Application of duck bone gelatin and sodium alginate-based edible coating materials on beef sausage quality during chilled storage

Muhammad Habbib Khirzin[1*], *Abdul* Holik[2], *Trias* A. Laksanawati[1], *Muhammad* Wildan Habibi[3], *Aisha* R. Fatmawati[1], and *Yuris* B.A. Firani[1]

[1]Livestock Product Processing Technology, Politeknik Negeri Banyuwangi, 68461, Indonesia
[2]Agribusiness, Politeknik Negeri Banyuwangi, 68461 Banyuwangi, Indonesia
[3]Natural Science Teaching, UIN Kyai Haji Achmad Siddiq Jember, 68136 Jember, Indonesia

Abstract. Edible coating is an eco-friendly packaging that is starting to be widely used as a primary packaging for processed meats such as sausages. One of the raw materials for making edible coatings was gelatin extracted from duck bones. The combination of gelatin with sodium alginate was expected to improve the quality of sausages. This research was conducted to study the efficacy of duck bone gelatin and sodium alginate coating materials on beef sausage quality during chilled storage. A randomized group design was used as an experimental design with four replications. The independent variable was storage time. The result showed that free fatty acid, protein content, total microbial count, and weight loss increased during storage. Meanwhile, moisture content, pH, color, aroma, and texture decreased. Non-coated sausage during 2 weeks of storage had a free fatty acid value of 1.23%, protein content of 16.21%, TPC of 7.38 log cfu/g, weight loss of 13.94%, moisture content of 60.43%, pH of 5.62, color of 2.3, aroma of 1.5, and texture of 1.9. Sausages with edible coating for 4 weeks of storage had a free fatty acid of 1.34%, protein content of 15.95%, TPC of 6.92 log cfu/g, weight loss of 14.72%, moisture content of 59.73%, pH of 5.67, color of 1.9, aroma of 1.8, and texture of 2.1.

1 Introduction

Packaging is a container used to protect products from spoilage [1]. The packaging that is often used is usually made from plastic, whether primary or secondary packaging [2]. This type of packaging has a weakness, namely low biodegradability, which makes it a source of increased waste. BPS data [3] shows that plastic waste in 2023 will reach 69 tons. One effort that can be made to reduce plastic waste is the use of environmentally friendly packaging such as edible packaging. Edible packaging is divided into three types, namely edible film, edible coating, and encapsulation [4]. Edible coating is packaging that comes from natural ingredients. Various studies show that edible coatings can act as anti-browning, antimicrobial, flavoring agents and as colorants [5]. The three main components

[*] Corresponding author: habbibkhirzin@poliwangi.ac.id

that make up edible coatings are hydrocolloids, lipids and composites. One of the hydrocolloids that can be used as a raw material for making edible coatings is gelatin, which is extracted from duck bones. Previous research, as reported by [6] stated that gelatin extracted from duck bones has physicochemical properties similar to commercial gelatin and meets SNI standards. [7] added that the use of gelatin composite materials with carbohydrate-based hydrocolloids (carrageenan, agar and starch) has the ability to coat products such as conventional plastics. This packaging can be used as primary packaging for processed meat products such as sausages.

The main purpose of using primary packaging is to protect the product from damage. Sausage casings generally use plastic [8]. Casing substitution with environmentally friendly materials, such as edible coatings, is a new trend in the packaging industry. The use of gelatin as an ingredient in making edible coatings has been widely studied. An edible coating made from a composite of beef gelatin and soybean isolate is able to maintain the quality of chicken sausages for up to 15 days during chilled storage [9]. An edible coating made from gelatin and chitosan composites is able to maintain the organoleptic quality of beef steak for 5 days at room temperature [10]. Antimicrobial agents from gelatin-based edible coatings are able to reduce *L. monocytogenes* contamination in turkey carcasses [11]. Gelatin and CMC composites with the addition of potassium sorbate have also been reported to be able to extend the shelf life of bacon during chilled storage [12]. The use of gelatin from duck bones as an ingredient for making edible films has been previously reported by [13]. However, information regarding the use of duck bone gelatin composites with hydrocolloids such as sodium alginate as a sausage coating material has not been widely reported. Therefore, this research was conducted to study the efficacy of duck bone gelatin and sodium alginate coating materials on beef sausage quality during chilled storage.

