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STUDY OF THE QUALITY OF BOILED MACKAREL TUNA FISH BY SOAKING IN LIQUID SMOKE FROM COCONUT SHELL AS A PRESERVATIVE DURING STORAGE

Kajian Mutu Ikan Tongkol Rebus Dengan Perendaman Asap Cair Tempurung Kelapa Sebagai Pengawet Selama Peyimpanan

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ABSTRACT

Mackarel tuna fish is a marine product that has high resource potential and economic value and has very high nutritional content but is easy to spoil. Therefore, it is necessary to carry out handling and processing processes to prevent a decrease in the quality of mackarel tuna. This study aimed to determine the effect of storing boiled mackarel tuna fish through soaking in coconut shell liquid smoke. The method in this research was an experimental method by experimenting in a laboratory. The research design used in this study was a completely randomized design (CRD) with a single factor (storage time: 0 hour, 24 hours, 48 hours, 72 hours, 96 hours and 120 hours) which was repeated 3 times to obtain 18 units by smearing on 2% coconut shell liquid smoke for 10 minutes. The observed parameters in this study were pH, water content, total microbes, and scoring and hedonic organoleptic (appearance, aroma, texture and taste) of boiled tuna. The data from the observation were analyzed using Analysis of Variance with real level 5% using Co-stat. if there was a significant difference, the further test was continued using Honestly Significant Difference (HSD) with real level 5%. The results showed that the long storage treatment by immersing coconut shell liquid smoke was able to maintain the quality of boiled tuna for up to 48 hours based on a pH of 5.92; water content 59.17%; total microbes 4.85 log CFU/gr; as well as organoleptic that is acceptable by the panelists.

Keywords: Boiled Mackarel Tuna Fish, Coconut Shell Liquid Smoke, Storage Time.

ABSTRAK

Ikan tongkol merupakan salah satu produk hasil laut yang memiliki potensi sumber daya dan nilai ekonomis yang tinggi serta memiliki kandungan gizi yang sangat tinggi tetapi mudah mengalami kerusakan. Oleh karena itu, perlu dilakukan proses penanganan dan pengolahan untuk mencegah kemunduran mutu dan kerusakan pada ikan tongkol. Penelitian ini bertujuan untuk mengetahui pengaruh lama simpan ikan tongkol rebus dengan perendaman asap cair tempurung kelapa. Metode yang digunakan pada penelitian ini yaitu metode eksperimental dengan percobaan di laboratorium, Rancangan penelitian yang digunakan pada penelitian ini adalah Rancangan Acak Lengkap (RAL) dengan faktor tunggal yaitu (lama penyimpanan: 0 jam, 24 jam, 48 jam, 72 jam, 96 jam, dan 120 jam) yang diulang sebanyak tiga 3 kali sehingga diperoleh 18 unit percobaan dengan direndam asap cair tempurung kelapa 2% selama 10

menit. Parameter yang diamati pada penelitian ini yaitu pH, kadar air, total mikroba, dan organoleptik (kenampakan, aroma, tekstur dan rasa). Data hasil pengamatan dianalisis menggunakan analisis keragaman dengan taraf nyata 5% dengan menggunakan aplikasi Co-stat. Apabila terdapat beda nyata, dilakukan uji lanjut dengan Uji Beda Nyata Jujur pada taraf 5%. Hasil penelitian menunjukkan bahwa perlakuan lama penyimpanan dengan perendaman asap cair tempurung kelapa mampu mempertahankan mutu ikan tongkol rebus hingga 48 jam berdasarkan pH 5,92; kadar air 59,17%; total mikroba 4,85 log CFU/gr; dengan organoleptik meliputi kenampakan, aroma, tekstur dan rasa yang dapat diterima oleh panelis.

Kata Kunci : Asap Cair Tempurung Kelapa, Ikan Tongkol Rebus, Lama Penyimpanan.

