

EFFORTS TO INCREASE THE SHELF LIFE OF RED NILE FISH MEATBALLS (*Oreochromis niloticus*) BY ADDING LIQUID SMOKE

Upaya Peningkatan Umur Simpan Bakso Ikan Nila Merah (*Oreochromis niloticus*) dengan Penambahan Asap Cair

Ardi Lesmana Saputra¹, Rizky Muliani Dwi Ujianti^{1*}, Iffah Muflihati¹, Fafa Nurdyansyah¹, Mega Novita²

¹Food Technology Department, Faculty of Engineering and Informatics, University of the Republic of Indonesia Teachers Association Semarang

²Natural Science Education, Postgraduate Program, University of the Republic of Indonesia Teachers Association Semarang

Sidodadi Timur Street, Karangtempel, East Semarang, Semarang City, Central Java, Indonesia 50232

*Corresponding Author: rizkymuliani@upgris.ac.id

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ABSTRACT

Red tilapia fish meatballs are a popular processed fishery product because they have a taste liked by various groups and are relatively affordable, making them accessible to all. However, red tilapia fish meatballs have a short shelf life, so safe, natural preservation methods are needed; one is liquid smoke. This study aims to determine the effects of soaking time and the addition of liquid smoke on the shelf-life of red tilapia fish meatballs (*Oreochromis niloticus*) during a shelf-life test. This study used a Completely Randomized Design (CRD) with two treatment factors: soaking time (30 minutes and 45 minutes) and liquid smoke at 1.5% and 3%. Analysis of red tilapia fish meatballs included testing for water content, ash content, total acid, total phenols, texture, a sensory test, and a shelf-life test. The results showed that the addition of liquid smoke significantly increased ash content and total acid, decreased water content, improved texture, and increased the shelf life of fish meatballs. The total acid analysis yielded values of 0.14%-0.36%, and the total phenol content yielded values of 0.06%-0.15%. Meanwhile, the analysis of fish meatball products included texture characteristics such as hardness (254.8-351.4), cohesiveness (0.87-0.93), and springiness (0.83-1.00). The moisture content analysis yielded values of 5.07%-5.73%, and the ash content analysis yielded values of 1.85%-2.82%. Based on the research results, liquid smoke is an effective natural preservative that improves the quality and shelf life of red tilapia fish meatballs.

Keywords: Liquid Smoke, Red Tilapia Fish Balls, Shelf Life

ABSTRAK

Bakso ikan nila merah (*Oreochromis niloticus*) merupakan produk olahan hasil perikanan yang digemari karena memiliki cita rasa yang disukai berbagai kalangan serta harganya relatif terjangkau, sehingga dapat dikonsumsi oleh semua masyarakat. Namun, bakso ikan nila merah

memiliki kelemahan di umur simpan produk yang tidak bertahan lama, sehingga diperlukan upaya pengawetan alami yang aman, salah satunya dengan penggunaan asap cair. Penelitian ini bertujuan untuk menentukan pengaruh lama perendaman dan penambahan asap cair pada bakso ikan nila merah terhadap uji umur simpan bakso. Penelitian ini menggunakan Rancangan Acak Lengkap (RAL) dengan dua faktor perlakuan, yaitu dengan lama perendaman 30 menit dan 45 menit, dan penambahan asap cair 1,5% dan 3%. Analisis terhadap bakso ikan nila merah meliputi pengujian kadar air, kadar abu, total asam, total fenol, tekstur, uji sensoris, serta uji umur simpan. Hasil penelitian menunjukkan bahwa penambahan asap cair berpengaruh nyata terhadap peningkatan kadar abu, total asam, total fenol, penurunan kadar air, serta perbaikan tekstur dan meningkatkan umur simpan bakso ikan. Hasil analisis total asam diperoleh nilai sebesar 0,14%-0,36%, serta total fenol diperoleh nilai sebesar 0,06%-0,15%. Sementara itu, hasil analisis pada produk bakso ikan mencakup karakteristik tekstur seperti *hardness* sebesar 254,8-351,4, *cohesiveness* 0,87-0,93, dan *springiness* 0,83-1,00. Analisis kadar air diperoleh nilai sebesar 5,07%-5,73%, dan kadar abu menghasilkan nilai sebesar 1,85%-2,82%. Berdasarkan hasil penelitian dapat disimpulkan bahwa penggunaan asap cair efektif sebagai pengawet alami dalam meningkatkan kualitas dan umur simpan bakso ikan nila merah.

Kata Kunci: Bakso Ikan Nila Merah, Asap Cair, Umur Simpan

INTRODUCTION

Fish is a high-protein food commodity, but it is more susceptible to spoilage than other food ingredients. Fish spoilage is influenced by the activity of natural enzymes in the fish's body and the growth of microorganisms from the environment. The high water content in fish also accelerates the development of spoilage microbes, resulting in a relatively short shelf life for fresh fish (Fikriyah *et al.*, 2024). Some bacteria that frequently cause spoilage in meat and fish include those from the genera *Pseudomonas*, *Achromobacter*, *Streptococcus*, *Leuconostoc*, *Bacillus*, and *Micrococcus* (Ariestya *et al.*, 2016). Therefore, proper processing and preservation efforts are necessary to maintain the quality and extend the shelf life of fishery products.

