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Characteristics of Powdered Shrimp Paste Sambal (Acetes Sp.) with Different Formulations

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A B S T R A C T

Shrimp (Acetes sp.) is one of the marine biological resources that has the potential to be processed into food products related to its high nutrition. One of the processed products from shrimp is shrimp paste. Shrimp paste is enjoyed by certain groups because it has a distinctive smell and savory taste. The use of shrimp paste includes additional ingredients in food products such as chili sauce. Shrimp paste is a chili sauce that is generally made from chili, shrimp paste, and garlic. The innovation of shrimp paste chili sauce into powder is an enrichment of chili sauce processing that has advantages in shelf life, taste consistency, and practical impression in its use. The purpose of this study was to determine the characteristics of shrimp paste chili sauce (Acetes sp.) powder with different formulations and its best formulation. The research method used was an experimental laboratory using a Completely Randomized Design with 3 different formulations, namely the composition of shrimp paste, chili, and garlic in F1 (40%; 15%; 45%), F2 (50%; 15%; 35%), and F3 (60%; 15%; 25%). The tests conducted were in the form of protein, water, glutamic acid, fat, ash, color, and hedonic levels. Data were tested for diversity and ANOVA and continued with the Honestly Significant Difference Test. F2 shrimp paste was the best with a panelist preference level of $6.29 \leq \mu \leq 7.03$. The results of the F2 sample test included glutamic acid levels of 0.3019%, protein of 31.020%, fat of 3.624%, water of 9.415%, and ash of 28.438%. This study shows that powdered shrimp paste can be a popular commercial product and introduce fishery products.

Keywords: shrimp paste, rebon shrimp, drying, Powdered shrimp paste chili sauce

1. Introduction

Terasi or shrimp paste is one of the traditional fishery products widely processed in Indonesia. It is a paste-like product made by adding salt and fermenting at a specific temperature for several days. Shrimp paste has a distinctive reddish-brown color. One of the foods prepared using shrimp paste is sambal terasi. Sambal terasi is a popular condiment in Indonesian cuisine, valued for its unique flavor and aroma, which enhance the overall taste experience. Its distinct flavor comes from a blend of shrimp paste (terasi), chili peppers, garlic, salt, and sugar, creating a deep, complex umami taste that complements various dishes (Permadi, 2016). Terasi, as the main ingredient in this sambal, plays a crucial role in determining its quality. Traditional sambal terasi, however, has some drawbacks, such as inconsistent flavor and a short shelf life. Powdered sambal terasi offers advantages, including a longer shelf life and more convenient use. Powder products represent a form of product innovation in the modern era. To date, no studies have been conducted on the formulation of powdered sambal terasi, making this research a pioneering effort. The composition of terasi in sambal terasi can significantly influence how it is received by taste panelists in sensory evaluations, as well as affect the sambal's characteristics, such as taste, texture, aroma, and appearance (Gunawan et al., 2023). Therefore, the characteristics of sambal terasi are not only determined by the type and quality of additional ingredients but are also highly dependent on the proportion and quality of the shrimp paste used. Variations in the nutritional content of the shrimp paste itself, such as the degree of fermentation or the origin of its raw materials, can also influence the final properties of the sambal, making it more or less acceptable to consumers in terms of taste, aroma, and texture (Fathurrozi et al., 2024).

2. Materials and Methods

Powdered Shrimp Paste Sambal Production

The process of making powdered sambal terasi, based on research by Suwandono et al. (2021), involves a modified formulation to achieve a powdered end product. The production process begins with raw material preparation and washing. Next, the ingredients are cooked to remove any raw odors and then blended using a chopper. The sambal terasi is then dried in an oven at 70°C to 80°C for six hours. Once dried, it undergoes a second round of grinding to achieve a fine powder texture. The final step involves packaging the powder in pre-prepared containers. The formulation used in producing powdered sambal terasi, with variations in the composition of shrimp paste, is shown in Table 1.

