCMS-QP2010 Plus Shimadzu which is equipped with a split-split less injector which is set at 260°C. The MS detector temperature was set at 200°C. The column used is Rtx-50 with an inner diameter of 0.25 mm, a length of 30 m, and a thickness of 0.25 m. The detector temperature was programmed at an initial temperature of 60°C for 3 minutes, and then the temperature was increased to 220°C for 20 minutes at a rate of 5°C/minute. Helium was used as the carrier gas at a rate of 3 mL/min. Samples of 1 L were injected by the split less method. Sampling time is 1.00 min with flow control in the pressure mode. The pressure used is 38.9 kPa with a total flow of 37.5 mL/min and a column flow of 0.78 mL/min. The linear velocity was measured at 32.2 cm/sec, the purge flow was measured at 3.0 mL/min, and the split ratio was set at −1.0. The analysis was carried out at the UPT Bioscience Laboratory, Jember State Polytechnic, Jember, East Java. The peaks on chromatogram were identified using Shimadzu Mass Spectral Libraries and Databases.

2.7. Color Analysis. For samples, all treatments except control of 100% mandai cempedak powder (sample F) were carried out using the Chromameter CR-400 instrument at the food technology laboratory of Gadjah Mada University Yogyakarta. L^*, a^*, and b^* values determine color coordinates in the CIELAB color space system.

3. Results and Discussion

3.1. Acceptance/Hedonic Analysis. Table 3 describes the acceptability (hedonic) analysis results for the six seasoning formulas derived from a mixture of mushroom-spice powder and mandai powder in terms of taste, color, aroma, texture, and overall acceptability parameters. In general, the aroma and texture of all samples were not significantly different compared to control references (samples F and G). However, in terms of taste acceptance, the seasoning sample with a composition of 70% flavored mushroom powder and 30% mandai cempedak powder (B) showed an acceptance closer to the control of commercial mushroom powder. Of course, this is because sample B has the highest content of the flavored mushroom powder. On the other hand, on the color parameter, the seasoning sample with a composition of 30% mushroom spice powder and 70% mandai cempedak powder (C) had a different reception when compared to control references (sample F and G). At the drying time, mandai cempedak powder will have a pale color, presumably because the color is influenced by water content. The phenomenon of discoloration in the drying process of foodstuffs has also been reported in garlic powder [13].

Overall, the panelists assessed that the seasoning sample with a composition of 40% flavored mushroom powder and 60% mandai cempedak powder (A) and the seasoning sample with a composition of 50% flavored mushroom powder and 50% mandai cempedak powder (D) were significantly different when compared to control references (samples F and G). Therefore, the difference in acceptance between the components of the assessment parameters does not seem to be a consideration for overall approval. Still, the panelists are likely to focus more on the hedonic quality than on the product's hedonic rating only. Therefore, it is suspected that the panelists emphasized the hedonic quality aspect, which is cognitively more valuable when compared to the general acceptance of likes and dislikes [14]. Furthermore, the psychochemical characteristics produced in each formula, including soluble protein and fat (Figure 1),

Table 2: Hedonic quality scale.

Scale	Savory taste	Browning color	Mandai cempedak-specific odor	Fineness/roughness texture
5	Very savory	White-pale	Highly sour cempedak fruit	Very smooth
4	Savory	Light brown	Sour cempedak fruit	Fine smooth
3	A bit savory	Brown	Slightly sour cempedak fruit	A bit smooth
2	Not savory	Dark brown	Less sour cempedak presence	Rough
1	Not very savory	Very dark	Cempedak presence not detected	Very rough

Table 3: The acceptability analysis for the six seasoning formulas.

Sample	Taste	Color	Odor	Texture	Overall
A	2.7 ± 1.0a	3.6 ± 0.6a	3.5 ± 0.8a	3.5 ± 0.8a	3.0 ± 0.8a
B	3.4 ± 1.0ab	3.9 ± 0.5a	3.6 ± 0.7a	3.9 ± 0.6a	3.7 ± 1.0b
C	3.0 ± 1.0a	3.2 ± 0.8b	3.2 ± 0.8a	3.6 ± 0.8a	3.2 ± 0.9b
D	2.7 ± 0.7a	3.4 ± 0.8a	3.1 ± 0.8a	3.5 ± 0.9a	3.0 ± 0.9a
E	3.1 ± 0.7a	3.6 ± 0.7a	3.3 ± 0.8a	3.6 ± 0.9a	3.1 ± 0.7b
F	3.1 ± 0.8a	3.6 ± 0.8a	3.2 ± 0.9a	3.3 ± 1.0a	3.5 ± 1.1b
G	3.6 ± 0.9b	3.8 ± 0.6a	3.5 ± 0.9a	3.7 ± 0.7a	3.6 ± 0.9b

