Physical Characteristics of Gelatin-Xylitol Edible Film

Abstract

This research objective was to obtain a gelatin-xylitol edible film with optimal physical characteristics. Research on the use of gelatin as a raw material for making edible films and xylitol as a plasticizer in making edible films was carried out from December 2022 to March 2023 which took place at the Laboratory of Animal Products Technology, Faculty of Animal Science, Universitas Brawijaya. This study focused on differences in the percentage of xylitol in the manufacture of gelatin-xylitol edible films with 5 treatments, namely T0 (0%), T1 (0.5%), T2 (1%), T3 (1.5%), and T4 (2%) with 3 repetitions each. The results showed the effect of different xylitol administrations on gelatin-xylitol edible films. There was a very significant difference ($P < 0.01$) in the analysis of the water resistance test, water vapor transmission rate, and thickness; a significant difference ($P < 0.05$) in the analysis of the elasticity and tensile strength tests; and there was no significant difference ($P > 0.05$) on the test for water content, solubility, and total solute. Based on the physical characteristics of the gelatin-xylitol edible film, it can be concluded that the addition of 0.5% xylitol produces a good edible film to be used as a product.

Keywords: *Edible film, gelatin, xylitol*

1. INTRODUCTION

The edible film is a product from processed livestock products called gelatin, which has great potential in its utilization. The edible film is a thin layer made of edible material, formed to coat food (coating) or placed between food components (film), that functions as a barrier to mass transfer (moisture, oxygen, lipids, solutes) and as an additive carrier, as well as to improve the handling of food (Manab et al., 2016). The edible film has the advantage of increasing food shelf life and its nutritional value (Supeni, 2012). Three main components make up edible films, composited by hydrocolloids, fats, and composites (Rodriguez, 2006).

Diversification of food products from livestock is one of the efforts to provide food for the community while at the same time increasing the usability of livestock commodities (Naiu, 2021). One of the main ingredients used in making edible films is gelatin, which belongs to the hydrocolloid group and is a material that is easy to get, cheap, and has various types in Indonesia (Setiani, 2013). Generally, Edible films are consumable directly, able to improve the product's organoleptic properties, and serve as nutritional supplements, flavors, dyes, antimicrobial agents, and antioxidants (Murdianto, 2005).

The addition of a plasticizer will improve the characteristics of the edible film to become elastic, flexible and not easily brittle. Sorbitol and glycerol have a content equaivalent to xylitol which is widely used in making edible films. Plasticizers are non-volatile materials, with high boiling points which, when added to other materials, can change the physical properties of the material. The addition of plasticizers can reduce intermolecular hydrogen bonds between polymers/termolecular strength (overcoming the brittle nature of film layers), increase film flexibility and reduce film barrier properties. Sorbitol is used because it has the advantage of reducing internal hydrogen bonds in intermolecular bonds so it is good for inhibiting the evaporation of water from the product, it can dissolve in each polymer chain so that it will facilitate the movement of polymer molecules, lower O_2 permeability properties, is available in large quantities, the price is cheap, and is non toxic (Astuti, 2010).

2. MATERIALS AND METHODS

2.1 Materials and Equipment

The materials used in the study consisted of the essential brand Gelatin obtained from a food store in Malang, the Xylitol Soho brand obtained from the Online Market (Tokopedia), and Aquadest obtained from a chemical Store in Malang.

The equipment used in the study consisted of Erlenmeyer 250 ml brand Pyrex, measuring cup 100 ml brand Pyrex, beaker glass 50 ml brand Duran, measuring cup 10 ml brand Pyrex, spoon spatula, thermometer, digital scale I-2000, hot plate, and magnetic stirrer (SBS-A06), aluminum foil, plastic clips, filter cloth, silicone mat, and Teflon.

The equipment used in the test consists of scissors, ruler, needle, pencil or pen, paper, petri dish, tweezers, oven (Memmert), centrifugation tube, centrifuge, 50 ml glass beaker Duran brand, spatula spoon, analytical scales (BC Series OHAUS Centrogram Balance), filter paper, transparent mica, transparent isolation, and desiccator.

