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MORALITY BEFORE KNOWLEDGE

Effectiveness of water extract of mangrove fruit flour (Rhizophora mucronata) as a natural preservative in skipjack fish fillets (Katsuwonus pelamis)

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ABSTRACT

Background: Gorontalo is quite potential for the development of capture fisheries potential including the development of skipjack (Katsuwonus pelamis) production. In its processing, natural additives containing antimicrobial compounds are needed to preserve the fish. Rhizophora mucronata or R. mucronata is one type of mangrove that is widely spread along the tourist location "Tracking Mangrove" Langge Village, North Gorontalo Regency. This study aims to analyze the effect of length of storage of skipjack on organoleptic quality soaked using mangrove fruit water extract and analyze the effect of length of storage of skipjack on the quality of TPC and pH soaked using mangrove fruit water extract. **Methods**: This study uses a laboratory experimental method with 1 treatment, namely the length of soaking with 3 levels of treatment and 2 replicates, namely P1 (10-hour soaking), P2 (12-hour soaking), and P3 (14-hour soaking). The parameters tested were organoleptic, pH, and TPC. The research data were analyzed using a non-factorial Completely Randomized Design (CRD) with One-way ANOVA test with a significance level of 5% and further tested using Duncan. **Finding:** The results of the analysis showed that the best soaking time of skipjack in the solution mangrove fruit extract R. mucronata was found in P1 (soaking time of 10 hours) with indicators meat incision slightly less brilliant and strong meat tissue; fresh odor and specific type less; and texture slightly soft and slightly less elastic. The TPC value of skipjack meat slices can be maintained up to 10 hours of immersion in the solution of mangrove fruit extract Rhizopora mucronate with pH being acidic. **Conclusion**: The study concludes that the optimal soaking time for skipjack in Rhizophora mucronata fruit extract solution is 10 hours, as it maintains acceptable organoleptic quality, a fresh odor, and a firm texture while effectively inhibiting bacterial growth. The TPC value remains stable up to 10 hours of soaking, with an acidic pH indicating preservation effectiveness. **Novelty/Originality of this article:** This research introduces the use of Rhizophora mucronata fruit extract as a natural preservative for skipjack, highlighting its antimicrobial properties and potential for extending fish shelf life. The findings provide new insights into sustainable fish preservation methods using natural additives, contributing to the development of eco-friendly post-harvest technologies in fisheries.

KEYWORDS: *Rhizopora mucronata* mangrove; Katsuwonus pelamis; fish preservation.

1. Introduction

Provide Tomini Bay area, especially in the administration of Gorontalo Province, is an area that has ecological, economic, and social values that are very meaningful for the survival of the surrounding community. Fisheries in the Tomini Bay region is one of the fields that is expected to support the economy of the community because of the fisheries sector. Tomini Bay has a large potential of fish resources in number and diversity (Mohamad et al., 2018).

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Total fisheries production in Tomini Bay is contributed by three provinces, namely North Sulawesi, Gorontalo and Central Sulawesi (Mohamad et al., 2018). One of the districts contributing to capture fisheries production in Gorontalo Province is Gorontalo District. Gorontalo Regency is quite potential for the development of capture fisheries potential including the development of skipjack (Katsuwonus pelamis) production. Gorontalo Regency with a coastline length of about 79.6 km (13.6%) of the length of the coast of Gorontalo Province) which is dominantly characterized by rocky / sandy beaches. The coastal area of Gorontalo Regency reaches 587.6 km^2 which stretches across 3 (three) sub-districts namely Batudaa Pantai, Biluhu and Bilato sub-districts with a total of 21 coastal villages.

Fish is one of the food sources that is needed by humans because it has a high nutritional content and several nutrients such as vitamins, minerals, water content, fat, carbohydrates and protein that are good for consumption (Fitri et al., 2016). Fish is an animal that has a fairly high water content of 76%, which is suitable for the life media of microorganisms or spoilage bacteria. So that fish quickly undergoes the process of decay or quality deterioration caused by dirty environmental conditions results in losses and many fish cannot be utilized (Siegers et al., 2022).

Fish is a food that rapidly deteriorates. The deterioration is caused by enzymatic and chemical reactions. In addition, the activity of microorganisms that cause decay naturally damages fish after the fish dies. The decline in fish quality is usually characterized by physical damage or organoleptic damage such as loss of fresh fish odor which turns into a rotten smell, changes in texture, gills, skin surface and eyes, thus making a decrease or change in the nutritional content of fish (Wati, 2023).