INTRODUCTION

Mackarel tuna fish is a marine product that has high resource potential and economic value, has very high nutritional content and delicious taste, and has a relatively cheaper price so it is liked by many people (Utomo, 2004). The weakness of Mackarel tuna fish is that it is very easily damaged, especially fresh fish (Siburian, 2012). Fresh mackarel tuna will be spoilage in 5-8 hours after being caught and will spoil if left at room temperature (Warsito, 2015). Therefore, it is necessary to carry out handling and processing processes to prevent loss quality and spoilage to the fish (Purwijantiningsih, 2019). Processing is mainly carried out for types of fish whose catch per year is quite large, such as mackarel tuna. The total catch of mackarel tuna in Indonesia reaches 8,000 tons/year (Sanger, 2010). One form of fish processing that is often carried out by people is boiled fish.

The process of processing fish by boiling has a drawback, namely that the water content in boiled fish is still high. Salmatia's research (2020) shows that the water content of boiled snakehead fish has increased which is thought to be caused by the use of large amounts of water and high temperatures during the boiling process so that the water components are more moist in the snakehead fish meat. This can cause fish to easily experience rotting by autolysis or microbial processes so that their durability is low (Atmodjo, 2003). Research by Kok (2007) shows that the high level of nutrition in fish meat causes boiled fish balls to only last 12-24 hours at room temperature.

One alternative to natural preservatives for fish products is the use of liquid smoke. Preservation with liquid smoke has the advantage of being more environmentally friendly because it does not cause air pollution, the substances contained in liquid smoke have antibacterial and antioxidant properties (Yulia, 2020). Apart from that, it is able to provide specific aroma, color and taste characteristics to the product (Ginayati, 2015). Liquid smoke can be made from coconut shells because it contains 26.6% cellulose, 29.4% lignin, 4.2% extraction solvent, 8% water, 27.7% pentose, 3.5% anhydrous uronate. , and ash of 0.6% (Husseinsyah, 2011). Wagiu's research (2022) shows that the yield of liquid smoke from shells contains more liquid than from coconut fiber and corn cobs. Gumant's research (2006) reported that wet noodle products mixed with coconut shell liquid smoke with a concentration of 0.09% in the mixture could last up to 2 days at room temperature. Research by Rasydta (2015) showed that milkfish soaked in coconut shell liquid smoke with a concentration of 2% for 20 minutes could last up to 3 days at room temperature. Ginayati's research (2015) proves that tofu that is not soaked using liquid smoke only lasts for 32 hours, but tofu that is soaked using liquid smoke can last up to 72 hours.

METHODS

This research was conducted in November 2022 using experimental methods carried out in the laboratory. The experimental design in this study was a completely randomized design with a single factor, namely (storage time: 0 hours, 24 hours, 48 hours, 72 hours, 96 hours and

120 hours) which was soaked for 10 minutes with 2% coconut shell liquid smoke. Each treatment was repeated 3 times to obtain 18 experimental units. The observation data were analyzed using analysis of variance at a significance level of 5% using Co-stat software. If there is a significant difference, further tests are carried out with the Honest Significant Difference (HSD) test for chemical, microbiological and organoleptic parameters.

Research Implementation

Preparation of Coconut Shell Liquid Smoke Solution

Making a 2% coconut shell liquid smoke solution is by preparing 7 mL of coconut shell liquid smoke then putting it into a 500 mL measuring cup, then adding 350 mL of distilled water and stirring until the solution becomes homogeneous so that it is then stored in a closed container at room temperature.

Preservation

The process of preserving boiled mackarel tuna using coconut shell liquid smoke is carried out by making samples of boiled mackarel tuna first. Sorting mackarel tuna is done to separate the fish from the stomach contents and gills. Washing the mackarel tuna is washed using running water until clean, which aims to remove dirt on the mackarel tuna. Dry salting with a concentration of 10% then boiled for 15 minutes at a temperature of ≥100ºC, then cooled for 5 minutes. Soaking the boiled mackarel tuna samples tested was soaked in a 2% coconut shell liquid smoke solution for 10 minutes and then drained for 5 minutes in order to reduce the water content of the soaking results. The storage of samples of boiled mackarel tuna that had been soaked in coconut shell liquid smoke was tested at 0 hours, 24 hours, 48 hours, 72 hours, 96 hours and 120 hours.

