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Analysis of the Quality of Tanjung Mackerel (Scomberomorus Commersoni) Satay with the Addition of Liquid Smoke

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A B S T R A C T

Sate Tanjung is a traditional dish from North Lombok made from marine fish such as mackerel, tuna, or barracuda. Conventional processing methods using charcoal grilling are considered less healthy due to the potential formation of carcinogenic compounds. Liquid smoke is considered a safer alternative, as it contains phenolic compounds, organic acids, and carbonyls that serve as natural preservatives, enhance smoky flavor, and extend shelf life. This study aimed to determine the quality and characteristics of Sate Tanjung with the addition of liquid smoke at concentrations of 0%, 2%, 4%, and 6%. The research employed a laboratory experimental method using a Completely Randomized Design (CRD) with four treatments and three replications. The processing included marination with liquid smoke-based seasoning and a three-stage oven drying process at 60°C, 70°C, and 90°C for one hour each. Parameters observed were moisture, ash, protein, fat, and carbohydrate content, hedonic tests (color, aroma, taste, and texture), and protein profile analysis using SDS-PAGE. Data were analyzed using ANOVA and further tested with Honestly Significant Difference (HSD) test. Results showed that the addition of liquid smoke significantly affected moisture, protein, fat, carbohydrate content, and hedonic values, but had no significant effect on ash content. The best treatment was found at 6% liquid smoke concentration, yielding the highest protein content (25.18 ± 0.08%), lowest moisture content (55.40 ± 0.09%), and highest hedonic scores. SDS-PAGE analysis revealed variations in protein band patterns across treatments, indicating structural changes due to liquid smoke application. In conclusion, different concentrations of liquid smoke effectively influenced the chemical, sensory, and structural characteristics of Sate Tanjung made from mackerel.

Keywords: tanjung satay, liquid smoke, spanish mackerel, quality characteristics, hedonic

1. Introduction

Tanjung satay is a traditional dish from North Lombok, West Nusa Tenggara, which uses pelagic sea fish such as mackerel as its main ingredient. The preparation process involves local spices and grilling, resulting in a distinctive flavor and high nutritional content. Originally used in traditional ceremonies, it has now become one way of utilizing local fishery products. Mackerel has a high protein content (around 19.29%) and other nutritional values that make it a highly nutritious food ingredient. Indonesia's fishery production continues to increase, making a significant contribution to national exports and demonstrating the great potential for developing products such as sate Tanjung. However, traditional grilling methods carry the risk of producing carcinogenic compounds (PAHs) if not properly controlled.Oleh karena itu, dibutuhkan inovasi teknologi pengolahan seperti penggunaan asap cair dalam proses marinasi. Asap cair, yang diperoleh dari pirolisis bahan organik, mengandung senyawa antioksidan, antimikroba, dan pembentuk aroma khas asap, yang sekaligus aman karena tidak menghasilkan PAHs. Dengan demikian, pengembangan sate Tanjung melalui pendekatan ilmiah dan inovasi teknologi seperti asap cair sangat penting untuk meningkatkan mutu, keamanan, dan promosi produk secara lebih luas.

Satay is generally cooked by grilling, but this method has drawbacks such as a bitter aftertaste, residue, and the potential for carcinogenic substances. Therefore, liquid smoke has been proposed as an alternative to grilling for Tanjung satay. The use of liquid smoke is considered healthier, more environmentally friendly, and still preserves the signature smoky flavor, while also extending shelf life. Considering the high nutritional value of Spanish mackerel and the advantages of liquid smoke, this research is important to conduct as an innovation in the processing of Tanjung satay.

2. Materials and tools

This research on the process of making Tanjung mackerel satay was conducted at the Packaging Laboratory, Faculty of Fisheries and Marine Science, Diponegoro University. The analysis included moisture content, protein, fat, ash, and carbohydrate levels. Meanwhile, the protein profile analysis used the method of SDS-PAGE. The equipment used includes a destructor (pyrex), a distillator (pyrex), a distillation tube (pyrex), a test tube (pyrex), a spectrophotometer (visible spectrophotometer 721), a flame photometer (Shimdazu), and a petri dish (pyrex).