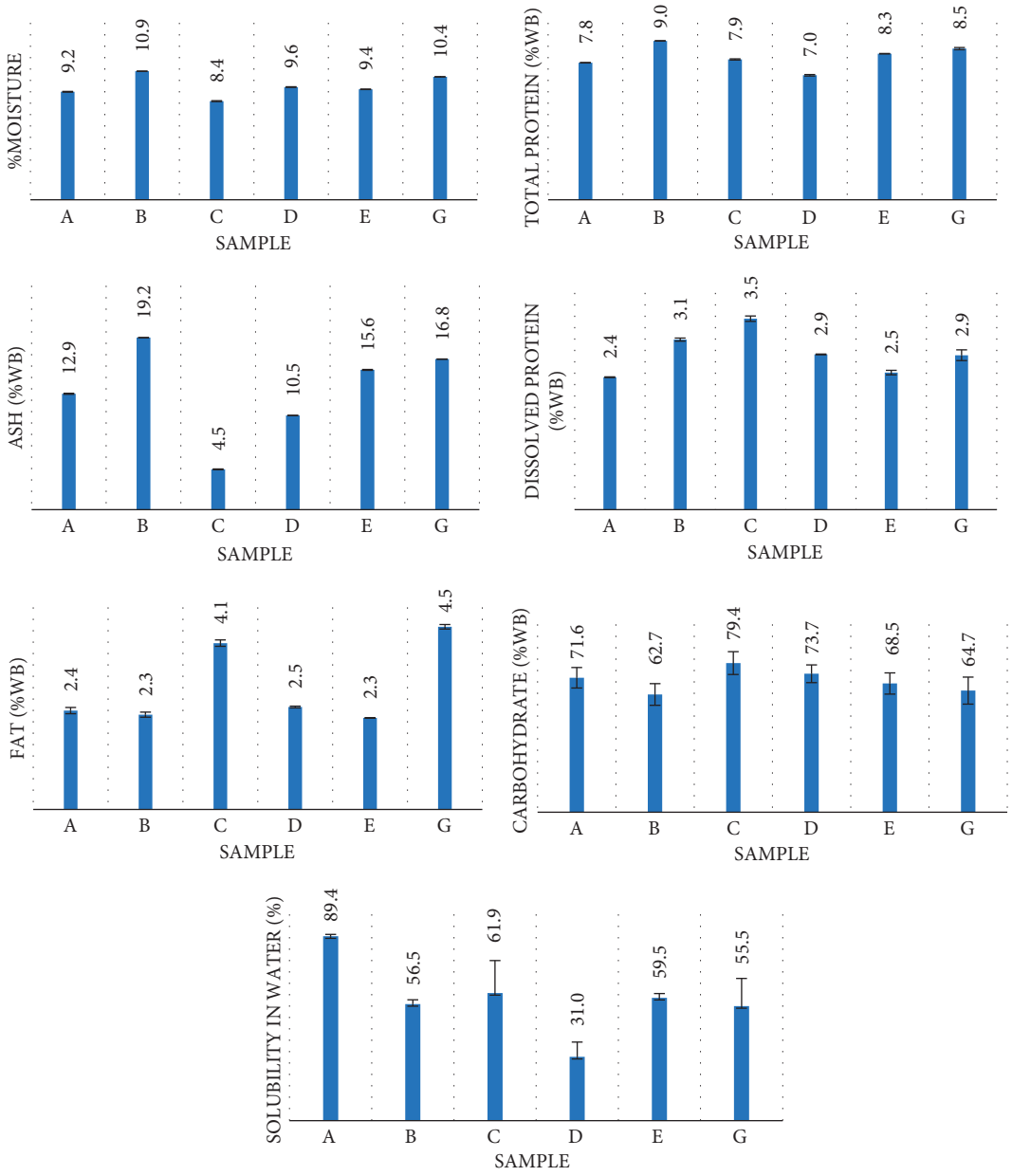

Figure 1: Results of the proximate analysis, soluble protein, and water solubility.

are thought to influence the likes and dislikes of a product [15].

Values are presented in average ± standard deviation. Different letter after the values indicates the respective values are significantly different ($p < 0.05$) in comparison to control references (samples F and G).

3.2. Hedonic Quality Analysis. Hedonic quality analysis was carried out on taste parameters with an umami scale of very unsavory to very savory, color parameters with a dark scale due to browning to pale white, aroma parameters with a ranking of very unscented to very fragrant, and texture parameters with a very coarse scale leading to very smooth. After going through the nonparametric ANOVA test, the aroma parameters were not significantly different for all samples (Table 4).

The highest savory taste was found in commercial mushroom powder (sample G). Furthermore, the seasoning sample with a composition of 70% flavored mushroom powder and 30% mandai cempedak powder (B) and a sample with a composition of 60% flavored mushroom powder and 40% mandai cempedak powder (E) were not statistically different ($p < 0.05$) when compared with control references (samples F and G). The combination of compositions in the range of 60–70% flavored mushroom powder and 30–40% mandai cempedak powder is a balanced composition in terms of the umami quality of the seasoning products produced. The composition plays an essential role in determining the taste of the final product, especially in seasoning, as has been observed in similar products [16], sea grape protein hydrolysate sauce [17], and dried *Suillus granulatus* products [18].

The panelists can significantly distinguish the two reference controls from the texture and color parameters (F and G). Flavored mushrooms play an important role in determining texture and color. The texture tendency of the combination composition of 50–70% flavored mushroom powder and 30–50% mandai cempedak powder (B, C, D, and E) is closer to the texture of commercial mushroom powder (G). Due to the presence of spices such as pepper and shallots, the seasoning color tends to be dark, with a score of 2.5 ± 1.2 (dark brown) to 3.4 ± 1.0 (pale brown). For texture, mixing mandai cempedak powder with mushroom spice powder increased the acceptability observed in the control of mandai cempedak powder, namely, 1.7 ± 1.0 (tends to be coarse) to a range of 3.6 ± 0.9 to 3.9 ± 0.6 (tends to be rough and fine). Brown color is an indicator of the Maillard reaction in food raw materials. The stronger the browning reaction caused by heating, the darker the resulting color. However, in the browning reaction of some products, such as *Takifugu obscurus* byproducts hydrolysates [19], the product's taste is more acceptable to the panelists as the degree of browning increases to a certain extent. The drying process, heat treatment, enzymatic hydrolysis, and frying will change the taste of the food. Amino acid umami imagers are generally primary residues of peptides that have the N-terminus position. Peptides have umami imagers with double or triple sequences because the heating process can amplify the umami taste [18].

Values are presented in average ± standard deviation. A different letter after the values indicates the respective value is significantly different ($p < 0.05$) in comparison to control references (samples F and G).

3.3. Proximate Analysis, Soluble Protein, and Solubility. Proximate analysis of seasoning of flavored mushroom powder and mandai cempedak powder was carried out to observe changes in composition due to formulation. For example, the seasoning sample with a composition of 70% flavored mushroom powder and 30% mandai cempedak powder (B) and a seasoning sample with a composition of 30% flavored mushroom powder and 70% mandai cempedak powder (C) turned out to contain dissolved protein, total protein, ash, fat, and carbohydrates were significantly different (Figure 1). Furthermore, the seasoning sample with a composition of 40% mushroom spice powder and 60% mandai cempedak powder (A) and the seasoning sample with a composition of 60% flavored mushroom powder and 40% mandai cempedak powder (E) also had significantly different proximate content and solubility. Likewise, the seasoning sample with a composition of 60% flavored mushroom powder and 40% mandai cempedak powder (D) was significantly different from all other samples tested. From Figure 1, it can be concluded that the 10% difference in each composition of the flavored mushroom powder and mandai cempedak powder will influence the proximate levels of the resulting seasoning.

