Preparation of Poliblend Suweg Starch-Chitosan with Addition of Essential Oil from Sweet Orange Peel as Edible Coating on Malang’s Apples

E Susilowati¹, L Mahardiani¹, and D Sulistyowati¹
¹Chemistry Education Department, Faculty of Teacher Training and Education, Sebelas Maret University
Jl. Ir Sutami 36 A Surakarta Indonesia 53126

Abstract. Poliblend edible coating of suweg starch-chitosan (SSC) was prepared as a package with the addition of essential oil from sweet orange peel as antibacterial because of the high limonene content (95%) to increase the shelf life of malang’s apples. There are 6 variations formulation of the suweg starch: chitosan, namely 10: 0, 9: 1, 8: 2, 7: 3, 6: 4 and 5: 5 in total volume 60 mL. Essential oil of sweet orange peel was added with variations in the concentration of essential oil is 0%; 2%; 4%, and 6%). Furthermore, characterization was carried out by mechanical testing, Water Vapor Transmission Rate (WVTR), solubility, and swelling of the SSC polyblend edible film and the antibacterial activity test of the SSCO polyblend edible coating on Staphylococcus Aureus bacteria before it was applied on malang’s apples. Organoleptic tests and physical observations of malang’s apples were carried out after the application of edible coating SSCO. The result characterization of the functional groups of polyblend edible film SSCO showed the absorption of the wave number 3373.64 cm⁻¹; 1646.32 cm⁻¹; 1570.12 cm⁻¹; 1416.78 cm⁻¹ and 1337.69 cm⁻¹; and 1040.64 cm⁻¹ with functional groups -OH, N-H, C=C, CH₃, and C-O. The variation composition affects on the physical properties of edible film SSC in the mechanical test, WVTR, and WVP with the optimum concentration edible film SSC 7: 3, while the solubility and swelling reach the optimum concentration edible film SSC of 5: 5. The addition of sweet orange peel as essential oil had an effect on the antibacterial activity of polyblend edible film SSCO with a maximum inhibition zone 16.55 mm on concentration 6% for S. aureus bacteria. Based on organoleptic test, consumers prefer edible coating SSC with the lowest essential oil content and malang’s apples can last 22 days on physical performance observations.

1. Introduction
Apples are a horticultural commodity that developed widely in Indonesia, one of which is in Batu City and Pujon District, Malang Regency, East Java [1]. Apple production in Malang Regency in 2012 reached 328,862 quintals, while national apple production reached 3,1327,270 quintals, so it can be said that Malang Regency contributed 10.48% of the national apple production. Based on BPS data for 2001, the import of apples reached 124,000 tons. In 2007, Chinese imported apples flooded the traditional and modern markets. Consumer preference for imported apples because the packaging is better than local apples with a packaging system that is still traditional. The fruit is damaged very quickly by mechanical, chemical, and microbiological influences so that it rots easily. Imported apples
are packaged with a waxing process so that they don't rot easily during the shipping, storage and sales processes.

Edible coating is a packaging that is safe to use and is able to minimize moisture loss, water and gas exchange, as well as improve product texture [2]. One of the edible coatings that can be applied on malang’s apples is an edible coating that made from Suweg starch. Suweg is cultivated in Indonesia, particularly in Sumatra and Java, but not widely used or processed, so this is the reason for making it as an alternative material for making edible coatings. Suweg starch has a high amylose content reaching 24.5% [3]. Edible coating made from starch has several weaknesses, namely the nature of starch which is not good for regulating water vapor migration and tearing easily. Therefore it is necessary to add a biopolymer that is hydrophobic so that edible coating obtained has a low water vapor permeability value.

One of the recommended hydrophobic biopolymers to improve the characteristics of starch films is chitosan [4]. The addition of chitosan was obtained from crustacean animal waste such as crabs which will be able to improve the mechanical characteristics of the film from suweg starch. Chitosan forms hydrogen bonds between chains in amylose and amylopectin in starch therefore increasing its mechanical properties. The hydrogen bonds between the chains in chitosan are formed from the amine functional groups, primary and secondary hydroxyl groups which has high reactivity. Chitosan edible film is strong, elastic, flexible, and difficult to be torn [5].

