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Effectiveness Edible Coating with The Addition of Liquid Smoke on The Oxidation Rate and Shelf Life of Anchovies (Stolephorus spp)

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A B S T R A C T

Anchovies are pelagic fish which usually found in coastal areas. Liquid smoke is known for the content of phenols which can be used as antioxidants in order to protect food products from lipid oxidation. Carrageenan-based edible coating has an advantage in protecting products from oxygen that can lead to lipid oxidation. This study aimed to determine the effect of liquid smoke added into carrageenan-based edible coating in increasing the shelf life of anchovies during room temperature storage. The research method used by experimental design of Split Plot in Time, where the concentration of liquid smoke as the main plot and the duration of storage as the sub-plot. Application of liquid smoke on edible coating by dyeing anchovies on edible coating, then ovened for 48 hours and stored at room temperature for 21 days. The analysis used were water content, fat content, protein content, peroxide value, thiobarbituric acid and fatty acid profile ($p<0,05$). The results showed that the moisture content (42.98±0,60-42.31±0,17), protein content (30.25-31.32), fat content (2.25±0,10-2.02±0,09), (1,91±0,017-1,71±0,15) decreased during the 21st day of storage. The peroxide and TBA value of coated anchovies was lower than the treatment, which showed a number of 0.54 and 1.11, respectively. The fatty acid profile showed that DHA, EPA, palmitic acid, stearate acid, and oleic acid were easily decomposed during storage. Based on the analysis that had been done, it can be seen that carrageenan edible coating added with liquid smoke was able to increase the shelf life for 21 days of room temperature storage.

Keywords: anchovies, carrageenan, edible coating, liquid smoke, shelf life

Introduction

Anchovies (Stolephorus spp) are pelagic fish and lives in groups. Many anchovies are produced from Sumatra and Java regions such as Jepara, Rembang and Demak. (Zamroni et al., 2021). Drying anchovies is a way to preserve fish so that their shelf life is longer, but generally fishery products are easily oxidized which causes rancidity in the product. The process of fat oxidation occurs during the storage process. There needs to be solutions and innovations to overcome the problem of oxidation of anchovy fat during the storage process. Pratiwi et al. (2019) states that dry fishery products usually suffer damage, the most frequent of which is changes in product quality due to the lipid oxidation process. Lipid oxidation can occur during the processing process as well as the storage process. This damage can be prevented in the presence of good antioxidants.

The development of technology is very rapid, one of which is the use of carrageenan into edible coating to coat products that function as protection from oxygen, moisture and light. Carrageenan is a thin layer of polysaccharides that can effectively provide protection against browning and lipid oxidation. This layer of polysaccharides can prevent moisture loss and has oxygen permeability so as to extend shelf life (Nanda et al., 2023). In addition, the use of liquid smoke is one of today's product innovations for the process of preserving products. Swastawati et al. (2022) stated that liquid smoke contains chemical components that function as antimicrobial properties and natural preservatives. Liquid smoke can be used as a food preservative due to its antimicrobial and antioxidant compounds such as aldehydes, carboxylic acids, and phenols.

This study was conducted to determine the difference in the quality of semi-dry rice anchovies without treatment with anchovies that were treated with edible coating coating with the addition of liquid smoke.

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MATERIAL AND METHODS

Material

The main raw materials used in the manufacture of edible coating are carrageenan, liquid smoke, glycerol, aquades, anchovies, semi-dried rice. The tools used are beaker glass, hot plate stirrer, measuring cup, pipette, scale, oven, pan, spatula, and container.

Methods

The creation of edible coating refers to Utami et al., 2017 with modifications Pratiwi et al., 2019. Making edible coating by dissolving 2% of carageenan in a 100 ml measuring cup and heated with a hot plate stier until 60 ° C. Then added 1% glycerol and 1% liquid smoke while stirring for 5 minutes. Anchovies are dipped in edible coating until the entire surface is coated. Immersion is carried out as much as two times. The final stage is anchovies that have been dipped in edible coating and then dried using an oven at 40 ° C for 48 hours.