3.4. Amino Acid Analysis. Table 5 presents the results of the amino acid analysis of (i) mandai cempedak powder, (ii) unflavored mushroom powder, (iii) flavored mushroom powder, and (iv) sample (E) 50% flavored mushroom powder and 50% mandai cempedak powder obtained with the chromatographic method. These data show that pure mushroom powder (ii) has more than double the total amino acid composition than mandai cempedak powder (i). The largest different compositions are in the amino acids leusine, glutamate, ileusine, aspartic acid, alanine, and phenylalanine. Amino acids related to umami taste are aspartic acid and glutamate.

The addition of spices increased the amino acids valine from 0.68 to 0.95% and aspartic acid by about 0.16%, and to a lesser extent, threonine, serine, and methionine (Table 5). The composition of the spices used was pepper (2.5%, w/w), shallot (10%, w/w), and garlic (8%, w/w). Glutamic acid, aspartic acid, leucine, proline, and alanine are dominant amino acids in pepper (*Piper nigrum*) powder [20]. Shallots (*Allium cepa*) have dominant amino acids: arginine, glutamate, aspartic acid, threonine, leucine, and valine [21]. The predominant amino acid contents of garlic (*Allium sativum*) are proline, glutamate, phenylalanine, valine, and asparagine, in addition to alliin and methiin degradation products [22]. The addition of valine from the composition of the spice ingredients is obtained from shallots and garlic. Aspartic acid in flavored mushroom powder (iii) is obtained

Table 4: Results of hedonic quality analysis.

Sample	Savory Taste	Browning Color	Mandai cempedak-specific odor	Fineness/roughness texture
A	2.8 ± 0.8a	2.5 ± 0.9a	3.2 ± 0.8a	3.8 ± 0.7a
B	3.2 ± 0.9b	3.4 ± 1.0c	3.3 ± 0.9a	3.6 ± 0.9ac
C	2.8 ± 0.9a	2.7 ± 1.2a	3.2 ± 0.9a	3.9 ± 0.6ac
D	2.7 ± 0.8a	2.5 ± 1.2a	3.4 ± 0.9a	3.8 ± 0.7ac

Table 5: Amino acid composition of flavored mushroom powder and mandai cempedak powder.

Amino acid (% w/w)	(i) Mandai cempedak powder	(ii) Unflavored mushroom powder	(iii) Flavored mushroom powder	(iv) Sample (E) 50% flavored mushroom powder and 50% mandai cempedak powder
Aspartic acid	0.55	1.12	1.28	0.72
Threonine	0.27	0.59	0.68	0.44
Serine	0.3	0.59	0.67	0.46
Glutamate	0.97	2.07	2.15	1.37
Glysine	0.31	0.62	0.63	0.43
Alanine	0.36	0.92	0.88	0.56
Valine	0.4	0.68	0.95	0.04
Methionine	0.03	0.19	0.21	0.82

from pepper and shallot. Threonine is mainly sourced from onions.

In the sample of 50% mushroom spice powder and 50% mandai cempedak powder, the most significant compositions of amino acids were ileusine (1.46%, w/w), glutamate (1.37%), methionine (0.82%), aspartic acid (0.72%), and then the other amino acids (Table 5). This shows that the resulting seasoning will enhance savory flavors [23]. The total amino acids for these products are 9.08% or less when compared to unseasoned mushroom powder.

3.5. Volatile Component Analysis (GCMS). The composition of volatile compounds from samples (i) mandai cempedak powder, (ii) mushroom powder without spices, (iii) mushroom powder, and (iv) samples (E) 50% flavored mushroom powder and 50% mandai cempedak powder were presented chromatographically on Figure 2, and the results of identification with the Mass Spectro (Shimadzu) databank are presented in Table 6. Several compounds that dominate when viewed from the % area for mandai cempedak powder are (1) 1-hexanol, 2-ethyl-(cas)2-ethyl hexanol (6% area), (2) 1-dodecanol (cas) n-dodecanol (6.89% area), (3) oxirane, [(dodecyloxy)methyl]-(cas) lauryl glycidyl ether (8.85% area), (4) morpholine, 4-octadecyl-(7.41% area), (5) 9-octadecenoic acid (z)-(cas) oleic acid (14.12% area), and (6) furo [3,4-d]-1,3,2-dioxaborole, 2-ethyltetrahydro-cis-(cas) (6.26% area). Halim et al. [24] have analyzed the aromatic components of tropical fruits such as jackfruit (Artocarpus heterophyllus). The aromatic components of the fruit are characterized as decanoic acid, 1-decene, methyl salicylate, and stearyl alcohol. Meanwhile, hexanol, dodecanol, oxirane, morpholine, and octadecenoic acid are characteristics of fermented and powdered mandai cempedak.

Some of the compounds identified for the mushroom powder samples without spices were (1) 1-hexacosanol (cas) hexacosanol-1 (10.97% area), (2) 2-heptanol, 5-ethyl-(cas) 5-ethyl-2-heptanol (8.29% area), (3) 6-methyl-5-hepten-2-one (15.51% area), and (4) octadecanoic acid (cas) stearic acid (5.81% area). Tagkouli et al. [25] and Selli et al. [26] identified aromatic compounds in fresh *Pleurotus ostreatus* mushrooms into groups of (1) eight carbon atoms compounds, (2) alcohols, (3) aldehydes, (4) fatty acids (FAME methyl esters), (5) toluene, and (6) ketones. The powdering process causes the volatile components of oyster mushroom powder to be dominated by alcohol, furan, and fatty acids and their derivatives.

Gas chromatography can be used to detect compounds that affect the olfactory, as in previous studies [27]. The validity of the test results from the GCMS is influenced by several things, mainly, the calibration of the tool, the accuracy of the test method, and the preparation of materials [28]. Judging from the results obtained in the tested samples (Table 6), the groups of compounds that appeared were mostly ethanol, furans, esters, ethers, fatty acids, and volatile acids. The flavored mushroom powder sample had several compounds identified as (1) 1-allyl-cyclopropane carboxylic acid (10.78% area), (2) 2,6-dihydro-2 h-pyran-2-one (5.76% area), (3) 1-dodecanol (cas) n-dodecanol (8.51% area), (4) ethanol, 2-(dodecyloxy)-(cas) dodecoxyethanol (8.34% area), (5) Hexadecanoic acid (cas) palmitic acid (6.16% area), and (6) 3′,4′-dihydro-2′-(morpholin-4-Yl) (7.68% area). Some compounds with significant area on the GCMS chromatogram for samples (E) 50% flavored mushroom powder and 50% mandai cempedak powder were (1) 6-methyl-5-hepten-2-one (8.26% area), (2) ethanol, 2-(dodecyloxy)-(cas) dodecoxyethanol (14.01% area), and (3) ethanol, 2-(tetradecyloxy)-(cas) 2-tetradecyloxyethanol (6.99% area).