2.2 Research Method

The method used is the experimental method (experiment) in the laboratory with a Completely Randomized Design (CRD). Based on the preliminary research, it was found that the control treatment was T0 without the addition of xylitol, while the comparison factor was different at the concentration of xylitol, which consisted of the addition of T1 (0.5 g), T2 (1 g), T3 (1.5 g), and T4 (2 g). Three repetitions were carried out. In the first phase of the study, an analysis of physical characteristics was carried out in the form of water content, water resistance, solubility, total solute, water vapor transmission rate, and sedimentation.

2.3 Making The Edible Films

Gelatin, which weighed as much as 3 g, was dissolved with 30 ml of distilled water using a 250 ml Erlenmeyer, and then xylitol was added in 0.5 g, 1 g, 1.5 g, and 2 g amounts. The edible solution is heated and homogenized using a hot plate-magnetic stirrer for 5 minutes until all the ingredients are well mixed at 60°C. Pour the solution into a 50 ml beaker glass and filter using a filter cloth. Measure 10 ml of the edible film solution with a measuring cup and pour it into a Teflon mold that has a silicone plastic backing. Wait for the edible film to dry for 24 hours. Remove the edible film from the silicone mat and store it in plastic clips.

2.4 Water Content

Prepare the edible film, then cut the edible film to 5x5 cm^2, prepare Petri dishes and cut filter paper according to the width of the cup, then weigh the edible film and filter paper using analytical scales, before weighing the Petri dishes, dry the dishes in the oven for 30 minutes with a temperature of 105^oC and a desiccator for 10 minutes, then after that the cup is weighed, the purpose of drying the petri dish is to get a constant weight in the petri dish, after each tool and material is weighed then, the edible film is placed on top of the petri dish that has been coated with filter paper then the edible film sample is in the oven for 30 minutes at 105^oC after that the cup is put into the desiccator for 10 minutes then the weight of each can be weighed again. Water content calculated by this formula:

$$Water\ content\ (\%) = \frac{(IW\ (g) - FW\ (g))}{IW\ (g)}\ x\ 100\%$$

Details:
IW = Initial sample weight
FW = Final sample weight

2.5 Water Resistance

Prepare the edible film that has been cut to a size of 5x5 cm^2, then weigh it analytically as the initial weight (W_1). Then take a plastic cup and fill it with distilled water, as much as 30 ml, and put the edible film into the cup. Soak for 2 minutes, then remove the edible film using tweezers. The next step is to remove the water from the surface of the edible film using tissue paper, and then the final edible film is weighed (W_2) after soaking using an analytical balance. Water resistance calculated by this formula:

$$Water\ resistance\ (\%) = \frac{W2 - W1}{W1} x100\%$$

Details:
W_1 = Weight before soaking
W_2 = Weight after soaking

2.6 Solubility

Prepare the edible film that has been cut to a size of 5x5 cm^2, also prepare Petri dishes and cut filter paper according to the width of the dish, then weigh the edible film and filter paper using analytical scales. Before weighing the Petri dishes, dry the dishes in the oven for 30 minutes on a temperature of 105°C and a desiccator for 10 minutes, then the dishes weighed, the purpose of drying the Petri dishes is to get a constant weight in the Petri dish.

After each tool and material is weighed, then the edible film is placed on top of the Petri dish that has been coated with filter paper. Oven the edible film samples for 30 minutes with a temperature of 105°C. After that put the dishes into the desiccator for 10 minutes then the weight of each can be weighed again as the initial dry weight (W_0). Prepared a plastic cup, fill it using distilled water as much as 20 ml, then put the edible film into the glass and soak for 5 minutes, then filtered using filter paper put it into the Petri dish. Dry the sample using an oven on a temperature of 105°C for 10 minutes, remove the petri dish using tongs and put it in a desiccator for 10 minutes. Weigh the sample as dry weight after immersion (W_1). The edible films solubility calculated by this formula:

$$Solubility\ (\%) = \frac{W0 - W1}{W0}\ x\ 100\%$$

Details:
S = Solubility
W_0 = Dry weight before soaking
W_1 = Dry weight after soaking

2.7 Total Dissolved Substances

Prepare the edible film that has been cut to a size of 5x5 cm^2, then weighed using an analytical scale and recorded the results of weighing the edible film as the weight of the film before testing, then prepared distilled water using a 6 ml measuring cup and put the distilled water into a centrifugation tube, then put the edible film into the centrifugation tube, then soaked the edible film for 10 minutes, then centrifuged using a 3000 rpm centrifuge for 5 minutes.

