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Utilization of Shrimp Waste as a Raw Material in Shrimp Sauce and Its Application on Shrimp Sauce Tilapia Dishes

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ABSTRACT

One of the innovations to increase the economic value of shrimp waste is the implementation of shrimp waste into shrimp sauce and its use in shrimp sauce tilapia dishes. The purpose of this study was to determine the protein and lead (Pb) content of shrimp waste and shrimp sauce, the degree to which shrimp sauce differed in aroma, taste, and color from commercial oyster sauce, and the degree to which panelists preferred shrimp sauce tilapia dishes via organoleptic tests. This was a two-repetition experimental study with a completely randomized design (CRD). The protein content was determined using the Kjeldahl semi-micro method, whereas the lead content was determined using the spectrophotometric method. The Duo-Trio Test was used to determine the difference in organoleptic properties between shrimp sauce and commercial oyster sauce, whereas ANOVA followed by DMRT was used to analyze the hedonic properties of shrimp sauce tilapia dishes. The results of this study indicate that shrimp waste contains 18.281 percent protein and shrimp sauce contains 6.107 percent protein. The content of lead (Pb) in shrimp waste was 0.750 mg/kg, while the content of lead (Pb) in shrimp sauce was 0.052 mg/kg. The organoleptic tests revealed that shrimp sauce had a distinct aroma, taste, and color from commercial oyster sauce, whereas the hedonic tests revealed no difference in the hedonic properties of the three dishes' aromas, but there were differences in the hedonic properties of their taste and properties. The three dishes exhibit hedonic color. Panelists preferred commercial oyster sauce tilapia dishes over shrimp sauce tilapia dishes and commercial oyster sauce mixed tilapia dishes in terms of aroma, taste, and color (1:1). The shrimp sauce formula should be refined further so that it more closely resembles commercial oyster sauce in terms of aroma, flavor, and color.

I. Introduction

In Indonesia, shrimp is a valuable export commodity. The increase in shrimp production in Indonesia has resulted in an increase in the amount of waste generated by the shrimp industry. In 2014, Indonesian shrimp production totaled 645,000 tonnes (Katadata, 2016). A number of 40-45 percent of a shrimp's weight is waste (skin and head parts) (Roy et al., 2020). According to reports, Indonesia produced between 387,000 and 451,500 tons of shrimp waste in 2014.

Shrimp waste is composed of approximately 41.9 percent protein, 17% chitin, 29.2 percent ash, and 4.5 percent fat (Batubara, 2000). Shrimp waste is extracted from the frozen shrimp processing industry as a whole. Generally, shrimp waste consists of the head, skin, tail, small prawns, and a small amount of shrimp meat. The high rate of shrimp waste has resulted in a high level of waste generated by the shrimp processing industry, which has not been optimized. According to researchers' observations on June 9, 2015, shrimp waste was sold for IDR 2,000 per kilogram in Sedati District, Sidoarjo Regency, East Java Province. The production of shrimp waste into high-value shrimp products is an integral part of obtaining high-protein food ingredients.

In Southeast Asian countries, fermented fishery products such as fish and shrimp sauce are popular condiments or seasonings in daily cooking (Kobayashi et al., 2020). Shrimp sauce is one of the products that uses shrimp waste as a main ingredient. Shrimp sauce is a texturizing sauce made from shrimp waste that is obtained through an enzymatic hydrolysis process using the papain enzyme, as well as spices and thickening agents. Since shrimp sauce has a strong salty and savory flavor and is used as a spice or flavoring ingredient in dishes, it is important to have a dish where shrimp sauce can be used as a simple spice. Tilapia shrimp sauce is an example of a dish that can be made with this sauce. Tilapia shrimp sauce consists of fried tilapia fish eaten with shrimp sauce. Mujair fish is a type of freshwater fish that is common among many people because it is inexpensive and high in protein. Tilapia fish is one of the most commonly purchased fish in Ghana and Kenya (Obiero et al., 2014).