Edible film suweg starch-chitosan (SSC) does not have antimicrobial activity so it is necessary to be added with an antimicrobial substance. Sweet orange peel essential oil is added as an antimicrobial agent to the polyblend edible film SSC because of the high limonene content of 95% so it is expected to be able to inhibit and kill microbial growth optimally. Inhibition of antimicrobial activity aims to prevent microbes from reproducing and being metabolized so as not to damage food ingredients. Sweet orange peel was chosen in an effort to utilize horticultural waste of sweet orange peel so as to reduce the volume of national waste, which amounts to 175,000-176,000 tons per day, of which 60% comes from organic waste. Sweet orange peel contains essential oil compounds in the form of limonene (95%), mirsen (2%), octanal (1%), decan (0.4%), citronellal (0.1%), mineral (0.1%), geranial (0.1%), valensent (0.05%), sinnial (0.02%), and synential (0.01%) [6].

This study aims to determine the effect of the composition of the variety of suweg starch-chitosan on the chemical properties of the polyblend edible film SSC functional group and the physical properties of the mechanical characteristics, WVTR and WVP, solubility and water resistance of polyblend edible film SSC. In chemical and physical properties, edible is molded on a film sheet to make it easier to be tested. The addition of oil essential sweet orange peel as an antimicrobial substance in polyblend edible coating suweg starch-chitosan with essential oil (SSCO) which is expected to be a solution in increasing the shelf life of malang’s apples so that it can reduce the high number of imported apples and increase the existence of malang’s apples.

2. Experimental

2.1 Materials

The ingredients used are essential oil of sweet orange peel produced through steam destilation, malang’s apples and suweg starch purchased from traditional market, chitosan produced by Surindo Biotech Cirebon Indonesia, and chemical reagents including: CH₃COOH, Na₂HPO₄, NaH₂PO₄ produced by Merck.

2.2 Preparation poliblend edible coating SSCO

One gram of chitosan was dissolved in 1% CH₃COOH solution and homogenized then allowed to stand in a closed glass beaker overnight. Suweg starch was made with a concentration of 3% w/v. The suweg starch was heated until completely gelatinized at 85°C for 25 minutes by stirring using a magnetic stirrer. The temperature lowered to 50°C to make the addition of chitosan which had been dissolved in 1% acetic acid. There are 6 variations formulation of the suweg starch: chitosan, namely 10: 0, 9: 1, 8: 2, 7: 3, 6: 4 and 5: 5 in total volume 60 mL. Then the formulation homogenized for 10
minutes. Furthermore, 0.8 ml of glycerol plasticizer was added and maintained for 15 minutes. After all the components dissolve completely, the hotplate is turned off and stirring is still carried out with a magnetic stirrer for ± 10 minutes to remove air bubbles and wait for it to reach room temperature then pour it into a plastic container. The best formulation of polyblend edible film SSC chosen according to mechanical tests and WVTR with varied ratio of essential oil composition. When all the components dissolved homogeneously, the temperature was lowered to 20°C and essential oil of sweet orange peel was added with variations in the concentration of essential oil are 0%; 2%; 4%, and 6%.

2.3 Mechanical Test
2.3.1 Tensile Strength
The test was carried out by means of the tip of the sample being clamped by a tensolab 5000 mesdanlab machine. Furthermore, the initial thickness and length of the sample were measured and the tool would draw the sample at a speed of 10 mm / minute until the sample was cut off. The tensile strength value is obtained from dividing the maximum stress by the cross-sectional area.

2.3.2 Elongation
The testing for the elongation polyblend edible film SSC was the same as the test for the tensile strength polyblend edible film SSC. The elongation obtained from dividing the strain at break by the initial length expressed as a percentage.

2.3.3 Modulus Young
The test for the elasticity polyblend edible film SSC was the same as the test for the tensile strength polyblend edible film SSC. The value of elasticity is obtained from the comparison of the value of tensile strength with elongation.

2.4 Water Vapor Permeability (WVP) dan Water Vapor Transmission Rate (WVTR) test
WVTR and WVP were determined gravimetrically according to the standard method of ASTM E 96-95. The film was measured for thickness and placed on an acrylic plate containing a desiccant silica gel. The film is clamped using a ring that has 4 symmetrical screws. The plate was then placed into a desiccator containing saturated salt with a relative humidity of 75% and a temperature of 28°C every 1 hour weighing up to 8 hours.