Observation Parameters

The parameters observed in this research are chemical, microbiological and organoleptic parameters. Chemical parameters include pH and water content analysis, microbiological parameters include total microbial tests, while organoleptic parameters include appearance, color, aroma and taste by scoring and hedonic methods.

RESULTS

pH

The results of observations and analysis of the effect of storage time by soaking coconut shell liquid smoke on the pH of boiled mackarel tuna can be seen in Table 1.

Table 1. Results of Advanced Test Analysis of HSD 5% Effect of Storage Time by Soaking in Liquid Smoke of Coconut Shell on the pH of Boiled Mackarel tuna Fish

Storage Time(O'clock)	Average pH Value
0	6,32ab
24	6.16b
48	5.92c
72	5.88c
96	6.42a
120	6.55a
HSD (0.05)	0.311

Note: Numbers followed by the same letters indicate no significant difference at the 5% level

Table 1 shows that the storage time for boiled mackarel tuna and soaking in coconut shell liquid smoke has a significantly different effect on the pH of boiled mackarel tuna. The pH value obtained showed that there was a decrease in the pH of boiled mackarel tuna from the 0 hour storage period to the 72 hour storage period, namely from 6.32 to 5.88.

Water content

The results of observations and analysis of the effect of storage time by soaking coconut shell liquid smoke on the water content of boiled mackarel tuna can be seen in Table 2.

Table 2. Results of Advanced Test Analysis of HSD 5% Effect of Storage Time by Soaking in Liquid Smoke of Coconut Shell on Water Content of Boiled Mackarel tuna Fish

Storage Time (Hours)	Average Water Content
0	60.12bc
24	59.72c
48	59.17c
72	58.97c
96	61.,52b
120	63.54a
HSD (0.05)	1,947

Note: Numbers followed by the same letters indicate no significant difference at the 5% level

Table 2 shows that the storage time by soaking in coconut shell liquid smoke has a significantly different effect on the water content of boiled mackarel tuna. The water content of boiled mackarel fish in the 0 hour storage period decreased in water content up to 72 hours storage time, namely from 60.12% to 58.97%.

Total Microbes

The results of observations and analysis of the effect of storage time by soaking in coconut shell liquid smoke on the microbiological quality (total microbes) of boiled mackarel tuna can be seen in Table 3.

Table 3. Results of Advanced Test Analysis of HSD 5% Effect of Storage Time by Soaking in Liquid Smoke of Coconut Shell on Total Microbes in Boiled Mackarel tuna Fish

Storage Time (Hours)	Average number of bacterial colonies (log CFU/gr)
0	4.47b
24	4.64b
48	4.85b
72	4.98b
96	5.79a
120	6.16a
HSD	0.676

Note: Numbers followed by the same letters indicate no significant difference at the 5% level

Table 3 shows that the storage time by soaking in coconut shell liquid smoke had a significantly different effect on the total microbial value of boiled mackarel tuna. The 0 hour shelf life treatment had a total microbial count of 4.47 CFU/gr and continued to increase until the 120 hour shelf life was 6.16 CFU/gr.

Organoleptic Quality

The results of observations and analysis of the effect of storage time by soaking coconut shell liquid smoke on organoleptic quality by scoring and hedonic can be seen in Table 4 and Table 5.