According to FAO in Husni & Putra (2018), one of the problems that arise in the fisheries sector is the problem of preventing and maintaining the decline in fish quality. In general, fish at room temperature will more easily experience the rigor mortis phase, if the rigor phase cannot be maintained longer, the decay caused by enzyme and bacterial activity will occur faster. This activity causes rapid changes so that the fish enters the post rigor phase. In this post rigor phase, the fish can no longer be consumed because it is already rotten. To prevent these things, fish must be handled carefully (careful), pay attention to cleanliness (clean), stored in a room with a cold temperature (cold) and quickly (quick). According to Husni & Putra (2018), one way to prevent the decline in fish quality is by preserving fish with various additives to maintain the freshness of the fish, one of which is formalin. Formalin is a very dangerous additive, so natural additives containing antimicrobial compounds are needed in preserving fish.

An alternative material that can be used as a natural additive containing antimicrobial compounds is mangrove by looking at the abundant availability of mangrove plants. Mangroves are tropical and subtropical plants that can survive in muddy substrates and high levels of water salinity (Faqih et al., 2024). Mangrove forests do many things for coastal ecosystems bioecologically, such as providing organic matter, providing nesting sites for various marine life, and protecting the coast from waves (Wantasen 2013). Mangrove ecosystems provide a place for several biota to find food, spawn, and nurture (Nur & Kuntjoro, 2020). The function of mangroves as a habitat for aquatic animals is because this area provides weathered material or litter which then turns into nutrients. In addition, mangroves and other organisms, such as mollusks (gastropods and bivalves) benefit from the nutrients present in the area (Baderan et al., 2019).

Several factors, including environmental conditions or mangrove habitat, food availability, and the structure of vegetation that makes up the substrate, generally affect the type of diversity of mangrove ecosystems (Senoaji & Hidayat, 2017). As for one type of mangrove Rhizophora mucronata which is widely spread along the tourist location "mangrove tracking" Langge Village, North Gorontalo Regency with an average size of ripe fruit length ±52 cm, ripe fruit width ±1.9 cm, and ripe fruit weight ±56 gr (Mile et al., 2021). Mangrove fruit used in this study is a ripe fruit because it has a yellow color on the neck of the hypocotyl. According to Kamal (2012), mangrove fruit is ripe when the hypocotyl length is more than 38.60-70.20 cm until the hypocotyl falls. The morphometric value of

Rhizophora mucronata hypocotyls obtained is greater than the hypocotyls of mangroves from Untung Jawa Island, Kepulauan Seribu.

Based on the results of research by Mile et al. (2021) the average morphometric value of Rhizophora mucronata fruit both in length and weight is greater indicating the carrying capacity of the environment to the development of mangrove plants is very good. Ati et al., (2014), stated that the vegetative development phase of Rhizophora mucronata is significantly correlated with climate change and environmental conditions. Mangrove fruit development can be made as mangrove fruit flour to be used as a preservative in fish and extend the shelf life of fish.

2. Methods

This research was conducted from November 2023 to May 2024. Organoleptic testing was carried out at the Biotechnology and Quality Characteristics of Fishery Products Laboratory of Fishery Products Technology, Faculty of Fisheries and Marine Science, Gorontalo State University. TPC and pH tests were conducted at the Biology Laboratory, Faculty of Mathematics and Natural Sciences, Gorontalo State University. The tools used in this research are knives, digital scales, gas stoves, baking sheets, blenders, trays, spoons, and pans. The raw materials used are skipjack fish skin on fillets taken from the Fish Auction Place (TPI) Tenda Village, Hulonthalangi Subdistrict, Gorontalo City, Gorontalo Province and Rhizophora mucronata mangrove fruit taken from Lito Village, Paguyaman Pantai Subdistrict, Boalemo Regency.

2.1 Preparation of Rhizophora mucronata mangrove fruit flour and extract solution of Rhizophora mucronata mangrove fruit flour samples

Preparation of R. mucronata mangrove fruit flour using the modified method of Podungge et al. (2015). R. mucronata mangrove fruit was separated from its skin and thinly sliced with a thickness of 1-2 mm. Then, the fruit slices were washed with running water to avoid contamination. Furthermore, drying is carried out for seven hours using direct sunlight for 3 days, and after drying for three days, the mangrove fruit is crushed for five minutes using a blender so that it becomes magrove fruit flour. After that sieving is done using 80 mesh size. The resulting mangrove fruit flour is boiled for 25 minutes, 30 minutes, 35 minutes and the best results will be used as a sample for immersion of skipjack fish. After boiling the mangrove fruit flour is filtered using filtration cloth filtration and after getting the extract from mangrove fruit flour, the extract will be used to soak the fish to be tested.