After centrifuging, the sample was filtered using filter paper and placed into a petri dish. The remaining sample was then used in an oven at 105°C for 30 minutes and then weighed on the edible film as the weight of the film after being tested. Total dissolved substances calculated by this formula:

$$TDS\ (\%) = \frac{(IF - FF)}{IF} x100\%$$

Details:
W_1 = Weight before soaking
W_2 = Weight after soaking

2.8 Water Velocity Transmission Rate

Prepare two edible films that have been cut to a size of 5x5 cm^2, also prepare two pieces of clear mica sheets, then cut the middle to a size of 4x4 cm^2 and insert edible film using two pieces of clear mica sheets. Prepare a Petri dish and fill it with 15 ml of distilled water. Then, a Petri dish that had been filled with water was coated with a clear mica sheet. Insert the edible film in between until all surfaces of the cup are covered, then the cup is put into a desiccator containing silica gel and allowed to stand for 24 hours. Water velocity transmission rate calculated by this formula:

$$WVTR = \frac{(W - W0)}{(t\ x\ A)} x\ 24$$

Details:
W_0 = Initial weight
W = Final weight after 24 hours
T = Time (24 hours)
A = film area (m^2)

2.9 Elasticity

Prepare the edible film that has been cut to a shape of letter T and size of 7x3 cm^2. Put it into analyzing device by measuring the initial length (T1), turn the device on until the film torn apart as it is the final length (T2). The elasticity of edible film calculated by this formula:

$$Elasticity\ (\%) = \frac{(P1 - P2)}{(P2)} x\ 100\%$$

Details:
T1 = Initial length
T2 = Final length

2.10 Tensibility

Prepare the edible film that has been cut to a shape of letter I and size of 7x3 cm^2. Put it into analyzing device vertically by measuring the breadth (A), turn the device on, and record the force (F) of edible film tensibility. It calculated by this formula:

$$Tensibility = \frac{F}{A}$$

Details:
F = Force (N)
A = Area (cm^2)

2.11 Sedimentation

Prepare the edible film that has been cut to a size of 5x5 cm^2, then dissolve the sample in 5 ml of distilled water. Filter the sample using filter paper and weigh the filter paper containing edible film (A) by an analytical scale, then bake the filter paper and sample solids at 105ºC for 3 hours, put them in a desiccator for 15 minutes, and then weigh the weight of filter paper (B). The sedimentation calculated by this formula:

$$Sedimentation = \frac{(A - B)}{A}$$

Details:
A = Weight before oven
B = Weight after oven

3. RESULTS AND DISCUSSIONS

3.1 Water Content

The average value of water content in edible films using gelatin and xylitol at different percentages is 0%. 0.5%, 1%, 1.5%, and 2% showed results that were not significantly different (P > 0.05) from water content, as can be seen in Table 1.

Table 1. Water content of edible film with gelatin and xylitol

Treatments	Water content (%)
T0 (0%)	9,56±1,43
T1 (0,5%)	15,05±0,60
T2 (1%)	11,79±0,88
T3 (1,5%)	12,60±9,27
T4 (2%)	15,20±7,90

Details: Various concentration of xylitol addition did not show any significant differences (P > 0.05).

The results of the analysis of variance showed that the treatment using different concentrations of xylitol did not make a significant difference (P > 0.05) to the water content, as seen in Table 1. Data analysis of the various water contents in the treatments T0, T1, T2, T3, and T4 yielded an average value of 9.56%, 15.05%, 11.79%, 12.60%, and 15.20%. The water content with the highest yield was found in the use of 2% xylitol at T4, namely 15.20%. The treatment of increasing xylitol concentrations showed that the value of the water content was increasing; this was because xylitol was the simplest glyceride compound with hydroxyl, which was hydrophilic and hygroscopic so that it easily binds to water. Increasing the concentration of xylitol can contribute to the water content of edible films due to xylitol's ability to absorb water. Rangel-Marron et al. (2013) stated that the increase in the water content of edible films was due to the effect of increasing glycerol concentrations and the mechanism of polymer-polysaccharide formation by the interaction between glycerol and glycerol-water, which changed the physical properties of edible films.