Table 4. Results of Advanced Test Analysis of HSD 5% Effect of Storage Time by Soaking in Liquid Smoke on Organoleptic Quality by Scoring of Boiled Mackarel tuna Fish

Storage Time (Hours)	Average			
	Appearance	Aroma	Texture	Taste
0	4.35a	3.85a	4.20a	3.70b
24	4.20a	4.05a	4.15a	4,10ab
48	4,10ab	4.15a	4.05a	4.30a
72	3.65b	4.25a	3.60b	-
96	2.75c	2.55b	2.55c	-
120	1.65d	1.80c	1.65d	-
HSD (0.05)	0.488	0.653	0.447	0.475

Note: Numbers followed by the same letters indicate no significant difference at the 5% level

Table 5. Results of Advanced Test Analysis of HSD 5% Effect of Storage Time with Liquid Smoke Soaking on Hedonic Organoleptic Quality of Boiled Mackarel tuna Fish

Storage Time (Hours)	Average			
	Appearance	Aroma	Texture	Taste
0	4.15a	3.80a	4.10a	4.15a
24	4.10a	3.25ab	4.00a	3.55b
48	3.85ab	3.05b	3.75ab	3.20b
72	3.40b	2.95b	3.35b	-
96	2.40c	2.15c	2.30c	-
120	1.55d	1.50d	1.25d	-
HSD (0.05)	0.627	0.644	0.515	0.386

Note: Numbers followed by the same letters indicate no significant difference at the 5% level

Tables 4 and 5 . showed that the treatment of storing boiled mackarel tuna by soaking in liquid smoke had a significantly different effect on the organoleptic quality of boiled mackarel tuna in terms of scoring and hedonic.

DISCUSSION

The pH of boiled mackarel fish soaked in coconut shell liquid smoke during storage decreased. This is caused by microbial activity that produces organic acids. Changes in pH are related to the degradation of organic acids in food into various components so that they can reduce the pH value (Secer *et al.,* 2020). Meanwhile, the pH value in the long storage treatment was 96 hours to 120 hours, namely from 6.42 to 6.55. This is because the storage time of 96 hours to 120 hours shows that the boiled mackarel tuna undergoes a putrefaction process due to the protein content of amino acids which are converted into ammonia compounds which are alkaline in nature. According to Chamidah (2000) report that during storage there is a process of protein decomposition by proteolytic enzymes with the help of bacteria into carboxylic acid, sulfide acid, ammonia and other types of acids which can cause changes in the pH value of food during storage. The results obtained are in line with the research of Hardiprasetya (2015),

the pH value of pindang mackarel tuna fish with the addition of bacteriocin experienced fluctuations where the decrease in pH tended to decrease on the 2nd day and on the 4th day it increased. The decrease in pH in fish meat is caused by the accumulation of lactic acid which is produced through the glycolysis process which breaks down glucose. Furthermore, there is an increase in the pH value due to the accumulation of volatile bases (Jiang, 1998).

The water content of boiled mackarel tuna by soaking in coconut shell liquid smoke during storage decreased. This decrease in water content is caused by environmental adjustment processes such as evaporation by boiled mackarel tuna during storage. This is in accordance with research by Swastawati (2013) that the decrease in water content in liquid smoked milkfish is caused by the movement of water vapor into the surrounding environment so that the water content in smoked fish decreases. An increase in water content occurred in the storage treatment of 96 hours to 120 hours, namely from 61.52% to 63.54%, which indicates that there was a deterioration in quality. This is because the storage time is 96 hours to 120 hours. Boiled mackarel tuna has undergone a putrefaction process which is characterized by the appearance of mucus and wateriness as a result of the increased water content caused by the activity of spoilage microbes. Supardi and Sukamto (1998) stated that several spoilage microbes in fish are *Serratis, Micrococcus, Bacillus, Achromobacter, Pseudomonas, Staphylococcus, and Flavobacterium* which produce water and mucus. This is in accordance with research by Himawati (2010) which states that the water content of smoked fish increases due to microbial activity in the fish which will produce water during metabolic processes during storage. The results obtained are in accordance with research by Fauziah (2014), the value of water content in pindang layang fish with the addition of 3% liquid smoke experienced fluctuations, namely where there was a decrease in water content until the 4th day of storage amounting to 44.94% due to evaporation during storage and an increase in storage on the 6th day was 48.87% which was caused by spoilage due to oxidation of fat in fish which contains various unsaturated fatty acids and microbial activity. An increase in water content can be caused by the process of breaking down proteins into components such as ammonia, indole H_2S, skatol which causes a foul smell and is followed by the release of bound water into free water by microorganisms (Nur, 2009). According to the Indonesian National Standardization Agency through SNI 2717:2017, the water content value that meets the quality requirements for pindang is a maximum of 60%, so in this case boiled mackarel tuna has a water content that is still within the standard limit, namely 58.97% for a storage period of 72 hours.