2 Materials and method

2.1 Materials

The main materials used in this study were duck boned obtained form local slaughterhouse, sodium alginate (Merck), glycerol, aquadest, meat, tapioca starch, and seasoning powder. Chemicals needed for the analysis include NaOH, HCl, phenolphthalein, 95% ethyl alcohol, H_2SO_4, kjeldahl tablet, boric acid, methylene blue, PCA (plate count agar), and physiological NaCl. All reagents used in this research were of analytical grade.

2.2 Gelatin extraction

This research was divided into 4 stages namely, duck bone gelatin extraction, sausage production, edible coating production, and application of edible coating to sausages. The preparation of duck bone gelatin was based on the methods of Abedinia *et al.* [14] and Abdullah *et al.* [15] with slight modifications. The bones were soaked in distilled water and then heated at 80°C for 1 hour to remove any remaining dirt. The bones were cut into 2-3 cm pieces and then soaked in 1.75 M NaOH 1:5 (w/v) for 2 hours. The bones were neutralized with distilled water and then soaked in 1 M HCl 1:5 (w/v) for 12 hours. The bones were neutralized again with distilled water. Soft bones (ossein) were soaked in distilled water 1:3 (w/v), then heated to 75 ^{0}C for 2 hours, and filtered using a cheesecloth. Ossein was reheated to 85 ^{0}C for 2 hours, then filtered. The filtrate from the first and second screenings was collected and then centrifuged at 7000 rpm for 15 minutes. The pellets were then dried in a vacuum oven to form powdered gelatin.

2.3 Making sausage, edible coating manufacture and application

The preparation procedures used to make sausage are described in [16]. 1000 grams of beef cut into small pieces and ground using a meat grinder. Next, flour and spices were mixed into the meat and made into a homogeneous dough. Sausage dough was formed using a stuffer and inserted into the sleeve. Sausages were boiled at 85-90 °C for 15-20 minutes, then cooled and ready to use. The procedure for making edible coating refers to [7]. 2% duck bone gelatin powder is dissolved in 100 ml of distilled water and then heated until completely dissolved. After that, 1% sodium alginate and 2 ml of glycerol were added to the solution then stirred using a hot plate stirrer at 70 °C for 5 minutes until an edible coating solution was formed. The procedure for coating beef sausage using edible coating begins with removing the sausage from the casing. Furthermore, the sausages were dipped in the edible coating solution for 5 minutes. Dyeing was repeated three times at the same time. Sausages that had been coated with an edible coating were then stored at 4 °C and observed in weeks 0, 1, 2, 3, and 4. Sausages without coating were used as control with the same storage time.

2.4 Analysis of sample

2.4.1 Free fatty acid (%)

Ten grams of sample were put into a 250 ml Erlenmeyer flask. Then it was dissolved in 50 ml of hot 95% ethyl alcohol, and then 5 drops of phenolphtalein were added. Next, stir with a magnetic stirrer for 30 seconds, and then titrate with 0.1 N NaOH solution. The titration is stopped if the color of the solution changes to pink, which takes more than 10 seconds. Free fatty acid levels were calculated in percentage (%) [17].

2.4.2 pH

The pH value was measured using a pH meter. The pH meter is calibrated with a pH 7.0 buffer solution. Next, the pH meter needle is inserted into the sausage, and its value is measured

2.4.3 Weight loss (%)

Sausages that have been stored in refrigerator and placed in a petri dish that is known to be weighed. Weight loss value calculated by weighing on a petry dish for 1-4 weeks. Weight loss was calculated in percentage (%) [9].

2.4.4 Moisture content (%)

The dish was sterilized and then put in the desiccator. The dish was weighed using an analytical balance, then 2 grams of sample were put into the dish and put in the oven at 105 °C for 6 hours or until a constant weight was obtained. The dish was cooled in a desiccator and then weighed. Water content expressed as a percentage (%) [18].