2.5 Solubility studies
Solubility test is the percentage of solubility of polyblend edible film SSC in distilled water. Initially weighed edible film (Wo) then immersed in distilled water for 24 hours. After that it is dried and weighed finally (W). The test was carried out 3x repetitions. The solubility of the edible film was calculated using equation 1:

\[
\text{Solubility (\%)} = \frac{W_0 - W}{W} \times 100\% 
\]  
(1)

2.6 Swelling studies
The swelling test is a test of the ability of polyblend edible film SSC in a phosphate buffer solution pH 7.4 for 1x24 hours. Initially weighed edible film (Wo) then immersed in a phosphate buffer for 24 hours. After that it is dried and weighed finally (W). The test was carried out 3x repetitions. As for swelling of the edible film was determined using equation 2:

\[
\text{Swelling (\%)} = \frac{W - W_0}{W_0} \times 100\% 
\]  
(2)
2.7 Antibacterial activity
The antibacterial activity used the agar disc diffusion method (Kirby Bauer). The suspension of Staphylococcus Aureus bacteria as much as 20 μL was tested on the petri agar medium then rubbed with teryl cotton wool on the test medium then the sterile cotton wool was rotated several times. Paper disc with a diameter of 6 mm. Positive control was Chloramphenicol 50 μg, negative control was starch-chitosan edible film without the addition of essential oil of orange peel. Then the disc is placed on the surface of the media according to the marked sample code. Furthermore, the media was incubated at 37ºC for 18-24 hours, the measurement of the inhibition zone was carried out with the sliding term expressed in millimeters. The clear area indicates the inhibition of microorganism growth by antimicrobial agents on the surface of the agar medium.

2.8 Organoleptic studies
Polyblend edible coating SSCO applied on malang’s apples uses the dipping method. The fruit stalks are tied using a rope, the fruit is dipped in a solution of polyblend edible coating SSCO at 50°C for 1 minute. The coated apples are removed and drained, then dried by hanging at room temperature for 30 seconds and stored at room temperature. To determine the panelists' acceptance of the coated poor apples, an organoleptic test was performed. Assessment parameters include color, aroma, texture and overall. The samples used were apples that had been coated with four variations in the concentration of essential oil. F1 is using the addition of essential oils as much as 0%, F2: 2%, F3: 4% and F4: 6%.

3. Result and Discussion
Preparation of polyblend edible film SSC begins with the gelatinization process of 3% starch solution at 85°C for 25 minutes until the starch solution thickens and homogeneously turns pale white. Furthermore, the process of making 1% chitosan solution dissolved in 1% acetic acid until the clear yellow solution is homogeneous and the chitosan is left to stand for 24 hours. Then the starch, chitosan, and glycerol solutions were homogenized with several concentration variations for 35 minutes. Based on observations, the more chitosan is used, the polyblend edible film SSC is getting clearer, stronger and more elastic. Whereas the greater the concentration of suweg starch, the resulting polyblend edible film SSC was opaque and stiffer. Figure 1 below is an edible film of suweg starch:chitosan blend:

![Figure 1. Poliblend edible film SSC](image)

3.1 Fourier Transform Infra-Red (FTIR) analysis
FTIR characterization was carried out for four samples, namely starch, chitosan, essential oil, and polyblend edible film SSCO. FTIR characterization was carried out to see whether or not new functional groups appeared in the SSCO edible film polyglend in the mixing process.
Based on FTIR spectra of suweg starch, there is a -OH functional group with sharp and wide peaks at the area of 3383.29 cm\(^{-1}\). The second absorption is the presence of Csp\(^3\)H with a sharp peak in the absorption area of 2930.96 cm\(^{-1}\). The -OH and C-H alifatik functional groups are the main functional groups making up amyllose and amylopectin in starch [7]. In the chitosan spectra, there is an overlap of the vibration absorption of the N-H and -OH functional groups in the 3446.94 cm\(^{-1}\) area with a sharp wide peak. The N-H functional group in the FTIR spectra is a typical functional group present in chitosan compounds. This is in accordance with the research of Dompeipen [8] that the typical absorption of chitosan appeared in the 1666 cm\(^{-1}\) area indicating the N-H stretching vibrations of the amide. In the spectra of the essential oil of sweet orange peel, a wave number appears in the area of 2968.65 cm\(^{-1}\) which indicates the presence of C-H alkene uptake. The second absorption, which is in the area of 2920.35 cm\(^{-1}\), shows that Csp\(^3\)H is a -CH\(_3\) group. This is in accordance with Sari and Supartono's research [9] that in memory essential oil there is a C-H alkane functional group; C-H alkenes; and C-C alkenes.