The higher the addition of xylitol to the edible film, the lower the water resistance, resulting in swelling in the sample. The high swelling is due to xylitol being a hydrophilic plasticizer, so the polymer bonds formed between gelatin and xylitol have a greater ability to bind water. Setiani et al. (2013) stated that the large molecular weight value of the plasticizer will affect water absorption. The greater the molecular weight of the plasticizer, the larger the gaps between molecules that can be filled by water molecules, causing water binding. The large number of OH-hydroxide groups in the edible film causes more water to be bound.

The addition of xylitol concentration causes a lower water resistance value to be produced. This is because the amount of water bound to polysaccharide compounds has decreased due to the addition of plasticizers. Riza et al. (2013) stated that the addition of a higher concentration of plasticizer will also increase the adhesive properties between molecules so that the amount of water bound to the polysaccharide compound will decrease, which causes lower water resistance. The greater the addition of the plasticizer concentration, the better the resistance of the resulting edible film and the lower the water absorption value.

3.2 Water Resistance

The average value of water resistance in edible films using gelatin and xylitol at different percentages is 0%. 0.5%, 1%, 1.5%, and 2% showed a significant difference (P < 0.01) from water resistance, as can be seen in Table 2.

Table 2. Water resistance of edible film with gelatin and xylitol

Treatments	Water resistance (%)
T0 (0%)	$3{,}95^{e}$±0,754
T1 (0,5%)	$3{,}17^{cd}$±0,480
T2 (1%)	$2{,}21^{bc}$±0,339
T3 (1,5%)	$2{,}12^{ab}$±0,490
T4 (2%)	$1{,}46^{a}$±0,721

Details: single superscript means the difference is significant (P < 0.01).

The results from ANOVA (analysis of variance) showed that the treatment with different concentrations of xylitol gave a very significant difference (P < 0.01) to water resistance, which can be seen in Table 2. Data on the analysis of variance of water resistance in treatments T0, T1, T2, T3, and T4 produces an average value of 3.95%, 3.17%, 2.21%, 2.12%, and 1.42%.

The water resistance with the highest yield was found in edible films without the addition of xylitol; this was due to an increase in xylitol concentration causing a decrease in intermolecular interactions in the solution for making edible films, which had an impact on increasing the solubility of edible films. Harumarani (2010) stated that the higher the plasticizer concentration, the lower the resulting water resistance value; this is because the amount of water bound to polysaccharide compounds has decreased due to the addition of plasticizers.

The higher the addition of xylitol to the edible film, the lower the water resistance, resulting in swelling in the sample. The high swelling is due to xylitol being a hydrophilic plasticizer, so the polymer bonds formed between gelatin and xylitol have a greater ability to bind water. Setiani et al. (2013) stated that the large molecular weight value of the plasticizer will affect water absorption. The greater the molecular weight of the plasticizer, the larger the gaps between molecules that can be filled by water molecules, causing water binding. The large number of OH-hydroxide groups in the edible film causes more water to be bound.

The addition of xylitol causes a lower water resistance value to be produced. This is because the amount of water bound to polysaccharide compounds has decreased due to the addition of plasticizers. Riza et al. (2013) stated that the addition of a higher concentration of plasticizer will also increase the adhesive properties between molecules so that the amount of water bound to the polysaccharide compound will decrease, which causes lower water resistance. The greater the addition of the plasticizer concentration, the better the resistance of the resulting edible film and the lower the water absorption value.

3.3 Solubility

The average value of water solubility in edible films using gelatin and xylitol at different percentages is 0%. 0.5%, 1%, 1.5%, and 2% showed results that were not significantly different (P > 0.05) from water content, as can be seen in Table 3.

Table 3. Solubility of edible film with gelatin and xylitol

Treatments	Solubility (%)
T0 (0%)	0,20±0,149
T1 (0,5%)	0,60±0,054
T2 (1%)	0,64±0,138
T3 (1,5%)	0,75±0,323
T4 (2%)	1,06±1,325

Details: Various concentration of xylitol addition did not show any significant differences (P > 0.05).