2.4.5 Protein content (%)

Two grams of sample were dissolved in 25 ml of 96% sulfuric acid and then added to kjeldahl tablets. The sample was digested for 3 hours, or until the liquid was clear green in

color. The sample was distilled with 3% boric acid. The sample was added with 3 drops of phenolphthalein indicator and then titrated using 0.1 M HCl until it was pink. Protein content was calculated as a percentage (%) [18].

2.4.6 Total plate count

One gram of the sample was crushed using a mortar. The sample was then put into a test tube containing 9 mL of peptone water solution, then vortexed until the solution was homogeneous and calculated as the first dilution. The solution was diluted to the 6th dilution using a reaction tube. The solution was poured into a petri dish, then 15 mL of sterile PCA media solution was poured over it until it was evenly distributed. The petri dish was then incubated for 24 hours at 37°C in the incubator. The number of bacteria that grew was counted using a colony counter [19].

2.4.7 Organoleptic test

Organoleptic tests were carried out on control sausages and sausages that were given an edible coating during storage for 1 to 4 weeks. Organoleptic testing uses a score sheet with the criteria number 1 as the lowest value and 5 as the highest value. Parameters observed were color, aroma, and texture [20].

3 Design experiment

This study used a factorial, Completely Randomized Design (CRD) with two factors and five treatment levels. The research factors consist of factor A, namely for beef sausages without edible coating (NC) and factor B for beef sausages with edible coating (EC). Treatment levels are storage times of 0, 1, 2, 3, and 4 weeks. Each treatment was repeated three times, so there were a total of 30 research samples. All data was analysed using analysis of variance (ANOVA) and the means were separated using the Duncan Multiple Range Test (DMRT) at 5% probability level (SPSS version 20).

4 Result and discussion

4.1 Physicochemical and Microbiology Test

The result of the physicochemical and microbiology tests are presented in Table 1.

Table 1. Physicochemical and microbiology tests of sausage during storage.

Parameters		**Storage Time (weeks)**				
		T0	**T1**	**T2**	**T3**	**T4**
Free fatty acid (%)	NC	0.56 ± 0.07^{e}	0.84 ± 0.07^{d}	1.23 ± 0.03^{c}	1.36 ± 0.05^{b}	1.49 ± 0.04^{a}
	EC	0.54 ± 0.08^{d}	0.75 ± 0.08^{c}	0.84 ± 0.04^{c}	1.13 ± 0.07^{b}	1.34 ± 0.05^{a}
pH	NC	6.04 ± 0.01^{a}	5.84 ± 0.02^{b}	5.62 ± 0.01^{c}	5.55 ± 0.03^{d}	5.50 ± 0.04^{e}
	EC	6.03 ± 0.03^{a}	5.99 ± 0.07^{a}	5.83 ± 0.03^{b}	5.73 ± 0.04^{bc}	5.67 ± 0.11^{c}
Moisture Content (%)	NC	70.54 ± 0.52^{a}	65.46 ± 0.48^{b}	60.43 ± 1.44^{c}	57.12 ± 0.56^{d}	54.09 ± 0.78^{e}
	EC	70.06 ± 0.62^{a}	67.19 ± 1.57^{b}	64.75 ± 0.93^{c}	62.15 ± 0.70^{d}	59.73 ± 0.54^{e}
Protein Content (%)	NC	12.54 ± 0.17^{e}	14.76 ± 0.63^{d}	16.21 ± 0.14^{c}	17.57 ± 0.80^{b}	19.71 ± 0.86^{a}
	EC	12.29 ± 0.27^{c}	13.33 ± 0.58^{b}	14.99 ± 0.03^{a}	15.57 ± 0.32^{a}	15.95 ± 0.98^{a}
Weight Loss (%)	NC	1.13 ± 0.30^{e}	7.58 ± 0.36^{d}	13.94 ± 0.14^{c}	16.90 ± 0.20^{b}	19.92 ± 0.83^{a}
	EC	0.66 ± 0.83^{e}	4.71 ± 0.25^{d}	9.37 ± 0.29^{c}	10.57 ± 0.53^{b}	14.71 ± 0.19^{a}