Heavy metals, which are a source of harmful contaminants for the aquatic environment, particularly for aquatic biota, can be found in waste produced from industrial activities in waters (Mahurpawar, 2015). Heavy metals are difficult to degrade, easily dissolve in water, settle in sediments, and accumulate in marine biota. The accumulation of heavy metals in aquatic biota of food sources, such as shrimp, can endanger human health as the end customer (Huang et al., 2020). Lead (Pb) is on the list of the most toxic heavy metals, and is the second level of a total of 20 heavy metals (Ibrahim & El-Regal, 2014).

According to the aforementioned issues, a study was conducted to determine the protein content and lead (Pb) content of shrimp waste and shrimp sauce, to compare shrimp sauce to commercial oyster sauce, and to perform a hedonic test on the use of shrimp sauce in tilapia shrimp sauce dish.

II. Method

This research was an experimental research. This research went through three stages, specifically: the first stage research was the enzymatic hydrolysis process of shrimp waste, the second stage research was the production of shrimp sauce and the third stage research was the use of shrimp sauce in shrimp sauce tilapia dishes.

A. First Phase Research

In this study, the enzymatic hydrolysis of shrimp waste was carried out. The formula in the enzymatic hydrolysis process of shrimp waste referred to the enzymatic hydrolysis formula of fish waste in making soy sauce from fish waste according to Astuti et al., (2012). The enzymatic hydrolysis of shrimp waste was determined through three experiments with the formula presented in Table 1.

Table 1. Shrimp Waste Enzymatic Hydrolysis Material

No.	Materials	Amount				
		Basic Materials	First Trial	Second Trial	Third Trial	Unit
1.	Mackerel tuna waste	40	-	-	-	gram
2.	Shrimp waste	-	40	60	100	gram
3.	Tamarind	2,4	2,4	3,2	6	gram
4.	Tamarind solvent (Wa)	100	100	150	250	ml
5.	Papain enzyme	2.4	2,4	3,2	6	gram
6.	Water	1000	1000	1000	1000	ml

Source: Astuti et al. (2011) modified

The hydrolyzate of shrimp waste produced from the enzymatic hydrolysis process was 900 ml. The hydrolyzate characteristics of shrimp waste were expected to be brownish cloudy white and have a strong shrimp aroma. In this study, the formula in the third trial was used as the basic material for the production of shrimp waste hydrolyzate, the characteristics of the shrimp waste hydrolyzate trial which can be seen in Table 2.

Table 2. Characteristics of Shrimp Waste Hydrolysate Trial

Trials	Evaluation Aroma	Consistency	Color	Category
First	Vague	Liquid	Cloudy white	Inappropriate
Second	Relatively strong	Liquid	Cloudy white	Relatively appropriate
Third	Strong	Liquid	Brownish cloudy white	Appropriate

B. Second Phase Research

Phase II research was conducted to obtain the best formula from shrimp sauce. The shrimp sauce formula referred to the basic formula for making oyster sauce according to Han (2001). Shrimp sauce formula trials can be seen in Table 3.

Table 3. Shrimp Sauce Formula Testing

No.	Ingredients	Amount				
		Basic ingredients	First Trial	Second Trial	Third Trial	Unit
1.	Oyster hydrolyzate	900	-	-	-	Ml
2.	Shrimp waste hydrolyzate	-	900	900	900	Ml
3.	Salt	90	90	90	90	Gram
4.	Palm Sugar	-	-	22.5	22.5	Gram
5.	Sugar	112.5	112.5	112.5	112.5	Gram
6.	Garlic	-	-	20	20	Gram
7.	Cornstarch	-	-	-	9	Gram
8.	CMC (Carboxymethyl Cellulose)	33.75	33.75	18	9	Gram
9.	Water	135	135	135	135	Ml
10.	MSG (Monosodium Glutamat)	38.25	38.25	-	-	Gram

Source: Han (2001) modified

The shrimp sauce produced from the cooking process is 250 ml. The characteristics of the shrimp sauce are expected to be blackish brown, semi-liquid, have a distinctive aroma of shrimp and have a savory taste. In this study, the formula in the third trial was used as a standard formula for organoleptic and chemical tests.

C. Third Phase Research

The third stage research was conducted to obtain the best formula from tilapia shrimp sauce. The cooking formula for shrimp sauce tilapia can be seen in Table 4.

