Characterization of Sodium Alginate-Based Edible Film with Addition of Gelatin and Casein

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Abstract. Edible film is a form of biodegradable packaging that is easily biodegradable and can be consumed at the same time with the product. The purpose of this study is to find characterization of edible films including physical tests (thickness, tensile strength, elongation, elasticity and high temperature resistance), chemical tests (water content and water vapor transmission rate), solubility tests and biodegradability tests on sodium alginate/glicerol-based edible films with the addition of gelatin and casein. This study was conducted using the single factor group random design method with data analysis using SPSS 29 software. The results showed that edible films made from only sodium alginate and glycerol only have advantages in characteristics of elasticity, edible films made from sodium alginate, glycerol and gelatin have advantages in characteristics of elongation, water content, solubility and biodegradability. Edible films made from sodium alginate, glycerol and casein have advantages in characteristics of consumer preferences, thickness, tensile strength, high temperature resistance and water vapor transmission rate.

1 Introduction

In the last two decades, plastic packaging has captured the world's packaging market share replacing cans and glass packaging. Plastic-based goods are synthetic polymer materials that are difficult to degrade in nature. The increase in the use of plastic-based goods is directly proportional to the plastic waste produced, which ultimately leads to the breakdown of the balance of nature [1]. Typically, edible packaging provides a consumable coating or wrapping made of sustainable, biodegradable material around the food, which leads to no waste being produced.

One of the packaging that can be used as an alternative is biodegradable packaging, which is packaging that is easily decomposed by the activity of microorganisms after being used and disposed of into the environment. In addition, biodegradable packaging is able to ensure product safety [2]. Packaging applications with edible materials can be done by coating the product directly with edible solutions that are made first [3]. Edible film is used to maintain the shelf life and quality of food products because it can inhibit the migration of water, oxygen, carbon dioxide, flavor and fat [4]. Edible film is a thin layer that has a function as a packaging material or coating for food ingredients that can also be eaten together with packaged products, and can be degraded by nature biologically [5].

One of the raw materials used in making edible film is sodium alginate. The function of *edible film* on sodium alginate in addition to protecting food products is also the original

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appearance of the product can be maintained. Sodium alginate compounds have the potential to form biopolymer film or coating components because sodium alginate has a unique colloidal structure, as a stabilizer, binder, suspension, film forming, gelling and emulsion stability [6]. However*, sodium* alginate-based edibles have weaknesses where their resistance to water is low, has properties that are easily oxidized and barrier properties to water vapor are also low so that it can affect the quality of the film produced and this deficiency will affect the shelf life of food to be less optimal [7]. For that, it is necessary to add other protein ingredients such as gelatin and casein.

Gelatin is a substance obtained from the extraction of cartilage collagen or animal skin such as cows, fish and pigs [8]. In applications in edible film, gelatin has the expected properties in its ability to form films and its high barrier properties. In addition, gelatin-based films can be used as carriers of bioactive additives so that they can achieve active packaging functions and are able to protect food from oxidation [9]. Gelatin is one of the edible film forming materials that has transparent, strong, flexible and able to inhibit the transfer of oxygen and carbon dioxide and film from skin gelatin material has properties that are not compact and sticky, therefore it is necessary to add ingredients that can improve the physical quality of edible film, namely casein protein [10]. Edible film from casein is a technology that makes for food preservation and can be used as an alternative to synthetic polymers. Films and layers made of casein are easily formed due to their exposed secondary structure [11]. The film also contains a barrier against water vapor, oxygen and carbon. The purpose of the study was to find characteristic of sodium alginate/glycerol-based edible films with the addition of gelatin and casein. which is resistant to heat during the processing of sausage products, has biodegradable properties, consumers acceptance, low of water vapor transmission rate, good in elongation, solubility and high tensile strength.