One of the freshwater fish commodities widely consumed by the public is red tilapia (*Oreochromis niloticus*). Red tilapia has various advantages, such as being easy to cultivate, rich in protein, thick flesh, and relatively few fine bones, making it easy to process into various food products (Jamilatun *et al.*, 2016). One form of diversified processing is fish balls, a processed product made from fish meat mixed with tapioca flour and spices, then formed into balls and boiled (Fillaili *et al.*, 2020). Fish balls have a chewy texture, a savory taste, and a distinctive fishy aroma, but they have the disadvantage of a short shelf life due to their high nutrient and water content. At room temperature, fish balls can only last about 12 hours to 1 day before experiencing quality degradation (Primadini *et al.*, 2021). These conditions make fish balls susceptible to microbiological damage and changes in sensory characteristics.

The issue of meatball shelf life encourages the use of preservatives to maintain product quality. However, the use of hazardous preservatives such as formaldehyde and borax, which are unsafe for health, is still found (Alamsyah *et al.*, 2021). One potential natural preservative alternative is liquid smoke. Liquid smoke is the condensate from the pyrolysis of biomass such as wood and coconut shells. It contains various active compounds, especially phenols and organic acids, with natural antimicrobial and antioxidant properties (Zebua *et al.*, 2024). In addition to inhibiting the growth of spoilage microorganisms, the use of liquid smoke is also considered safer than traditional smoking methods because it can minimize the formation of carcinogenic compounds such as Polycyclic Aromatic Hydrocarbons (PAH) (Rieuwpassa *et al.*, 2025). Grade 1 liquid smoke is known to be safe for use in food products, including meatballs, because it is free of hazardous compounds (Fauzan & Ikhwanus, 2017).

Several previous studies have shown that liquid smoke is effective as a natural preservative for fishery products. Several previous studies have shown that liquid smoke is an effective natural preservative for fishery products. Harini *et al.* (2014), reported that liquid smoke can inhibit the growth of pathogenic bacteria, including *Escherichia coli*, *Pseudomonas aeruginosa*, *Bacillus subtilis*, and *Staphylococcus aureus*. Research by Livia *et al.* (2023), showed that adding liquid smoke, combined with an edible carrageenan coating, can extend the shelf life of fish meatballs by reducing total microbial counts while maintaining texture and sensory quality. Research by Setyastuti *et al.* (2022), also showed that liquid smoke can improve the stability of fish quality during storage. However, most of these studies focused more on microbiological and physical parameters. In contrast, studies on the suitability of consumption based on sensory parameters during storage of red tilapia fish meatballs are still limited. Furthermore, the effect of the combination of soaking time and liquid smoke concentration on the shelf life of red tilapia fish meatballs has also not been widely studied.

Based on these problems, this study was conducted to determine the effect of different soaking times and liquid smoke concentrations on the shelf life of red tilapia (*Oreochromis niloticus*) meatballs. The treatments used included soaking times of 30 minutes and 45 minutes, and liquid smoke concentrations of 1.5% and 3%. This study is expected to provide information on the optimal treatment for maintaining quality and extending the shelf life of red tilapia meatballs, based on indicators of damage, including mucus formation, aroma changes, and panelist acceptance levels. In general, this study hypothesizes that the use of liquid smoke at certain concentrations and soaking times can inhibit the growth of spoilage microorganisms, thereby maintain the quality and extend the shelf life of red tilapia meatballs.

RESEARCH METHODS

Tools and Materials

The main tools used in this study were a chopper, an Ohaus analytical balance, a beaker, and a measuring cup. The tools used for testing were UV-vis spectrophotometry, a measuring cup, a micropipette, a petri dish, a test tube, a texture analyzer, a Thermo Scientific furnace, an Iwaki burette, a Memmert oven, a Thermo Scientific vortex, a fume hood, and a desiccator.

The main ingredients used in this study include red tilapia (*Oreochromis niloticus*) measuring approximately 250 grams obtained from Peterongan Market, Semarang City, Central Java, food grade liquid smoke brand Lubna, and complementary ingredients for making meatballs including tapioca flour, ice cubes, finely ground garlic, ground pepper, flavoring, and salt tapioca flour, salt, and egg white. Chemical ingredients for analysis are distilled water, phenolphthalein (PP), NaOH, methanol, Folin-Ciocalteu reagent, sodium carbonate (Na₂CO₃), and DM water.

Place and Time

This research was conducted at the Food Processing Engineering Laboratory and the Food Chemistry and Biochemistry Laboratory of the Food Technology Study Program, Faculty of Engineering and Informatics, Universitas PGRI Semarang. This research was conducted for four months, from August 2025 to December 2025.

Making Red Tilapia Fish Meatballs

The red tilapia is cleaned by removing the head, skin, and bones, then washed under running water until clean. The cleaned fish meat is then cut into small pieces to facilitate grinding. The grinding process is carried out using a chopper until the fish meat is smooth, with ice cubes added throughout. The smooth red tilapia meat is then mixed with food additives, namely tapioca flour, salt, ground garlic, ground pepper, flavoring, and egg white. All ingredients are stirred until homogeneous to obtain an elastic dough. The formed dough is then

rounded by hand into uniform-sized meatballs, each weighing 10 grams. The meatballs are then boiled in hot water until they float to the surface, indicating they are done. The cooked meatballs are then removed, drained, and cooled at room temperature before being treated.