Water Content

Water content analysis is performed to determine the amount of water content contained in the sample. The ash content shows the total minerals contained in the sample. Analysis of the moisture content of food stuffs directly, the determination of their moisture content is based on weighing the weight of the ingredients. The difference in the weight of fresh material and its dry weight is the sought-after moisture content contained in the material being inspected. (Kristiandi et al., 2021)

Protein Content

Protein content testing using the Kjeldahl method with the principle of being into three stages, including the destruction stage, the distillation stage and the titration stage. The first stage is the destruction stage, this stage the sample will be heated into concentrated sulfuric acid so that decomposition will occur into elements such as C, H, O, N, S and P. Decomposed N elements will be used to determine the protein content in a material. The final result of protein testing is characterized by a constant change in the color of the solution to a constant pink (Purnama et al., 2019).

Fat Content

The fat test process, fat can be calculated using various analytical methods including the direct extraction method. This method is also known as the Soxhlet method. The principle of this method is the extraction of fat with fat solvents such as petroleum benzene, petroleum ether, acetone and others. The weight of the fat is then determined by separating the fat from the solvent (Asmariani et al., 2017).

Peroxida value

The peroxide value is determined based on the amount of iodine released after the fat is added KI which is then reacted with acetic acid solvents and chloroform then iodine form is determined by titration (Winarno, 1984).

Thiobarbituric acid

TBA (Thiobarbituric Acid) is a test to determine the TBA value of the product. The TBA value is an index to determine the degree of oxidation of fats calculated based on the amount of Malonaldehyde (MDA) in the product. Malonaldehyde can be formed due to free radical attacks on the unsaturated bonds of a fatty acid, especially multi-chain unsaturated fatty acids which are usually called (PUFA) Peroxide in products is the beginning of the formation of malonaldehyde in a product. (Arbi et al., 2016).

Fatty Acid Profile

Fatty acids are a source of volatile compounds that form and can usually affect the aroma of the product. The fatty acid profile can be determined using cold temperatures in its fat extraction such as the Bligh Dryer method (Pratama et al., 2018).

RESUL AND DISCUSSION

Water Content

The moisture content value of anchovies with edible coating treatment given an additional 1% liquid smoke is presented in the table below.

Table 1. The value of the water content of anchovies during storage

Duration of storage (day)	*Treatment*	
	K	*A*
0	*49,55±0,31* [a]	*43,52±0,48* [a]
7	*49,25±0,20* [a]	*43,28±0,43* [a]
14	*47,68±0,44* [b]	*42,98±0,60* [b]

21	*47,32±0,33[b]*	*42,31±0,17[b]*

The lowest decrease in control rice anchovies occurred on day 14 of storage, with an average of 49.25 to 47.68, while for treated anchovies on day 21 with an average of 42.98 to 42.31. Hutomo et al. (2015) stated that the use of liquid smoke in products has the potential to maintain the durability of a product, namely the content in liquid smoke is able to bind free water content which can reduce water content so that if the water content decreases, it increases the fat content so as to prevent fat damage to the product.

The value of the water content of anchovies treated with edible coating with the addition of liquid smoke has decreased water content. This is due to the evaporation of water during room temperature storage causing inhibition of the development of microorganisms that can preserve the product, in addition to the content of liquid smoke, namely phenol which can bind water in the product so that the moisture content during storage decreases. Harumarani et al. (2015) stated that the effect of low water content is due to additional ingredients in edible coatings containing glycerol. The high and low water content is influenced by the concentration of plasticizers, namely glycerol which is used in addition to making edible coatings that serve to increase flexibility. The higher the glycerol concentration, the lower the moisture content value.

Protein Content

The value of protein content of semi-dried anchovies with edible coating treatment with additional 1% liquid smoke is presented in the table below.

Table 2. The value of the protein ontent of anchovies during storage

Duration of storage (day)	Treatment	
	K	A
0	31,69±0,45[a]	31,41±0,64[a]
21	30,25±0,41[a]	31,32±0,94[a]

The protein content in anchovies during storage has decreased. This is due to the effect of adding liquid smoke to anchovies containing phenols. The maintained value of protein content in anchovies is also due to the addition of edible coating which serves to maintain the product so that protein denaturation does not occur during the storage process. Changes in protein content are also caused by changes in the value of fat content and water content. This increase in protein levels is caused by the addition of liquid smoke to the product which is able to increase the value of protein levels and durability of the product because liquid smoke has acidic properties that cause protein insolubility. The addition of liquid smoke can also inhibit microorganisms that can decompose proteins. A partial decrease in water content causes protein levels to increase. Hutomo et al. (2015) states that the decrease in protein levels in products soaked in liquid smoke during the storage process is due to the phenol content in liquid smoke. Phenol will react with the protein so as to reduce the protein content in the product. The existence of this reaction causes the protein to denature during the storage process.