2 Materials and Method

2.1 Materials

The materials used in this study were food grade sodium alginate (Ocean Health), food grade casein (International Healthcare), food grade and halal gelatin (Gelita), food grade glycerol (Wilmar), aquades, food grade silica gel(natural from Zeloid quarry rock), water and soil medium. The equipmentss used in this study were beaker glass (pyrex), measuring cup (pyrex), 1 mL drip pipette (OneMed), hotplate stirrer (HMS-79), petri dish (OneMed), porcelain cup (pyrex), spatula (stainless steel), glass jar, silicon mold 15 x 15 cm, analytical balance accuracy 0.01 gram (Jadever), dehydrator (DHY-D5A), oven (Kirin), aluminum foil, thermometer rod, 0.01 mm accuracy micrometer, distillation tool, gas stove, plastic container, boiling pan (stainless steel), gas stove, Universal Testing Machine and moisture analyzer (Radwag).

2.2 Preparation of Edible film

Edible film made consists of three treatments or formulas, namely: 1) sodium alginate with added glycerol and aquades; 2) sodium alginate with added glycerol, aquades and gelatin; 3) sodium alginate with added glycerol, aquades and casein. The preparation of edible film is carried out by referring to [12], which has been modified, namely sodium alginate weighed as much as 3 g, and put into a 250 mL erlenmeyer with 100 mL aquades added, then added 10% glycerol (b/w) then stirred with a magnetic stirrer and heated with a *hotplate* at 70°C for 15 minutes. After that, the edible solution of film condition is poured on a glass mold measuring 15*15 cm and dried using a 50°C oven for 24 hours. For the the second treatment/formula an addition of 6 grams of gelatin was added and the third treatment/formula added 7 grams of casein. Each treatment/formula is made three times.

2.3 Consumer Preferences

Consumer preference testing of sodium alginate-based edible films was carried out by testing favorability using 30 panelists. Panelists were asked to rate the appearance, texture and aroma of edible film based on a hedonic score sheet on a scale of 1-9 with scale 1 very disliked, scale 5 neutral and scale 9 very fond. Hedonic testing is carried out on each edible film making treatment.

2.4 Characterization of edible films

2.4.1 Thickness of edible film

The thickness test refers to [13]. The film solution is poured with a film mold silicon plate with a size of 15 x 15 cm and flattened with a film leveling silicon plate until it forms a thin and flat sheet of film. Then allowed to dry and put in the oven at 50°C for 24 hours. After being lifted from the oven, the edible film is removed from the mold and placed on a plastic mat and placed in a kelium plastic bag [14]. For silicon plates, square plates with sides measuring 15 cm and 5 cm high are used. Thickness is measured using a digital micrometer (accuracy 0.001 mm) measured at 5 points thus representing the sample and improving accuracy.

2.4.2 Tensile strength

Tensile strength testing was carried out referring to [15]. Edible film is cut according to standard provisions. Both ends of the sample are clamped to the tensile testing machine found in the universal testing machine. The machine is set with a starting distance between the clamps of 10 mm and a speed of 10 mm/min. Next, the initial length is recorded and the ink tip of the logger is placed at position 0 in the graph. The start button is pressed and the tool will pull the sample until it breaks and the tensile strength (Fmax) is recorded by measuring the amount of tensile force required until a sample is disconnected. Then the tensile strength will be obtained by the following equation:

$$\gamma = \frac{Fmax}{A} \times 100\ \%$$

2.4.3 Elongation

The elongation test refers to [15], which is based on the lengthening of the film when the film breaks. The percentage of elongation is measured using the Universal Testing Machine. The measurement of break elongation is carried out in the same way as tensile strength testing. The extension is calculated by the following equation: :

$$Elongation\ (\%) = \frac{strain\ at\ breaks\ length\ (mm)}{initial\ length\ (mm)} \times 100\%$$

2.4.4 Elasticity

Elasticity is a measure of the flexibility of an object or the ability of objects to return to their original shape after being subjected to attractive or compressive forces. Formulated elasticity through a comparison of tensile strength and elongation further expressed in Mega Pascal [16], formulated by the equation:

$$Elasticity(MPa) = \frac{tensile\ strength}{elongation}$$

2.4.5 High temperatures resistance

The high temperatures resistance test is carried out by making a film measuring 5 x 5 cm which will be inserted into a waterbath with a temperature adjusted to the cooking temperature of the sausage, which is 80^{O}C for 40 minutes [17]. Then periodic checks are carried out every five minutes on the film by paying attention to the solubility of the film to water decoction and the resistance of the film to the temperature of heating water.