Soaking Red Tilapia Fish Balls in Liquid Smoke Concentration

Red tilapia fish meatballs were cut into two pieces, each weighing 5 grams, before soaking. The meatballs were then soaked in a liquid smoke solution prepared at 1.5% and 3% concentrations, using distilled water as the solvent. The soaking of red tilapia fish meatballs was carried out with a soaking time level, namely, 30 minutes and 45 minutes, resulting in 5 treatments, namely, control (without liquid smoke soaking), 1.5% liquid smoke soaking for 30 minutes, 1.5% for 45 minutes, 3% liquid smoke soaking for 30 minutes, and 3% liquid smoke soaking for 45 minutes. During the soaking process, all parts of the meatballs were ensured to be evenly submerged. The sample was then drained for 5 minutes.

Observation Parameters

Water Content Analysis (AOAC, 2005)

Water content was determined using an empty aluminum dish, which was dried in an oven at 105°C for 30 minutes.

Ash Content Analysis (AOAC, 2005)

Ash content was determined by placing the sample in a furnace at 550°C.

Total Acidity Analysis (AOAC, 1995)

Total acidity analysis was performed by adding distilled water and phenolphthalein to the ground sample, then titrating it with 0.1 N NaOH.

Total Phenol Analysis (Setyati *et al.*, 2020)

Total phenol content was determined using UV-Vis spectrophotometry using the Folin-Ciocalteu method.

Texture Analysis (Texture Profile Analyzer)

The texture of red tilapia meatballs was determined using a texture analyzer.

Sensory Test (Descriptive Test)

Conducted by 10 inspection panelists, with four parameters: smoke aroma, fishy aroma, smoke flavor, and firmness.

Shelf-Life Test

Shelf-life testing was conducted by observing smoked tilapia meatballs soaked in liquid smoke for 4 days (until spoiled) and checking for foul odor, slime, and unfitness for consumption. Organoleptic testing of the smoked tilapia meatballs was conducted using a descriptive method with 10 trained panelists.

Data Analysis

Data analysis was performed using analysis of variance (ANOVA) using SPSS. A significant difference test was performed using the Duncan Multiple Range Test (DMRT) to compare mean differences between treatments. The data was then compiled into tables, and the results were presented in bar graphs.

RESULT

Water Content

Water content is a chemical parameter that significantly influences the quality of a food product. The presence of water in food can determine the appearance, texture, and taste of the resulting product. The results for water content are shown in Figure 1.

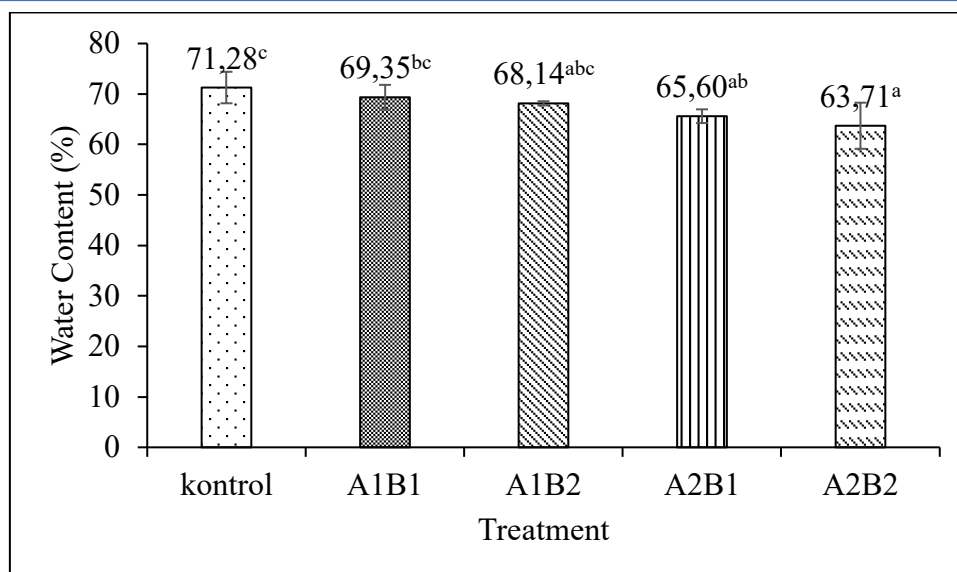


Figure 1. Results of Analysis of Water Content of Red Tilapia Fish Balls with Soaking Time and Addition of Liquid Smoke

Ash Content

Ash content is a mixture of inorganic or mineral components contained in a food ingredient. The addition of liquid smoke can affect ash content by contributing minerals. Results of Analysis of Ash Content of Red Tilapia Fish Balls with Soaking Time and Addition of Liquid Smoke are shown in Figure 2.