In this study, the mangrove flour extract used was mangrove fruit flour which was boiled for 30 minutes. Mangrove fruit flour weighed as much as 50 grams and added 500 mL of distilled water. After that, the sample was stirred for 30 minutes at 70ºC and filtered to get the extract. Then, the mangrove fruit flour extract was used to soak fish fillets for 10 hours, 12 hours and 14 hours. After soaking, the fish was tested for quality (Organoleptic, TPC, pH) skipjack.

2.2 Testing procedure

Testing of skipjack tuna samples with mangrove fruit flour preservation was carried out through organoleptic tests of hedonic quality, pH, and Total Plate Count (TPC). In organoleptic testing, assessments are carried out using human senses (sensory). This test assesses the quality level based on a numerical scale from 1 (lowest value) to 9 (highest value). To ensure representative results, each testing session involved six standard panelists or 25 non-standard panelists.

Furthermore, pH measurements were carried out using a pH meter as stated by Rahmanto et al. (2020). This process begins by weighing the sample that has been sliced into small pieces as much as 10 grams, then homogenized for one minute using a mortar with 20 mL of distilled water. After that, the mixture is poured into a glass beaker as much

as 10 mL, then the pH is measured using a pH meter. Before measurement, the needle on the pH meter must first be calibrated using a pH 7 buffer solution. The pH reading results are then taken after the scale needle is stable.

Total bacterial analysis was carried out using the spread method as explained by Alhabsyi et al. (2016). In this method, 10 grams of sample were mixed with 90 mL of 0.85% NaCl solution, then a multilevel dilution was carried out with a factor of 10, such as dilution 10^{-1}, 10^{-2}, and so on as needed. Furthermore, 1 mL of each dilution was pipetted and placed in a sterile petri dish, with each dilution carried out in duplicate. After that, NA media was added and stirred until evenly distributed. After freezing, the petri dish was then incubated at 20°C for 48 hours in an inverted position. After the incubation process was complete, the growing colonies were counted, where the number of colonies acceptable for counting ranged from 30 to 300.

2.3 Data analysis

Analysis of research data in the form of organoleptic, pH, and TPC values using non-factorial complete randomized design analysis with 3 treatment levels (10 hours, 12 hours and 14 hours) and 2 replications. Data were analyzed for diversity using One-way ANOVA with a significance level of 5% and further tested using Duncan with the help of Statistical Package for Social Science 16 (SPSS) software. The Complete Randomized Design (CRD) formula is as Equation 1 and 2, where N represents the product colony count (colonies per milliliter or per gram), $\sum C$ is the total number of colonies counted on all cups, $n1$ is the number of cups counted in the first dilution, $n2$ is the number of cups counted in the second dilution, d denotes the first dilution calculated, Yij is the value of the observation results in the i-th treatment and j-th replication, μ is average value of treatment treatment, τi is effect of immersion time of immersion, and ∈ is error factor.

$$N = \frac{\sum C}{[(1xn1) + (0{,}1xn2) + etc]x(d)} \quad \text{(Eq. 1)}$$

$$Yij = \mu + Aij + \in \quad \text{(Eq. 2)}$$

Significant analysis results were further analyzed using Duncan's test to determine significant differences between treatments for the analyzed parameters. The Duncan test equation, as described by Aprilia & Destiana (2023), is presented in Equation 3, where LSR represents the least significant range, and SSR refers to the significant student range (from the table) at db = db error and the number of repetitions.

$$LSR\ \alpha = SSR\ \alpha . Sx \quad \text{(Eq. 3)}$$

3. Results and Discussion

3.1 Phytochemical test

Phytochemical test with mangrove fruit flour extract with code A and B with phytochemical samples divided into two. Alkaloid and Triterpanoid which the results of both positive conclusions with indicators there is a precipitate at the bottom. Rhizophora mucronata fruit flour extract produced from the boiling process using water at 70oc for 30 minutes was tested for phytochemicals in the form of alkaloids and triterpenoids.

Alkaloids are organic compounds that are alkaline and can be found in various plants, such as medicinal plants, vegetables, and fruits. Triterpenoid compounds are an abundant group of hydrocarbon organic compounds produced by various types of plants that have various biological activities, such as antioxidants, anti-inflammatory, anticancer, and

antibacterial (Fadhliah et al., 2021). The results of the phytochemical test of Rhizophora mucronata mangrove fruit flour extract can be seen in Table 1.