Table 1 Weight and percentage of ingredients for Powdered Shrimp paste Sambal

Ingredients	Powdered Shrimp Paste Sambal Formulation					
	F1		F2		F3	
	Weight (g)	%	Weight (g)	%	Weight(g)	%
Shrimp paste (Terasi)	40	40	50	50	60	60
Chili peppers	15	15	15	15	15	15
Garlic	45	45	35	35	25	25

Test Method of Powdered Shrimp Paste Sambal

Protein content (BSN,2006)

A sample of 2 g is weighed and placed in a digestion flask. Next, 2 Kjeldahl tablets and 15 ml of concentrated H_2SO_4 are added. Digestion is conducted at 410°C for 2 hours, or until the solution becomes clear. The solution is then left to cool to room temperature, after which 50 to 75 ml of distilled water is added. A 4% H_3BO_3 solution containing a BCGMR indicator is prepared in an Erlenmeyer flask to collect the distillate. The digestion flask is then set up in the steam distillation apparatus, and 50-75 ml of 30% NaOH solution is added. Distillation is carried out until the distillate volume reaches at least 150 ml. The distillate is then titrated with 0.2 N HCl until the color changes from green to pink. Protein content is calculated using the following formula:

Protein content (%) $= \frac{(\text{vA}-\text{vB})\text{x N HCl x } 14.007\text{x}6.25}{\text{W x } 1000} \times 100\%$

Fat content (BSN, 2017)

The fat test using the Soxhlet method begins by weighing a 2 g sample and placing it in a beaker. Next, 30 ml of 10 N HCl and 20 ml of water are added, and the mixture is boiled for 2 minutes. The sample is then hot-filtered until no longer reactive with acid, followed by washing with boiling water. The filter paper with its contents is dried at 100-105°C. Then, 50 ml of hexane extract is mixed with the filtered sample at 80°C for 2–3 hours. The hexane extract is subsequently distilled, and the fat extract is dried at 100-105°C, cooled, and weighed. The final step is calculating the fat content using the following formula

Fat content (%) = (C-A)/B×100%

Water content (BSN, 2015)

The analysis is conducted based on the difference in sample weight before and after drying (SNI 01-2354.2-2015). The sample is dried in an oven for 16 to 24 hours at 105°C until a constant weight is achieved. Water content is calculated using the following formula

Water content (%)$= \frac{\text{B}-\text{C}}{\text{B}-\text{A}} \times 100\%$

Ash content (BSN, 2010)

Ash content testing is conducted using the gravimetric method (SNI 2354.1-2010). The crucible to be used is placed in a muffle furnace at 550±5°C for 16 to 24 hours. The crucible is then cooled in a desiccator for 30 minutes and weighed (A). A 2 g ground sample is placed in the crucible and dried in an oven at 100°C for 16 to 24 hours. The crucible containing the sample is then transferred to a muffle furnace at 550°C for 16 to 24 hours or until white ash is obtained. The sample is then cooled in a desiccator for 30 minutes. The ash is gently moistened with distilled water, dried on a hot plate, and re-ashed at 550°C until a constant weight is achieved. The crucible with the sample ash is cooled again in a desiccator for 30 minutes and then weighed (B). Ash content is calculated using the following formula:

Ash content (%)$= \frac{\text{B}-\text{A}}{\text{sample weight (g)}} \times 100\%$

Color Measurement (Instructor Manual, 2002)

Color testing was performed using a Chroma Meter CR-400. The procedure began with preparing the sample, which was then cut in half. The chromameter was set up and connected to a power source. After pressing the power button to turn on the device, the calibration button was pressed to calibrate it. The options USER CALIB – NEW – L*ab** were selected from the menu, and the measurement button was pressed. The measuring head was placed horizontally on the sample. Once the indicator light was on, measurement could begin. The displayed L, a*, and b* values were recorded. This process was repeated 2-3 times following the same steps. The hue of the sample was determined by calculating the hue angle (˚Hue) with the formula: ˚Hue = $\tan^{-1}$(b*/a*), and the color point was determined using the Color Express 1.3.0 software by entering the a*, b*, and L values from the chroma meter.