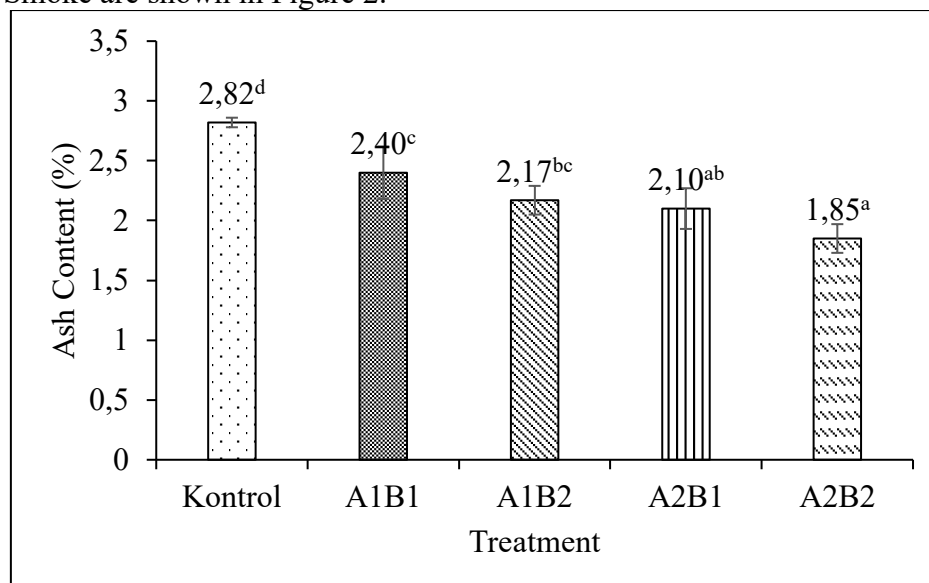


Figure 2. Results of Analysis of Ash Content of Red Tilapia Fish Balls with Soaking Time and Addition of Liquid Smoke

Total Acid

Total acidity (titratable acidity) is the total amount of acid in a food ingredient. This component is an important factor in determining the quality of the resulting liquid smoke. The results of the acid levels are shown in Figure 3.

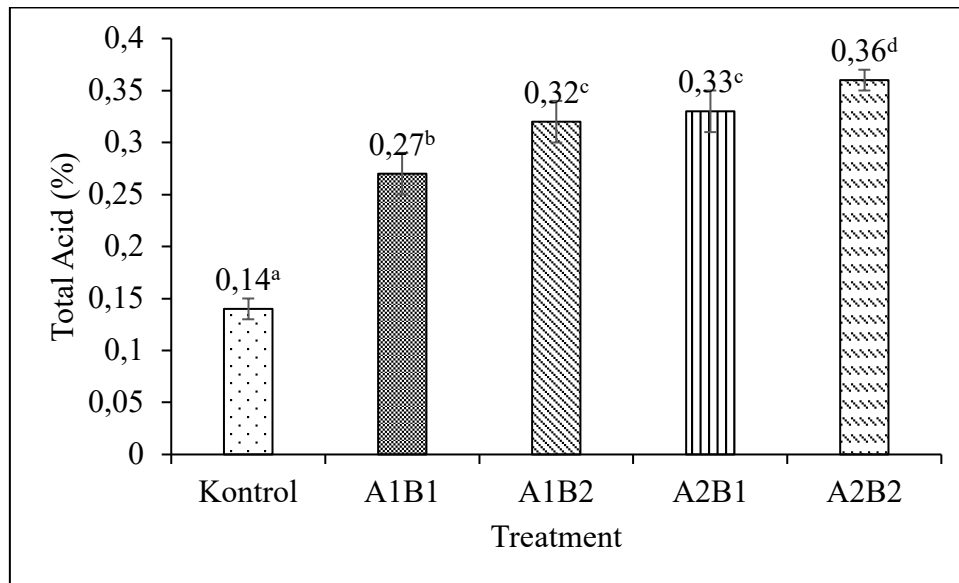


Figure 3. Results of Total Acid Analysis of Red Tilapia Fish Balls with Soaking Time and Addition of Liquid Smoke

Total Phenols

Phenol compounds act as antioxidants, extending the shelf life of smoked products. Phenols also impart a distinctive flavor and color to processed products. Phenols are active ingredients that act as antibacterials. The higher the total phenol content in liquid smoke, the more acidic it is. The results of the total phenol analysis are shown in Figure 4.

