

Study of Edible Film from Corn Starch (*Zea Mays* L.) on the Quality of Minimally Processed Jackfruit

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ABSTRACT

Minimally processed jackfruits can usually be found in traditional markets, but the fact found that jackfruit is sold unpackaged and the fruit is not fresh, some have even browned and are infested with flies. Refrigerator is usually applied, but this technology is relatively expensive and not all farmers/traders can afford it. Edible film is an alternative that is easily degraded and decomposed by natural composers plus zinc oxide (ZnO) which is a piezoelectric ceramic that has anti-microbial properties. The purpose of this research was to determine the effect of ZnO concentration on the characteristics of edible films and to determine the best concentration of ZnO and its effect on packaging in jackfruit. Variations in the concentration of ZnO used 0%, 3%, 9% and 12%. Observations on jackfruit were carried out at room temperature. Results showed the higher the concentration of ZnO, the better the ability of edible films with ZnO to maintain the quality and shelf life of jackfruit. Edible film with 12% ZnO was able to extend the shelf life of processed jackfruit for at least 5 days at room temperature .

1. INTRODUCTION

Jackfruit is a very famous tropical fruit in Indonesia. Jackfruit is famous for its bright yellow flesh, the texture of the fruit is thin and soft and the specific aroma makes this fruit very popular. Jackfruit production in Indonesia was recorded at 906,514 tons in 2021. This number grew 10.00% compared to the previous year which amounted to 824,068 tons and 14 254,00 tons in Sumatera Barat (BPS, 2021). Consuming fresh fruit with high nutritional content is very important for humans. but considering the high level of human activity causes most people to choose something that is practical, then choose ready-to-eat fruit available in the market. Minimally processed jackfruit can usually be found in traditional markets, but the fact found in most traditional markets is that jackfruit is sold unpackaged and the fruit is not fresh. Some have even experienced browning and flies are

infested. This is due to a decrease in quality. Quality degradation is usually marked by damage to the product caused by environmental, chemical, biochemical, and microbiological factors during storage. The presence of other substances such as water, oxygen, light, and ambient temperature can also accelerate product quality degradation (Chen *et al.*, 2006).

Agricultural products will experience a decline in quality after the harvesting process, over time during the post-harvest process such as washing, sorting, grading, transportation time to the market to the distribution process to consumers' hands (Pujimulyani, 2009). Postharvest technology which is usually applied to fresh jackfruit products is storage technology in the refrigerator which will inhibit the respiration process in fresh jackfruit (Widyastuti, 1993). Unfortunately, this technology is constrained by its relatively expensive price and operation, and not all farmers/traders can afford to have these rooms/refrigerators. An alternative to the refrigerator is by providing packaging.

According to Hui (2006), one way to prevent or slow down food spoilage is with proper packaging. Packaging is a process of storing a product by wrapping it using appropriate packaging materials so that product quality is maintained. One of the packaging materials that are often encountered in everyday life is plastic. Along with the times, the world community increasingly understands the importance of food quality, especially in terms of packaging that is safe for health and safer for environmental health, packaging that is easily degraded and decomposed by natural composers. The current situation demands research on biodegradable packaging materials. According to McHugh & Krochta (1994), packaging technology that is safe and does not damage the environment is very necessary, one example is edible film. Edible film is a thin layer that can be used as a coating for food or agricultural products and can be made from starch (Anugrah, 2014). Starch is an example of a hydrocolloid which is abundantly available in the nature. One of the plants that has a fairly high starch content is corn. West Sumatra Province is an area with a fairly large corn production with the type of corn grown from one of the superior corn, namely the hybrid type. Statistics record that in 2018, the total production of corn plants in West Sumatra reached 925,564 tons with the largest production produced by the West Pasaman Regency area of 367,865 tons (BPS, 2016). Most of the corn production is intended to meet the needs of making animal feed.

The large amount of corn production can be used for the manufacture of edible films, which is an alternative packaging that is environmentally friendly because of its biodegradable nature. The end result of this degradation is CO₂, H₂O, other organic compounds in the form of organic acids and aldehydes that are not harmful to the environment (Kholish, 2012). Edible films can be made by mixing natural polymers with synthetic polymers, the aim is to improve the mechanical properties, namely increasing the tensile strength and elasticity of edible films (Bourtoom, 2008).