3.6. Color Analysis. The color mapping of a product sample referring to the CIELAB color space is identified by three parameters: L^*, a^*, and b^*. The L^* represents the brightness from dark (black) to light (white), starting from zero (dark) to 100 (light). In contrast, a^* is the range with the identification of green (negative a^*) to red (positive a^*) and the b^*

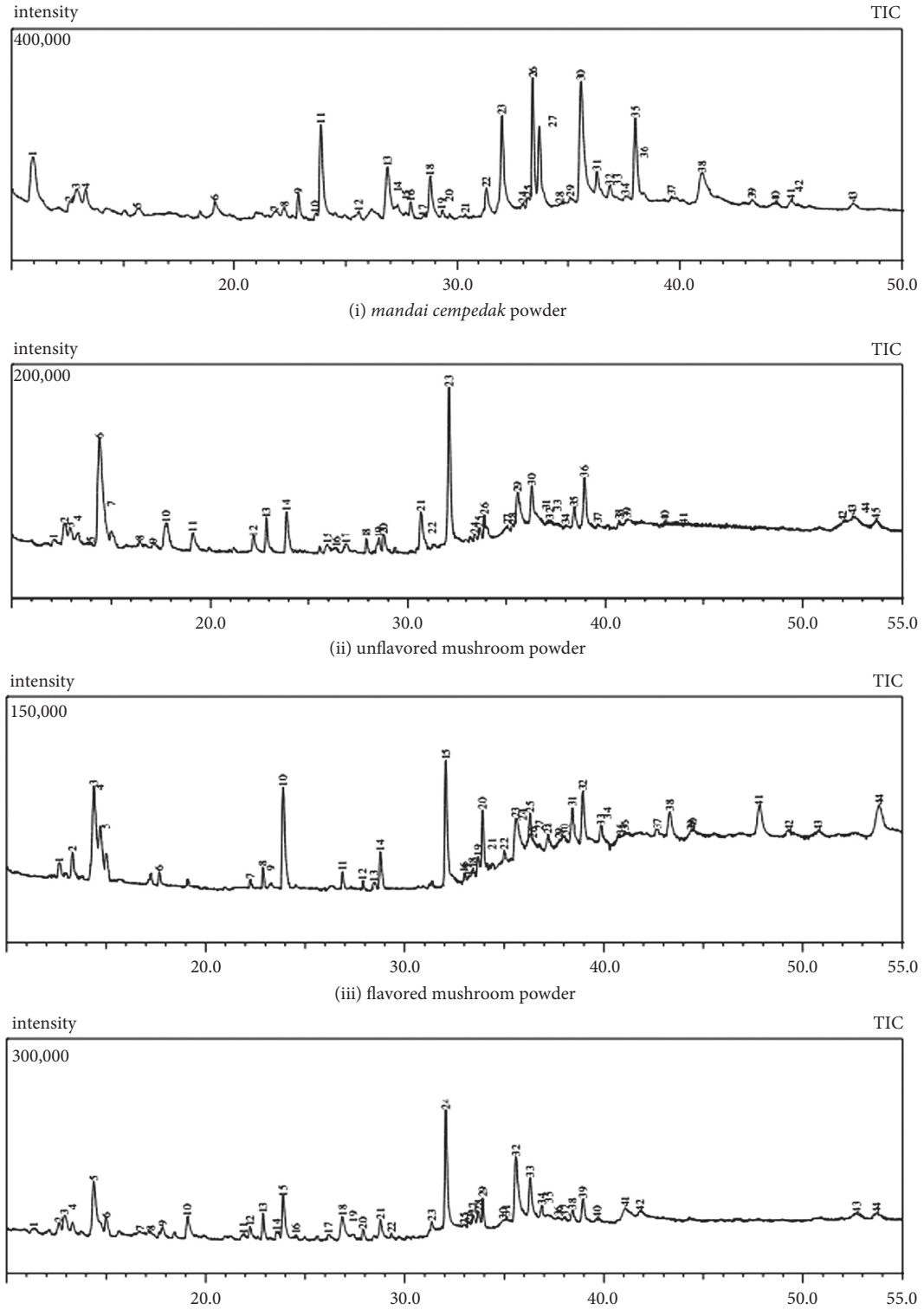

Figure 2: Chromatogram of GCMS.

axis is the range with the identification of blue (negative b^*) to yellow (positive b^*) [29]. All formulations had a color tendency similar to that of commercial mushroom powder control referring to the data presented in Table 7, namely, with brightness ranging from 65.68 to 67.06 (tends to be pale), positive a^* chromatic (tends to red), and positive b^* chromatic with larger values (tends to strengthen to yellow). The a^* color chromatic range for all samples and controls of commercial mushroom powders was 4.53–5.83 and b^* 21.46–22.46. From this data, it can be concluded that the color tendency of the formulation is slightly reddish yellow with a paleness level of around 66–67%.

Table 6: Results of GCMS identification of the content of volatile compounds.