2. Methods

2.1.1. Water Content (BSN, 2013)

Moisture content analysis is carried out using the gravimetric principle, which relies on weighing the amount of free water molecules in a food material. This procedure involves removing water molecules by heating with a vacuum oven at a temperature of 95-100 °C for 5 hours, or using a non-vacuum oven at 105 °C for 16-24 hours. The determination of water weight is calculated based on the difference in the sample's weight before and after the drying process. Water content testing according to BSN, SNI No. 2908: 2013 The water content obtained can be calculated using the following calculations:

$$(\%) = \left(\frac{W1 - W2}{W1 - W0}\right) \times 100\%$$

Water content

2.1.2. Ash Content (SNI 01-2354.1-2006)

Ash content testing is carried out based on the gravimetric method, which involves the difference in weight before and after ashing, to determine the amount of inorganic residue produced from the ashing process. The sample is oxidized at a temperature of 550°C in a muffle furnace for 8 hours or until white ash is obtained, then calculated based on gravimetry.

2.1.3. Protein Content (AOAC, 2002)

The measurement of protein content is carried out using the Kjeldahl method. There are three main stages in the process: destruction, distillation, and titration, which are performed to analyze the sample. During the destruction stage, the sample is heated with concentrated H_2SO_4 until it breaks down into its elemental components. To speed up this process, catalysts such as Na_2SO_4, $CuSO_4$, and selenium are used. The process is considered complete when the solution becomes clear or colorless. Next, in the distillation stage, ammonium sulfate is broken down into ammonia by adding NaOH until the solution becomes alkaline and then heated. The resulting ammonia is collected in concentrated H_3BO_3 that has been mixed with BCG and methyl red indicators. The amount of H_3BO_3 that reacts with the ammonia can be determined through titration using 0.02 M HCl, with the end of the titration indicated by a color change in the solution from dark blue to pink. A blank treatment is conducted to measure the nitrogen originating from the reagents used.

2.1.4. Fat Content (SNI 01-2354.3-2006)

The principle of this test is to separate fat or oil from the material by extracting it using an appropriate organic solvent, in this case, chloroform is used. The dried sample is placed into the extraction cartridge and repeatedly extracted with the solvent in the Soxhlet apparatus. The extracted fat will collect in the extraction flask. After the extraction process is complete, the solvent is removed by evaporation using a stream of nitrogen gas (N_2) or by heating in a vacuum oven to ensure no solvent remains. Next, the remaining fat extract is weighed to determine the fat content in the sample.

2.1.5. Protein Profile Through SDS-PAGE

The protein profile is a depiction of the protein content present in a sample, where protein molecules are specifically separated based on their molecular weight using the SDS-PAGE method (Laemmli, 1970). Analytical sample preparation for protein profile identification refers to Amalia et al. (2023). The sample that has been ground is then weighed at 1 g. It is dissolved in 9.5 ml of physiological saline (NaCl 0.9%) in a 50 mL beaker and then homogenized with a magnetic bar and magnetic stirrer at 4 °C for 1 minute. It is then stirred constantly for 20 minutes at 2 °C, after which it is centrifuged for 30 minutes at 4 °C at a speed of 4000 rpm. The supernatant is placed in a freezer at -20°C before SDS-PAGE analysis.

The gel used in gel electrophoresis consists of 4% stacking gel and 12.5% separating gel. Prepare the supernatant by adding buffer at a 1:1 ratio, then heat it at 100°C for 5 minutes. Load 20 µl of each sample into the wells of the gel. Electrophoresis is carried out at a current of 20 mA for 40-50 minutes or until the tracking dye reaches a distance of 0.5 cm from the bottom of the gel. Next, the gel is soaked for 60 minutes in a staining solution containing 1 g of Coomassie Brilliant Blue R-250 in 450 ml methanol: 100 ml glacial acetic acid: 450 ml water at room temperature. Then, the destaining step is performed. The molecular weight of each protein band is then calculated according to the standard curve (10.5 ± 175 kDa). Making Liquid Smoke Squid

The process of making liquid smoked squid begins with cleaning the squid from dirt. Then soak the squid in water mixed with salt and liquid smoke with each concentration liquid smoke, namely 0%, 1%, 3%, and 5% for 30 minutes. The next step is to drain the squid which has been soaked for 30 minutes. Squid smoking is carried out in stages, namely 45°C, 70°C and 90°C with a time of one hour each. The aim of smoking in stages is so that the texture and nutritional content of the squid are not damaged.