Polyblend edible film SSCO has three absorbances, the first absorption is in the area 3373.64 cm\(^{-1}\) with a wide and sharp peak, this shows the amount of overlap that occurs in the vibration absorption range of the -OH and NH groups originating from starch and chitosan. The second uptake was in the 2933.85 cm\(^{-1}\) area which indicated the presence of C-H alkanes with small but strong peaks indicating the large overlap of -CH\(_3\) derived from starch and essential oils. The third absorption is in the area of 1570.12 cm\(^{-1}\) which indicates the presence of C = C which is a typical group of essential oils. Based on the results of FTIR characterization, it shows that the process of making polyblend edible film SSCO starch-chitosan-essential oil is a physical mixing process because no new functional groups are found, only changes in peak intensity [10].

### 3.2 Mechanical Test

![Figure 2](image-url)

**Figure 2.** FTIR spectra for samples suweg starch, chitosan, essential oil, and poliblend edible film SSCO

| Composition of Suweg Starch:Chitosan | Tensile Strength (MPa) | Elongation (%) |
|-------------------------------------|------------------------|----------------|
| 10:0                                | 1.22                   | 13.33          |
| 9:1                                 | 1.65                   | 29.13          |
| 8:2                                 | 2.58                   | 47.06          |
| 7:3                                 | 6.82                   | 51.55          |
| 6:4                                 | 4.02                   | 48.89          |
| 5:5                                 | 2.85                   | 39.94          |

(a) Composition of Suweg Starch:Chitosan

(b) Composition of Suweg Starch:Chitosan
Mechanical test of polyblend edible film SSC begins by cutting the sample with a width of 5 mm and a length of 50 mm in accordance with ASTM which is suitable for testing the tensile strength of polyblend edible film SSC. Next measure the sample that has been cut using Universal Testing Machine. The traction speed used is 10 mm / minute. The mechanical test results of the SSC edible film can be seen in Figure 3.

### 3.2.1 Tensile Strength

The tensile strength value is the maximum tensile strength that can be achieved until the film can hold on before the film is torn or broken [11]. Based on figure 3 (a) the graph of tensile strength polyblend edible film SSC, the increase in the concentration of the chitosan solution caused the tensile strength of the polyblend edible film SSC increase significantly until it reached the optimum value in the ratio of starch: chitosan 7: 3 of 6.82 MPa after that the tensile strength value decreased until the ratio of starch: chitosan 5: 5 was 2.85 MPa. The lowest tensile strength value in the ratio of starch: chitosan 10: 0 was 1.22 MPa. When compared with the tensile strength value of the moderate properties group, for the tensile strength value of 1-10 MPa [9], so the polyblend edible film SSC has standard tensile strength value. Compared with the edible film starch suweg-glycerol, the tensile strength value was in the range 0.2-5.43 MPa in the Saputra study [3] and the polyblend edible film tapioca flour-cornstarch had the optimum tensile strength value of 0.37 MPa in Haryanto's research [12] polyblend edible film SSC has higher tensile strength value. When compared with the research of Setiani [10], the tensile strength value of the polyblend edible film of breadfruit starch-chitosan was 2.97-16.34 MPa, the tensile strength of the polyblend edible film SSC was smaller. This shows that the addition of chitosan increases the tensile strength of the polyblend edible film SSC based on starch. The increase in the concentration of chitosan solution was able to increase the tensile strength of the SSC polyblend edible film due to the presence of hydrogen bonds due to the amine functional groups, primary and secondary hydroxyl groups in chitosan which bind to the amylose and amylopectin chains in starch so that the edible film becomes tighter [10]. The presence of hydrogen bonds between the chitosan-amylese-amylpectin chains causes the chemical bonds to be strong and difficult to break the edible film because it requires a large amount of energy to break the bond. If the concentration of the starch solution is increased, the starch polymer bond chain in the solution is located between the chitosan polymer bond chains so that the interaction between the chitosan polymer chains decreases and the tensile strength of the polyblend edible film SSC decreases [3].
3.2.2 Elongation

Elongation is the proportion of change in the length of the film after being stretched until it breaks [13]. Based on figure 3 (b) the graph of the results of the elongation test for the polyblend edible film SSC, the increase in the concentration of chitosan solution caused the tensile strength value of the polyblend edible film SSC to increase significantly until it reached the optimum value in the ratio of starch: chitosan 7: 3 of 51.55% after that the elongation value decreased until the starch:chitosan ratio 5: 5 was 39.94%. Decrease in the value of elongation due to a decrease in the intermolecular bond distance. The lowest elongation value in the ratio of starch: chitosan 10: 0 was 13.33%. When compared with the moderate properties group elongation value, the standard elongation value is 10-20%, then the polyblend edible film SSC is included in the standard elongation value.