2.4.6 Water content

The way this method works, is that an empty cup is heated in an oven at 105^{0}C for 30 minutes for drying cup, then cooled in a desiccator for 15 minutes and weighed (W0). Then a sample of 2 grams is put in a dish that has known weight, weighed (W1), then dried in the oven at 105^{0}C for 3 hours to evaporate water inside sample and cooled in a desiccator for 15-30 minutes. Next, the cup and its contents are weighed and dried again for 1 hour, and cooled in a desiccator and finally weighed again (W2).

$$Water\ content\ (\%) = \frac{W1 - W2}{W1 - W0} \times 100$$

2.4.7 Water vapor transmission rate (WVTR)

Water vapor transmission rate testing (ASTM E96-01, 1997), *edible film* cut with a diameter of 4.5 cm (adjusting to the diameter of a beaker glass of 50 mL as a water vapor transmission test medium). The film is placed on top of the beaker glass until it covers the surface of the beaker glass that has been filled with 2 grams of silica gel (0% relative humidity), then tightened with a rubber band. The cup is weighed, then placed into a goblet glass containing aquades (relative humidity 100%, temperature 28^{0}C). The cup is weighed at intervals of 24 hours.

2.4.8 Solubility

Solubility testing of edible film is carried out by cutting edible film and weighing as much as 2 grams then immersed in aquades for 24 hours. The sample is then filtered and then dried at 100^{0}C for 30 minutes. The solubility of *edible film* can be calculated by the equation:

$$Solubility(\%) = \frac{\Delta W}{W0} \times 100$$

2.4.9 Biodegradability

Biodegradability tests are performed to determine the speed of edible films in being degraded by microorganisms in an environment. Biodegradability test using soil burial test method or burial method. Film samples are cut to a weight of 3 x 3 cm. The sample was weighed initially (2 grams) before burial (W1). The samples were buried for 12 days in soil containing compost and cow dung as a source of microorganisms to degrade the film. Samples are observed every 3 days by taking samples and cleaning the soil with tissues, then weighing the final weight (W2). Next, the percent weight loss and biodegradability rate are calculated with the following equation [18].

$$Biodegradability(\%) = \frac{W1 - W2}{W1} \times 100$$

2.5 Data analysis

The research design used was a one-way group randomized design with 3 repeats. The data were analyzed with Kruskal-Wallis and analysis of variance (ANOVA) using SPSS 29 software.

3 Result and Discussion

3.1 Consumer preferences

Consumer preference test is a test to determine the level of liking or acceptability of edible film. The results of hedonic rating tests on several edible attributes of alginate-based films can be seen in Table 1.

Table 1. Characteristic of sodium alginate/glycerol-based edible film with addition of gelatin and casein