The longer the storage time by soaking coconut shell liquid smoke, the greater the total number of microbial colonies found in boiled mackarel tuna. This is because boiled mackarel tuna provides a suitable environment for the growth of microbes such as nutrients and water content in boiled mackarel tuna. Activity water (aW) which increases during storage becomes an opportunity for microbial growth media, causing an increase in total microbes (Widyasari, 2006). The results obtained in this study are in accordance with research by Himawati (2010) which shows that the total plate count value of pindang layang fish added with 1%, 2% and 3% distilled liquid smoke on days 0 to 6 has increased. . On days 4 to 6 there was a significant increase, ranging from 1.3x105 to 2.2x105. During storage, fish will experience a process of protein degradation into simpler molecules so that these conditions become an optimal growth medium for microbes (Ako, 2016). According to the Indonesian National Standardization Agency 2717:2017, it is determined that the total microbes in fish pindang should not exceed $1.0x10^5$ CFU/mL or 5.00 log CFU/mL. This means that the total microbes of boiled mackarel tuna fish up to 72 hours of storage time by soaking in coconut shell liquid smoke still meet the requirements of SNI 2717:2017, namely with a colony count of 4.98 CFU/gr. Meanwhile, based on research by Asriani (2022), it shows that pindang lemuru fish stored at room temperature without any treatment experienced a significant increase during storage, namely

on day 1 there was a very rapid increase in the number of colonies, namely 1.3 x 106 due to temperature storage. space that is suitable for the development of microorganisms, therefore the number of colonies increases significantly so that it does not meet the requirements of SNI 2717:2017.

Treatment for storing boiled mackarel tuna for a long time by soaking in liquid smoke had a significantly different effect on the organoleptic appearance of boiled mackarel tuna in terms of scoring and hedonic. This is due to the appearance of fresh boiled mackarel tuna, which is typical of boiled fish that has just been cooked, so it is liked by the panelists. The appearance of boiled mackarel tuna after a storage period of 72 hours with a score of 3.65 also still shows the criteria for intact boiled fish even though the color has changed to become less dull. This shows that a storage period of up to 72 hours can still maintain the appearance of boiled mackarel tuna due to a decrease in water content. The decrease in water content also plays a role in removing matrices such as mucus so that the appearance of the body of boiled fish becomes more attractive (Buckle, 1987).

The lowest value for the appearance of boiled mackarel tuna, namely 1.65, with the appearance criteria being "very crushed and blackish brown" occurred in the 120 hour storage sample because the tail and head of the boiled mackarel tuna had started to come off and the color changed to blackish brown, which indicated the occurrence of decay so that it cannot be accepted by the panelists. Changes in the color of boiled fish can be caused by microbial activity during storage. The higher the number of microbes in the food and the faster the oxidation process of the food, the lower the brightness value, this is due to the decomposition of certain compounds in the food (especially pigments) (Jannah, 2018). This is in accordance with Mulyani's (2016) research, the change in color of boiled fish during storage can be caused by a fat oxidation reaction in fish tissue which causes the myoglobin pigment found in fish to be degraded into other pigments which can give a different color.