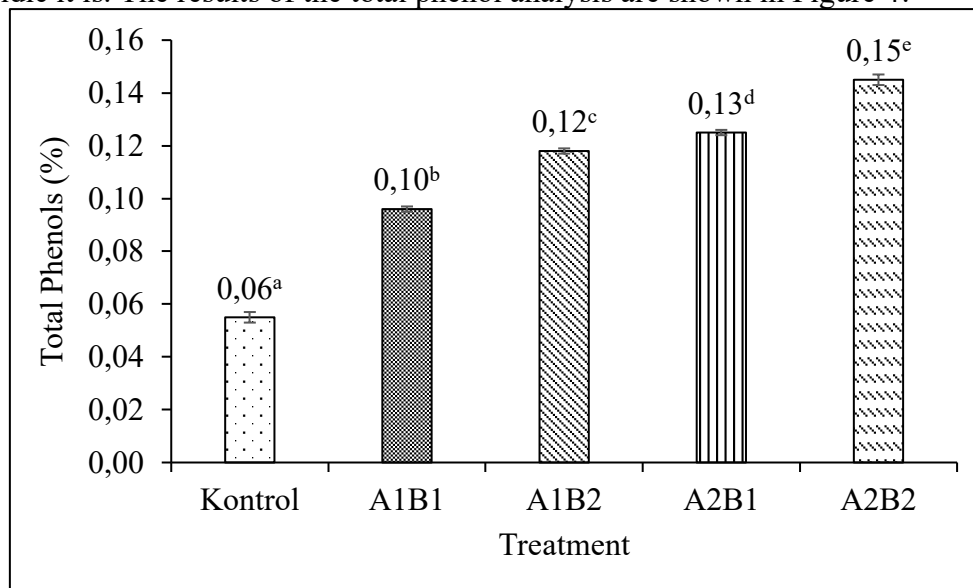


Figure 4. Results of Total Phenol Analysis of Red Tilapia Fish Balls with Soaking Time and Addition of Liquid Smoke

Texture

Texture analysis of red tilapia fish meatballs includes hardness, cohesiveness, and elasticity. Results of hardness texture analysis are shown in Figure 5, and Results of cohesiveness texture analysis are shown in Figure 6, and Results of springiness texture analysis are shown in Figure 7.