According to research by Saputro [3] and Nafiyanto [14], an increase in the concentration of chitosan in the edible film starch of canna-chitosan and banana-chitosan stump causes the elongation value to decrease due to the presence of starch that is still bound in the extract. The presence of starch adds solids to the film which makes the film less elastic. The results are in accordance with the research of Saputra [3] suweg-glycerol starch edible film has an elongation value in the range of 23.33% -43.33% where the addition of suweg starch the elongation value decreases. The more starch contained in polyblend edible film SSC, the more rigid the edible film SSC was so that the elongation value decreased. Polyblend edible film SSC has a greater range and optimum value than the starch-glycerol polyblend edible film SSC so that chitosan has an effect on the increase in the elongation value of polyblend edible film SSC.

3.2.3 Modulus Young

Modulus young is a measure of the stiffness of a material obtained from the ratio of tensile strength and elongation values. Figure 3 (c) shows a specific modulus young pattern, namely polyblend edible film SSC with a ratio of 10: 0 experiencing a decrease but in the ratio of starch: chitosan 9: 1 and 8: 2 there was an insignificant increase, namely from 2.83% to 2.88% and reached the optimum value in the ratio of starch: chitosan 6: 4 of 1.62 MPa. This shows that an increase in the concentration of chitosan solution can reduce the modulus young value until the starch:chitosan ratio reaches the optimum value. Compared with previous research [15] showed that the modulus young edible film of avocado seed starch: chitosan was in the range 1.46% -4.65%, so the value of modulus young polyblend edible film SSC is smaller. In figure 3 (c) it can be seen that in the starch: chitosan ratio of 10: 0, the highest modulus of young is 17.03% so that the increase in the concentration of the starch solution increases the stiffness of the film. This is in accordance with the research of Saputra [3] in his research on starch: glycerol, that increasing the concentration of starch solution in each treatment will increase the value of young modulus which is in the range 15.23% -60.19%.

3.3 Water Vapor Permeability (WVP) dan Water Vapor Transmission Rate (WVTR) Test

Water vapor transmission is the amount of water vapor that passes through the surface of the film per unit time divided by the area of the film. Water vapor transmission occurs due to differences in the moisture of food products with the surrounding environment. Therefore, polyblend edible film SSC serves to withstand the migration of water vapor so that the transmission of water vapor must be as low as possible [16].
Figure 4. WVTR (a) and WVP (b) test of poliblend edible film SSC

The results of the WVTR test showed that increasing the concentration of the chitosan solution could significantly reduce the WVTR value up to a certain ratio, then increased with the addition of the concentration of the chitosan solution. The addition of chitosan can increase the mass density between the chains so that chitosan will fill the empty space in the amyllopectin structure in amorphous starch so that water vapor transmission will be reduced [10]. Polyblend edible film SSC in the ratio of starch: chitosan 7: 3 had an optimum WVTR value of 28.2751 g H$_2$O/m$^2$.h because the added chitosan solution filled the pores or bond gaps between polymer chains evenly. According to previous research [17], the addition of the concentration of chitosan solution above the optimum conditions results in increased water vapor transmission because the added chitosan solution will form a layer on top of the edible film. The largest water vapor transmission value in the ratio of starch: chitosan 10: 0 was 51.2033 g H$_2$O/m$^2$.h. The value of water vapor transmission is high because it is influenced by the ratio of the composition of materials that are hydrophilic and hydrophobic. The constituent materials of polyblend edible film SSC in the form of starch and chitosan include polysaccharides which are polar polymers and have high free hydrogen bonds so that they are able to absorb water in environments with high humidity. As a result, the absorption of water will interfere with the intermolecular chain interaction, which is then followed by an increase in diffusivity and is able to absorb water vapor from the air [14].