Table 4. Formula From Tilapia Shrimp Sauce

Ingredients	Variant of Sauce			Unit
	Basic Formula	Second Formula	Third Formula	
Ingredients I				
Tilapia fish meat	500	500	500	gram
Lime juice	20	20	20	ml
Salt	2	2	2	gram
Ingredients II				
Cooking oil	20	20	20	ml
Garlic	25	25	25	gram
Shrimp sauce	-	50	25	gram
Commercial oyster sauce	50	-	25	gram
Salty soy sauce	3	3	3	gram
Salt	5	5	5	gram
Ginger	1	1	1	gram
Pepper	2	2	2	gram

Source: Sutomo & Chen (2015)

D. Data Collection and Analysis

The research data were obtained from the results of chemical tests which included protein content using the semi-micro Kjeldahl method (AOAC, 2000) and lead (Pb) using the spectrophotometric method on shrimp waste and shrimp sauce carried out at the Chemical Laboratory of Muhammadiyah University of Malang.

The hedonic test data of tilapia shrimp sauce was statistically analyzed using the ANOVA (Analysis of Variance) test, while the organoleptic test data obtained from filling out the duo-trio test assessment form which included aroma, taste and color in shrimp sauce were analyzed using the Critical Number of table. Correct Responses in a Duo-Trio Test (Meilgaard, Vance Civille, & Thomas Carr, 1999). If the data that has been analyzed using ANOVA (Analysis of Variance) is different, then it is continued by using the DMRT (Duncan's Multiple Range Test).

III. Results and Discussion

A. Protein Content

The results showed that the protein content in 100 grams of shrimp waste was 18.281% and the mean protein content in shrimp sauce was 6.107%. The results of the protein content analysis are presented in Table 5.

Table 5. Protein content

Sample	Reduplication		Total (%)	Avg (%)
	I	II		
Shrimp Waste	18,303%	18,258%	36,561	18,281
Shrimp Sauce	6,104%	6,110%	12,214	6,107

Protein content in shrimp waste decreases after it is processed into shrimp sauce for a variety of reasons, including protein breakdown during the enzymatic hydrolysis process, heating during the boiling process of shrimp sauce, and the addition of other ingredients during the production process of shrimp sauce. Proteins are broken down into smaller parts, specifically amino acids, during the hydrolysis process with the enzyme papain. Temperature, pH, substrate concentration, and inhibitors all have an effect on the rate of enzyme decay (Murray, Granner, & Rodwell, 2003). Heating protein may produce anticipated or unexpected reactions. The boiling technique is used to prepare shrimp sauce.

The boiling process could degrade nutritional content, as food ingredients exposed directly to boiled water lose nutrients, particularly water-soluble vitamins (such as vitamin B complex and vitamin C) and protein. Boiling can help minimize the water content of animal foods that contain more protein. Boiling at 100° C allows the protein to coagulate as a result of protein denaturation, releasing more water from the meat than plant foods with a lower protein content (Sundari, Almasyhuri, & Lamid, 2015). Protein denaturation occurs between 55 and 75° C (deMan, Finley, Hurst, & Lee, 2018). After boiling, the nutritional value of protein and amino acid content of shrimp decreased by approximately 20.62-7.90 percent (Jacoeb, Cakti, & Nurjanah, 2008).

Other ingredients, such as water and salt, will alter the protein content of the shrimp sauce. Protein content decreases due to the presence of some basic proteins that are water and salt soluble. Two additions of water occur during the process of producing shrimp sauce, particularly during the production of shrimp waste hydrolyzate and during the cooking of shrimp sauce, where the protein content gradually decreases.

However, according to Kobayashi et al., (2020), the amino acid content of shrimp sauce protein, specifically glutamic acid and alanine, actively contributes to the umami and sweet taste, which is why it is commonly used as a unique ingredient in Myanmar dishes that provide a delightful taste.

B. Heavy Metal Content (Pb)

The mean heavy metal content (Pb) in 100 grams of shrimp waste was 0.750 (mg/kg) and the mean heavy metal content (Pb) in shrimp sauce was 0.052 (mg/kg). The results of the heavy metal (Pb) content test can be seen in Table 6.