(i) Mandai cempedak powder		(ii) Unflavored mushroom powder		(iii) Flavored mushroom powder		(iv) Sample (E) 50% flavored mushroom powder and 50% mandai cempedak powder	
Compound name	% Area	Compound name	% Area	Compound name	% Area	Compound name	% Area
1-Hexanol, 2-ethyl- (cas) 2-ethylhexanol	6.48	Beta,d-xylopyranose tetrabenzoate	0.66	Ethanol, 2- (2-ethoxyethoxy)- (cas) 2- (2-ethoxyethoxy) ethanol	1.26	4-Heptanol (cas) dipropylcarbinol	0.75
Ethane, 1,1′-oxybis [2-ethoxy- (cas) bis (2-ethoxyethyl) ether	0.81	Ethane, 1,1′-oxybis [2-ethoxy- (cas) bis (2-ethoxyethyl) ether	2.53	1-Octanol (cas) octilin	1.80	Ethane, 1,1′-oxybis [2-ethoxy- (cas) bis (2-ethoxyethyl) ether	1.28
Ethanol, 2,2′-oxybis- (cas) diethylene glycol	2.79	Butanoic acid, 4-chloro	2.08	1-Allyl-cyclopropanecarboxylic acid	10.78	Butanoic acid, 4-chloro	2.52
1-Decanol (cas) decyl alcohol	1.83	1-Pentanol, 3-methyl- (cas) 3-methyl-1-pentanol	1.50	2,6-Dihydro-2h-pyran-2-one	5.76	1-Hexanol, 3-methyl- (cas) 3-methyl-1-hexanol	1.28
Butanoic acid, butyl ester (cas) n-butyl n-butyrate	0.64	Ethanedial, monohydrate, dimer (cas) glyoxal monohydrate dimer	0.51	2,5-Furandione (cas) maleic anhydride	2.29	6-Methyl-5-hepten-2-one	8.26
1-Heptanol, 6-methyl- (cas) 6-methyl-1-heptanol	1.17	6-Methyl-5-hepten-2-one	15.51	3-Oxo-alpha-ionone	0.69	2-Propenoic acid, 3-[(phenylmethyl) sulfonyl]-, methyl ester, (z)	1.75
Heptanoic acid (cas) heptoic acid	0.59	2,5-Furandione (cas) maleic anhydride	1.83	[3r- (3.alpha.,3a.alpha.,5as,7a.alpha.,11a.beta.,11b.alpha.)]-(+)-1,3,3a,6,7,7a,8,9,10,11,11a,11b-Dodecahydro-3-hydroxy-8,8,11a-trimethyl-2h-cyclobuta [j] phenanthren-3-carboxylic acid methyl ester	0.49	2-Furan methanol, tetrahydro- (cas) tetrahydrofurfuryl alcohol	0.74
1-Pentanol, 5-cyclopropyliden-	0.76	2H-Pyran, 2-butoxytetrahydro- (cas) n-butyl tetrahydropyranyl ether	0.47	Bis-[3-oxo-6′-diethylamino-spiro (phthalan-1,9′-xanth-2-yl] sulphide	1.15	Phenyllactic acid benzyl ester	0.94
2-Propenamide, 2-methyl-n-phenyl-	1.38	4-Benzyloxy-1-bromobutane	0.46	Acetonyl decyl ether	0.43	2 (3H)-Furanone, dihydro-4-methyl- (cas) lactone 3-methylbutyric acid	1.35
Decanoic acid, 2-hydroxy- (cas) 2-hydroxy decanoic acid	0.32	Guanidine, methyl-hydrochloride (cas) n-methylguanidine hydrochloride	3.41	1-Dodecanol (cas) n-dodecanol	8.51	Oxetane, 2-propyl- (cas) 2-n-propyl-oxetan	2.50
1-Dodecanol (cas) n-dodecanol	6.89	Oxetane, 2-propyl- (cas) 2-n-propyl-oxetan	1.98	1-Tetradecanol (cas) alfol 14	0.88	Rs-2,3-hexanediol	0.65
2-Propyldecan-1-ol	0.36	Beta-myrcene	1.25	2-Nonen-1-ol	0.43	Cyclohexylidene triflate	1.31
Hexadecanoic acid (cas) palmitic acid	5.11	2-Propenamide, 2-methyl-n-phenyl-	2.21	6.Beta-acetoxy-3.alpha-angeloyloxy-1,10.beta-epoxyfuranolremophilan	0.64	Decane, 1-chloro- (cas) 1-chlorodecane	1.76
Tridecane, 4-cyclohexyl	1.61	1-Dodecanol (cas) n-dodecanol	3.30	1-Heptadecene (cas) hexahydroaplotaxene	2.68	1- (1,3-Dimethylcyclohex-2-enyl) propan-2-one	0.85
1,3-Dimethyl-1,3-dispeptidin-2,4-dione	0.39	Azetidine, 1-nitroso- (cas) nitrosoazetidine	0.84	Ethanol, 2- (dodecyloxy)- (cas) dodecoxyethanol	8.34	1-Undecanol (cas) n-undecanol	4.17

Table 6: Continued.