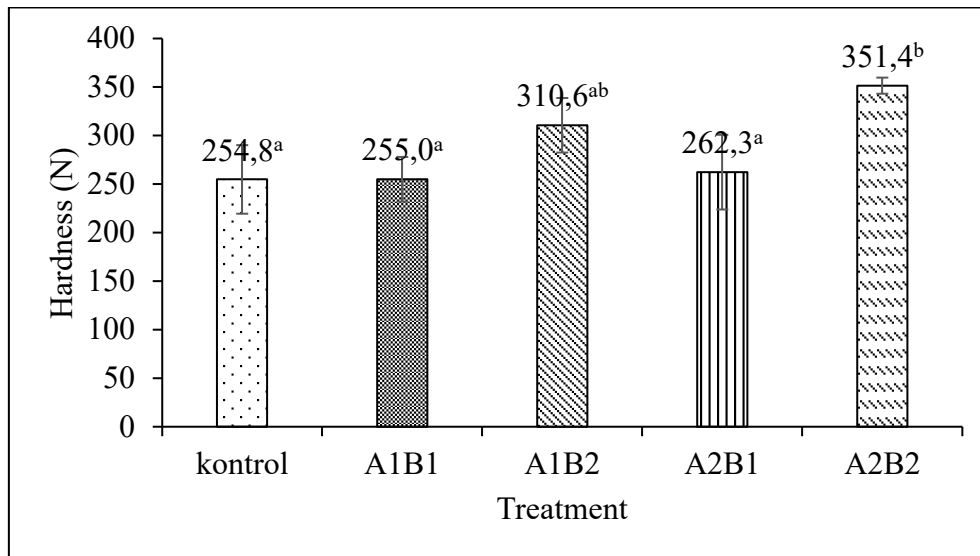


Figure 5. Results of Hardness Texture Analysis

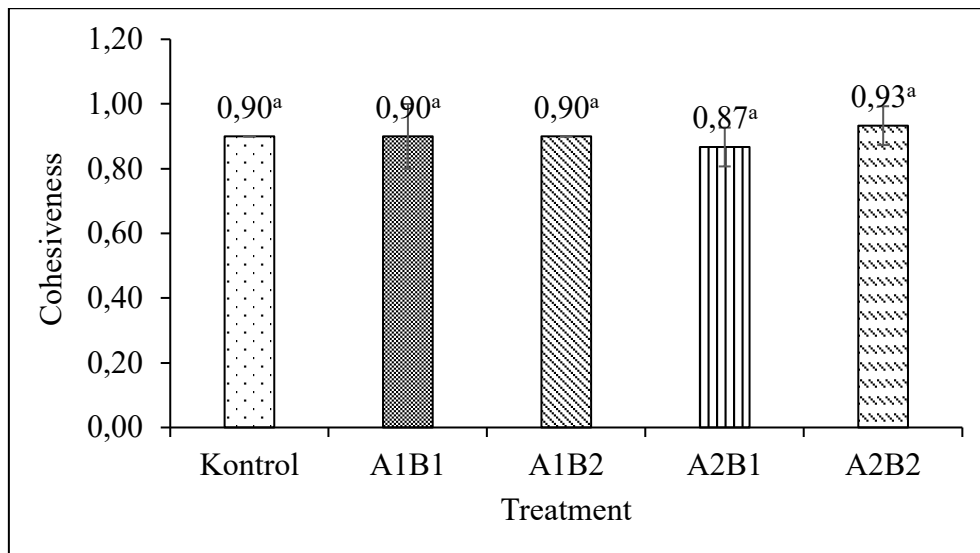


Figure 6. Results of Cohesiveness Texture Analysis

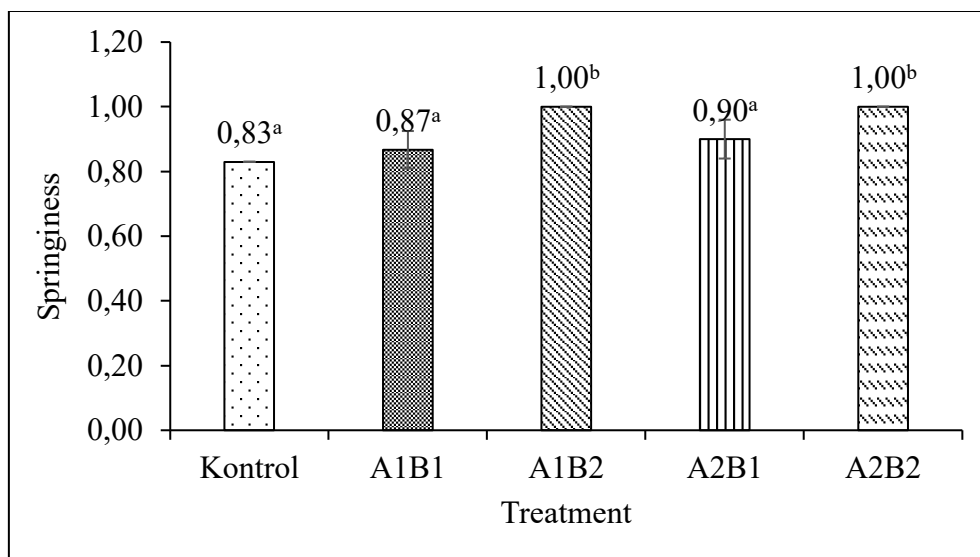


Figure 7. Results of Springiness Texture Analysis

Sensory Testing (Descriptive)

Sensory testing is a method for assessing the quality of a material or product using the five human senses. Aspects tested can include color, taste, odor, and texture. Results of Sensory Test Analysis of Red Tilapia Fish Meatballs are shown in Table 1.

Table 1. Results of Sensory Test Analysis of Red Tilapia Fish Meatballs

Treatment	Parameter			
	Smoky Aroma	Fishy Aroma	Smoky Flavor	Chewiness
Control	0.5 ± 0.6 ^a	4.8 ± 2.3 ^b	0.4 ± 0.4 ^a	2.9 ± 2.2 ^a
A1B1	3.0 ± 1.8 ^b	2.6 ± 1.1 ^a	3.6 ± 1.9 ^b	3.4 ± 1.8 ^{ab}
A1B2	4.0 ± 1.8 ^b	2.4 ± 1.5 ^a	3.1 ± 1.7 ^b	4.1 ± 1.6 ^{bc}
A2B1	3.8 ± 1.6 ^b	3.1 ± 1.6 ^a	3.2 ± 1.7 ^b	3.4 ± 1.1 ^{ab}
A2B2	4.0 ± 1.6 ^b	2.7 ± 1.6 ^a	3.6 ± 1.8 ^b	4.3 ± 1.8 ^c

Shelf-Life Testing

Shelf-life testing is a method used to assess the quality of a material or product using human senses. Aspects tested include foul odor, mushiness, and unfitness for consumption. Results of the Analysis of the Shelf-Life Test of Red Tilapia Fish Meatballs are shown in Table 2.

Table 2. Results of the Analysis of the Shelf-Life Test of Red Tilapia Fish Meatballs

Day of Storage-	Treatment	Frozen Smell	Mucus	Unfitness for Consumption
0	Control	1 ± 0	1 ± 0	1 ± 0
	A1B1	1 ± 0	1 ± 0	1 ± 0
	A1B2	1 ± 0	1 ± 0	1 ± 0
	A2B1	1 ± 0	1 ± 0	1 ± 0
	A2B2	1 ± 0	1 ± 0	1 ± 0
1	Control	1.2 ± 0.4	1 ± 0	1.9 ± 0.7
	A1B1	1.1 ± 0.3	1 ± 0	1.8 ± 0.6
	A1B2	1.1 ± 0.3	1 ± 0	1.7 ± 0.7
	A2B1	1.1 ± 0.3	1 ± 0	1.7 ± 0.7
	A2B2	1.1 ± 0.3	1 ± 0	1.7 ± 0.7
2	Control	3.5 ± 0.7	3.3 ± 0.8	4.1 ± 0.6
	A1B1	2.4 ± 1.0	2.8 ± 0.9	3.6 ± 1.0
	A1B2	2.2 ± 0.8	2.4 ± 0.5	2.4 ± 0.5
	A2B1	3.2 ± 1.1	3.1 ± 0.9	3.6 ± 0.7
	A2B2	2.1 ± 0.9	1.9 ± 0.7	2.2 ± 0.6
3	Control	4.2 ± 0.8	4.4 ± 0.7	5 ± 0.0
	A1B1	3.8 ± 1.0	4.2 ± 0.8	4.7 ± 0.5
	A1B2	3.5 ± 1.1	3.5 ± 0.7	4.2 ± 0.8
	A2B1	3.9 ± 1.0	4.2 ± 0.9	4.6 ± 0.5
	A2B2	3.6 ± 1.0	3.8 ± 0.8	4.4 ± 0.7