Characteristic	Edible film			
	Na alginate+Glycerol	**Na alginate+Gelatin +Glycerol**	**Na alginate+Casein+ Glycerol**	**Commercial (control)**
Consumer preferences -Appearance -Texture -Aroma	 8.29 ± 0.42 [a] 8.28 ± 0.34 [a] 8.72 ± 0.34 [a]	 6.42 ± 0.26 [b] 8.69 ± 0.33 [b] 6.28 ± 0.44 [b]	 8.68 ± 0.43 [c] 8.68 ± 0.47 [bc] 8.74 ± 0.41 [ac]	 - - -
Thickness (mm)	0.11 ± 0.01 [c]	0.14 ± 0.01 [d]	0.10 ± 0.01 [b]	0.08 ± 0.01[a]
Tensile strength (MPa)	10.69 ± 0.03 [c]	7.12 ± 0.09 [a]	14.78 ± 0.02 [d]	7.30 ± 0.01 [b]
Elongation (%)	41.98 ± 0.07 [b]	95.11 ± 0.10 [d]	66.64 ± 0.07 [c]	13.04 ± 0.02 [a]
Elasticity (MPa)	0.25 ± 0.00 [c]	0.07 ± 0.00 [a]	0.22 ± 0.00 [b]	0.56 ± 0.00 [d]
High temperature resistance (second)	480.44 ± 3.44 [b]	359.33 ± 3.38 [a]	657.89 ± 7.39 [c]	2400 ± 0.00 [d]
Water content (%)	17.80 ± 0.01 [d]	12.67 ± 0.01 [b]	14.56 ± 0.01 [c]	10.36 ± 0.01 [a]
Water vapor transmission rate (g/m^2.24 hour)	1.00 ± 0.17 [c]	2.04 ± 0.12 [d]	0.64 ± 0.06 [b]	0.00 ± 0.00 [a]
Solubility (%)	33.33 ± 0.38 [c]	51.84 ± 0.18 [d]	23.19 ± 0.34 [b]	2.43 ± 0.03 [a]
Biodegradability (%)	81.68 ± 0.28 [c]	90.95 ± 0.28 [d]	76.78 ± 0.29 [b]	2.67 ± 0.29 [a]

Note: values with different letter superscripts on the line indicate a noticeable difference between treatments

Based on consumer preference of edible film, the preferred formula is edible sodium alginate film with the addition of casein protein. The characteristic appearance of edible film without protein and with the addition of casein is clean, clear but not transparent and slightly shiny for films with the addition of casein. As for the appearance of the film with the addition of clean gelatin, it is not too clear, the color is slightly yellowish to golden and not transparent and not shiny. The yellow to golden color of gelatin materials is caused by several factors, namely the source of raw materials, production processes, acid concentration, extraction temperature, moisture content and ash content [19].

The texture value of edible film is the highest value in the film formula with the addition of gelatin followed by the film with the addition of casein. Gelatin has hydrocolloid properties that can form elastic and flexible films so that gelatin can form a good tissue structure on edible films [20]. Casein has hydrocolloid properties that can form elastic and flexible films and casein has good adhesive properties so that it can form strong edible films so that it can form a good tissue structure on edible films [21].

Aroma is very important for a product because it is a consumer consideration in choosing products and consuming products [22]. Films with the addition of casein produce films that do not have an aroma because the material is made with natural ingredients such as materials that tend not to have a strong odor because they do not use chemical additives that can give a certain aroma or odor to the resulting product [21]. Meanwhile, films with the addition of gelatin produce an unpleasant aroma caused by several factors such as the use of additives in making gelatin, the source of raw materials derived from cowhide and the ash production process when producing gelatin [19].

3.2 Thickness of edible film

The thickness value of the edible film (Table 1), shows that the thickness of the sodium alginate edible film without protein differs markedly from the edible film with the addition of gelatin protein and casein protein. The thickness of edible film in each formula in this study has met Japanese Industrial Standard (0,25 mm). The thickness value of edible film without protein in this study is lower when compared to the study of [12], sodium alginate-based film has a thickness value of 0.14 – 0.71 mm. The factors that cause differences in thickness values are the surface area of printing, the method of heating application.

In the sodium alginate formula with the addition of gelatin has a higher thickness value compared to other formulas. The edible thickness value of sodium alginate film with the addition of gelatin in this study is lower than the research of [23]. Gelatin-based films which have a thickness value of 0.18 mm, this is due to the high concentration of glycerol and gelatin, the higher the film thickness value. According to [23], gelatin and glycerol are hydrophilic which are able to bind water and in the evaporation process which causes a decrease in water content in edible film, which in turn can affect film thickness where the higher the water content, the higher the thickness value on edible film [24].