TPC (log cfu/g)	NC	3.05 ± 0.60[d]	5.18 ± 0.07[c]	7.38 ± 0.46[b]	8.58 ± 0.29[a]	8.05 ± 0.71[ab]
	EC	2.99 ± 0.45[c]	3.40 ± 0.23[c]	5.47 ± 0.32[b]	5.80 ± 0.25[b]	6.92 ± 0.50[a]

Values are presented as means ± standard deviation of four replicate experiments.
T0, 0 weeks ; T1, 1 weeks ; T2, 2 weeks ; T3, 3 weeks ; T4, 4 weeks.
NC, non coating treatment ; EC, edible coating treatment
[a-e] Figures with different letters within the same rows differ significantly ($p<0.05$).

4.1.1 Free fatty acid

The storage time was found to have a significant effect ($P<0.05$) on FFA percentage. The mean initial FFA percentage was 0.54 ± 0.08 and 0.56 ± 0.07 % for the edible coating sausage and control during chilled storage, respectively. FFA percentage increases with increasing storage time. Initial FFA increased to final FFA of 1.34 ± 0.05 and 1.49 ± 0.04 % for the edible coating sausage and control treatment, respectively. This reflected a 0.8 and 0.93% increase of FFA for the edible coating sausage and control treatment during chilled storage, respectively. The decrease in the quality of sausages during storage occurs due to oxidation reactions and fat hydrolysis, which produce free fatty acids [21]. Oxidation reactions and fat hydrolysis can occur quickly in the presence of water content in foodstuffs [22].

Sausages without an edible coating (NC) had an FFA value of 1.23% at 2 weeks of storage, while sausages with an edible coating (EC) had an FFA value of 1.13 % at 3 weeks. The maximum limit for the FFA value in a food product is 1% [23]. Edible coatings made from gelatin are able to act as a barrier to air entering the product during storage. coatings can slow down oxygen penetration because the coating matrix has tight, strong, and compact bonds, so the possibility of oxidation processes occurring is also lower. This is why sausages with EC are more able to withstand the rate of oxidation than sausages with NC [24]. The FFA value that increases during storage is the result of the product triggering the destruction of the volatile fraction in the product, which causes rancidity. The edible coating used has a certain density so that the availability of oxygen on the surface of the sausage is reduced [25]. Ratnaduhita and Wianto [26] reported that chicken sausages coated with cassava flour-based edible film were better able to withstand the rate of oxidation compared to sausages without edible coating.

4.1.2 pH

The effect of edible coating on pH in sausage was determined over the 4 weeks of storage periods. The storage time was found to have a significant effect ($P<0.05$) on pH. pH values were 6.03 ± 0.03 and 6.04 ± 0.01 for the edible coating sausage and control during chilled storage, respectively, at the beginning of the storage periods. The control treatment had a lower pH value than the edible coating sausage at the end of storage. The final pH of each treatment was 5.67 ± 0.11 and 5.50 ± 0.04. It can be said that the pH value decreased by 0.36 for the edible coating treatment and 0.54 for the control treatment. [27] state that a decrease in pH value is related to an increase in the amount of acid present in a food product. The longer the storage time, the total percentage of acid increases due to microbial activity that produces other organic acids such as acetic acid, formic acid, and diacetyl. Asiah *et al*. [28] add the statement that microbes can still carry out metabolic activities during cold storage even though they run slowly. Acid compounds resulting from microbial secondary metabolites cause the pH value to decrease.

The decrease in the pH value of sausages with edible coating was slower than the control. This can happen because the edible coating of sausage has a layer containing duck bone gelatin, which is incorporated with Na-alginate. Edible coating are able to protect the

product from microbial damage. Gelatin has the ability to block oxygen from damaging food [29]. Sodium alginate can be a barrier against air and light. The combination of these two materials is known to form a layer that has a strong and dense matrix so that it will minimize the contact between food ingredients and oxygen [30].