The results from the ANOVA showed that the treatment using different concentrations of xylitol did not make a significant difference (P > 0.05) in the solubility, as can be seen in Table 3. An average of 0.20%, 0.60%, 0.64%, 0.75%, and 1.06% solubility with the highest yield was found in the use of xylitol, as much as 2% in T4, namely 1.06%. This is because xylitol is hydrophilic, which allows for easier interaction with the polymer chains, leading to an increased affinity for water. Ghanbarzadeh et al. (2011) explained that at high xylitol concentrations, it does not bind to gelatin molecules, but interactions between water molecules through hydrogen bonds reduce the cohesiveness of the gelatin matrix and increase the solubility of edible films.

Solubility in water is an indication of the hydrophilicity of an edible film, which is influenced by several factors including the type of xylitol, temperature, pH, and other solutes. The presence of plasticizers also affects the solubility of edible films, whereas hydrophilic plasticizers can increase the solubility of edible films in water. Farahnaky et al. (2013) explained that increasing the concentration of glycerol can increase the solubility of edible films because the nature of glycerol as a plasticizer in general can increase the solubility of edible films.

The solubility percentage of an edible film can be used as an indicator to measure the biodegradability of edible films used as processed product ingredients. Tong et al. (2013) stated that plasticizers can increase the solubility of edible films because they are hydrophilic, thus allowing for easier interactions with polymer chains, which leads to increased affinity for water (Mali et al., 2005).

3.4 Total Dissolved Substance

The average value of total dissolved substance in edible films using gelatin and xylitol at different percentages is 0%. 0.5%, 1%, 1.5%, and 2% showed results that were not significantly different (P > 0.05) from water content, as can be seen in Table 4.

Table 4. Total dissolved substance of edible film with gelatin and xylitol

Treatments	Total dissolved (%)
T0 (0%)	0,35±0,219
T1 (0,5%)	0,28±0,164
T2 (1%)	0,23±0,120
T3 (1,5%)	0,11±0,082
T4 (2%)	0,06±0,047

Details: Various concentration of xylitol addition did not show any significant differences (P > 0.05).

The results of the analysis of variance showed that the treatment using different concentrations of xylitol did not provide a significant difference (P > 0.05) to the total solute, as can be seen in Table 4. Data analysis of the variance of water resistance in treatments T0, T1, T2, T3, and T4 produces an average value of 0.35%, 0.28%, 0.23%, 0.11%, and 0.06%. Total dissolved substances with the highest yield were found in edible films without the addition of xylitol. This is due to the increasing concentration of xylitol in the manufacture of edible films, which causes more and more film matrices, so that the structure of the film network is more compact and the edible film is not easily destroyed because water along with it reduces the total value of dissolved substances. Pitak and Rakshit (2011) stated that high solubility causes edible film to dissolve easily in water, and its ability to hold water decreases so that the total dissolved substance decreases less.

Edible film with high solubility is very good for use in ready-to-eat food products because it dissolves easily when consumed. High solubility is also related to the biodegradability of edible films. Low solubility is an important requirement for edible films, especially for use as food packaging, which generally has high water content and water activity, or for the use of edible films that come into contact with water and act as a protector for food products (Singh et al., 2015).

3.5 Water Vapor Transmission Rate

The average value of water vapor transmission rate in edible films using gelatin and xylitol at different percentages is 0%. 0.5%, 1%, 1.5%, and 2% showed a significant difference (P < 0.01) from water resistance, as can be seen in Table 5.

Table 5. Water vapor transmission rate of edible film with gelatin and xylitol

Treatments	Transmission rate ($g/m^2/jam$)
T0 (0%)	$0,05^{a}$ ± 0.006
T1 (0,5%)	$0,06^{ab}$ ± 0.010
T2 (1%)	$0,06^{ab}$ ± 0.011
T3 (1,5%)	$0,05^{bc}$ ± 0.006
T4 (2%)	$0,09^{d}$ ± 0.004

Details: single superscript means the difference is significant (P < 0.01).