In the edible formula alginate film with the addition of casein has a higher thickness value [25]'s research, casein-based films have an edible film thickness value of 0.080 – 0.082 mm. But in this study, films with the addition of casein produce the lowest thickness value, this is because according to [26], casein has hydrophobic properties that can repel water so that in the evaporation process which causes a decrease in water content in edible film, which in turn can affect the thickness of the film where the lower the moisture content, the lower the thickness value on the edible film.

3.3 Tensile strength

The tensile strength of the edible film shows that there is a significant difference between the administration of proteins that vary in the sodium alginate-based edible film. In [27] stated that in the 1975 Japanese Industrial Standard (JIS), edible film has a minimum tensile strength value of 0.3 MPa. The tensile strength value of edible film in each formula in this study has met JIS 1975. The tensile strength value determines the resistance of edible film in packaging products, the lower the value, the more fragile the edible film due to its weak molecular bonds [28]. The tensile strength value of edible film without protein in this study has almost the same value when compared to the research of [12], which has tensile strength values ranging from 0.07-0.84 MPa. The factors that cause the tensile strength value are not much different, namely the concentration and ratio of constituent materials and also the method of application and drying that affect the distribution of drying on films that have several similarities. The sodium alginate formula with the addition of gelatin has a lower tensile strength value when compared to other formulas and compared to [28] research which has a tensile strength value ranging from 9,609-465,904 MPa. Meanwhile, the edible formula of sodium alginate film with the addition of casein protein has a higher tensile strength value compared to other formulas and the tensile strength of edible casein film in the study of [29], which has a tensile strength value ranging from 4.47-12.98 MPa.

3.4 Elongation

The elongation value of edible film shows that there is a real difference between the treatment in the use of edible film In [27] stated that in the 1975 Japanese Industrial Standard (JIS), *edible* film has an elongation of at least 70%. The elongation value of *edible film in* each formula in this study, there are films that have not met JIS 1975. This can be caused by several factors such as the collaboration of the basic constituent materials used.

From the results of the elongation test or percent elongation, it is stated that the film formulation with the addition of gelatin is an edible film that meets JIS 1975. This is due to the addition of gelatin to sodium alginate and glycerol. Gelatin has good elastic properties and has the ability to stretch and return to its original shape after being applied pressure or tension [30]. Thus, the addition of gelatin in the edible film formulation can provide high elasticity to the film, so as to increase the elongation of the film as well. The elongation value in this study has almost the same elongation value when compared to the research of [28], which has an elongation value ranging from 8-108%. The factor that influences this is by the factor of using a low glycerol concentration, where the higher the glycerol concentration can reduce the tensile strength of elasticity properties in the gelatin film [31].

In the alginate formula with the addition of casein has an elongation that has not met JIS 1975, but casein has the ability to form a film with good elasticity and casein as the main protein in milk, also has significant elastic properties. So that the addition of casein in the formulation of sodium alginate-based edible film can provide elasticity and tensile strength to the film which can increase the elongation of the film before fracture or break up on film [31]. The elongation value in this study is lower when compared to the research of [29], which has an elongation value ranging from 33.07-80.50%. The factors that affect the elongation value are in the use of constituent concentrations and glycerol, the use of different types of gelatin and drying application methods applied in filmmaking.

3.5 Elasticity

The elasticity value of the edible film shows that there is a real difference between the administration of proteins that vary in the sodium alginate-based edible film and the elasticity of the sodium alginate. Edible film without protein is significantly different from the edible film with the addition of gelatin protein and casein protein. The value of elasticity in the study was obtained from the value of tensile strength divided by the elongation value in this study. If the division results are getting bigger, the elasticity of the film decreases [10], the smaller the value of the elasticity division, the more elastic the edible film is because elastic edible films tend to be easier to apply to food products, easier to form and cut, and more easily broken down by digestive enzymes in the human body. However, in this study, the edible film produced did not meet the elasticity of JIS 1945, because the resulting film has high elasticity and cannot be applied to all food products. Such a film with high elasticity is good for use on fresh produce and not necessarily good on processed products such as sausages.