Zinc oxide (ZnO) is a piezoelectric ceramic that has anti-microbial properties because it can reduce moisture so that if it is used as a packaging composition, food will not spoil quickly (Erfan, 2012). Research on the manufacture of edible films from starch with the addition of glycerol and zinc oxide is still a little done. Several previous studies that have used zinc oxide concentrations in the manufacture of edible films included sweet potato starch (Ervan, 2012), gadung tuber starch (Saputra *et al.*, 2019), tapioca and corn *ampok* (Rahmatunisa, 2015), cassava starch (Ridwan, 2018), and soy protein (Putri *et al.*, 2018). Several studies have revealed that there is an effect on changing characteristics from each addition of concentration or amount of ZnO

nanoparticle. This research aim to determine the effect of ZnO nanoparticle concentration on the characteristics of edible films from corn starch (*Zea mays* L.) and to determine the best ZnO concentrations as a mechanical strengthening agent for edible films made from corn starch and their effect on jackfruit packaging .

2. MATERIALS AND METHODS

2.1. Materials

The tools and materials used during the research were: the main ingredients were 10 kg of corn with hybrid varieties, distilled water (H₂O), glycerol (C₃H₈O₃), filter paper, and tissue paper. The ZnO used in this study was obtained from T&T Chemical. Glycerol used in this study was obtained from PT. Brataco. Jackfruit is obtained from Solok region in a ripe condition. The jackfruit has received peeling treatment, separation of the fruit from the skin so that the fruit is ready for consumption.

The tools used in this research were magnetic stirrer, digital oven, analytical balance, screw micrometer, universal testing machine (COM-TEN Testing Machine 95T series 5K), spectrophotometer, Erlenmeyer, beaker, measuring cup, dropper pipette, sieve 100 mesh, blender, petri dish, scissors, aluminum foil, plate, and knife.

2.2. Design of Experiment

This study used a completely randomized design (CRD) using the SPSS application with the one-way-ANOVA method. This experiment was carried out with a series of processes to produce edible films with the addition of ZnO at various concentration ([Ridwan, 2018](#)) regarding the synthesis and quality testing of biodegradable plastics from cassava starch. The ZnO concentrations used in this study were 0%, 3%, 6%, 9%, 12% (w/v total). As much as 5 g of starch was used with the addition of glycerol as much as 50%. Edible film was applied to minimally processed jackfruit with observation parameters including weight loss, hardness, TPT test, and microbial test. In this study control treatments (without edible film) was also carried out for comparison. All treatments were performed with 3 replications and 10 days of observation, so the number of samples needed was 180. In addition, edible film characteristic (thickness, water resistance, tensile strength, and elongation) was analyzed for 5 treatments in triplicates (15 samples). So the total edited films made were 195 samples.

2.3. Edible Film Preparation

Edible film was prepared following the work method of [Ridwan \(2018\)](#) with a few modifications. Corn starch was used as much as 5 g as the main ingredient. The amount of glycerol was 50% of the amount of starch ([Kasmawati \(2018\)](#)). The glycerol and ZnO with variations of 0%, 3%, 6%, 9% and 12% (v/v total) were mixed into 100 mL of distilled water and stirred using a magnetic stirrer for 15 min until homogeneous. After that, 5 g of corn starch was added to a solution containing a mixture of ZnO, glycerol, and distilled water and then homogenized at 80 °C to 90 °C using a magnetic stirrer for 40 min. The mixture was then casted on a glass mold measuring of 20 cm x 20 cm and dried at 60 °C in the oven for 5 h ([Kasmawati, 2018](#)).

2.4. Observation and Measurement

2.4.1. Weight loss

Weight loss was calculated based on the percentage reduction of the sample weight from the beginning to the end of storage. Observation of weight loss was carried out

every 2 days until the fruit was in a rotting condition. Jackfruit was weighed using a digital balance, and the weight loss was calculated by Equation (1).

$$S_b = \frac{W_o - W_a}{W_o} \times 100\% \quad (1)$$

with S_b is jackfruit weight loss (%), W_o is initial weight of jackfruit, and W_a is weight of jackfruit at the end of storage.