The results from the ANOVA showed that the treatment of using different concentrations of xylitol gave a very significant difference (P < 0.01) to the Water Vapor Transmission rate, which can be seen in Table 5. Data analysis of the variance of water resistance in treatments T0, T1, T2, T3, and T4 yielded average values of 0.06 g/m2/hour, 0.05 g/m^2/hour, 0.06 g/m2/hour, 0.050 g/m^2/hour, and 0.09 g/m2/hour. The water vapor transmission rate with the highest yield was found in edible films without the addition of xylitol. This is due to the addition of xylitol-containing hydrophilic alcohol and polyhydric monosaccharide compounds. The increase in the hydrophilic component contained in the film causes water vapor to easily penetrate the film, thereby increasing the value of the water vapor transmission rate. Hidayati et al. (2015) stated that xylitol is hydrophilic (capable of binding water) and softens the surface of the film so that the addition of xylitol concentration can increase the transmission rate of water vapor.

Increasing the amount of xylitol produces a hydrophilic film, causing water to be easily absorbed into the tissue. Ananta (2002) stated that the application of a plasticizer could theoretically reduce the intermolecular strength along the polymer chain, increase the flexibility of the film, and reduce the barrier properties of the film. The air bubbles present in the coating and the addition of the hydrophilic component can increase the transmission rate of water vapor. Sothorvit and Krochta (2000) stated that the increase in the water vapor transmission value also increased the permeability value of the edible film. Increased permeability is not expected in food products, so the use of plasticizers in edible films must be limited. In hydrophilic edible film permeability, water solubility and diffusion coefficient increase when water vapor increases due to the moisture affinity of the edible film and the addition of plasticizers.

3.6 Elasticity

The average value of film surface in edible films using gelatin and xylitol at different percentages is 0%. 0.5%, 1%, 1.5%, and 2% showed results that were slightly different (P < 0.05) from water content, as can be seen in Table 6.

Table 6. Elasticity of edible film with gelatin and xylitol

Treatments	Elasticity (%)
T0 (0%)	$27,78^{a} \pm 5.09$
T1 (0,5%)	$35,56^{ab} \pm 5.09$
T2 (1%)	$40,00^{bc} \pm 8.82$
T3 (1,5%)	$43,33^{cd} \pm 3.34$
T4 (2%)	$43,33^{e} \pm 3.34$

Details: Details: single superscript means the difference is slight (P < 0.05).

The results from the ANOVA showed that the treatment with different concentrations of xylitol gave a very significant difference (P < 0.05) to the elasticity, which can be seen in Table 6. Data analysis of the variance of water resistance in treatments T0, T1, T2, T3, and T4 yields an average value of 0.06%, 0.05%, 0.06%, 0.05%, and 0.09%. The elasticity with the highest yield was found in edible films without the addition of xylitol. This is because the higher the concentration of xylitol used in making edible films, the fewer the intermolecular interactions between the impactful polymer chains. Increasing the concentration of glycerol plasticizer will increase the elongation of the edible film to a certain concentration (Wiset et al. 2014).

Increasing the concentration of xylitol led to increased elongation. This is because increasing xylitol concentrations can increase the stretching of the intermolecular space of the edible film matrix structure, increase flexibility, and reduce the number of hydrogen bonds, thereby reducing brittleness and not breaking easily. Huri, Huri, and Nisa (2014) stated that the treatment of increasing glycerol concentrations resulted in increased elongation of edible films, and besides that, the addition of plasticizers was very important to overcome brittle films and increase flexibility. Films made without the addition of plasticizers will become very brittle and break easily during handling.

Vieira et al. (2011) stated that increasing the concentration of glycerol in the edible film formulation increased the elongation value. The Japanese Industrial Standard stipulates that the percentage of elongation is categorized as bad if it is less than 10% and very good if it is more than 50% (Ariska and Suyatno, 2015). Based on the tensile strength and elongation values, the edible film produced in this study can be used as primary packaging for food products.

3.7 Tensibility

The average value of film surface in edible films using gelatin and xylitol at different percentages is 0%. 0.5%, 1%, 1.5%, and 2% showed results that were slightly different (P < 0.05) from water content, as can be seen in Table 7.