2.1.6. Hedonic Testing

The hedonic test is a method used to assess consumers' level of preference for a product based on sensory attributes such as color, aroma, texture, and taste. In this study, the test was conducted by 30 panelists who are students of Fisheries Product Technology and have met the criteria as consumer panelists. Each panelist was asked to evaluate four samples of Tanjung satay that had been randomly coded, then give their level of preference

2.2 Making Sate Tanjung

The raw mackerel is first washed and cleaned with running water, then filleted to remove the skin and bones, leaving only the fish meat. The process of preparing the Tanjung satay seasoning begins with peeling and washing the spices, such as shallots, garlic, chili, galangal, candlenut, and turmeric. Next, these spices are ground together with sugar, salt, shrimp paste, a small amount of mackerel meat (with a ratio of 50% of the main ingredient), and enough liquid coconut milk until well mixed and smooth. The next stage in making Tanjung satay is the marination process. This involves mixing the fish meat with the previously ground spices. The ground seasoning is divided into four portions, then liquid smoke is added to each at concentrations of 0%, 2%, 4%, and 6%. The fish meat is evenly coated with the seasoning until it covers the entire surface of the meat. Then, the marination process is allowed to sit for approximately 30 minutes to let the flavors absorb into the mackerel. The baking process is used to cook the fish meat as a substitute for grilling in satay preparation. Baking is carried out in stages at different temperatures: the first hour at 60°C, the next hour at 70°C, and the final hour at 90°C. To ensure the satay cooks evenly, turn the satay over during baking.

2.3 Data analysis

This study focuses on the characteristics of Tanjung satay with different liquid smoke soaking times, namely 0 minutes (A), 30 minutes (B), 60 minutes (C), and 90 minutes (D). The data obtained were processed using SPSS 16, and the resulting parametric test data were then subjected to statistical tests, including normality test, homogeneity test, and followed by ANOVA test. The parametric tests included protein, ash, fat, carbohydrate, and moisture content analysis. The homogeneity test was conducted to determine whether the data obtained from the production of Tanjung satay were homogeneous and normally distributed as expected. Data that showed normality and homogeneity were then analyzed using ANOVA variance analysis.

3. Result and Discussions

Table 1. Characteristics of Tanjung Satay

Treatment	Water	Ash	Protein	Fat	Carbohydrate
A	$61,36 \pm 0,10^{d}$	$2,62 \pm 0,03^{a}$	$20,23 \pm 0,12^{a}$	$5,70 \pm 0,02^{a}$	$8,82 \pm 0,05^{b}$
B	$58,33 \pm 0,08^{c}$	$2,65 \pm 0,01^{bc}$	$23,55 \pm 0,08^{b}$	$6,74 \pm 0,06^{c}$	$7,80 \pm 0,20^{a}$
C	$56,55 \pm 0,05^{b}$	$2,68 \pm 0,00^{c}$	$24,56 \pm 0,07^{c}$	$6,26 \pm 0,12^{b}$	$10,13 \pm 0,15^{c}$
D	$55,40 \pm 0,09^{a}$	$2,65 \pm 0,02^{bc}$	$25,18 \pm 0,08^{d}$	$6,22 \pm 0,10^{b}$	$8,78 \pm 0,05^{b}$

3.1 Water Content

The moisture content of Tanjung mackerel satay shows a decrease with the addition of liquid smoke. The highest value is found in the 0% treatment (67.83%) and the lowest in the 6% treatment (63.20%). The differences between treatments are, in sequence, 3.03% (0–2%), 1.28% (2–4%), and 0.32% (4–6%), with the largest difference of 3.03% occurring between the 0–2% treatments. This indicates that a 2% concentration of liquid smoke is the most effective in reducing moisture content. This reduction in moisture is thought to be due to phenol and carbonyl compounds in the liquid smoke being able to inhibit microbial growth and accelerate the evaporation of water during heating (Nurilmala et al., 2018). According to Putri et al. 2020, the decrease in moisture content is directly related to enhanced shelf life of processed fish products, as low moisture content can slow down microbiological spoilage.