Glutamic Acid Content (Bioassay System, 2009)

First, a calibration curve was prepared by mixing 600 µL of 2.5 mM glutamate premix, made by combining 15 µL of a 100 mM standard with 585 µL of distilled water. The standard solution was diluted according to these instructions. Then, 20 µL of the standard was transferred to a 96-well plate. Reagents were prepared next, and the enzyme mix was homogenized before pipetting. For optimal results, 60 µL assay buffer, 1 µL enzyme mix, 5 µL NAD, and 14 µL MTT were combined to create the reagent.

Hedonic Test (BSN, 2015)

This test was conducted with 30 panelists who evaluated the product based on a provided scoresheet. The rating scale ranged from 1 to 10, where the highest score was 10, and the lowest score reflected the standard deviation, ultimately providing a hedonic value.

Data Analysis

Data testing involved two types of analyses: parametric and non-parametric. Parametric data analysis included one-way analysis of variance with normality and homogeneity tests, followed by an Analysis of Variance (ANOVA) to determine differences among treatments. Non-parametric data analysis was performed using the Kruskal-Wallis's test, followed by the Mann-Whitney test to determine differences among treatments. A significance level of 5% ($P < 5\%$) was used for this analysis. The tests were performed using SPSS 25 software.

3. Results And Discussions

The test results for Sambal Terasi Bubuk can be seen in table 2.

Tabel 2. Test Results for the Contents of Powdered Shrimp Paste Sambal

Parameter	Sample (%)		
	F1	F2	F3
Glutamic Acid	0.25 ± 0.00^{a}	0.32 ± 0.00^{b}	0.33 ± 0.00^{b}
Proteins	28.41 ± 0.31^{a}	31.02 ± 0.52^{b}	32.20 ± 0.20^{b}
Water	7.70 ± 0.10^{a}	9.41 ± 0.10^{b}	7.26 ± 0.35^{b}
Fat	2.60 ± 0.30^{a}	3.62 ± 0.30^{b}	3.44 ± 0.13^{b}
Ash	25.29 ± 0.35^{a}	28.43 ± 0.21^{ab}	29.35 ± 0.17^{b}

Information:

Data are the average results of three repetitions with standard deviation

Data followed by different superscript letters indicate a significant difference

Glutamic Acid Content

Currently, there is no Indonesian National Standard (SNI) that specifically regulates the minimum glutamic acid content (either natural or as monosodium glutamate/MSG) in food products. However, regulations regarding glutamic acid or MSG are available through the Indonesian Food and Drug Authority (BPOM) and the FAO/WHO Codex Alimentarius guidelines. The Codex allows MSG use in foods under "Good Manufacturing Practices" (GMP), with a limit of 30 mg/kg or 3% (Mortensen et al., 2017). Glutamic acid in shrimp paste products is produced through fermentation, which breaks down proteins into amino acids, including glutamic acid. Shrimp paste from small shrimp has been found to contain 12.39–12.72% glutamic acid (Karim et al., 2014). The results of glutamic acid testing in powdered shrimp paste chili sauce with varying formulations can be seen in Table 2.

The table shows that glutamic acid levels in powdered shrimp paste chili sauce varied significantly, ranging from 0.25% to 0.33%. This indicates that varying amounts of shrimp paste affect the glutamic acid content, with significant differences across treatments ($p<0.05$). The glutamic acid level in powdered shrimp paste chili sauce is lower than reported by Rochminta (2021), where shrimp paste from small shrimp contained 3.3–3.8% glutamic acid.

Protein Content

The increased protein level in powdered shrimp pastes chili sauce results from the natural protein in the shrimp paste, which has a relatively high protein content (Karim et al., 2014). Other ingredients that may influence the protein content include chili and garlic. Chili contains a small amount of protein, approximately 1-2% per 100 grams of fresh material (Asmal, 2023), while garlic also has a small amount of protein, approximately 2-3% per 100 grams of fresh material (Abubakar, 2023).

The protein level in powdered shrimp paste chili sauce is lower than in raw shrimp paste, as reported by Andriyani et al. (2012), which found protein levels of 35.86% and 39.90% in shrimp paste from small shrimp. This difference is due to the addition of other ingredients to the powdered chili sauce.