Table 7. Tensibility of edible film with gelatin and xylitol

Treatments	Tensibility (N)
T0 (0%)	$6{,}13^{e} \pm 0.569$
T1 (0,5%)	$5{,}23^{cd} \pm 0.404$
T2 (1%)	$4{,}83^{bc} \pm 0.351$
T3 (1,5%)	$4{,}76^{ab} \pm 0.351$
T4 (2%)	$4{,}76^{a} \pm 0.569$

Details: single superscript means the difference is slight (P < 0.05).

The results from the ANOVA showed that the treatment using different concentrations of xylitol gave a very significant difference (P<0.05) in the tensile strength, which can be seen in Table 7. Data on the analysis of variance for water resistance in treatments T0, T1, T2, T3, and T4 yielded average values of 0.06 N, 0.05 N, 0.06 N, 0.05 N, and 0.09 N. The tensile strength with the highest yield was found in edible films without the addition of xylitol. This is because the addition of xylitol contains many components that are hydrophilic, causing it to increase the flexibility of the edible film and reduce its tensile strength. Sanyang et al. (2015) explained that the phenomenon of decreasing tensile strength due to the effect of increasing plasticizer concentration can be explained through the role of plasticizers, which reduce the strong molecular attractions between starches and encourage the formation of hydrogen bonds between starch and plasticizer molecules. The weakening of the hydrogen bonds between the starch chains causes a decrease in the tensile strength of the edible film.

Tensile strength is one of the important mechanical properties of edible films because it is related to their ability to produce processed products that are flexible and easily soluble. Pitak and Rakshit (2011) state that edible films with high tensile strength are required for use as food product packaging, which aims to protect food ingredients during handling, transportation, and marketing.

The addition of xylitol to the solution for making edible films causes the intermolecular bonds that make up the edible film to increase, resulting in an increasingly elastic edible film. Ariska and Suyatno (2015) stated that the higher the concentration of plasticizer added in making edible films, the stronger the film matrix will form, so that the force needed to break the edible film is also greater.

3.8 Sedimentation

The average value of sedimentation in edible films using gelatin and xylitol at different percentages is 0%. 0.5%, 1%, 1.5%, and 2% showed results that were not significantly different ($P > 0.05$) from water content, as can be seen in Table 8.

Table 8. Sedimentation of edible film with gelatin and xylitol

Treatments	Sedimentation (%)
T0 (0%)	0,08±0,101
T1 (0,5%)	0,09±0,002
T2 (1%)	0,09±0,048
T3 (1,5%)	0,13±0,017
T4 (2%)	0,16±0,011

Details: Various concentration of xylitol addition did not show any significant differences ($P > 0.05$).

The results from the ANOVA showed that the treatment using different concentrations of xylitol did not make a significant difference ($P > 0.05$) in sedimentation, as can be seen in Table 8. Data analysis of the variance of sedimentation in treatments T0, T1, T2, T3, and T4 yielded averages of 0.08%, 0.09%, 0.13%, 0.16%, and 0.09%. Sedimentation with the highest yield was found in the use of 1.5% xylitol at T3, on 0.167. This is because the higher addition of xylitol to the edible film causes the substances contained therein to increase, so that the sedimentation value increases along with the addition of xylitol as a plasticizer. Ahmadi et al. (2012) report that sedimentation is a test to determine the amount of residue contained in edible film during the dissolution process. The higher the concentration of xylitol used, the higher the sedimentation value will be. This is because the more concentration is added, the more precipitate is contained in it. Sudaryati et al. (2010) stated that the increase in sedimentation was due to the influence of plasticizer concentration since glycerol molecules occupy cavities in the edible film matrix and interact with carrageenan molecules to form polymers, which led to an increase in the distance between the polymer molecules, thereby increasing the sedimentation of the edible film.

4. CONCLUSION

The conclusion of this study is that edible film gelatin with xylitol addition as a plasticizer at a concentration of 0.5% at T1 has optimal properties in making edible films based on the physical characteristics of edible films with a water content value of 15.05%, a water resistance value of 3.171%, a solubility value of 0.601, a total dissolved water of 0.284%, a water vapor transmission rate of 0.056 g/m^2/hour, an elasticity value of 35.56, the tensile strength value of 5.233 N, and the sedimentation value of 0.092%.

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