Hedonically, storage time and soaking in coconut shell liquid smoke had a significantly different effect on the appearance of boiled mackarel tuna with values ranging from 4.15 to 1.55 (like-very dislike). The highest score was 4.15 "liked" the appearance of boiled mackarel tuna with a shelf life of 0 hours, because the appearance of boiled mackarel tuna was still intact, clean and had a dull color so the panelists liked the appearance of boiled mackarel tuna. The appearance of boiled mackarel tuna with the lowest score of 1.55 "really don't like it", namely the storage time of 120 hours because the longer the storage time, the appearance of boiled mackarel tuna, the higher the damage that occurs, such as a very crushed appearance and a blackish brown color.

The longer the storage time, the appearance value will decrease, but the appearance of boiled mackarel tuna soaked in liquid coconut shell smoke parameters decreases. This is in accordance with research by Sutanaya (2018) where the fastest decrease in appearance parameters occurred in the treatment without any additions, while the slowest occurred in the treatment with the addition of liquid smoke. Based on the National Standards Agency through SNI 2717:2017, it is stated that fish pindang that is acceptable and suitable for consumption is clean, intact and brilliantly colored (species specific). Thus, the long-storage treatment of up to 48 hours is an appearance of boiled mackarel tuna that is still acceptable to the panelists in accordance with SNI requirements.

Tables 4 and 5 show that the long-storage treatment of boiled mackarel tuna with soaking in liquid smoke had a significantly different effect on the organoleptic aroma of boiled mackarel tuna in terms of scoring and hedonic. For aroma quality, the scoring has a significant effect with values ranging from 4.25 to 1.80 (smells typical of smoked boiled fish with a foul smell). The panelists felt the highest score was 4.25 with the criteria "distinctive aroma of smoked boiled fish" for a shelf life of 72 hours. This shows that the longer it is stored by soaking in liquid smoke, the more it absorbs the smoke aroma in the boiled

mackarel tuna, resulting in a strong smoke aroma. The aroma of boiled mackarel tuna is caused by the presence of phenolic compounds. This is in line with Taufik's (2016) research that the aroma in beef is caused by phenol compounds from liquid smoke during soaking, phenol compounds which are responsible for the formation of flavor which is caused by the presence of phenol that is absorbed in the meat. The lowest value for the aroma of boiled mackarel tuna is 1.80 with the criteria "very foul smelling" for a shelf life of 120 hours. This is due to the decomposition of the chemical components in boiled mackarel tuna, causing the aroma to become rotten and rancid. The longer the storage, the higher the number of microbes in boiled mackarel tuna, which can cause the process of decomposing compounds in the fish such as protein, amino acids, lactic acid and reducing sugars by decomposing bacteria, resulting in a foul smell (Himawati, 2010). This is in accordance with Handayani's (2019) research that the bad smell in tilapia dumplings is caused by the formation of volatile bases during the storage process. The longer it is stored, the smell of smoked meat gets worse. Food ingredients that contain a lot of protein, if subjected to microbial damage, will produce a protein-specific foul odor (Arizona, 2011).

Hedonically, the length of storage by soaking in coconut shell liquid smoke has a significantly different effect on the aroma of boiled mackarel tuna with values ranging from 3.80-1.50 (somewhat like-very dislike), this is because the longer the aroma of boiled mackarel tuna is stored. becomes increasingly pungent and rotten, resulting in a decrease in the hedonic value of the aroma of boiled mackarel tuna. The highest score, namely 3.80 "somewhat like" was received by the panelists at a shelf life of 0 hours because the aroma produced was a fresh aroma typical of boiled fish so it was liked by the panelists. The panelists still accepted the 48 hour shelf life treatment with a hedonic score of 3.05, namely "rather like" with the criteria of the distinctive aroma of smoked boiled fish. The lowest value, namely 1.50 "very dislike" was received by the panelists for a storage period of 120 hours because the longer the storage time, the higher the number of microbes that grow, resulting in the formation of ammonia which causes acid and rot which is not accepted by the panelists. The foul smell arises due to the protein degradation process by microorganisms into complex compounds such as ammonia, indole, H2S, and amines, especially outresin and cadaverine (Rachmat, 2015).