The increased protein content is also caused by the process of ovening anchovies after being given edible coating. The heat from the oven causes the product to lose water so that the protein content increases in the product. The decrease in protein levels in control anchovies was caused by the denaturation of protein in the product during the storage process. Microorganisms produce enzymes that can break down protein molecules so that protein degradation occurs in products that cause protein content to decrease. The reduction in protein levels in control and treatment anchovies did not differ significantly either between treatments or between the duration of storage. Utami et al. (2017) states that the protein content value of products with edible coating application has higher protein content than non-coating. This is because the product applied edible coating undergoes an ovening process first so that it makes the product lose water and increases protein levels in the product. Lower protein levels during storage are caused by protein degradation during storage.

Fat Content

The fat content value of rice anchovies with edible coating treatment with additional 1% liquid smoke is presented in the table below.

Table 3. The value of the fat content of anchovies during storage

Duration of storage (day)	*Treatment*	
	K	*A*
0	*2,43 ±0,90[a]*	*2,34 ±0,17[a]*
7	*2,04 ±0,60[ab]*	*2,26 ±0,14[a]*
14	*1,91 ±0,017[b]*	*2,25 ±0,10[a]*
21	*1,71 ±0,15[c]*	*2,02 ±0,09[a]*

The table above shows the value of the fat content of anchovies during room temperature storage. The data showed no significant difference between treatment and storage duration. This is shown from the difference in values between treatments and between storage periods that are not significant. In conclusion, the treatment of edible coating coating with the addition of liquid smoke does not have a significant effect on the value of fat content in anchovies. The lowest decrease in control fat levels occurred on day 7, which was 2.43 to 2.04, while the lowest decrease in treated anchovies occurred on day 21, which was 2.25 to 2.02.

The value of the fat content of anchovies without edible coating treatment with the addition of liquid smoke decreased the fat content. The decrease in fat content is due to the oxidation of fat in anchovies during the room temperature storage process. The fat content in anchovies treated with edible coating and liquid smoke is higher than ydroge. Inats et al. (2020) stated that the application of edible coatings on products can prevent oxidation of fat so that it can improve appearance and prevent microbial growth. The addition of liquid smoke to edible coating also has a function as an antioxidant. This is due to the influence of the use of liquid smoke as an antioxidant that prevents oxidation in rice anchovies. Mekarsari et al. (2016) states that the process of immersing products in liquid smoke can maintain the fat content of a product, this is because each liquid smoke contains phenol compounds that have antioxidant activity so as to prevent an oxidation reaction. Antioxidants in phenols have a role as hydrogen donors that can prevent oxidation reactions.

High fat content can accelerate the rate of oxidation in the product. The decrease in fat content occurs due to oxidation reactions during storage. Pratiwi et al. (2019) stated that increased fat content is related to the value of water and protein content in the sample. Increased fat content in the sample has a high potential for increasing the rate of fat occupation. This affects the value of thiobarbituric acid (TBA) which affects the rancidity, taste, and color of the product.

Peroksida Value

PV values of anchovies with edible coating treatment with additional 1% liquid smoke are presented in the table below.

Table 4. The value of the Peroxide number of anchovies during storage

Duration fo storage (day)	*Treatment*	
	K	*A*
0	*0,20±0,08*[a]	*0,23 ±0,02* [a]
7	*0,35 ±0,01*[ab]	*0,29 ±0,01*[ab]
14	*0,62±0,04*[b]	*0,47±0,03*[bc]
21	*0,84±0,10*[c]	*0,54±0,05*[c]

The table above is the peroxide value of anchovies during room temperature storage. PV values in control anchovies were higher than those of treated anchovies. This was proven by the PV value on day 7 to day 21, the peroxide value of control anchovies was higher than that of anchovies with edible coating coating added with liquid smoke. The number of peroxides in each week between treatments has a difference that does not differ much. The difference in peroxide value is due to differences in treatment of rice anchovies. In conclusion, the addition of edible coating with liquid smoke has an effect on the storage of anchovies, but the change is not significant. The highest increase in peroxide number in control anchovies occurred on day 14 at 0.35 meqO2/kg to 0.62meqO2/kg, while in rice anchovies with the highest treatment the highest increase occurred on day 14 at 0.29 meqO2/kg to 0.47 meqO2/kg.