2.5.2. Hardness

The hardness of jackfruit was measured using a digital force gauge. Measurements were taken daily at 3 points, namely base, middle, and tip. Hardness was expressed in units of N.

2.5.3. Total Dissolved Solids

Measurement of total dissolved solids was carried out using a refractometer. The liquid from the material is dripped on the refractometer glass. The refractometer is pointed at the light to see the value in it, the value is taken in five times by taking liquid from several different sides of the jackfruit, namely, the base, the tip, and the middle. The value obtained is expressed in units of °Brix. Observation of total dissolved solids was carried out every day until the jackfruit was in a rotting condition.

2.5.4. Microbial Test

The total microbial test was analyzed using the dilution method. The minimally processed jackfruit is weighed as much as 5 grams and put into a test tube containing 10 mL of physiological NaCl (100), then homogenized. Take 1 mL of dilution (100) put into a test tube containing 9 mL of physiological NaCl (10^{-1}) then homogenize and so on. Dilutions were made up to dilution (10^{-5}). Take 1 mL of each dilution using a micropipette into a sterile petri dish. Add Sodium Agar (NA) media and homogenize it by moving it like writing a figure eight. Then for 48 hours incubation was carried out at 37°C. The microorganisms that grow were observed and counted by Equation (2):

$$A = B/C \quad (2)$$

with A is colonies per ml or per gram, B is number of colonies per plate, and C is dilution factor.

2.5.5. Color Analysis

Quantitative color observations were carried out using a spectrophotometer, to determine the color changes that occurred during the observation. The color values to be processed were brightness L^* (0 = black; 100 = white), a^*b^* (color trend) with a^* (+) is red, a^* (-) is green, b^* (+) is yellow, and b^* (-) is blue.

2.5.6. Moisture Content (Sudarmadji *et al.*, 1997)

Measurement of the moisture content was carried out using the oven method, the material from the jackfruit was weighed using a digital scale in an aluminum cup which had been measured for weight and then the material was weighed 10 g. The material was dried in an oven at 105 °C until constant weight. Water content (M) was measured daily until the fruit rotten. The water content was calculated as:

$$M = \frac{b - c}{b - a} \times 100\% \quad (3)$$

where a is weight of cup (g), b is weight of the cup plus the fresh jackfruit sample (g), and c is weight of cup plus weight of dry jackfruit sample (g).

2.5.7. Data Analysis

Data analysis used a one-way CRD of one factor (ZnO concentration). Factorial of two factors, namely the length of days of storage and the concentration of zinc oxide. Decision making is done by comparing statistical results. The statistical test consists of 2 hypotheses, namely:

H0 = ZnO concentrations did not affect the characteristics of the edible film.

H1 = ZnO concentrations affected the characteristics of the edible film.

H0 = ZnO concentration and storage days did not affect the observed value of minimally processed jackfruit.

H1 = ZnO concentration and storage days affected the observed value of minimally processed jackfruit.

H0 is rejected (H1 is accepted) if $P < 0.05$, it can be concluded that the addition of zinc oxide with varying concentrations of 0%, 3%, 6%, 9% and 12% has an effect on the characteristics of the edible film. If the P value is < 0.05 (H0 is rejected) then proceed with another test, namely Duncan's Multiple Range Test (DMRT).

3. RESULTS AND DISCUSSION

Table 1 shows the effect of ZnO concentration in edible coating on the observed quality parameters of minimally processed jackfruit, including weight loss, hardness, TDS, total microbial, and water content.

Table 1. Effect of ZnO concentration on the quality parameters of minimally processed jackfruit

Treatment	Weight loss (%)	Hardness (N)	TDS (°Brix)	Microbial (unit)	Water content (%)
Control	8.85 b	0.411 b	20.00 a	1.6E+05 a	59.66 a
ZnO 0%	8.48 b	0.305 a	20.56 a	7.5E+05 d	45.22 a
ZnO 3%	5.74 a	0.326 ab	21.48 a	6.7E+05 cd	48.26 a
ZnO 6%	5.29 a	0.356 ab	20.93 a	4.7E+05 b	49.96 a
ZnO 9%	5.86 a	0.329 ab	21.80 a	5.9E+05 bc	69.77 a
ZnO 12%	6.33 a	0.350 ab	21.91 a	6.5E+05 cd	69.73 a