Based on figure 4 (b), the water vapor permeability value of polyblend edible film SSC has the lowest value of 0.0886 gm$^{-1}$.h$^{-1}$.kPa$^{-1}$ and the highest value of 0.2802 gm$^{-1}$.h$^{-1}$.kPa$^{-1}$. The water vapor permeability value of polyblend edible film SSC made from linear starch with film thickness [18]. In the ratio of starch: chitosan 7: 3 had a lower WVP value of 0.0975 gm$^{-1}$.h$^{-1}$.kPa$^{-1}$ compared to the ratio of starch: chitosan 6: 4 of 0.0989 gm$^{-1}$.h$^{-1}$.kPa$^{-1}$. This is because WVTR in the starch: chitosan ratio of 7: 3 has an optimum value so that the resulting WVP value is lower. In addition to the thickness of the film, the WVP value is also influenced by the nature of the basic material that makes up the film, namely starch, which is hydrophilic so that it has many free hydroxyl groups hydrogen bonds with water molecules thereby increasing the WVP value [19]. The addition of chitosan solution can reduce water vapor permeability because chitosan fills the bond gap between the chains so that the film matrix is dense and the permeability value decreases.

3.4 Solubility studies

Solubility is a quality parameter of polyblend edible film SSC when consumed and is a determining property of biodegradable film when used as a food packaging material [20]. The results of the solubility test for polyblend edible film SSC can be seen in Figure 5.
Based on the solubility test of polyblend edible film SSC, it was found that increasing the concentration of chitosan solution decreased the solubility percentage of polyblend edible film SSC in water significantly. The lowest solubility percentage of polyblend edible film SSC was in the ratio of starch: chitosan 5:5 of 3.3333% and the highest percentage of solubility of polyblend edible film SSC was in the ratio of starch: chitosan 10:0 of 26.3157%. The addition of concentration of chitosan solution causes the free amino groups to be difficult to dissolve in water at neutral pH so that the resistance of polyblend edible film SSC in water increases. The greater the concentration of the starch solution, the percentage of solubility of the polyblend edible film SSC increased because the -OH functional group in starch easily binds to water molecules through hydrogen bonds [21]. The percentage of solubility is also influenced by the thickness and concentration of polyblend edible film SSC filler. According to Larasati [22], the higher the filler concentration of a polyblend edible film SSC, the higher the solubility presentation. The ratio of starch: chitosan 10:0 had the highest filler and thickness, namely the volume of starch 3% (v/v) of 60 mL with a film thickness of 0.146 mm. Another study on polyblend edible film SSC glucomannan-cornstarch with a thickness of 0.1828 mm and a concentration of 15% glucomannan had a higher solubility than films with a thickness of 0.1613 mm and a concentration of 0% glucomannan. [21].

3.5 Swelling studies
The water resistance test is a test to determine the absorption capacity of polyblend edible film SSC to water which is expressed in percent swelling where the polyblend edible film SSC with low percent swelling has high water resistance [23]. The swelling test was carried out in a salt phosphate buffer at a pH of 7.4 so that the polyblend edible film SSC was at a neutral pH so that the film was not acidic or alkaline. The swelling test for the polyblend edible film SSC can be seen in Figure 6.

Based on the swelling studies of polyblend edible film SSC, it was obtained that the addition of the concentration of chitosan solution could reduce the percent swelling of polyblend edible film SSC.
The highest percentage of swelling was in the ratio of starch: chitosan 10: 0 of 19.7761% and the lowest percentage of swelling was in the ratio of starch: chitosan 5: 5 of 3.6496%. This is consistent with the research of Saputro and Arruum Linggar Ovita [24] and Nafiyanto [14] that increasing the concentration of chitosan can reduce the percent swelling. Chitosan has perfect solubility at a pH of about 4.0 and is difficult to dissolve in solutions with a pH above 6.5 so that the addition of chitosan makes the percent swelling of polyblend edible film SSC smaller. Analysis of the basic ingredients of starch containing amylose and amylopectin which have many branching causes the bonds between the chains in amylopectin to break easily [25]. The nature of amylopectin which breaks easily results in many voids (empty space) so that the mass density between the starch chains is small and water absorption is quite large. The amount of water absorption in the linear swelling test with the addition of the concentration of the starch solution.