Fat Content

The increased fat level in powdered shrimp paste chili sauce is due to the natural fat content in the shrimp paste (Fridayati et al., 2017) and the addition of ingredients like garlic and chili. Chili contains small amounts of essential oils with unsaturated fatty acids, such as linoleic acid, which may impact the fat content (Mario and Marwati, 2022). Garlic also contains small amounts of fat, mainly as essential oils with sulfur compounds like allicin, affecting the product's fat content (Kurniasari and Yuwono, 2015).

The graph shows that the fat content of powdered shrimp pastes chili sauce ranges from 2.6% to 3.6%. This indicates that the shrimp paste addition influences the fat content, with significant differences between sample F1 and samples F2 and F3, while no significant differences were observed between samples F2 and F3 ($p<0.05$). The fat content in powdered shrimp paste chili sauce is lower than in shrimp paste-based sauces such as sambal gami, with a reported fat content of 12.31% (Nurminabari et al., 2022), due to the absence of frying with oil, which could substantially increase fat content.

Water Content

According to SNI 2716: 2016, water content limits are set at a maximum of 45% for shrimp paste in pasta form, 35% for solid block shrimp paste, and 10% for dry powdered or granulated shrimp paste. Factors influencing water content include raw material moisture, processing, and particle size. Fresh chili has a high-water content, typically between 60–85% (Khoirunnisa, 2023), while garlic ranges from 60.9-67.8% (Husna et al., 2017). According to Haviz (2020), smaller particle sizes release moisture more easily from the product. Results of water content testing in powdered shrimp paste chili sauce with varying formulations are shown in Table 2.

Samples F1 and F3 showed no significant differences in water content, while F2 differed significantly. All samples met SNI 2716: 2016 standards. The graph shows water content ranges from 7.26% to 9.41%, indicating that shrimp paste variations do not significantly impact moisture, with significant differences between F1 and F3 compared to F2 ($p<0.05$).

Ash Content

Shrimp paste from small shrimp contains minerals such as calcium, phosphorus, magnesium, and sodium that do not completely combust in the ash test, thus contributing to the ash content in the chili sauce. Fermentation and salt addition enrich the mineral content, resulting in higher ash residues in the final product. Other ingredients, such as chili and garlic, also contribute minerals. Chili contains minerals such as potassium, calcium, magnesium, and iron (Andriyani et al., 2020), while garlic contains selenium, potassium, calcium, and magnesium (Moulia, 2018). Drying processes may also increase ash content. According to Cahyo et al. (2016), ash content is the residual level after burning all organic components.

Ash content in samples F1, F2, and F3 increased with shrimp paste addition. The graph shows ash content ranging from 25.2% to 29.3%, indicating that shrimp paste variations significantly affect ash content across samples ($p<0.05$).

Color Analysis

Color differences are influenced by shrimp paste concentration due to natural pigments and color changes during processing. The Maillard reaction occurs between amino acids and sugars in shrimp paste during fermentation and chili sauce preparation, producing melanoidins with a dark brown color (Inayah et al., 2023). Carotenoids, red-orange pigments in chili, also influence color (Kusumiyati et al., 2021), affecting the color scale values of a* (red-green) and b* (yellow-blue) (Nurbaeti et al., 2021). Garlic contributes a pale white or yellowish color, slightly lightening the sauce (Srihari et al., 2017).

Table 3. Color Measurement of Powdered Shrimp Paste Sambal

Powdered Shrimp Paste Sambal	L*	a*	b*
F1 (40%;15%;45%)	42.35 ± 0.52^{a}	9.10 ± 0.06^{a}	23.93 ± 0.73^{a}
F2 (50%;15%;35%)	40.62 ± 0.94^{a}	8.82 ± 0.27^{a}	22.45 ± 0.07^{b}
F3 (60%;15%;25%)	34.36 ± 3.42^{b}	7.44 ± 0.32^{b}	17.15 ± 0.10^{c}

Information:

Data are the average results of three repetitions with standard deviation

Data followed by different superscript letters indicate a significant difference

The table shows that increasing shrimp paste concentration deepens the red and yellow hues, indicated by lower a* and b* values from F1 to F3. The L values range from 34.36 to 42.35, with no significant difference between F1 and F2 but a significant difference between F1 and F2 compared to F3. The a* values range from 7.44 to 9.10, with a similar pattern. The b* values range from 17.15 to 23.93, with significant differences across samples ($p<0.05$).