Note: The same letter in the same column means not significantly different under DMRT at $\alpha = 0.05$

3.1. Weight Loss

Weight loss is shrinkage in fruit that occurs due to loss of water vapor due to the evaporation process during storage. The weight loss of minimally processed jackfruit with edible film coating at various ZnO concentrations can be seen in Figure 1. The weight loss at various concentrations of ZnO increased during storage at room temperature. Weight loss is caused by the transpiration and respiration process in the fruit (Sari, 2015). The transpiration causes a loss of H_2O , while the respiration causes a loss of CO_2 so that the fruit loses weight (Hartuti, 2006). Minimal processing of jackfruit accelerates the weight loss because the skin of the jackfruit has been removed. Giving edible film acts as a skin of peeled fruit Hartuti (2006).

Figure 1 shows that the weight loss of minimally processed jackfruit treated using corn starch edible film with various concentrations of zinc oxide was lower than that of

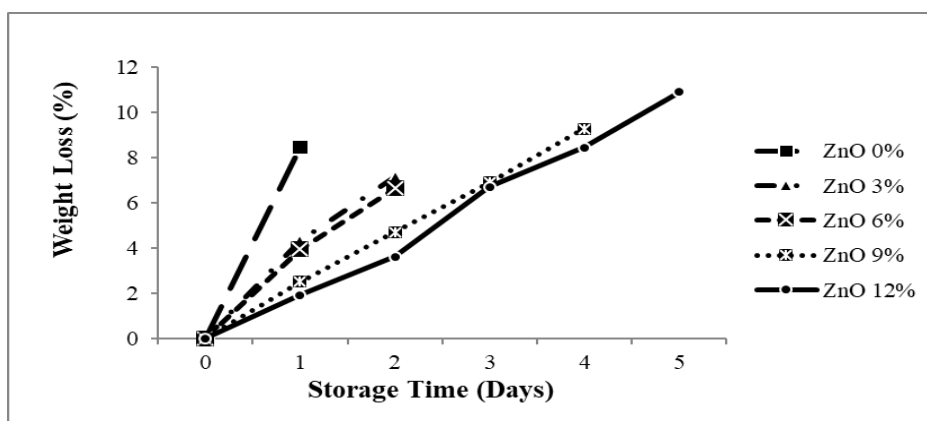


Figure 1. Weight loss of jackfruit using edible film corn starch with variation of ZnO

control (without edible film). Jackfruit treated with edible film at ZnO concentration of 12% had the lowest rate of weight loss, while the control treatment had the highest weight loss rate. This is because edible film with 12% ZnO has the thickest edible film layer which is able to inhibit the evaporation of water so that the thickness of the corn starch edible film is maintained and experiences less water evaporation. This is in line with [Darmajana et al. \(2017\)](#) which states that the weight loss value of cut melon fruit without coating is greater than that of fruit coated with edible coating, both by wrapping and coating methods. One role of coating is to reduce evaporation of water from the fruit so that the fruit remains fresh because the movement of water into the air is restrained by the coating material so that the water vapor pressure in the cell does not decrease.

Figure 1 also shows that jackfruit stored with edible film coating has a longer shelf life than without edible film treatment (control). The graph shows that the concentration of ZnO has also an effect on the resistance of jackfruit. The greater the concentration of ZnO, the longer the durability of the jackfruit. [Meindrawan \(2017\)](#) stated that the addition of nanoparticles can increase the water vapor permeability of the film so that weight loss due to water loss can be inhibited. This is because the presence of NP-ZnO in the coating polymer can improve the mechanical properties of the polymer used. coatings were able to reduce weight loss of salak fruit better than controls ([Marpaung et al., 2015](#); [Sabarisman et al., 2015](#)). In this research process, jackfruit is stored at room temperature. Jackfruit with control treatment can only survive for 1 day after which it will be watery and rot, this indicates that the jackfruit can no longer be consumed. Jackfruit stored in ediblefilm packaging can last up to 5 days, on day 6 the jackfruit has shown signs of decay and is no longer fit for consumption.