The acidic compounds produced by microbes will be inhibited by the edible coating layer, which acts as an antioxidant during storage, so that the pH value of the sausages coated with edible coating is higher when compared to the control. The control treatment does not have a layer that acts as an antioxidant, so the pH value decreases more quickly. According to [31], hydrocolloid incorporated in a coating solution has the ability to act as a chelating agent so that it can function as an antioxidant compound. [32] state that the coating material is made by heating at a temperature above 80° C for 15 minutes. This causes the formation of intermolecular disulfide bonds and hydrophobic interactions, which produce antioxidant activity.

4.1.3 Moisture content

The result of the variance analysis in Table 1 showed that the difference in storage time had a significant effect ($P<0.05$) on moisture content. The moisture content were approximately 70.06 ± 0.62 and 70.54 ± 0.52 % for the edible coating sausage and control during chilled storage, respectively, at the beginning of the storage periods. Initial moisture content decreased to final moisture content of 59.73 ± 0.54 and 54.09 ± 0.78 % for the edible coating sausage and control, respectively. This reflected a 14.74 and 23.32 % loss of moisture content for each treatment during research periods. The ambient temperature and humidity in the storage room can affect the moisture content. A decrease in water content can occur due to the release of free water from inside the sausage. The free water that comes out of the sausage is used by microorganisms for growth [33]. [34] stated that during chilled storage there was activity of endogenous and microbial protease enzymes that could damage the protein content in the sausage so that the protein could not bind water. The reduced ability of meat to bind water indicates a loss of myofibrillar protein integrity and the presence of microbial activity during cold storage.

Both the edible coating and control treatment experienced a decrease in moisture content. However, the control treatment experienced a greater rate of decrease in moisture content. This is thought to be due to the absence of a layer that is able to withstand the evaporation of free water from the sausage during chilled storage. An edible coating of gelatin can bind water when applied to food [7]. [30] state that the use of alginate as a basic material for making edible coatings can also be a cause of decreased moisture content. This is because alginate has the property of being able to immobilize water, which causes the amount of absorbed water and free water in food to decrease.

The combination of gelatin and sodium alginate raw materials in the manufacture of edible coatings is known to be able to withstand the rate of decrease in moisture content. This combination is known to have hydrophilic groups that bind to each other to form a three-dimensional matrix. Water vapor that will come out of the food during the desorption process during storage will be trapped in the matrix, so the moisture content value of coated sausages has a higher value when compared to the control. Similar research, as reported by [24] stated that pork sausage coated with stingray gelatin had a water content of between 69.9 and 75.8%. The edible coating treatment has a higher water content compared to the control.

4.1.4 Protein content

The initial protein content increased from 12.29±0.27 to 15.95 ±0.98% for the edible coating sausage during chilled storage. Meanwhile, the protein content of the control treatment increased from 12.54±0.17 to 19.71±0.86% during 4 weeks of storage. The storage time had a significant effect (P<0.05) on protein content. The increase in protein content during storage is due to free water evaporating from the sausage. This causes the sausage to become dry and affects the protein percentage in the sample. [35] state that the decrease in water content in sausages causes protein levels to become high during storage. This is a material equilibrium pattern. Sausages become drier and denser as protein increases.

Sausages in the control treatment had higher protein content values than edible coating sausages. The minimum protein content in processed meat products is 13% [20]. The control treatment and edible coating still meet these standards. Similar to the research reported by [36], sausage protein content increased from 19.14 to 43.42% during 21 days of storage. Meanwhile, [37] reported that the protein content of chicken meat increased from 18.75 to 19.51% during storage.

4.1.5 Weight loss

The effect of edible coating on weight loss in sausage was determined over the 4 weeks of storage periods. The storage time was found to have a significant effect (P<0.05) on weight loss. Weight loss values were 0.66 ± 0.83 and 1.13 ± 0.30 for the edible coating sausage and control during chilled storage, respectively, at the beginning of the storage periods. The control treatment had higher weight loss value than edible coating sausage at the end of storage times. The final weight loss for each treatment was 14.71 ± 0.19 and 19.92 ± 0.83. The weight loss value shows the ability of a material to withstand the rate of water evaporation from the food. The increase in weight loss usually follows the rate of increase in free water. A food product is said to be stable if it has a low weight loss value [38].