Table 6. Heavy Metal Content (Pb)

Sample	Reduplication		Total (mg/kg)	Mean (mg/kg)
	I	II		
Shrimp Waste	0,741 mg/kg	0,758 mg/kg	1,499	18,281
Shrimp Sauce	0,052 mg/kg	0,052 mg/kg	0,104	0,052

The reduction of heavy metals (Pb) in shrimp waste following processing into shrimp sauce is assumed to be due to the immersion of tamarind during the process of hydrolyzing shrimp waste. Salamah et al., (1997) concluded that soaking fish in acidic pH solutions such as vinegar, lime, or tamarind will help reduce Pb levels by damaging the metal protein complex bonds. The Pb content of shrimp sauce in this study is still less than the maximum limit set by the FDA of Republic of Indonesia (BPOM RI, 2018), which is 0.20 mg/kg, despite the fact that it is made from shrimp waste with a higher Pb content.

Numerous studies have recorded a variety of adverse effects of lead on human health. Lead can impair the male reproductive system by lowering the quality of sperm; exposure to lead at a concentration of 5.29–7.25 g/dl can impair the quality of sperm in males. If the blood lead concentration is greater than 20 g/dl, it can deplete hemoglobin and increase the risk of developing anemia (Liu, McCauley, Yan, Shen, & Pinto-Martin, 2011). Additionally, it was confirmed that 28 out of 33 metal casting employees (84.8 percent) had liver dysfunction.

C. Different Levels of Shrimp Sauce Aroma with Commercial Oyster Sauce

According to the findings of the study, shrimp sauce has a distinct scent from commercial oyster sauce. The scent disparity between the two products is due to the raw materials used. Commercial oyster sauce is made with oyster raw materials to impart an oyster aroma, while shrimp sauce is made with shrimp waste to impart a shrimp aroma. Commercial oyster sauce has a more distinctive fishy aroma than shrimp sauce. This is most likely due to the fact that oyster raw materials have a higher fat content than shrimp waste. Oysters contain 35 percent fat (United States Department of Agriculture, 2008), while shrimp waste contains 0.249 percent fat. Bernadeta et al., (2013) states that the fat hydrolysis process also produces components that give fish meat a fishy odor. Fat is converted to free fatty acids and glycerol during the hydrolysis process (Mangku, Udayana, Rudianta, & Upadani, 2021). Oysters contain 1.9 grams of saturated fatty acids (United States Department of Agriculture, 2008).

D. The Level of Flavor Difference Level between Shrimp Sauce and Commercial Oyster Sauce

Shrimp sauce has a distinct flavor from commercial oyster sauce. The taste difference between the two products is due to the use of different basic ingredients and food additives. According to Toker et al., (2020) taste is influenced by a variety of factors, including chemical compounds and the variety of chemical compounds that produce distinct tastes. Commercial oyster sauces typically have a savory, distinct oyster flavor. The savory flavor of commercial oyster sauce is derived from the oyster itself and the addition of MSG (Monosodium Glutamate), whereas shrimp sauce is flavored with salt and sugar. Monosodium glutamate (MSG) is a sodium salt of glutamic acid that acts as a flavor enhancer (Rani, Khatri, & Chauhan, 2013; Septiyana, Darmanti, & Setiari, 2019).

The savory flavor of oyster sauce is also influenced by oysters' high protein content of 35%. (United States Department of Agriculture, 2008). Oyster protein is composed of a variety of amino acids, including glutamic acid, leucine, and lysine. According to Kusnandar (2011), several amino acids can influence the formation of flavors in dishes. For example, glutamic acid imparts a savory flavor, leucine imparts a sweet flavor, and lysine imparts a sweet or bitter flavor.

According to Nguyen & Wang (2012), up to 75 volatile components were identified in commercial oyster sauce, with the alcohol, furan, aldehyde, and priracin groups being the most abundant. In all samples, glutamate is the predominant free amino acid. Sweet amino acids such as threonine, serine, glycine, and alanine have a strong sweet sensory aroma. It is believed that phosphate and potassium contribute to the saltiness.

Meanwhile, Zhu et al., (2019) reported that they identified 89 volatile components using SPME and GC-MS. The two-year-old fermented shrimp sauce had the highest umami amino acid content and the best taste of the three samples. The flavor of shrimp sauce is determined by the amount of free amino acids present, particularly glutamic and aspartic acids (Kim, Shahidi, & Heu, 2003).