The value of the peroxide number determines the rancidity of a product. Peroxide value is used as an indicator in the oxidation stage of fats because the peroxide value can be formed during the oxidation propagation stage. The peroxide value in anchovies with the addition of liquid smoke and edible coating treatment has a lower value than control anchovies. This is due to the treatment of adding liquid smoke to anchovies which is effective as an antioxidant for a product. Products that are still suitable for consumption must not exceed the peroxide value. Nainggolan et al. (2016) stated that the parameter to determine the oxidation of products is by peroxide value. Peroxide value is the most important value that determines the breakdown of a fat. Peroxide value quality standards in Indonesia are in accordance with SNI 01-3741-2013, which is a maximum of 10 meqO2 / kg.

The value of the peroxide number during storage changes, the longer the storage, the value of the peroxide number will increase, but in anchovy products that are treated with edible coating with the addition of liquid smoke, the increase in the value of the peroxide number is only slightly. This is due to the treatment of adding liquid smoke and edible coating which can suppress the increase in peroxide number value. The phenol content in liquid smoke can suppress oxidation so that the peroxide value does not increase significantly. Manurung et al. (2017) stated that oxidation of fat affects the peroxide value. The PV can be inhibited by the addition of liquid smoke because liquid smoke is an antioxidant because it contains phenol compounds that can inhibit the formation of hydroperoxides at the propagation stage.

TBA (Thiobarbituric acid)

The TBA value of anchovies with edible coating treatment with additional 1% liquid smoke is presented in the table below.

Table 5. The value of the Thiobarbituric acid of anchovies during storage

Duration of storage (day)	*Treatment*	
	K	*A*

0	*0,45 ±0,015[a]*	*0,23 ±0,01[a]*
7	*0,66 ±0,098[a]*	*0,37 ±0,05[a]*
14	*1,14 ±0,12[b]*	*0,69 ±0,03[b]*
21	*1,34 ±0,09[b]*	*1,11 ±0,06[c]*

The table above is the TBA value of anchovies during room temperature storage. The TBA value above indicates that there is a difference in value between control and treatment. The TBA value with treatment was lower than the TBA value of control anchovies, but the difference in TBA values between treatments was not significantly different. This is shown by the difference in TBA values between treatments each week which has an insignificant difference. In conclusion, the treatment of edible coating coating with the addition of liquid smoke to rice anchovies has an effect on the TBA value but is not significant. The highest increase in TBA value in control rice anchovies occurred on day 14 by 0.66 to 1.14 while in anchovies treated the highest increase occurred on day 21 by 0.69 to 1.11.

TBA test analysis was carried out to determine the degree of oxidation of anchovy fat during the storage process. The factor causing the difference in TBA values in control and treatment anchovies is because in anchovies that are treated with edible coating treatment with the addition of 1% liquid smoke, there is an antioxidant content in liquid smoke, thus inhibiting the oxidation process in rice anchovies. This is reinforced by research by Namaskara et al., (2017), the addition of liquid smoke to anchovy samples can suppress the rate of increase in TBA because at the time of soaking liquid smoke is effective to inhibit lipid oxidation which is shown by the TBA value of products soaked in liquid smoke is lower than without liquid smoke. The addition of edible coating on anchovies can also inhibit the increase in TBA value in anchovies, this is due to the increase in TBA value that occurs during room temperature storage indicating that there is fat degradation in anchovy tissue which can produce malonaldehyde. The formation of malonaldehyde occurs when the lipid peroxidation reaction is in the form of breaking carbon bonds. Malonaldehyde is the result of fat oxidation reactions. According to Sitompul and Zubaidah (2017), the TBA value of products packaged with edible has a lower value compared to those that are not packaged edible. This is because the product does not experience direct contact with air but is protected by edible so that there is no oxidation process in the product.