The longer the storage time by soaking in coconut shell liquid smoke, the lower the level of panelists' liking for the aroma of boiled mackarel tuna. The strong smell of smoke along with the long storage of boiled mackarel tuna was not liked by the panelists. The long-term storage treatment of 96 hours to 120 hours showed that the boiled mackarel tuna had a distorted aroma because it had rotted so it was not safe for consumption. This is in accordance with Tinungki (2007) that food that is still good has a distinctive smell from the food and of course will be more stimulating to eat. If the smell is different or distorted then the food is considered to have started to rot.

The results obtained in this study showed that the acceptance score for samples of boiled mackarel tuna with coconut shell liquid smoke soaking during storage was still acceptable to the panelists compared to treatment without any additions because coconut shell liquid smoke can give a distinctive smoky aroma to boiled mackarel tuna. Based on the National Standards Agency through SNI 2717:2017, it states that the aroma of pindang with good quality is very fresh, has a specific pindang aroma or is like the aroma of freshly boiled fish without a rancid smell according to SNI 2717:2017. Thus, the aroma of boiled mackarel tuna can still be accepted by the panelists, namely in the long storage treatment of up to 48 hours with a distinctive aroma of smoked boiled fish and is somewhat liked by the panelists.

Tables 4 and 5 show that the treatment of storing boiled mackarel tuna for a long time with liquid smoke soaking had a significantly different effect on the organoleptic texture of boiled mackarel tuna in scoring and hedonic terms. For texture quality, scoring has a significant effect with values ranging from 4.20 to 1.65 (dense and compact-very soft), for the

highest value of 4.20, the texture of boiled mackarel tuna "solid and compact" occurs at a storage time of 0 hours which shows the texture congested. According to Pandi (1997), on day 0 the pindang fish still had a dense and compact texture because the microbes had not yet carried out their activities so that there had been no change in the components of the pindang fish meat. Apart from that, the texture of boiled mackarel tuna by soaking in coconut shell liquid smoke can still be maintained for up to 48 hours, which shows that the texture of boiled mackarel tuna is still "dense and compact". The lowest value for the texture of boiled mackarel tuna, namely 1.65, with the criteria "very soft" occurred in samples treated with a shelf life of 120 hours, due to the high water content which provides an opportunity for increased microbial growth, causing boiled mackarel tuna to have a soft and slimy texture. The formation of mucus indicates that the product has experienced a decline in quality due to bacterial activity, so it should no longer be consumed (Siskos, *et al.,* 2007). The decrease in texture is also caused by the activity of microorganisms which degrade proteins into simpler compounds and cause the protein's ability to bind water to decrease. The lower the protein content, the lower the water binding capacity because protein has hydrophilic groups that can bind water (Santoso, 2006).

Hedonically, storage time and soaking in coconut shell liquid smoke had a significantly different effect on the texture of boiled mackarel tuna with values ranging from 4.10 to 1.25 (like-very dislike). The highest score was 4.10 "liked" the texture of boiled mackarel tuna with a shelf life of 0 hours, because the texture of boiled mackarel tuna was solid which indicated the fish was still fresh so the panelists liked the texture of boiled mackarel tuna. The texture of boiled mackarel fish soaked in coconut shell liquid smoke was also liked by the panelists with an acceptance score of 4.00-3.75 with the criteria of "liked-somewhat liked" which occurred in the 24 hour and 48 hour shelf life treatments. Meanwhile, the lowest score was obtained at 1.25 with the criteria of "very dislike" namely the storage time of 120 hours because the longer the storage time, the texture of the boiled mackarel tuna fish became increasingly slimy and mushy, indicating that microbial growth was high so it was easy to spoil. A damaged texture indicates damage to the quality of the boiled mackarel tuna so the panelists don't like it. Based on the National Standards Agency through SNI 2717:2017, it is stated that the criteria for pindang that is acceptable and suitable for consumption is pindang with a dense and compact texture. Thus, the long storage treatment of up to 48 hours is a boiled mackarel tuna texture that is still acceptable for the panelists in accordance with SNI requirements.