E. The Level of Color Difference between Shrimp Sauce and Commercial Oyster Sauce

The hedonic test revealed a difference in color between shrimp sauce and commercial oyster sauce. The two products differ in color due to the different dyes used. One of the causes of a colored food ingredient is the addition of natural and synthetic dyes (Sigurdson, Tang, & Giusti, 2017). Commercial oyster sauce is typically colored with synthetic food coloring, specifically Caramel III-Ammonia Process, to achieve a strong blackish brown hue. Shrimp sauce is dyed entirely with natural ingredients, specifically palm sugar.

The ANOVA analysis of the hedonic properties of tilapia with shrimp sauce revealed no significant difference in the aromas of the three shrimp sauce tilapia dishes with the addition of different shrimp sauces. This is because the distinctive aroma of tilapia fish is more dominant and stronger in dishes than the aromas of the two sauces, so the resulting aroma is unaffected by the addition of oyster sauce and shrimp sauce to the dish.

F. The Level of Preference for the Taste of Shrimp Sauce Tilapia Dish

The hedonic nature of tilapia shrimp sauce is markedly different than that of tilapia dishes mixed with shrimp sauce and commercial oyster sauce (1:1). The hedonic nature of tilapia cooked with a 1:1 mixture of shrimp sauce and commercial oyster sauce was not significantly different from the hedonic nature of commercial oyster sauce tilapia dishes, but the hedonic nature of tilapia cooked with commercial oyster sauce was significantly different from the hedonic nature of tilapia cooked with shrimp sauce.

The difference in the hedonic nature of the flavors produced by the three dishes is due to the fact that oyster sauce and shrimp sauce are made with different raw materials and food additives. Commercial oyster sauces frequently contain MSG (Monosodium Glutamate), a flavor enhancer. The panelists preferred the taste of dishes with commercial oyster sauce because it had a stronger flavor than dishes with only shrimp sauce. MSG (Monosodium Glutamate) is highly addictive due to its effect on the taste receptors in the brain (Fernstrom, 2018).

G. The level of preference for the color of the shrimp sauce tilapia dish

The Duncan method analysis revealed that the hedonic nature of tilapia cooked in shrimp sauce was significantly different from the hedonic nature of tilapia served in a shrimp sauce and commercial oyster sauce mixture (1:1). The hedonic nature of the color of tilapia cooked in a mixture of shrimp sauce and commercial oyster sauce (1:1) was not significantly different from the hedonic nature of the color of tilapia cooked in commercial oyster sauce, whereas the hedonic nature of the color of tilapia cooked in commercial oyster sauce was significantly different from the hedonic nature of tilapia cooked in commercial oyster sauce.

The difference in hedonic nature between the three dishes was due to the quantity of commercial oyster and shrimp sauce added. The more commercial oyster sauce added, the more appealing and preferred the color of the dish. The difference in the proportion of commercial oyster sauce results in a dark brown color for tilapia in commercial oyster sauce, a dark brown color for tilapia in a mixture of shrimp sauce and commercial oyster sauce (1:1), and a light brown color for tilapia in shrimp sauce.

IV. Conclusion

According to the findings of this study, shrimp waste contains 18.281 percent protein while shrimp sauce contains 6.107 percent protein. Shrimp sauce complies with SNI 01-4275-1996 regarding oyster sauce in terms of protein content. Shrimp waste contains 0.750 mg/kg of lead (Pb), whereas shrimp sauce contains 0.052 mg/kg of lead (Pb). The concentration of heavy metals (Pb) in shrimp sauce remains within the safe limit established by SNI 01-4275-1996 for oyster sauce. The organoleptic test revealed that shrimp sauce and commercial oyster sauce had distinct aromas, tastes, and colors. The aroma hedonic properties of commercial oyster sauce tilapia dishes, commercial tilapia mixed shrimp sauce and oyster sauce dishes, and shrimp sauce tilapia dishes are identical; however, the taste and color hedonic properties of the three dishes differ. Panelists prefer commercial oyster sauce tilapia dishes over shrimp sauce tilapia dishes or commercial oyster sauce mixed tilapia dishes in terms of aroma, taste, and color (1:1).

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