3.2 Ash Content

The ash content of Tanjung mackerel satay increases with the addition of liquid smoke concentration. The lowest value is found in the 0% treatment (3.42%) and the highest in the 6% treatment (3.60%). The differences between treatments are 0.08% (0–2%), 0.07% (2–4%), and 0.03% (4–6%), with the largest difference of 0.08% observed between 0–2%. Although the differences are relatively small, the tendency for increased ash content indicates the addition of minerals from the liquid smoke into the product. According to Wahyuni et al. 2019, the increase in ash content in smoked fish may be caused by the absorption of inorganic components present in liquid smoke, such as calcium, potassium, and sodium, which contribute to the flavor and nutritional value of the product.

Ash content can indicate the presence or absence of mineral content in smoked fish. This is carried out as an assessment of the nutritional content in smoked fish products. The results of the ash content analysis following the addition of liquid smoke to Tanjung-style mackerel satay show that there is no significant difference. These factors are important to consider when understanding the nutritional composition found in fish. According to Gultom et al. (2015), the ash content found in fish can be influenced by several factors, such as the fish's habitat and the food consumed within that habitat. Environmental factors such as water quality, temperature, and the presence of predators can also affect the growth and development of the fish, which in turn impacts the ash content. Fish that live in cleaner and more nutrient-rich environments tend to have lower ash content, reflecting better mineral availability.

3.3 Protein Content

The protein content of Tanjung mackerel satay increases with the addition of liquid smoke. The lowest value was found in the 0% treatment (18.25%) and the highest in the 6% treatment (20.19%). The differences between treatments were 0.20% (0–2%), 1.42% (2–4%), and 0.32% (4–6%), with the highest difference of 1.42% occurring between the 2% and 4% treatments. This indicates that the addition of 4% liquid smoke is the most effective in increasing protein content. This increase may be attributed to the smoking effect, which helps reduce protein degradation and maintain protein structure during heating (Ahmed et al., 2022). Ramdani et al. 2021 also stated that smoking treatment can relatively increase protein content due to reduced water content, which leads to a higher percentage of protein.

Based on the results of this study, the protein content in Tanjung tuna satay increases along with the rise in liquid smoke concentration. This is due to the higher liquid smoke concentration binding more water. This is supported by Syarafina (2014), who stated that the higher the concentration of liquid smoke used, the higher the protein content becomes, since many components of liquid smoke serve as water binders. The greater the amount of water lost, the higher the percentage of protein content. The increased protein content is also caused by protein denaturation in Tanjung satay. According to Darmanto et al. (2009), the heating process causes protein denaturation, which reduces its solubility, so when evaporation occurs, the protein remains due to coagulation. In addition, the use of saline solution during the soaking process results in an increase in the protein content of smoked fish.

3.4 Fat Content

The fat content of Tanjung mackerel satay increases with the addition of liquid smoke. The lowest value is found in the 0% treatment (7.12%) and the highest in the 6% treatment (8.40%). The successive differences between treatments are 0.23% (0–2%), 0.75% (2–4%), and 0.30% (4–6%), with the highest difference of 0.75% occurring between the 2–4% treatments. This increase in fat content is thought to be due to the smoking process, which minimizes excessive fat oxidation, thus preserving the fat content. Rizwan et al. (2020) explained that the phenol components in liquid smoke can act as antioxidants, slowing down fat degradation and resulting in a relatively higher fat content in the final product.