(i) Mandai cempedak powder		(ii) Unflavored mushroom powder		(iii) Flavored mushroom powder		(iv) Sample (E) 50% flavored mushroom powder and 50% mandai cempedak powder	
Compound name	% Area	Compound name	% Area	Compound name	% Area	Compound name	% Area
2-Propenamide, 2-methyl-n-phenyl	0.88	2H-Pyran-3,4-dihydro-2-carboxamide	0.65	Butane, 2,2-dimethyl- (cas) 2,2-dimethylbutane	0.61	10-Oxoundecyl acetate	0.52
1-Propyl-1-[(tert-butyldimethylsilyl) oxy] perfloroheptene	0.20	Tridecanoic acid (cas) tridecylic acid	0.88	Methyl 2-azidobenzoate	0.43	3-Chloro-2-methyl-1-propanol	0.78
1-Tridecanol (cas) n-tridecanol	3.55	Bis-[3-oxo-6′-diethylamino-spiro (phthalan)-1,9′-xanth-2′-yl]sulphide	0.79	1- (3- (Morpholin-4-yl) propyl)cyclopentanol	0.83	Hexadecanoic acid (cas) palmitic acid	3.42
Oxirane, 2,3-diethyl- (cas) 3,4-epoxyhexane	0.45	2H-Pyran-2-one, tetrahydro-6-pentyl- (cas) 5-decanolide	1.16	N,n-dimethyl-heptadecylamine	1.42	3-Hydroxy-4,4-dimethyldihydro (2-13c)furan-2-one	0.68
Cyclohexane, (1,1-dimethylethyl)- (cas) tert-butylcyclohexane	0.22	1-Heptadecanol (cas) n-heptadecanol	1.39	Nonanoic acid, 7-methyl-, methyl ester (cas) methyl 7-methylnonanoate	4.39	Bis-[3-oxo-6′-diethylamino-spiro (phthalan-1,9′-xanth-2'-yl]sulphide	0.84
Di-lauryl thio-di-propionate	0.14	Acetamide, n- (2-phenylethyl)- (cas) n- (2-phenylethyl) acetamide	3.84	(+)-Dehydrocamphor	0.43	1-Hexadecanol (cas) cetal	2.22
Octadecanoic acid, (2-phenyl-1,3-dioxolan-4-yl) methyl ester (cas) benzylidene glycerol stearate	2.34	7.Alpha-methacryloyloxy-or-tiglinoyloxy-9-beta-methacrycoyloxy-or-tiglin-oyloxy-1-oxo-alpha	0.42	Dodecane, 1,1′-oxybis- (cas) didodecane ether	1.12	2-Hexylallyl alcohol	0.58
Oxirane, [(dodecyloxy) methyl]- (cas) lauryl glycidyl ether	8.85	1-Hexacosanol (cas) hexacosanol-1	10.97	Hexadecanoic acid (cas) palmitic acid	6.16	Butane, 2-chloro-2-methyl- (cas) tert-amyl chloride	1.74
Ethanedione, diphenyl- (cas) benzil	0.85	1- (3- (Morpholin-4-yl) propyl) cyclopentanol	0.51	3-Methyldioxopiperazine	0.69	Ethanol, 2- (dodecyloxy)- (cas) dodecoxyethanol	14.01
1-Undecene, 9-methyl- (cas)	0.78	2-Propenamide, n-[2-(dimethylamino) ethyl]-	0.88	2,3,6,7-Tetramethyl-10- (4-methylphenylsulfonyloxy)-1,4,4.alpha.,5,8,8a.beta.,9.beta.,9a.beta.,10.alpha.,10a.alpha.-decahydroanthracen-9-ol	3.63	N-methyl-n-nitro-o-benzoylhydroxylamine	0.72
Morpholine, 4-octadecyl-	7.41	Nonanoic acid, 7-methyl-, methyl ester (cas) methyl 7-methylnonanoate	2.03	Pulegone	0.97	1 h-1,2,4-Triazole, 1-methyl- (cas) 1-methyl-1,2,4-triazole	0.67
Furo [3,4-d]-1,3,2-dioxaborole, 2-ethyltetrahydro-, cis- (cas)	6.26	9-Octadecenoic acid (z)- (cas) oleic acid	1.34	1,6-Dioxaspiro [4.4] non-3-ene	0.42	4-Methylpent-3-en-2-ol	1.45

Table 6: Continued.

(i) Mandai cempedak powder		(ii) Unflavored mushroom powder		(iii) Flavored mushroom powder		(iv) Sample (E) 50% flavored mushroom powder and 50% mandai cempedak powder	
Compound name	% Area	Compound name	% Area	Compound name	% Area	Compound name	% Area
2h-Pyran-2-methanol, tetrahydro- (cas) 2-methanol tetrahydropyran	0.46	Bicyclo (3.3.1) nonan-1-ol	0.71	Docosane (cas) n-docosane	1.55	1-Hydroxy-cyclohexanecarboxylic acid tert-butyl-amide	1.50
Ethyl tridecanoate	0.82	Octadecanoic acid (cas) stearic acid	5.81	2-Ethyl-5-methylfuran	0.40	Heptadecanoic acid, methyl ester (cas) methyl heptadecanoate	1.72
9-Octadecenoic acid (z)- (cas) oleic acid	14.12	2-Heptanol, 5-ethyl- (cas) 5-ethyl-2-heptanol	8.29	Pentanal, 2,3-dimethyl- (cas) 2,3-dimethylpentanal	1.18	1-Fluoro-2,2,4,4-tetramethyl-3-pentanone	0.81
1-Docosanol (cas) behenic alcohol	3.53	(3r*,4r*)-3,4-Dimethyl-1-butyn-4-ol	0.79	10-Undecenoic acid, methyl ester (cas) methyl 10-undecenoate	3.64	1,2-Hydrazinedicarboxaldehyde (cas) 1,2-diformylhydrazine	1.11
1,14-Tetradecanediol (cas) tetra decamethylene glycol	1.83	6- (Allyloxy) hexane-1,2-diol	1.43	9-Octadecyne (cas)	3.94	9-Octadecenoic acid (z)- (cas) oleic acid	10.24
Butanoic acid, 3-methyl-, 3-methylbutyl ester (cas) apple oil	0.44	2-Pyrazoline, 1-butyl-5-methyl- (cas) 5-methyl-1-n-butyl-delta[2]-pyrazoline	1.14	Diethyl (decyloxy)-borane	2.13	Ethanol, 2- (tetradecyloxy)- (cas) 2-tetradecyloxyethanol	6.99
5-Undecene, 3-methyl-, (e)- (cas)	0.92	Morpholine, 4-octadecyl	0.90	Methyl 3-[(tetrahydropyranyl)oxy] but-2-enoate	0.44	2-Cyanato methyl cyclohexane	2.25
Morpholine, 4-octadecyl-	6.49	Methylester of 3-cyclohexyl-propionic acid	2.20	1,3-Dioxolane, 2- (1,1-dimethylethyl)- (cas) 2-*t*-butyl-1,3-dioxolane	0.44	5-Oxo-tetrahydro-furan-2-carboxylic acid	2.18
Nonanoic acid, 7-methyl-, methyl ester (cas) methyl 7-methylnonanoate	0.65	Bombykol	4.92	1-Methyl-cis-2- (n, n-dimethylaminomethyl-d2) isopropylidenecyclopentane	0.96	2,3,13-Trioxabicyclo [8.2.1] tridecane	1.13
Silane, chloro (1,1-dimethylethyl) dimethyl-	0.56	Propane, 2-chloro-2-methyl- (cas) tert-butyl chloride	0.59	5-Iminopyrrolidine-2-carbonitrile	0.49	2-Thiazolamine (cas) abadol	0.81
9-Octadecenoic acid (z)- (cas) oleic acid	4.45	4-Methylchloride-hex-4-ene-1-ol	0.47	3′,4′′-Dihydro-2′′- (morpholin-4-yl)-5′,7′-dinitrospiro [cyclopentane-1,3′-quinazoline]	3.00	Methylester of 3-cyclohexyl-propionic acid	1.63
Nonane, 3-methyl-5-propyl- (cas)	0.49	Cyclohexanepropanoic acid (cas) 3-cyclohexylpropionic acid	1.27	Octanal, 7-methoxy-3,7-dimethyl- (cas) methoxycitronellal	0.62	Cyclooctene, 3-methyl-	2.88
Laurinsaeure, hex-3-enylester	0.63	1-Vinyl-1-cyclopropyl methyl ether	0.43	1,3-Dioxolane, 2-pentadecyl- (cas) 2-pentadecyl-1,3-dioxolane	0.61	Propane, 1- (ethenyloxy)-2-methyl- (cas) isobutyl vinyl ether	0.78
Morpholine, 4-octadecyl-	0.69	1-Thymine-2-deoxy-.beta.-d-ribofuranos-5-yl butanoate	0.49	Heptadecane, 2,6,10,15-tetramethyl- (cas) 2,6,10,15-tetramethylheptadecane	4.67	Hexadecanoic acid (cas) palmitic acid	3.09
Spiropentane-1,3-dicarboxaldehyde	0.13	Citronellyl isobutyrate	2.30	1,3-Dioxolane, 2-pentadecyl- (cas) 2-pentadecyl-1,3-dioxolane	0.65	Cyclohexaneethanol (cas) 2-cyclohexylethanol	1.63