DISCUSSION

Water content indicates the amount of water contained in a food ingredient. The level of moisture plays a significant role in the activity of microorganisms, thus indirectly affecting the shelf life and resistance of food to spoilage (Nasution *et al.*, 2021). Figure 1, shows that the water content of red tilapia fish meatballs with varying soaking times and with or without liquid smoke differed significantly. The ANOVA results showed that soaking time and the addition

of liquid smoke had a significant effect on the water content of red tilapia fish meatballs. The control treatment achieved 71.28%; in treatment A1B1, 69.35%. Treatment A1B2 obtained results of 68.14%, and treatment A2B1 obtained results of 65.60%. Treatment A2B2 achieved a 63.71% result. Increasing the concentration of liquid smoke when soaking red tilapia fish balls causes the water content of red tilapia fish balls to decrease. The higher the concentration of liquid smoke, the lower the water content (Nuryana, 2022). According to research by Herwati *et al.* (2017), increasing the concentration of liquid smoke used in the smoked fish processing process decreases the product's water content. This decrease in water content is caused by the liquid smoke powder solution used for soaking seeping into the fish's body through osmosis, forcing free water out. This is consistent with research by which states that the acidic compounds in liquid smoke can cause protein denaturation in food. This protein denaturation causes the protein to lose its biological ability to bind water, resulting in a decrease in the product's water content. According to Zebua *et al.* (2024), the water content in food significantly affects its shelf life because water supports the growth and activity of microorganisms that cause food spoilage.

Ash content is a mixture of inorganic or mineral components contained in a food ingredient. The addition of liquid smoke can affect ash content by contributing minerals. The higher the concentration of liquid smoke used, the lower the resulting ash content tends to be. This is thought to occur because some mineral components dissolve during the liquid smoke soak (Yulia *et al.*, 2022). Based on Figure 2, shows that the ash content of red tilapia fish meatballs with varying soaking times and liquid smoke differed significantly. The ANOVA results showed that soaking time and the addition of liquid smoke had a significant effect on the ash content of red tilapia fish meatballs. The control treatment yielded 2.82%; in treatment A1B1, 2.40%. Treatment A1B2 obtained a result of 2.17%, treatment A2B1 obtained a result of 2.10%, and treatment A2B2 obtained a result of 1.85%. Using liquid smoke can reduce the ash content in food products. The decrease in ash content occurs during immersion in liquid smoke, which triggers the precipitation of mineral elements. Some of the minerals in the material can be released or precipitated during immersion (Yulia *et al.*, 2022). The results of this study are supported by research by Anggraini *et al.* (2022), which showed that the application of liquid smoke treatment affects the ash content of catfish.

Total acid (titratable acidity) is the total amount of acid in a food ingredient. The organic acid that plays a significant role in liquid smoke is acetic acid. The value obtained is expressed as a percentage of acetic acid based on the amount of base solution that reacts with the acidic component in the sample. Acetic acid can affect food taste and product shelf life (Swastawati, 2019). Based on Figure 3, shows that the use of liquid smoke, with varying soaking times and concentrations, in red tilapia fish meatballs results in significantly different total acid percentages in the control, A1B1, A1B2, A2B1, and A2B2. The ANOVA results show that soaking time and liquid smoke concentration have a significant effect on the total acid content of red tilapia fish meatballs. The control treatment got a result of 0.014%. The A1B1 treatment got a result of 0.27%. The A1B2 treatment got a result of 0.32. The A2B1 treatment got a result of 0.33%. The A2B2 treatment got a result of 0.36%. The increase in total acid in products treated with liquid smoke is due to the organic acids in the liquid smoke, especially acetic acid, which diffuse into the material during soaking. This is in line with research by Djalil *et al.* (2024), which shows that increasing the concentration of coconut shell liquid smoke increases the product's acid content. The results of this study are in line with research by Solissa, (2024), which shows that the longer the soaking time in liquid smoke, the greater the increase in the total acid in food products. This occurs because the organic acids in liquid smoke diffuse into and are absorbed by the tissue during the soaking process.

Phenol, carboxylic acid, or benzenol is a colorless crystalline substance that has a distinctive odor (Laksono *et al.*, 2015). According to Maulina *et al.* (2018), phenolic

compounds act as antioxidants, thereby extending the shelf life of smoked products. Figure 4 shows that the total phenol content of red tilapia fish meatballs with varying soaking times and liquid smoke addition was significantly different. The ANOVA results showed that soaking time and the addition of liquid smoke had a significant effect on the total phenol content of red tilapia fish meatballs. The control treatments, A1B1, A1B2, A2B1, and A2B2, showed increases in total phenol with increasing liquid smoke concentration and soaking time. The control treatment yielded a total phenol content of 0.06%, while treatment A1B1 yielded 0.10%. Treatment A1B2 obtained a result of 0.12%, and treatment A2B1 obtained a result of 0.13%. Treatment A2B2 obtained a result of 0.15%. These results are supported by the research of Widiastuti *et al.* (2019), which showed that increasing the concentration of liquid smoke significantly increased the total phenol content of smoked cuttlefish. This indicates that the higher the concentration of liquid smoke, the greater the absorption of phenolic compounds into the smoked cuttlefish. This occurs because phenolic compounds are water-soluble, allowing them to diffuse and penetrate the food matrix during immersion (Mahardani & Yuanita, 2021).