The edible coating treatment had a slower rate of increase in weight loss compared to the control. This is because the edible coating is able to resist free water evaporation from the sausage, so that the moisture content is maintained. The cross-links formed between the components that make up edible coatings can reduce the rate of water evaporation. Weight loss was influenced by water loss during storage. Weight loss will be high if water loss is high [9]. [39] state that edible coating is a good component in retaining oxygen and water. This type of packaging is widely applied to processed meat, fish, semi-wet food and fruit products.

The weight loss value is related to the water content value. The lower the moisture content, the more free water comes out of the sausage. This results in higher weight loss. [36] reported in their research that the weight loss of fermented sausages increased from 3.23% to 47.34% during 21 days of storage. [9] also reported that chicken sausages with an edible coating experienced an increase in weight loss from 1.09 to 13.77% during 15 days of storage.

4.1.6 Microbial count

The treatment of edible coatings and controls had a significant effect (P<0.05) on total microbes. The total microbial value increased from 2.99 ± 0.45 to 6.92 ± 0.50 cfu/g for the edible coating treatment. The control treatment had a higher value, namely from 3.05 ± 0.60 to 8.05 ± 0.71 cfu/g. It can be said that the total bacteria in the edible coating treatment increased 2.3 times from the initial number, while the control treatment increased 2.6 times from the total bacteria at the beginning of storage. According to [40], psychrophilic-type bacteria can still carry out metabolic and biological activities during chilled storage even

though they run slowly. This bacteria can grow at a temperature of 0-5° C. [41] reported that the combination of gelatin and essential oil from lemongrass in making edible coatings is able to inhibit bacterial growth in up to 2 phases in snapper slices.

The maximum limit for the number of bacteria in food products is 5.0 log cfu/g [20]. The edible coating treatment reached its maximum limit at 2 weeks of storage, while the control treatment reached its maximum limit at 1 weeks of storage. The edible coating is a layer that can withstand the rate of water and oxygen so that it inhibits the growth of bacteria. Structural proteins such as gelatin have a good chemical structure in the manufacture of coatings [9]. [42] reported that edible film based on chicken leg can inhibit *S.aureus* and *E. Coli* on meat product.

Total bacteria were closely related to the parameters of water content and pH. The water content of sausages during storage decreased. This is due to free water that evaporates. This free water was used by bacteria for growth. Bacteria produce secondary metabolites, so this causes the pH value to become acidic. The longer the storage time, the lower the pH due to increased bacterial growth. Similar research was reported by [43]. Fish sausage coated with semi-refined carrageenan had a total bacteria value of between 2.03 and 3.66 cfu/g. While [24] reported that gelatin-coated sausage had total bacteria value of 5.5 log cfu/g during 4 weeks of storage. [44] also reported that *pempek* which was given a nanocomposite edible coating, had a total bacterial value of 6.0 log cfu/g at room temperature storage for 48 hours.

4.2 Organoleptic Test

The result of the organoleptic tests are presented in Table 2.

Table 2. Organoleptic tests of sausage during storage.

Parameters		Storage Time (weeks)				
		0	**1**	**2**	**3**	**4**
Color	NC	4.80 ± 0.20^{a}	3.73 ± 0.21^{b}	2.30 ± 0.10^{c}	1.93 ± 0.10^{cd}	1.52 ± 0.15^{d}
	EC	4.90 ± 0.17^{a}	4.10 ± 0.20^{b}	3.37 ± 0.25^{c}	2.93 ± 0.15^{c}	1.97 ± 0.12^{d}
Aroma	NC	4.90 ± 0.17^{a}	3.60 ± 0.50^{b}	1.50 ± 0.10^{c}	1.30 ± 0.10^{c}	1.13 ± 0.06^{c}
	EC	4.93 ± 0.06^{a}	4.30 ± 0.20^{b}	3.30 ± 0.26^{c}	2.37 ± 0.25^{d}	1.87 ± 0.21^{e}
Texture	NC	4.93 ± 0.12^{a}	3.60 ± 0.36^{b}	1.93 ± 0.15^{c}	1.73 ± 0.15^{cd}	1.40 ± 0.10^{d}
	EC	4.90 ± 0.17^{a}	4.07 ± 0.15^{b}	3.40 ± 0.26^{c}	2.73 ± 0.15^{d}	2.13 ± 0.15^{e}

Values are presented as means ± standard deviation of four replicate experiments
T0, 0 weeks ; T1, 1 weeks ; T2, 2 weeks ; T3, 3 weeks ; T4, 4 weeks.
NC, non coating treatment ; EC, edible coating treatment
[a-e] Figures with different letters within the same rows differ significantly ($p<0.05$).