The high concentration of liquid smoke in Tanjung satay can increase the fat content of the resulting product. Compared to the fat content in the control treatment, the fat content in Tanjung satay with added liquid smoke shows a significant increase. The rise in fat content indicates that adding liquid smoke concentration has a substantial effect on the fat content of Tanjung satay. The increase in fat content in Tanjung satay is suspected to be caused by the phenolic components contained in the liquid smoke. The fat content of fish treated with liquid smoke will have a higher phenolic content compared to those not treated with liquid smoke, thus being able to prevent harmful chemical reactions from the fat in fish treated with liquid smoke. Meanwhile, compared to a quality study conducted by Efendi (2016), the high fat content in fish makes them more prone to oxidation and rancidity. The phenolic compounds in liquid smoke can prevent the oxidation process of fat in fish. Phenolics are easily dissolved in fat, and the higher the fat content in food products, the more appealing the aroma that is produced.

3.5 Carbohydrate

The lowest value was found in the 0% treatment (3.38%) and the highest in the 6% treatment (3.75%). The differences between treatments were 0.17% (0–2%), 0.15% (2–4%), and 0.05% (4–6%), with the highest difference of 0.17% observed between the 0–2% treatments. The increase in carbohydrate content may be influenced by the Maillard reaction during the heating process, which involves the interaction between reducing sugars and amino acids (Hasibuan et al., 2019). This reaction can contribute to the formation of the distinctive color, flavor, and texture of Tanjung satay products.

In its fresh state, the carbohydrate content in fish is generally only around 0.5-1% (Ahmed et al., 2022), but in the Tanjung satay product it contains 10%. This is due to the use of additional food ingredients such as spices, which cause the carbohydrate content in Tanjung satay to increase. The addition of liquid smoke can further increase the carbohydrate value of Tanjung satay. This is because coconut shells themselves contain lignin and cellulose. Lignin and cellulose are components that make up carbohydrates in food, so the more liquid smoke is added, the higher the carbohydrate content in a food product will be. This is supported by Winarno (2008), who stated that carbohydrates are mostly found in plant-based ingredients, whether in the form of simple sugars, hexoses, or carbohydrates with high molecular weight such as lignin and cellulose. Therefore, the increase in carbohydrate levels in Tanjung satay is closely related to the combination of added spices and the contribution of active components from the liquid smoke used during the processing.

3.6 Anlisis Profil Protein Melalui SDS-PAGE

The results of protein analysis using the SDS PAGE method of Tanjung mackerel satay with different concentrations of liquid smoke are presented in Figure 1 as follows:

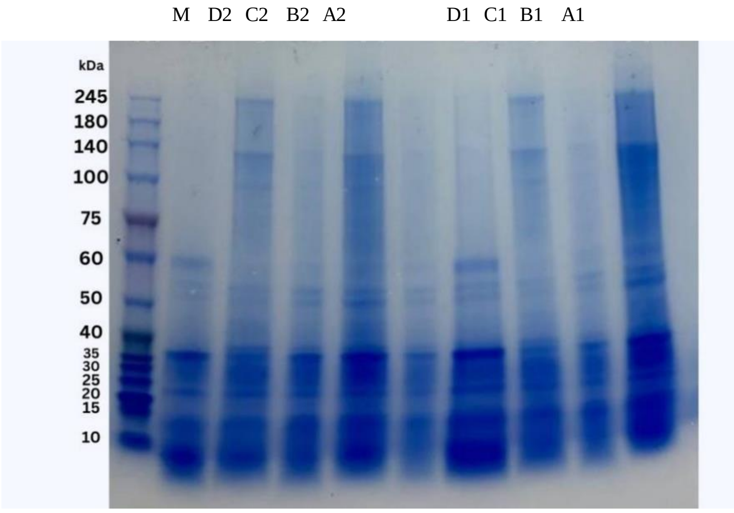


Figure 1. Protein Profile of Tanjung Satay Made from Mackerel with Addition of Liquid Smoke Concentration (A (0%); B (2%); C (4%); D (6%); 1 = replicate 1; 2 = replicate 2; injection volume 20 µL)