Table 1. Phytochemical test results of Rhizophora mucronata mangrove fruit flour extracts

Compound	Replication		Summary	Description
	1	2		
Alkaloids	+	+	Positive	There is sediment on the part
Triterpenoids	+	+	Positive	under

Based on the test results, R. mucronata mangrove fruit flour extract identified the presence of alkaloids and triterpenoids with indicators of sediment at the bottom. This is supported by the statement of Podungge et al. (2015) that in mangrove fruit extracts there are alkaloid and triterpenoid compounds. Based on the results of research by Podungge et al. (2015) showed that in the E30 extract preparation, flavonoids, triterpenoids, and steroids were detected as well as dominant tannin, saponin, and quinone compounds. The results of phytochemical tests conducted by Kamal (2012) did not detect the presence of triterpenoid compounds in mangrove hypocotyl extracts. The compound can come from the cotyledon part contained in the mangrove fruit extract.

Alkaloids are the most commonly found organic compounds, as most alkaloid substances come from plants. In general, alkaloids are chemical compounds that contain one or more nitrogen atoms and tend to be basic, so they are known as alkaloids. Alkaloids play a role in protecting plants from disease and pest attacks, and function as regulators of development and mineral balance in plants by regulating existing ions. Alkaloids produced by plants are part of the secondary metabolite group.

In general, alkaloids are compounds that have basic properties because they contain nitrogen atoms in their structure, and amino acids play an important role in the formation of these compounds during the alkaloid biosynthesis process. Almost all alkaloids have a core skeleton such as pyridine, quinoline, isoquinoline, or tropane, and affect physiological effects in humans and animals. Alkaloid side chains can be derived from terpenes or acetates (Suparno, 2015). Alkaloids are compounds that are basic and reactive as basic compounds. When reacting with acids, alkaloids form anhydrous crystalline salts. Most alkaloids are crystalline solids such as atropine, but some are liquid like lobelin or nicotine.

Alkaloid compounds have various functions, one of which is as an antibacterial. Antibacterials are compounds that can inhibit the growth or kill bacteria. Meat is one of the food ingredients that is easily spoiled due to the presence of spoilage bacteria that can grow on fish meat. The presence of alkaloids can inhibit the growth of spoilage bacteria in fish meat. This is based on the research of Rahmah et al. (2023), namely fish meat given rambusa leaf extract containing alkaloids showed lower growth of putrefactive bacteria than those not given rambusa leaf extract, so that the presence of alkaloid content can increase the shelf life of fish meat. This is due to the presence of antibacterial effects that can inhibit the growth of spoilage bacteria by disrupting bacterial cell walls, bacterial cell membranes, or enzymes that are important for bacteria.

Triterpenoid compounds are a category of hydrocarbon organic compounds that are generally produced by various types of plants (Fadhliah et al., 2021). This compound generally has a strong aroma and act as plant protectors from herbivores and predators. Triterpenoids are also found as the dominant component in essential oils extracted from various types of plants and flowers, which are widely used in the perfume and aromatherapy industries.

Triterpenoids are found in various plants, animals, fungi, and bacteria. Triterpenoids have various biological activities, such as antioxidant, anti-inflammatory, anticancer, and antibacterial. Triterpenoids can damage bacterial cell membranes by inhibiting the synthesis of lipids needed to build cell membranes (Alouw et al., 2022). Triterpenoids can increase the shelf life of foodstuffs by inhibiting the growth of spoilage bacteria. This can reduce damage to food ingredients so that food ingredients can be consumed in a longer period of time. Based on research by Nuraeni & Sulistijowati (2021) and Fitri et al. (2016), it shows that the presence of triterpenoid content can increase the durability of tilapia and

milkfish. Safitri & Roosdiana (2021) suggest that triterpenoid content has a diverse effect on bacterial growth, depending on the type and source. Some triterpenoids can inhibit bacterial growth by disrupting the synthesis of nucleic acids, proteins, or cell membranes. For example, lupeol can inhibit the growth of Listeria monocytogenes (Gram-negative bacteria). Based on the discussion above, it can be concluded that the presence of alkaloid and triterpenoid content in mangrove fruit extract (Rhizopora mucronata) can reduce the growth of spoilage bacteria so that it can help increase the durability of the decay process by bacteria.

3.2 Hedonic quality organoleptic test of skipjack fish

Organoleptic testing of skipjack tuna (Katsuwonus pelamis) conducted is a hedonic quality test. Based on SNI 01-2346-2006, organoleptic assessment of fresh fish includes the quality specifications of the appearance of the outer surface, odor and texture. The assessment was conducted by 25 semi-visible panelists.