Texture analysis of red tilapia meatballs showed that soaking time and liquid smoke concentration influenced the product's physical characteristics, including hardness, cohesiveness, and springiness (Khotimah *et al.*, 2024). The highest hardness value was shown in the A2B2 treatment at 351.4%, which showed the highest increase, while the control treatment without liquid smoke immersion produced the lowest hardness value at 254.8%. This research aligns with that of Mu'tamar *et al.* (2018), who reported that immersion in liquid smoke increases hardness and osmotic pressure, thereby drawing water out of gourami meat tissue. This condition triggers protein denaturation and coagulation in the meat. The highest cohesiveness value was observed in the A2B2 treatment (0.93), indicating the greatest increase.

Meanwhile, the A2B1 treatment produced a cohesiveness value of 0.87. According to Setyastuti *et al.* (2022), changes in texture are influenced by changes in fish protein solubility, which increases during storage due to denaturation. Decreased protein extraction capacity and protein denaturation lead to reduced firmness and elasticity, as well as increased fish meat hardness. This is primarily due to the aggregation of myosin proteins, which results in a tougher meat texture and decreased water-binding capacity. The results of the texture analysis of the springiness parameter for red tilapia fish meatballs ranged from 0.83 to 1.00. These results are in line with research by Indiarito *et al.* (2016), which found that the use of coconut shell liquid smoke in smoked chicken meat can improve texture parameters, including elasticity.

This sensory testing uses descriptive testing. Descriptive testing is an approach to sensory analysis that involves a trained panel of panelists. The panelists are tasked with objectively and systematically identifying, describing, and measuring a product's sensory characteristics. This testing involves approximately 8-12 panelists who have received special training. Sensory test parameters include smoky smell, fishy smell, smoky flavor, and chewiness:

1. Smell Smoky:

The sensory test results of the smoked aroma parameters of red tilapia fish meatballs in the control treatment showed an average panelist acceptance level of 0.5. Treatment A1B1 showed an average panelist acceptance level of 3.0. Treatment A1B2 showed an average panelist acceptance level of 4.0. Treatment A2B1 showed an average panelist acceptance level of 3.8. Treatment A2B2 showed an average panelist acceptance level of 4.0. The highest average panelist acceptance level was in sample A2B2, at 4.0. This shows that using a higher concentration of liquid smoke produces a stronger and more distinctive smoke aroma.

2. Fishy Smell:

The control treatment had the highest value (4.8), while the A1B2 treatment had the lowest (2.4). The high value in the control treatment indicates that the fishy aroma remains

dominant, as there is no soaking treatment or liquid smoke added. The lowest value in treatment A1B2 indicates that the combination of soaking and a 3% liquid smoke concentration is effective in reducing the intensity of the fishy aroma.

3. Smoky Flavor:

The lowest smoke flavor parameter result had a value of 0.4 in the control treatment, and the highest smoke flavor had a value of 3.6 in the A2B2 treatment. The higher the concentration of liquid smoke and the longer the soaking time of the liquid smoke, the more phenol compounds will be absorbed into the product.

4. Chewiness:

The lowest elasticity parameter had a value of 2.6 in the control treatment, and the highest elasticity parameter had a value of 4.5 in the A2B2 treatment. Soaking in liquid smoke has been shown to affect the product's texture significantly. This effect is closely related to changes in water content during the soaking process.

The shelf-life test in this study was a sensory assessment to assess product attribute quality based on panelists' perceptions of foul odor, slimy texture, and unfitness for consumption. A specific rating scale was used. 10 trained panelists conducted the test to ensure consistent and objective results. The assessment was conducted over four days of observation to determine changes in product quality during storage.

1. Foul Odor:

The foul odor parameter increased with increasing storage duration. On day 0, all samples had a value of 1. However, on day 3, the control group reached its highest value of 4.2, indicating a very pronounced foul odor. In contrast, the A1B2 and A2B2 treatments suppressed foul odor values to 3.5 and 3.6, respectively.

2. Slimy Texture:

Slime formation in the samples increased with increasing storage time. On day 0, none of the samples showed any mucus with a value of 1. However, on day 3, the control group achieved the highest mucus value of 4.4, while the immersion treatment with liquid smoke at 3% A1B2 and A2B2 concentrations suppressed mucus formation to 3.5 and 3.8, respectively.

3. Unfitness for Consumption:

The unfitness for consumption parameter is an accumulative indicator of the decline in aroma and mucus texture. On day 3, the control group reached a maximum value of 5, indicating the sample was no longer fit for consumption. In contrast, the A1B2 treatment showed the lowest value on day 3 at 4.2, which is still within the tolerance limit and better than the red tilapia meatballs without the liquid smoke soaking treatment.

CONCLUSION

Based on the results of the study on the effect of soaking time and the addition of liquid smoke concentration on the shelf life of red tilapia fish meatballs, the following conclusions can be drawn: increasing the soaking time and the concentration of liquid smoke significantly reduced the water and ash contents. It increased the total acid and total phenol contents in red tilapia fish meatballs. The addition of liquid smoke was organoleptically effective in suppressing the formation of foul odors and delaying the appearance of slime and unfitness during storage. The best treatment was a 45-minute soak at 3% liquid smoke concentration (A2B2), which maintained meatball quality until the third day. Meanwhile, the treatment without liquid smoke soaking (control) was no longer fit for consumption on the second day. Liquid smoke has proven effective as a natural preservative, extending the shelf life of red tilapia fish meatballs.

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