Table 6: Continued.

(i) Mandai cempedak powder		(ii) Unflavored mushroom powder		(iii) Flavored mushroom powder		(iv) Sample (E) 50% flavored mushroom powder and 50% mandai cempedak powder	
Compound name	% Area	Compound name	% Area	Compound name	% Area	Compound name	% Area
Heptadecane, 2,6,10,15-tetramethyl- (cas) 2,6,10,15-tetramethylheptadecane	0.73	Bicyclo [2.2.2] octan-1-ol (cas) 1-hydroxybicyclo [2.2.2] octane	2.44	3-Dodecanol, 3,7,11-trimethyl- (cas) hexahydronerolidol	0.40	2,3,4-Trimethyl-1-pentanol	1.79
		2-{[5-Methyl-1- (1-methylethenyl)-5-hexenyloxy] methyl}furan	0.57	3′,4′-Dihydro-2'- (morpholin-4-Yl)-5′,7′-dinitrospiro [cyclopentane-1,3′-Quinazoline]	7.68	Tricosane, 2-methyl- (CAS) 2-methyltricosane	1.70
		2H-Pyran-2-methanol, tetrahydro- (cas) 2-methanol tetrahydropyran	1.87				

Table 7: Results of color analysis.

Code	Sample (flavored mushroom powder: mandai cempedak powder, %)	L^*	a^*	b^*
A	40 : 60	66.28	5.83	21.46
B	70 : 30	66.8	5.82	21.48

4. Conclusion

Hedonic quality assessment on seasoning samples of flavored mushroom powder and mandai cempedak powder plays a more critical role in accepting the final product. Seasoning samples with a composition of 60–70% flavored mushroom powder and 30–40% mandai powder had a savory taste which was statistically ($p < 0.05$) not significantly different from the control of commercial mushroom powder. All seasoning formulations of flavored mushroom and mandai cempedak powder have a moisture content of 8.4–10.9%, total protein 7.0–9.0%, soluble protein 2.4–3.5%, ash content 4.5–19.2%, fat content 2.3–4.5%, carbohydrates 62.7–79.4%, and the solubility is 31.0–89.4%. Samples of 50% mushroom spice powder and 50% mandai cempedak powder had the dominant amino acid profiles of ileusine (1.46%, w/w), glutamate (1.37%), methionine (0.82%), and aspartic acid (0.72%), as well as volatile compounds. In addition, the formula had dominant heptanone, dodecoxyethanol, and etradecyloxyethanol with a pleasant aroma profile, pungent fruity, green, citrus, and herbal. The color tendency of the entire formulation is slightly reddish yellow with a paleness level of about 66–67%.

Data Availability

The raw data for hedonic analysis and proximate analysis are provided at https://doi.org/10.13140/RG.2.2.23808.51207.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Supplementary Materials

The GCMS method, machine condition, chromatogram, and interpretation results are provided in the supplementary material: (i) mandai cempedak powder with file name: mandai.pdf; (ii) unflavored mushroom powder with file name: mushroom.pdf; (iii) flavored mushroom powder with file name: flavored mushroom.pdf; (iv) sample (E) 50% flavored mushroom powder and 50% mandai cempedak powder with file name: seasoning mandai-mushroom.pdf. *s* (*Supplementary Materials*)

References

[1] A. Rahmadi, Y. Sabarina, and S. Agustin, "Different drying temperatures modulate chemical and antioxidant properties of mandai cempedak (*Artocarpus integer*)," *F1000Research*, vol. 7, p. 1706, 2018.

[2] A. Rahmadi, F. A. R. Firdaus, and M. Marwati, "Karakterisasi sifat sensoris, proksimat, antioksidan, total BAL, dan uji pasar es krim berbahan puree dan bubuk mandai cempedak," 2018b, http://litbang.kemenperin.go.id/jrti/article/view/4057/0.

[3] M. Tangyu, J. Muller, J. B. Christoph, and C. Wittmann, "Fermentation of plant-based milk alternatives for improved flavour and nutritional value," *Applied Microbiology and Biotechnology*, vol. 103, no. 23, pp. 9263–9275, 2019.

[4] U. K. Akpi, C. I. Nnamchi, and J. O. Ugwuanyi, "Development of starter culture for the production of african condiments and seasoning agents," *Advances in Microbiology*, vol. 10, pp. 599–622, 2020.

[5] A. Ricci, M. Cirlini, A. Guido et al., "From byproduct to resource: fermented apple pomace as beer flavoring," *Foods*, vol. 8, no. 8, p. 309, 2019.

[6] S. Zhou, F. Ma, X. Zhang, and J. Zhang, "Carbohydrate changes during growth and fruiting in *Pleurotus ostreatus*," *Fungal Biology*, vol. 120, no. 6-7, pp. 852–861, 2016.

[7] N. Widyastuti, "Processing of oyster mushroom as an alternative the needs of nutrition," *Jurnal Sains dan Teknologi Indonesia*, vol. 3, no. 15, pp. 1–7, 2013.