4.2.1 Color

The result of variance analysis in Table 2 showed that the difference in storage time had a significant effect ($P<0.05$) on color. The color value both of edible coating sausage and control treatment decreased during chilled storage. But the decrease in color values in edible coating sausages took longer than the control. The control treatment had a value of 1.9 at 3 weeks of storage, while the edible sausages had a value of 1.9 at 4 weeks of storage. Sausages are declared unfit for acceptance if the color value is 1, which means dark brown. The longer storage time, the more the sausage to turn brown. The browning phenomenon in sausages is thought to occur due to an oxidation reaction. [45] stated that oxidation reactions can have an impact on the occurrence of changes in color pigments, so that the meat will turn darker. Changes in color during storage can occur because the

myoglobin contained in the sausage is oxidized to produce metmyoglobin, which causes the sausage to have a dark color.

Color data is closely related to FFA. The increase in FFA value is accompanied by a decrease in color value. The increase in FFA occurs due to oxidation reactions. The same thing happens with color. Edible coatings based on gelatin and na-alginate are able to withstand the rate of color loss in sausages. [46] state that gelatin has the physical properties of being transparent and brightly colored. Gelatin is able to resist product damage from oxygen and light. Gelatin-based food product coatings are able to withstand the rate of quality degradation.

4.2.2 Aroma

Data in table 2 showed the control sausage had a lower aroma value than edible coating sausage over the 4 weeks of chilled storage. The aroma value significantly ($P<0.05$) decreased for both of control sausage and edible coating sausage. The control treatment had a value of 1.5 at 2 weeks of storage, while the edible sausages had value of 1.87 at 4 weeks of storage. Sausages are declared unfit for acceptance if the aroma value is 1, which means acid/sour. The sour smell of sausages is caused by bacteria. [7] stated that the factor that influences the reduction of aroma in sausages is microbial activity. Bacteria produce secondary metabolites in the form of acidic compounds during growth.

Aroma data is related to pH and total bacteria. Total bacteria during storage increased, while pH and aroma decreased. The edible coating treatment was more able to extend the shelf life compared to the control. According to [47], the three-dimensional structure produced by edible coating is able to protect the product from oxygen. This causes bacterial growth to be inhibited, so that the formation of acid compounds takes longer. Junge *et al.* [40] state that psychrophilic bacteria can still grow at low temperatures. These bacteria produce acid compounds that cause product damage.

4.2.3 Texture

The treatment of edible coatings and controls had a significant effect ($P<0.05$) on texture. The texture value decreased from 4.90 ± 0.17 to 2.13 ± 0.15 for the edible coating treatment after 4 weeks of storage. The control treatment had a lower value, namely from 4.93 ± 0.12 to 1.93 ± 0.15 at 2 weeks of storage. Sausages are declared unfit for acceptance if the texture value is 1, which means hard. Generally, sausages have a cohesive texture. Texture data is closely related to moisture content. The moisture content decreases during chilled storage. This is also accompanied by a decline in hardness. According to Zhang *et al.* [48], the functional properties of protein include being able to absorb and retain water so that the compact texture of the product is maintained. The use of gelatin combined with na-alginate was able to maintain the rate of decrease in the texture of the sausage.

5 Conclusion

The application of a duck bone gelatin and sodium alginate as an edible coating on beef sausage during chilled storage has a significant effect ($P<0.05$) on free fatty acid, pH, moisture content, protein content, weight loss, total microbe, and organoleptic properties (color, aroma, texture). Edible coating sausage was still acceptable until 4 weeks of storage, except for free fatty acid and total microbial parameters. The edible coating was able to inhibit the decline in sausage quality compared to the control treatment.

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