Hedonic test

The results of hedonic testing on Sambel Terasi Bubuk with differences in formulation between samples can be seen in the following table 4;

Sample Formula	Parameter				Confidence Interval
	Appearance	Aroma	Taste	Texture	
F1	5.80 ± 1.37^{a}	7.17 ± 0.65^{a}	6.43 ± 1.10^{a}	5.97 ± 1.19^{a}	$6.07\leq\mu\leq6.61$

F2	7.20±1.30^{b}	6.50±1.01^{b}	6.37±1.16^{a}	6.57±1.50^{b}	6.40≤μ≤6.92
F3	5.93±1.62^{a}	6.37±1.35^{b}	7.03±1.03^{b}	6.77±1.19^{b}	6.18≤μ≤6.88

Table 4. Hedonic Results of Powdered Shrimp Paste Sambal

Information:

Data are the average results of three repetitions with standard deviation

Data followed by different superscript letters indicate a significant difference

Appearance

Sample F2 was rated as having the best appearance. F2's more attractive color resulted from the shrimp paste concentration, with F2 appearing more appealing than F1 due to F1's high garlic content (35%), which lightens the color. Chili also contributes a red color, enhanced by the Maillard reaction between amino acids and sugars in garlic and chili at high temperatures, creating a golden-brown color (Rosida et al., 2013).

Aroma

Shrimp paste has a strong aroma from volatile compounds like trimethylamine, ammonia, and sulfur (Prihanto et al., 2020). Chili's capsaicin and aldehyde produce a spicy aroma (Renate et al., 2014), while garlic's sulfur compounds like allicin provide complexity (Srihari et al., 2017). Aroma testing showed a decrease due to higher shrimp paste concentrations from F1 to F3, with values ranging from 7.17 to 6.37.

Taste

The preference for taste in samples F1 and F2 showed no significant difference, but F3 was significantly preferred. Increased concentration enhances umami, with F3 being most liked. Shrimp paste provides umami compounds like glutamic acid, which enriches flavor (Ropikoh et al., 2022). Chili's capsaicin increases taste receptor sensitivity, amplifying umami (Rahmadani, 2023). Garlic's allicin gives a strong, spicy taste (Ahmad and Asep, 2018).

Texture

Shrimp paste's natural fats enhance mouthfeel with a slight oiliness, making the sauce richer and smoother (Iswoyo et al., 2023). The Maillard reaction also produces a drier, coarser texture on garlic and chili particles. Texture tests showed significant differences, with F1 differing from F2 and F3 due to increased fat, enhancing texture quality.

4. Conclusions

The conclusion that can be drawn is that differences in formulation result in variations in the characteristics of powdered sambal terasi. This is due to the increased concentration of shrimp paste from sample F1 to F2 and F3. One aspect of the powdered sambal terasi characteristics affected by the increase in shrimp paste concentration is the glutamic acid content, with sample F1, F2, and F3 showing 0.2522%, 0.3019%, and 0.3321%, respectively, indicating an increasingly savory flavor with higher shrimp paste concentration. This is also reflected in the protein content, with samples F1, F2, and F3 containing 28.412%, 31.020%, and 32.197% protein, respectively. There was also an increase in ash content, with each sample having 25.291%, 28.438%, and 29.353% ash. The water content of samples F1, F2, and F3 was 7.706%, 9.415%, and 7.263%, respectively, showing that all three samples meet the Indonesian National Standard for maximum water content in shrimp paste products, set at 10%. The fat content for samples F1, F2, and F3 was 2.609%, 3.624%, and 3.439%, respectively. Color testing showed that as the shrimp paste content in the powdered sambal terasi increased, the color became darker with lower red and yellow hues. The final test, the hedonic test, indicated the highest preference for sample F2, with a confidence interval of 6.29≤μ≤7.03, followed by sample F3 with 6.04≤μ≤7.01, and sample F1 with 5.73≤μ≤6.96.

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