It can be seen in Figure 4.1 that A1 and A2 have 5 major bands and 4 minor bands, while B1 and B2 have 2 major bands and 4 minor bands. Samples C1 and C2 have 6 major bands and 2 minor bands, while D1 and D2 show 4 major bands and 3 minor bands. The differences in the number of bands observed in each sample are suspected to be due to the different liquid smoke treatments. Samples C1 and C2, which have 6 major bands, are thought to still retain more types of main proteins, while B1 and B2, which only have 2 major bands, are suspected of experiencing a decrease in protein quantity as a result of damage or changes in protein structure during the processing. The appearance of minor bands in each sample is thought to originate from protein fragments or proteins with small molecular weights. Research by Irawan et al. (2005) showed that treatment with liquid smoke from coconut shells on mackerel fish can inhibit protein damage and maintain protein structure, as detected through SDS-PAGE analysis. These results further support the assumption that variations in liquid smoke concentration in Tanjung-style mackerel satay products can affect the diversity and stability of the proteins formed during processing.

The wells in samples A1 and A2 contained 9 protein bands with an injection volume of 20 µL and a molecular weight range between 10–231 kDa, which are suspected to include high molecular weight proteins such as thyroglobulin. The relatively large number of bands and wide molecular weight range suggest that, in this treatment, protein diversity remains quite high and relatively stable. These results are consistent with the findings of Swastawati et al. (2024), who found that increasing the concentration of liquid smoke in fish samples can increase the number of protein bands detected through SDS-PAGE and help maintain their stability during processing.

The wells in samples B1 and B2 showed 6 protein bands with an injection volume of 20 µL and molecular weights ranging from 10–53 kDa. This range is suspected to indicate the presence of proteins such as Glutamate dehydrogenase (around 55 kDa) and Leucine aminopeptidase (around 52 kDa), which are commonly found in fish muscle tissue. Glutamate dehydrogenase plays a role in the oxidative deamination of glutamic acid, which produces α-ketoglutarate in the Krebs cycle and serves as an indicator of tissue metabolic activity (Fournier et al., 2002). Meanwhile, Leucine aminopeptidase functions to cleave leucine residues from the N-terminal end of proteins and is related to protein degradation in fish muscle (Gao et al., 2017). Both of these proteins tend to appear at medium molecular weights and are detected in extraction results from processed fish meat, especially after being treated with liquid smoke.

The wells in samples C1 and C2 showed 8 protein bands with molecular weights ranging from 10–231 kDa and an injection volume of 20 µL, which are suspected to include large proteins such as thyroglobulin. The range of bands at these high molecular weights indicates that the treatments applied to sample C were able to preserve the main protein structures. This is consistent with the findings of Syarafina et al. (2014), who reported that liquid smoke can enhance protein stability in mackerel and milkfish meat by inhibiting oxidative damage that leads to protein denaturation during the smoking process. Thus, large protein bands like thyroglobulin remain detectable, reflecting the diversity and stability of the main proteins in sample C.

Meanwhile, samples D1 and D2 showed 7 protein bands with molecular weights between 10 – 59 kDa. In this range, the presence of catalase protein is suspected, as it has a molecular weight of around 59 kDa and is known as an antioxidant enzyme that plays a role in detoxifying reactive oxygen species (ROS) in tissues. The presence of catalase in the SDS-PAGE results may indicate that liquid smoke treatment in sample D triggers a biological defense response against oxidative stress, causing this enzyme to remain active or even increase. Khan et al. (2016) explained that catalase is one of the key enzymes in the antioxidant system of fish, while according to Kurniawan et al. (2022), the activity of this enzyme tends to increase in processed fish products treated with liquid smoke as a form of adaptation to exposure to active compounds such as phenols and carbonyls.