3.2.1 Appearance

The average results of the hedonic test of organoleptic quality on the appearance parameter of fillet skin on skipjack (Katsuwonus pelamis) can be seen in Table 2. Organoleptic quality on the appearance parameter in the treatment of 0 hours, 10 hours, and 12 hours has a value of 8 (rounded) which means that the meat incision is brilliant, specific type, strong meat tissue. While the 14-hour treatment is worth 7, which means that it has a slightly less brilliant meat incision specification and strong meat tissue.

Table 2. Average quality score of the appearance of skipjack fillet skin on (Katsuwonus pelamis).

Parameter	Hedonic test mean value			
	P1 (0 hours)	P2 (10 hours)	P1 (0 hours)	P4 (14 hours)
Appearance	8.4 ± 0.64[a]	8.04 ± 0.84[b]	7.60 ± 0.70[c]	6.76 ± 1.16[d]

Note: a,b,c,d are similar letter notation means there is no real difference at the 5% test value level.

The quality value of the appearance of fish meat can deteriorate after the fish dies and the cessation of blood and oxygen circulation. According to Kasmawati et al. (2022) in fish meat that is filleted using a knife where the knife is made of iron and then comes into contact with water, oxygen will oxidize valence 2 iron into valence 3 iron. As a result, there is a decrease in quality and discoloration of meat caused by the reaction between iron and hemoglobin to form metmioglobin which is blackish red. The appearance of fillet skin on skipjack (Katsuwonus pelamis) can be seen in Figure 1.

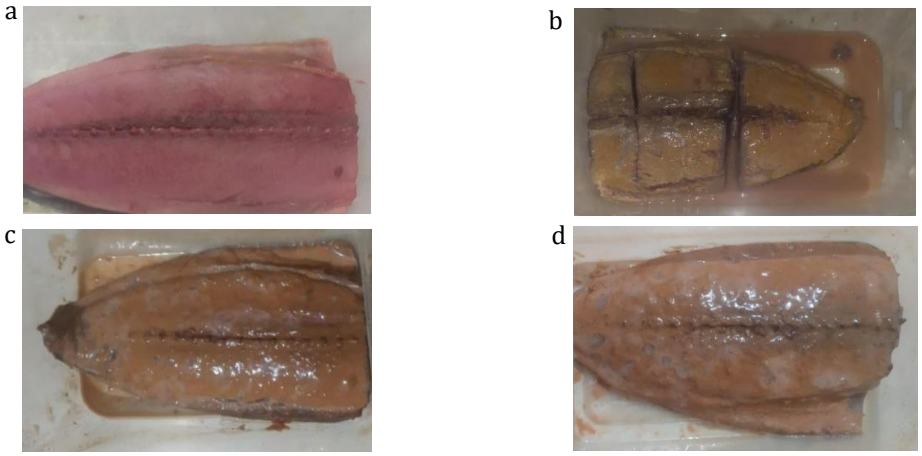

Fig. 1. The effect of fillet skin on skipjack fish (Katsuwonus pelamis)
(a) Fresh fish; (b) 10 Hours soaking; (c) 12 Hours soaking; (d) 14 Hours soaking

According to Suptijah et al. (2008) changes in the appearance of fish meat occur when the quality decreases chemically. This is because the fish meat contains fat and is oxidized when the fish dies and the conditions become anerobic, so that color changes can occur chemically with the oxidation of the fat in the fish. Based on the results of the study, the use of longer soaking time causes the appearance of tuna meat to decrease. It is suspected that the solution that permeates the fish meat causes the color of the meat to become less brilliant, so that the visual quality of tuna meat continues to show a downward trend or experience a process of quality deterioration (Suprayitno et al., 2021).

In the pre-rigor stage, fish experience the release of mucus in the form of clear or transparent liquid that coats their entire body (Supriyanto et al., 2021). This mucus is considered an ideal environment for microbial growth. Oxidation in this phase can cause a yellow or light brown color to appear on certain parts such as skin or muscle. In the rigor mortis phase after the fish dies, anaerobic conditions occur where enzymes in the body break down ATP. This biochemical process triggers the contraction of muscle proteins such as actin and myosin, which causes the muscle stiffen (rigor). Oxidation in this phase can cause a bright red color to appear on certain parts such as muscles or tissues. In the post-rigor phase, when the fish meat slowly softens again, oxidation can cause yellow or light brown color to become more dominant than bright red color.