In accordance with the threshold limit of TBA value in a product, which is 1-2 mg MDA / Kg while for TBA values allowed in food is below 2 mg MDA / Kg sample. Anchovy treatment with the use of edible coating can reduce sample contact with oxygen because the glycerol in the edible coating can form a film tightly so as to reduce oxygen transmission and reduce the level of rancidity in the product. According to Fauziah et al. (2014), the increased TBA value during storage is caused by fat damage which will cause odor and taste due to oxidation reactions. The product can be said to be still suitable for consumption if the TBA content is below 3 MA / kg.

Fatty Acid Profile

The value of the fatty acid profile content of anchovies with edible coating treatment given additional 1% liquid smoke in the first week and last week is presented in the table below.

Table 6. The value of the fatty acid profile of anchovies during storage

Fatty Acid	*Control*		*Treatment*	
	I	*IV*	*I*	*IV*
Palmitic Acid	*0,72%*	*0,37%*	*0,99%*	*0,63%*
Stearate Acid	*0,22%*	*0,12%*	*0,32%*	*0,21%*
DHA	*451,5 mg/100gr*	*180,7 mg/100gr*	*583 mg/100gr*	*298,3 mg/100gr*
EPA	*186 mg/100gr*	*80,8 mg/100gr*	*279,4 mg/100gr*	*149,3 mg/100gr*
Oleic Acid	*0,10 %*	*0,06 %*	*0,15 %*	*0,10 %*

Anchovies contain many unsaturated fatty acids that are easy to oxidize due to long storage. The amount of fatty acid content is also influenced by the PV value or peroxide number in anchovies. That is because the increased PV value will form hydroperoxides, one of which occurs in the reaction of singlet oxygen with fatty acids. In conclusion, the value of fatty acids is also influenced by the value of the peroxide number in anchovies. Shelf life in anchovies also affects the value of fatty acids because deterioration in fish quality can cause fatty acid components to be damaged. The application of liquid smoke in edible coatings is able to inhibit the oxidation process so that fatty acids can be maintained.. According to Setyastuti et al. (2015), fish treated with liquid smoke have higher levels of fatty acids compared to those without liquid smoke treatment. Liquid smoke as an antioxidant and antimicrobial that can prevent the rancidity process so that damage to unsaturated fatty acids can be avoided. This is reinforced by research by Nashiruddin et al., (2016), the EPA content with liquid smoke immersion has increased. This is because phenol levels are getting higher as a result of the process of soaking into liquid smoke, causing the EPA content to increase. Liquid smoke soaking also increases the content of unsaturated fatty acids, namely oleic acid due to the antioxidant content of liquid smoke

The fatty acids of anchovies in the table above if sorted from easily decomposed fatty acids namely DHA, EPA, palmitic acid, stearic acid and oleic acid.it can be seen from the table above that the decrease in DHA fatty acids is very significant. The fatty acid content in fish usually depends on the species of fish, the age of the fish and the food consumed by the fish. The results of the study, the fatty acid content in anchovies consists of palmitic acid, stearate acid, DHA, EPA, and oleic acid. According to Swastawati et al. (2018), compound components of liquid smoke as antioxidants that prevent rice anchovies from the fat oxidation process so that the EPA and DHA content can be protected from oxidation processes that can be caused by heat, oxygen exposure and processing.

CONCLUSION

The conclusion that can be drawn from the study of the Application of Liquid Smoke in Carrageenan Edible Coating on the Shelf Life of Anchovies (Stolephorus spp) at Room Temperature is that the results of the study showed that the value of moisture content during storage decreased, namely in the control on day 14 while for treatment on day 21. The reduction in treatment protein levels was slower than the control by 30.25-31.32. The decrease in treatment and control fat levels was lowest on day 21 storage. The increase in the value of the control peroxide number was higher than the treatment, which was 0.84 in the control and 0.54 in the treatment. The increase in control TBA values was higher than the treatment, which was 1.34 in the control and 1.11 in the treatment. The fatty acid profile content that is easily decomposed during storage sequentially is DHA, EPA, palmitic acid, stearate acid and oleic acid.

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