3.7 Hedonic Analysis

Table 2. Hedonic Analysis of Tanjung Satay

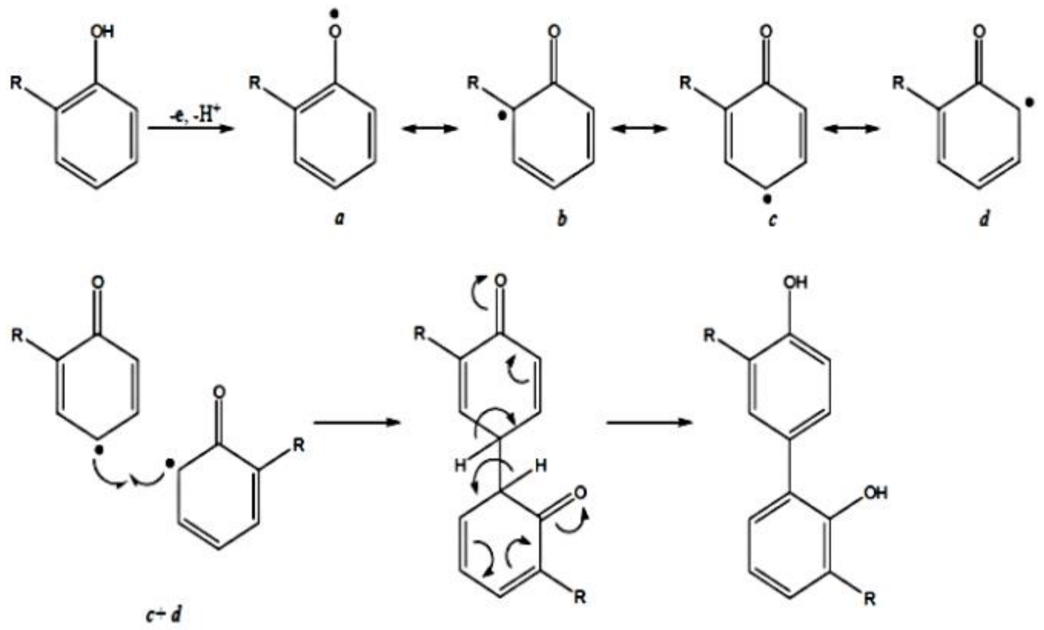
Concentration Liquid Smoke	Parameter			
	Color	Texture	Smell	Flavor
0%	$7,3 \pm 1,37^{a}$	$7,4 \pm 1,50^{a}$	$6,7 \pm 1,84^{a}$	$6,7 \pm 1,69^{a}$
2%	$7,4 \pm 1,31^{a}$	$6,5 \pm 1,63^{ab}$	$6,9 \pm 1,50^{bd}$	$7,3 \pm 1,64^{b}$
4%	$7,6 \pm 1,05^{a}$	$6,6 \pm 1,76^{b}$	$7,1 \pm 1,59^{cd}$	$7,9 \pm 1,61^{a}$
6%	$7,1 \pm 1,13^{a}$	$5,8 \pm 1,68^{b}$	$5,6 \pm 1,72^{d}$	$6,1 \pm 1,76^{bc}$

The appearance test of Tanjung mackerel satay color with the addition of liquid smoke showed that the concentration of liquid smoke affects the product's appearance. Satay without liquid smoke (0%) was the most preferred because its color was more brownish, glossy, and intact. This color is formed due to the reaction of phenol and carbonyl compounds in the liquid smoke with air and the fish meat proteins, resulting in a yellowish-brown color and a glossy effect. This reaction occurs in acidic conditions that naturally exist in liquid smoke. This study shows that acids, phenols, and carbonyls in liquid smoke play an important role in color formation in Tanjung satay. According to Nugroho et al. (2018), the ideal color of products resulting from the oven process is golden brown. The golden brown color in Tanjung satay with the addition of liquid smoke is caused by a chemical reaction between phenol compounds and air, while the glossy appearance is formed due to the reaction between formaldehyde and phenol, which produces a thin layer on the product's surface.

The hedonic test for the texture of Tanjung satay ranged from 5.8 to 7.6, and descriptively, the panelists rated it as somewhat liked to liked. In this study, it was seen that the panelists gave an average score of 6.55 for hedonic quality, differing from the results of the hedonic test. The results of the hedonic test scores for the texture of smoked mackerel Tanjung satay are presented in Table 4.7. Tanjung satay with the addition of 4% liquid smoke had the highest score among all treatments. According to Talib et al. (2020), smoked fish soaked in liquid smoke produces a better texture. This is consistent with the research by Salindeho and Lumoindong (2017), who explained that the panelists' preference is thought to be due to the moisture content in the product, which can result in a more desirable texture. Higher moisture content will result in a lower texture score. Tanjung satay with the addition of liquid smoke has a denser, more compact, and intact texture compared to the control treatment, which produced a softer texture due to the concentration of added liquid smoke.