The presence of soaking with mangrove fruit extracts cannot withstand the rate of decline in the quality of the appearance of fish meat. This is evidenced by the test results, where the alkaloid and triterpenoid content in mangrove fruit only works as an antibacterial, so it can only withstand the rate of quality decline in the phase where bacteria or microbes are active in reducing the quality of fish. Meanwhile, changes in the quality of the appearance of fish meat begin since the process of filling fish meat and work chemically. However, based on Table 2, it can be seen that the 10-hour immersion is not significantly different from the 0-hour immersion, indicating that the presence of other chemical content of mangrove fruit can play a role in this situation. This event has similarities with the research of Nuraeni & Sulistijowati (2021) which states that in their research they found that mangrove fruit also contains chitosan.

3.2.2 Smell

The average results of the hedonic test of organoleptic quality on the odor parameter of fillet skin on skipjack (Katsuwonus pelamis) can be seen in Table 3. Organoleptic quality the odor parameter at 0 hours, 10 hours, 12 hours and 14 hours of soaking has no difference. The four treatments obtained a value of 7 (rounded) which means they have fresh odor specifications and specific types of less. Table 3 shows the organoleptic value of skipjack meat odor in each treatment. In all four treatments, the quality value shown has a fresh odor specification and a specific type of less. Furthermore, tests were conducted to test whether there were differences in mangrove fruit extract soaking on the odor quality of skipjack meat.

Table 3. Mean odor quality score of skipjack fillet skin on (Katsuwonus pelamis)

Parameter	Hedonic test mean value			
	P1 (0 hours)	P2 (10 hours)	P1 (0 hours)	P4 (14 hours)
Smell	7.24 ± 1.47[a]	7.24 ± 1.26[a]	7.16 ± 1.14[a]	7.28 ± 0.93[a]

Note: a,b,c,d are similar letter notation means there is no real difference at the 5% test value level.

The test results show that the use of the longer damping time treatment does not cause the odor of tuna to decrease, so it can be stated that there is no effect on the quality of tuna odor. Addition, the odor of tuna during the study can be influenced by the terurain of compounds such as protein and fat by microorganisms in tuna, so that the distinctive aroma that smells becomes less pleasant. This is in accordance with research conducted by Desriyanti (2021) in Aprilia & Destiana (2023), that microorganisms have various enzymes

that can break down components that cause changes in food properties such as appearance, taste, odor and texture.

The content of mangrove fruit identified in this study is an antibacterial compound that inhibits the process of decay by microbes so that the rate of deterioration of tuna meat quality can be inhibited. The deterioration of tuna meat odor quality above is in line with research by Pariansyah et al., (2018) which suggests that the presence of antibacterial compounds in mangrove fruit can slow down dead fish meat.

Based on the description above, soaking tuna meat with mangrove fruit extract can maintain the quality of fish odor. This refers to the test results which show that there is no significant difference so that the quality of fish odor is maintained in all treatments. Odor which is an indicator of quality deterioration can be inhibited by the presence of antibacterial content in mangrove fruit so that the activity of micro organisms decreases and the quality of fish meat odor does not decrease significantly.

3.2.3 Texture

Fish texture is one of the organoleptic tests that can be used as a parameter of fish freshness. The average results of hedonic test of organoleptic quality on the texture parameter of fillet skin on skipjack (Katsuwonus pelamis) can be seen in Table 4. Based on the test results, it can be seen that the 0-hour immersion has a better texture than the other immersion lengths. The 0 hour treatment obtained a value of 7 (rounded) meaning that it has a rather soft and somewhat elastic specification. Meanwhile, the treatment of 10 hours, 12 hours and 14 hours obtained a value of 6 (rounded) which has a rather soft and slightly less elastic specification.

Table 4. Mean value of texture quality of skipjack fillet skin on (Katsuwonus pelamis)

Parameters	Hedonic test mean value			
	P1 (0 hours)	P2 (10 hours)	P1 (0 hours)	P4 (14 hours)
Texture	6.60 ± 1.73[a]	5.60 ± 1.41[b]	6.00 ± 1.52[b]	5.56 ± 1.66[b]

Note: a,b,c,d are similar letter notation means there is no significant difference at the 5% value test level.

Table 4 shows that the aqueous extract solution of mangrove fruit flour during soaking on tuna affects the organoleptic value of texture. The decrease in texture organoleptic value occurs due to the difference in the length of time of immersion in tuna using mangrove fruit flour extract solution that occurs in . Fish texture is one of the organoleptic tests that can be used as a parameter of fish freshness. Fish meat is almost entirely composed of transverse striped meat formed by fibers. The worse the quality of the fish, the softer the texture will be, this is because microorganisms have broken down the components of the fish including protein, fat, and water.