3.6 High temperature resistance

The high temperature resistance test refers to the cooking temperature of sausages, which is 80^0C for 40 minutes [17]. Through the high temperature resistance test, it can evaluate, see that the integrity of the film is not damaged or not released or destroyed when exposed to high temperatures during the boiling process when making the film as a coating against sausages. This is important to ensure that the coating provides protection, improving the quality of sausage products [32].

The value of high temperature resistance in edible film shows that there is a real difference between the administration of proteins that vary in sodium alginate-based edible film. The results of the edible film boiling temperature test in the study stated that the three edible film formulations had not been able to meet the minimum temperature limit for boiling sausages until cooked. Alginate has thermo irreversibility properties, where the alginate gel becomes resistant to heat, which means sodium alginate can be used for high temperature treatment without damage [33]. But not for a long time, so edible film based on alginate is commonly used to coat processed low-temperature food products such as coating on dodol [6] and fresh crabs [34]. Gelatin is one type of protein that is widely obtained from natural collagen found in the skin and bones and in the manufacturing process does not use temperatures that are too high to avoid denaturation in gelatin proteins [35], such as research on horseskin gelatin which can denature at high temperatures and reactions take place exothermic in a short time [20]. So that gelatin-based edible films are commonly used as coatings on fresh fruit products [36]. As for casein which is one type of protein that is widely obtained from milk and is used in the manufacture of various food products, such as cheese, yogurt and ice cream. In the process of making casein, it begins to show a decrease in viscosity at 80°C so that casein can denature at high temperatures. So that casein-based edible film is commonly used as a coating for chicken meat products [37].

3.7 Water content

The results of water content test in the study stated that from among the three edible film formulations, it has not been able to meet the minimum limit of water content. The water content of films without protein in the study had the same value when compared to the research of [38], which had water content of carrageenan-based films ranging from 17.14% to 20.86%. This is because alginate film has hydrophilic properties that can absorb water and form a gel-like structure so that it has a high enough water content in the film [6].

From the results of the water content test, it states that the film formulation with the addition of gelatin is the film that has the lowest water content of the three formulas and has met Japan Industrial Standard. The water content of the film with the addition of gelatin in the study had the same value as the research of [28], which had a gelatin-based water content ranging from 10.46% to 13.88%. Then followed by the film formula with the addition of casein which has a moisture content value that has met Japan Industrial Standard. In general, films composed of protein have low water content, because protein has low water content as well [39].

In this study using the main raw material alginate with the addition of protein and glycerol so as to increase the value of water content in edible film. This is because in making edible films using glycerol plasticizers, where glycerol has an OH group, where the OH group is hydrophilic, which has the ability to bind water. So, the lower the glycerol concentration results in the lower the water bound to the edible film matrix, so that the edible film moisture content is also low [28]. So the value of water content in the film with the addition of gelatin, casein in alginate-based films and the use of glycerol which are both hydrophilic or can bind water, can affect the value of edible film moisture content .

3.8 Water vapor transmission rate (WVTR)

The water vapor transmission value shows that there is a marked difference between protein administration (gelatin and casein) which varies in edible film-based. Water vapor transmission in edible alginate film without protein differs markedly from edible film with the addition of gelatin protein and casein protein. From the results of the water vapor transmission test, it states that the film formulation with the addition of gelatin has met the Japan Industrial Standard and has the highest water vapor transmission value of the three formulas. The water vapor transmission value in the film formula with the addition of gelatin has the same value as [40]'s research, about gelatin-based films has a water vapor transmission value ranging from 0.1 to 0.3 g/m^2.24 hours. Then followed by a film without the addition of protein. This is because the constituent components of the film, namely sodium alginate, gelatin and glycerol are hydrophilic [6], which can increase the rate of water vapor transmission.