The results of the hedonic test and hedonic quality test on the aroma of Tanjung satay with the addition of liquid smoke tend to increase along with the increase in liquid smoke concentration. The hedonic test results for aroma yielded scores between (5.5-6.9), and descriptively, the panelists rated it as somewhat liked to liked. The highest level of aroma preference was found in the 2% treatment, while the lowest was found in the 6% treatment. The hedonic quality of the aroma of Tanjung satay with the addition of liquid smoke averaged (various values), with the specification of less fragrant aroma, sufficient smokiness, no additional disturbing odors, and other specifications such as pleasant smokiness without any interfering smell. The lowest hedonic quality score for the aroma of smoked Tanjung mackerel satay was found in the control treatment, and the highest in the 7% treatment. The hedonic and hedonic quality test results for the aroma of Tanjung satay with the addition of liquid smoke are presented in Table 4.7. The aroma of Tanjung satay with the addition of liquid smoke is caused by the presence of volatile compounds in the smoke, which provide a distinctive smell. The phenolic compounds responsible for the aroma and taste are guaiacol, 4-methyl-guaiacol, and 2,6-dimethoxy phenol. According to Swastawati et al. (2017), compounds found in phenolic smoke result in smoked fish having a mild to fairly strong or strong smoke aroma, not rancid, without a rotten or musty smell, and without a sour odor. Based on the results of the hedonic test and hedonic quality test for the aroma of Tanjung satay with liquid smoke addition in this study, the standards of SNI 01-2346-2006 were met, which stipulate a minimum organoleptic value of 7 for smoked fish products (BSN, 2009).

The hedonic taste test for Tanjung satay ranged from 6.1 to 7.9, and descriptively, the panelists rated the product as likable. In this study, it was observed that the panelists gave an average score of 7 in the hedonic test results. The treatment with the addition of 4% liquid smoke yielded the best result for the taste of Tanjung satay, receiving a score of 7.9. The next hedonic parameter observed was taste. The taste-active components are generally nonvolatile compounds, such as free amino acids, nucleotides, sugars, mineral salts, organic bases, organic acids, and inorganic compounds. These taste-active components play a significant role in changing the flavor of fishery products if they are removed from a mixture. Taste-active components such as glutamate, inosine monophosphate, and glycine influence the savory taste and sweetness level of fishery products (Kawai et al., 2009). Taste is affected by several factors, namely chemical compounds, temperature, concentration, and interactions with other taste components. In Tanjung satay with added liquid smoke, the salty taste is produced by some inorganic salts. Common inorganic salt is NaCl (Winarno, 2008). Sodium ions are responsible for the flavor derived from salt. The important function of sodium for flavor perception is not only the salty taste it provides but also its ability to enhance the intensity of other flavors present due to sodium. In Tanjung satay made from mackerel with the addition of liquid smoke, the resulting flavor is also influenced by the Tanjung satay seasonings such as shallots, garlic, turmeric, chili, candlenut, and the umami taste from the fish mashed together with these spices as the marinade for Tanjung satay. According to Winarno (2008), the umami taste is associated with the presence of compounds such as glutamic acid or its salts in food ingredients, for example, monosodium glutamate and types of 5-nucleotides like inosine 5-monophosphate (IMP) and guanidine 5-monophosphate. Free glutamic acid is found in all fish species and is the most important and primary contributor to umami taste.



4. Conclusions

The addition of liquid smoke has a significant effect on the chemical quality of Tanjung satay. A 6% concentration of liquid smoke yields the highest protein content (25.18%), the lowest moisture content (55.40%), and relatively stable fat and carbohydrate levels. This indicates that increasing the concentration of liquid smoke can improve the proximate quality of the product. The addition of liquid smoke also affects organoleptic characteristics. Based on hedonic testing, liquid smoke concentrations of 4% and 6% provide the highest level of acceptance from panelists, especially in terms of taste, aroma, and texture. This shows that the use of liquid smoke can maintain the distinctive flavor of Tanjung satay without direct grilling.

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