According to Naiu (2011), changes in a texture in fish meat are caused by the activity of proteolytic enzymes. Proteolytic enzymes can break down proteins into simpler compounds, such as polypeptides, amino acids, and ammonia. This process can cause softening of the texture in fish meat. Proteolytic enzyme activity can be caused by bacteria. Proteolytic bacteria are bacteria that produce extracellular protease enzymes, which are protein-breaking enzymes produced inside the cell and then released out of the cell. All bacteria have protease enzymes inside the cell, but not all have extracellular protease enzymes. The activity of protein degradation into amino acids is carried out by bacteria, which act as the main driving force in nitrogen metabolism that occurs in sediments. Bacteria can hydrolyze protein polymers with enzymes as biocatalysts. All of these activities can cause deterioration in the textural quality of fish meat.

Based on the description above, the soaking of skipjack using mangrove fruit extract containing antibacterial compounds can cause the texture quality of skipjack to not be able to extend the length of time for quality deterioration. This is in accordance with the test

results which show that at 0 hour, 10 hours, 12 hours and 14 hours of soaking there is a significant difference in the texture quality of tuna meat.

3.2.4 pH value of skipjack tuna fillet skin on skipjack tuna

The degree of acidity or pH is done to measure the acidity or basicity of a solution (Alouw et al., 2022). The pH results of tuna skin fillet during soaking in mangrove fruit flour extract solution (R. mucronata) ranged from 5.46 - 6.04. The 0-hour immersion had a pH of 6.04 ± 0.16 which was the highest pH and the 14-hour immersion had the lowest pH value of 5.46 ± 0.04. In general, if the four treatments are considered linear, there is a trend of decreasing pH values with the length of soaking time.

The results of measuring pH using a pH meter in each treatment show that all fish from soaking have acidic properties, this is in accordance with Alouw et al. (2022) which suggests that pH is the sum of the concentration of Hydrogen ions (H+) in a solution which states the level of acidity and basicity possessed. pH is a physical quantity and is measured on a scale of 0 to 14. When pH <7 the solution is acidic, pH>7 the solution is alkaline. The pH value of tuna fillets in the 10-hour treatment indicates that the fish has entered the rigor mortis phase, this is because a pH of 5.61 is an indication of the entry of phase. This in accordance with research by Linggi et al., (2021) which states that during rigor mortis, the pH of fish muscles begins to decrease from around 7.0 to 5.3-5.5. With a decrease in pH, the ATP content in the muscle begins to decrease from the pre-rigor concentration of 5.9 micromol/g at pH 7.0 - 7.2 to near zero at pH 5.3-5.5. In the 12-hour and 14-hour immersion treatments, tuna fillets have entered the rigor mortis phase based on the pH value indicator. This is due to the muscles contracting due to chemical reactions influenced by bacterial decay activity.

After the fish dies, the metabolism in the fish body changes from aerobic to anaerobic. According to Nurjanah et al. (2011) under anaerobic conditions, glycogen in fish muscles is converted into lactic acid. This lactic acid production will cause a decrease in the pH of the meat which will occur gradually from normal pH to a final pH of around 3.5 to 5.5. In addition, the decrease in pH is also caused by the activity of proteolytic enzymes where proteolytic enzymes can break down proteins into simpler compounds, such as polypeptides, amino acids, and ammonia. This process can change the pH value.

Based on the description above, mangrove fruit flour extract used to soak tuna meat can maintain the pH of the fish. The test results showed that there was no significant difference in the pH value of tuna at an interval of 10 hours, 12 hours and 14 hours. This is the impact of the content of mangrove fruit extract that plays a role in reducing the activity of proteolytic enzymes so that the rate of decline in fish pH can be maintained.

3.2.5 TPC value of fillet skin on skipjack tuna

TPC or Total Plate Count is a test conducted to determine the total bacteria present in the sample. Based on the results of the TPC test Fillet skin on tuna in mangrove fruit flour extract solution (R. mucronata) during immersion in Figure 3 ranged from 8.38 x 103 - 27.09 x 103. The TPC value at 0 hour immersion in skipjack fish obtained results of 27.09 x 103± 0.91, 10 immersion amounted to 15.39 x 103± 0.62, 12 hours immersion amounted to 8.38 x 103± 0.35, and 14 hours immersion had a value of 10.82 x ±3.04. The 12-hour immersion obtained the lowest TPC value and the 0-hour immersion obtained the highest TPC value (Figure 2).