Taste testing was only carried out for the shelf life treatments of 0 hours, 24 hours and 48 hours. Meanwhile, for the storage time treatment of 72 hours, 96 hours and 120 hours, no testing was carried out on the taste parameters of boiled mackarel tuna because at that time some of the products had started to become slimy and emit an unpleasant odor, so they were no longer suitable for consumption because they could endanger health.

Tables 4 and 5 show that the treatment of storing boiled mackarel tuna for a long time with liquid smoke soaking had a significantly different effect on the organoleptic taste of boiled mackarel tuna in terms of scoring and hedonic. For the quality of taste, the scoring has a significant effect with values ranging from 4.30 to 3.70 (savory and typical taste of smoked boiled fish - savory taste and slightly smoked pindang taste). The highest value, namely 4.30, with the criteria of "typical pindang smoke" occurred in samples with a shelf life of 48 hours due to the presence of phenolic components in liquid smoke which play a role in producing the taste of boiled mackarel tuna. The taste of boiled mackarel tuna soaked in coconut shell liquid smoke creates a smoky taste the longer it is stored. This is in accordance with research by Maulana *et al.,* (2020) that the smoked taste of catfish becomes stronger during storage because fat oxidation occurs which causes the formation of aromatic compounds which give a smoked aroma and taste. The lowest value for the taste of boiled mackarel tuna was 3.70 with

the criteria for the taste of boiled mackarel tuna being "a bit like the taste of smoked boiled fish" which occurred in samples treated with a shelf life of 0 hours. This is because the sample has not experienced too much absorption of liquid smoke compounds so the resulting smoke taste is not too significant. According to Saloko (2014), the distinctive taste caused by encapsulated liquid smoke is caused by the type and amount of phenolic and acid compounds contained in the liquid smoke. Daun (1979) added that the flavor characteristics of smoked products are caused by the presence of phenolic components that are absorbed on the surface of the product. The phenolic compounds that play a role in the formation of smoke flavor are guaikol, 4-methyl guaikol, and 2,6-dimethoxy phenol. Guaikol plays a greater role in the formation of smoke flavor.

Hedonically, storage time and soaking in coconut shell liquid smoke had a significantly different effect on the taste of boiled mackarel tuna with values ranging from 4.15 to 3.20 (liked to somewhat liked). The highest value is 4.15 with the criteria of "liking" the taste of boiled mackarel tuna with a shelf life of 0 hours. Meanwhile, the lowest value was 3.20 with the criteria of "rather liked" the 48 hour storage treatment due to the taste of pindang cob which was slightly pungent or typical of smoked pindang due to the phenol compounds in liquid smoke. This shows that the panelists don't really like the smoked taste of boiled mackarel tuna as a result of the addition of liquid smoke, where the longer it is stored, the stronger the smoked taste and the level of liking decreases. According to the National Standardization Agency (2017), fish pindang that is acceptable and suitable for consumption has a savory taste, is very tasty, and is specific to the type, in this case storage for up to 48 hours with the criteria of a slightly distinctive taste of smoked boiled fish is still acceptable to the panelists.

CONCLUSION

The long storage treatment for boiled mackarel tuna with soaking in coconut shell liquid smoke had a significantly different effect on pH, water content, total microbes, organoleptic appearance, aroma, texture and taste both scoring and hedonic. Soaking with coconut shell liquid smoke can maintain the quality of boiled mackarel tuna for up to 48 hours based on pH 5.92; water content 59.17%; total microbes 4.85 log CFU/gr; as well as organoleptic appearance, aroma, texture and taste that can be accepted by panelists.

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