[8] J.-L. Mau, "The umami taste of edible and medicinal mushrooms," *International Journal of Medicinal Mushrooms*, vol. 7, pp. 119–125, 2005.

[9] B. M. Watts, G. L. Ylimaki, L. E. Jeffery, and L. G. Elias, *Basic Sensory Methods for Food Evaluation*, International Development Research Centre, Canada,, 1989.

[10] S. B. Sudarmadji, *Analisa Bahan Makanan Dan*, Liberty, Yogyakarta, Indonesia, 2007.

[11] A. dan Rohman and Sumantri, *Analisis Makanan*, Universitas Gajah Mada, Yogyakarta Indonesia, 2007.

[12] J. Misnawi and B. S. T. Ariza, "Use of gas chromatography-olfactometry in combination with solid phase micro extraction for Cocoa liquor aroma analysis," *International Food Research Journal*, vol. 18, pp. 829–835, 2011.

[13] N. Utama-ang, T. Cheewinworasak, N. Simawonthamgul, and R. S. Samakradhamrongthai, "Effect of drying condition of thai garlic (*Allium Sativum L.*) on physicochemical and sensory properties," *International Food Research Journal*, vol. 25, no. 4, pp. 1365–1372, 2018.

[14] B. Ciccantelli, T. Pribic, C. Malagelada, A. Accarino, and F. Azpiroz, "Relation between cognitive and hedonic responses to a meal," *Neuro-Gastroenterology and Motility*, vol. 29, no. 5, Article ID e13011, 2017.

[15] C. V. Schmidt, L. Plankensteiner, P. Lionet Faxholm, K. Olsen, O. G. Mouritsen, and M. B. Frøst, "Physicochemical characterization of sous vide cooked squid (*Loligo forbesii* and *Loligo vulgaris*) and the relationship to selected sensory properties and hedonic response," *International Journal of Gastronomy and Food Science*, vol. 23, Article ID 100298, 2021.

[16] L-B. Sun, Z.-Y. Zhang, G. xin et al., "Advances in umami taste and aroma of edible mushrooms," *Trends in Food Science & Technology*, vol. 96, pp. 176–187, 2020.

[17] M. N. Ghoyatul Amin, C. Rustyana, F. Rohim et al., "Optimization of sauce formulation from sea grape (*Caulerpa racemosa*) protein hydrolysate using response surface

methodology," *Journal of Applied Phycology*, vol. 33, pp. 1217–1227, 2021.

[18] X. Zhao, Y. Wei, X. Gong, H. Xu, and G. Xin, "Evaluation of umami taste components of mushroom (suillus granulatus) of different grades prepared by different drying methods," 2020, https://www.sciencedirect.com/science/article/pii/S221345302030135X.

[19] N. Zhang, Y. Yang, W. Wang, Y. Fan, and Y. Liu, "A potential flavor seasoning from aquaculture by-products: an example of takifugu obscurus," *Lebensmittel-Wissenschaft und -Technologie*, vol. 151, Article ID 112160, 2021.

[20] H. Liu, J. Zheng, P. Liu, and F. Zeng, "Pulverizing processes affect the chemical quality and thermal property of black, white, and green pepper (Piper nigrum L.)," *Journal of Food Science & Technology*, vol. 55, no. 6, pp. 2130–2142, 2018.

[21] Ž. Fredotović, B. Soldo, M. Šprung, Z. Marijanović, I. Jerković, and J. Puizina, "Comparison of organosulfur and amino acid composition between triploid onion allium cornutum clementi ex visiani, 1842, and common onion *Allium cepa L.*, and evidences for antiproliferative activity of their extracts," *Plants*, vol. 9, no. 1, p. 98, 2020.

[22] J. Lee and J. M. Harnly, "Free amino acid and cysteine sulfoxide composition of 11 garlic (allium sativum L.) cultivars by gas chromatography with flame ionization and mass selective detection," *Journal of Agricultural and Food Chemistry*, vol. 53, no. 23, pp. 9100–9104, 2005.

[23] M. Dermiki, N. Phanphensophon, D. S. Mottram, and L. Methven, "Contributions of non-volatile and volatile compounds to the umami taste and overall flavour of shiitake mushroom extracts and their application as flavour enhancers in cooked minced meat," *Food Chemistry*, vol. 141, no. 1, pp. 77–83, 2013.

[24] H. R. Halim, D. P. Hapsari, J. Ahmad, A. W. Ritonga, A. Natawijaya, and R. Poerwanto, "Metabolomics dataset of underutilized Indonesian fruits; rambai (baccaurea motleyana), nangkadak (artocarpus nangkadak), rambutan (nephelium lappaceum) and sidempuan salak (salacca sumatrana) using GCMS and LCMS," *Data in Brief*, vol. 23, 2019.

[25] D. Tagkouli, G. Bekiaris, P. Stella et al., "Volatile profiling of pleurotus eryngii and pleurotus ostreatus cultivated on agricultural and agro-industrial by-products," *Foods*, vol. 10, p. 1287, 2021.

[26] S. Selli, G. Gamze, S. Onur, and K. Hasim, "Variations in the key aroma and phenolic compounds of champignon (Agaricus bisporus) and oyster mushrooms (pleurotus ostreatus) after two cooking treatments as elucidated by GC-MS-O and LC-DAD-ESI-MS/MS," *Food Chemistry*, vol. 354, Article ID 129576, 2021.

[27] B. Zellner, P. Dugo, G. Dugo, and L. Mondello, "Gas chromatography-olfactometry in food flavour analysis," *Journal of Chromatography*, vol. 1186, no. 1-2, pp. 123–143, 2008.

[28] K. C. Hernandes, É. A. Souza-Silva, C. F. Assumpção, C. A. Zini, and J. E. Zini, "Validation of an analytical method using HS-SPME-GC/MS-SIM to assess the exposure risk to carbonyl compounds and furan derivatives through beer consumption," *Food Additives & Contaminants: Part A*, vol. 36, pp. 1808–1821, 2019.

[29] K. L. Bao Chau, E. B. Dyer, J. L. Feig, A. L. Chien, and S. Del Bino, "Research techniques made simple: cutaneous colorimetry: a reliable technique for objective skin color measurement," *Journal of Investigative Dermatology*, vol. 140, no. 1, pp. 3–12, 2020.