3.6 Antibacterial activity

Antibacterial activity test aims to determine the ability of antibacterial substances to inhibit bacterial growth seen in the formed clear zone. The method used is disc diffusion by looking at the size of the clear zone formed. The clear zone is an indication of the absence or inhibition of microorganisms due to the excretion of antibacterial substances [26]. The result of antibacterial test can be seen in figure 7. Bacteria that used is the gram-positive Staphylococcus aureus bacteria which usually contaminates food and is easily transmitted by hand. The positive control used was chloramphenicol and the negative control was polyblend edible coating SSCO starch-chitosan with a concentration of essential oil 0%. In the positive control, a clear zone was formed and in the negative control there was no clear zone formed so that the antibacterial activity was derived from the essential oil of sweet orange peel. The incubation process is carried out at 37°C for 18-24 hours because the bacterial growth phase occurs in a stationary phase where the rate of growth and death of bacteria is the same so that the number of bacteria remains [27]. The mechanism of antibacterial inhibition against bacterial growth can be in the form of damage to the cell wall which results in lysis or inhibition of cell wall synthesis, alteration of the permeability of the cytoplasmic membrane resulting in the release of food material through the cell wall, denaturation of cell proteins and destruction of the metabolic system in cells by inhibiting the work of intracellular enzymes [28].

![Figure 7. Antibacterial activity of polyblend edible coating SSCO with varying concentration essential oil (1) 6%, (2) 4%, (3) 2%, (4) 0%(v/v)](image)

Antibacterial activity is classified into four according to Cockerill [29] in Baharun [30], namely strong positive (inhibition zone ≥ 20 mm), moderate (inhibition zone 15-19 mm), weak or resistant (inhibition zone ≤ 14 mm), and negative (-). Based on the antibacterial activity test, inhibition of Staphylococcus aureus bacteria occurs in a clear zone at a 4% essential oil concentration of 11.48 nm.
which is classified as weak and the orange peel essential oil concentration of 16.55 mm which is classified as moderate. This is according with studies of Kindangen [31] and Febrianti [32] where the higher the concentration of essential oils, the larger the clear zone is formed. Compared with the Kindangen study [31], the antibacterial activity test of Kalamansi orange peel essential oil inhibits S. aureus bacteria. The clear zone is formed with a diameter range of 5.16 mm-11.16 mm, so that the essential oil of sweet orange peel has a larger inhibition zone diameter.

3.7 Organoleptic and shelf life test

Based on Table 1, it can be seen that the color parameter of the formulation F4 has a significant difference with the control. The aroma parameters of the F3 and F4 formulations had significant differences with the control and the F3 and F4 formulations also had significant differences. The texture parameters of the formulations F3 and F4 have significant differences with the control and formulations F3 and F4 have significant differences. Meanwhile, the F1 and F2 formulations did not have a significant difference with the control of both color, aroma, and texture parameters.

| Table 1. Organoleptic test of Malang’s apple coated SSCO |
| Parameter | Level of Significance (α) | Result |
|-----------|--------------------------|--------|
| Color     | 0.05                     | The F4 formulation has a difference significant with control and the less the addition of the essential concentration |
| Aroma     | 0.05                     | The F3 formulation has no significant difference with F4 formulation, but both F3 and F4 formulation have a significant difference with control |
| Texture   | 0.05                     | The F3 formulation has significant difference with F4 formulation, but both F3 and F4 formulation have a significant difference with control |

Selection of the essential oil concentration of sweet orange peel at the maximum variation because it has the largest inhibition of S. aureus bacteria, although it is not very popular with consumers based on the organoleptic test. Based on the results of physical observations on the surface of the skin of the poor apples, it was found that the skin of the poor apples was damaged on the 22nd day so that the poor apples lasted 8 days longer than the poor apples that were not coated with polyblend edible coating SSCO. The effect of applying edible coating on malang’s apples can be seen at figure 8.

Figure 8. Malang’s apple coated (right) dan malang’s apple not coated (left)

4. Conclusion

Characterization of the functional groups polyblend edible film SSCO showed functional groups -OH, N-H, C=C, CH₃. The variation composition affects on the physical properties of edible film SSC in the mechanical test, WVTR, and WVP with optimum concentration edible film SSC 7: 3, while the
solubility and swelling reach the optimum concentration edible film SSC of 5: 5. The addition of essential oil had an effect on the antibacterial activity of polyblend edible film SSCO with a maximum inhibition zone 16.55 mm with concentration 6% in S. aureus bacteria. Based on organoleptic test, F3 and F4 formulations have a significant difference with the control of both color, aroma, and texture parameters and malang’s apples can last 22 days on physical performance observations.

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