The film with the addition of casein has met the Japan Industrial Standard and has the lowest moisture transmission value of the three formulas. The value of water vapor transmission in films with the addition of casein has a slightly higher value when compared to [41], about gelatin-based films has a water vapor transmission value ranging from 0.3 to 0.5 g/m^2.24 hours. This affects the low value of water vapor transmission in films with the addition of casein protein, because casein is hydrophobic, so it can form flexible films with a rather high permeability to water vapor, and low to oxygen and carbon [26]. The increase in the rate of water vapor transmission in edible film can be caused by several factors, such as the film experiencing swelling by water vapor [40], composition of edible film forming materials, such as alginate, gelatin, casein, glycerol; film thickness can affect water vapor transmission, where the thinner the film, the higher the water vapor transmission; humidity of the environment around the film during testing as well may affect the water vapor transmission value.

3.9 Solubility

The solubility value of the edible film shows that there is a real difference between the administration of proteins that vary in the sodium alginate-based edible film and the solubility of the edible film of sodium alginate without protein is significantly different from the edible film with the addition of gelatin protein and casein protein. From the solubility test results, it states that the film formulation with the addition of gelatin has met the Japan Industrial Standard and has the highest solubility value of the three formulas. The solubility value of the film formula with the addition of gelatin has a higher value when compared to the research of [13], on gelatin-based films which have solubility values ranging from 29.10% to 39.90%. Then followed by a film without the addition of protein. The high solubility value of edible sodium alginate film with the addition of gelatin protein is because sodium alginate and gelatin have hydrophilic properties that can absorb water well [23].

The film with the addition of casein has not met the Japan Industrial Standard and has the lowest solubility value of the three formulas. This affects the low solubility value of the film with the addition of casein protein, because casein is hydrophobic, so it can form flexible films with a rather low permeability to water vapor, and low to oxygen and carbon [26]. The factors that affect the solubility value of edible films are different, namely the composition of film materials, including the type and concentration of forming materials such as proteins and polysaccharides can affect the solubility of films in certain solvents; Interaction with glycerol plasticizers and physical properties or physical characteristics of casein such as molecular structure, particle size, and intermolecular bond strength can affect solubility in edible film-forming solutions.

3.10 Biodegradability

The biodegradability value of edible film shows that there is a real difference between the administration of proteins that vary in sodium alginate-based edible films and also the solubility of edible sodium alginate films without protein is significantly different from the biodegradability of edible films with the addition of gelatin protein and casein protein. The biodegradability value of films with the addition of gelatin protein has met SNI 7188.7: 2016 and is the highest value of the three formulations, followed by films without protein addition. This can happen because films composed of sodium alginate and gelatin can degrade naturally in a relatively short time, are non-toxic and biodegradable.

In general, films made from sodium alginate and gelatin are used as basic materials in making biodegradable films [42], so they can be used in various applications in the food and non-food industries that are environmentally friendly. Films with the addition of casein have also met SNI 7188.7: 2016 and have the lowest biodegradability value of the three formulas, because casein is hydrophobic, so it can form flexible films with a rather low permeability to water vapor, and low to oxygen and carbon [26]. However, in edible film research that is made intended as a sausage casing, so that the best biodegradability value has a low value. And in this study the best value for the biodegradability of sausage casings was with the addition of casein.

4 Conclusion

The characteristics of edible film consisting of consumer preferences, thickness, tensile strength, elongation, elasticity, high temperature resistance, water content, vapor transmission rate, solubility and biodegradability, are influenced by the use of sodium alginate, gelatin and casein in the manufacture of edible films. Edible films made from only sodium alginate and glycerol only have advantages in characteristics of elasticity, edible films made from sodium alginate, glycerol and gelatin have advantages in characteristics of elongation, water content, solubility and biodegradability, and edible films made from sodium alginate, glycerol and casein have advantages in characteristics of consumer preferences, thickness, tensile strength, high temperature resistance and water vapor transmission rate. An interesting result is that the use of single sodium alginate or mixed with gelatin or casein is not able to withstand high temperatures when compared to commercial edible films. Another interesting thing is that commercial edible films used in research are more difficult to decompose by microbes than edible films made from sodium alginate or sodium alginate mixed with gelatin or casein.

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