The concentration of Rhizophora mucronata mangrove leaf extract greatly affects colony growth in each fishery. The higher the concentration, the less the growth of bacterial colonies that develop. The longer the storage period, the more the number of bacteria that develop, this is because the storage time is carried out in an open space so that the decay process occurs more quickly. The mechanism of action of the compound. The effectiveness of antibacterials in inhibiting growth is influenced by extract concentration, storage time, temperature, microbial properties, and object conditions.

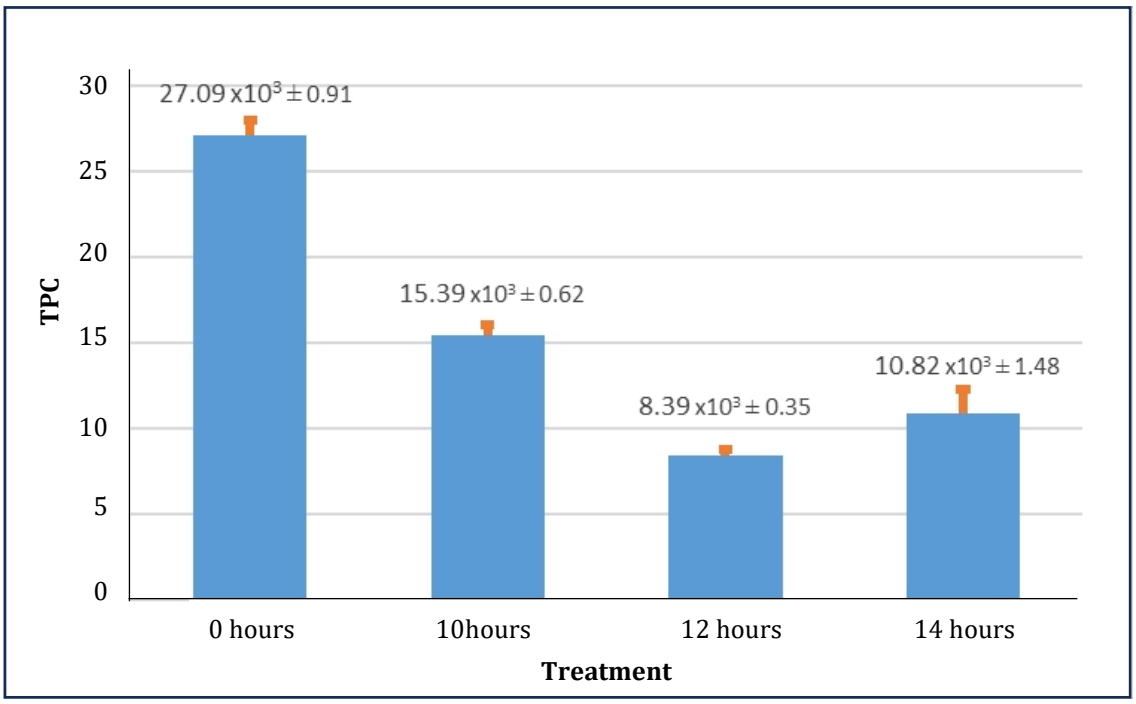

Fig. 2. Histogram of TPC of skipjack fillet skin on during immersion in mangrove fruit flour extract solution (Rhizophora mucronata)

The content of mangrove fruit identified in this study, namely alkaloids and triterpanoids, is an antibacterial compound that causes a decrease in the rate of bacterial growth. This is in line with Ekaputri & Gusti, (2019) which states that the two compounds can effectively withstand the growth rate of bacteria. Based on the description above, the content in mangrove fruit extract can withstand the growth of spoilage bacteria in skipjack meat effectively up to 12 hours of soaking. This is supported by the test results which show that there is a significant difference in the treatment of soaking tuna meat with mangrove fruit extract based on the TPC value indicator which has decreased significantly.

4. Conclusions

Based on the research results, it can be concluded that: 1) By soaking mangrove fruit extracts (Rhizophora mucronata) with alkaloid and tritepanoid content can provide durability of 14 hours against skipjack (Katsuwanosus pelamis) based on the quality of the odor as well as the appearance texture remains a decrease in quality due to chemical oxidation processes. 2) The value of TPC in skipjack meat incision can be maintained up to a length of soaking 14 hours in a solution of mangrove fruit extract R. mucronate with an acidic pH value.

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Author Contribution
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