The treatment of ZnO concentration and storage days affected the weight loss value of jackfruit. This is indicated by the results of ANOVA analysis (Table 1) that revealed that storage days and the ZnO concentration affect the weight loss with $p < 0.05$, so it can be concluded that H_0 is rejected and H_1 is accepted. The lowest percentage of reduction in weight loss was found in jackfruit treated with 12% ZnO concentration which could be observed up to day 5, while the highest percentage in weight loss was found in jackfruit which was not given edible film (control) with a value of 0 because on day 0 the fruit the jackfruit was rotten and could not be observed for the next day. The weight loss percentage of jackfruit without edible film (control) was significantly higher than those of with edible film. The ability of edible coating with 0% ZnO was not

different with control and significantly higher than those of edible film with ZnO addition. This indicates the role ZnO concentration in the decreasing of weight loss in minimally processed jackfruit.

3.2. Hardness

One of the parameters used to see the level of fruit damage is hardness. The results of measuring the hardness of jackfruit minimally processed with edible film coating at various ZnO concentrations is presented in Figure 2. It shows that the hardness of minimally processed jackfruit given corn starch edible film with various concentrations of ZnO decreased during storage at room temperature. Syafutri *et al.* (2006) stated that the decrease in hardness was caused by the process of transpiration and respiration that occurred in fruits. The transpiration process causes minimally processed jackfruit to wither and shrivel due to evaporation so that the fruit is softer. The respiration process causes the breakdown of carbohydrates contained in jackfruit to be minimally processed into simpler compounds. This breakdown of carbohydrates results in the breakdown of tissue in the fruit so that the jackfruit is minimally processed to become soft.

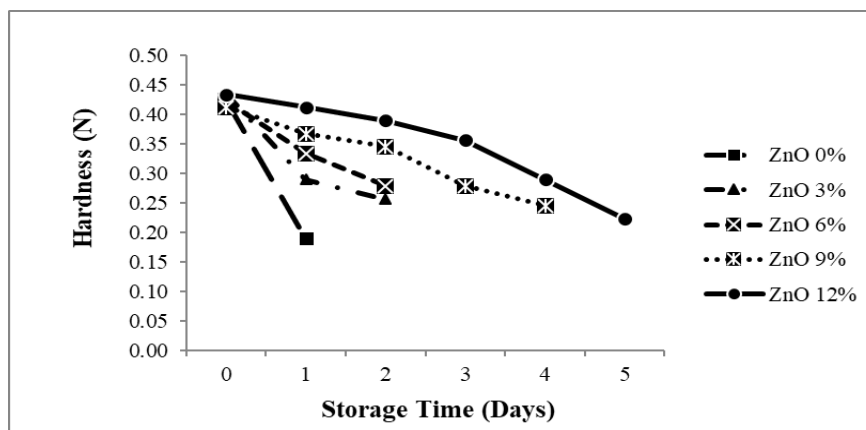


Figure 2. Hardness of jackfruit using edible film corn starch with variation of ZnO

The hardness value of minimally processed jackfruit that was given corn starch edible film with various concentrations of ZnO was higher than that of not given edible film (control) at the beginning of the 0th day of observation. The treatment with hardness value close to control is ZnO 9%. The highest hardness value was found in minimally processed jackfruit that was treated with 12% ZnO and was the best jackfruit hardness value that was close to the initial observation value of each day of observation, while the lowest hardness value was found in minimally processed jackfruit that was given the control treatment. This proves that the edible film is able to slow down the decrease in the hardness of the minimally processed jackfruit during storage. Widaningrum *et al.* (2015) stated that packaging or coating can inhibit respiration rate and suppress fruit softening. Several studies also reported that NP-ZnO-based coatings and packaging are able to delay the decrease in fruit hardness such as jujube (Li *et al.*, 2009), kiwi (Meng *et al.*, 2014) and salaca (Marpaung *et al.*, 2015).

The minimally processed jackfruit with control treatment could only be observed on day 0, because on day 1 it smelled bad and was moldy. Minimally processed jackfruit treated with 0% ZnO had a shelf life of up to day 1. The shelf life increase to day 2 with 3% and 6% ZnO, and to day 4 with 9% ZnO. The longest shelf life was found with 12%

ZnO treatment, which is up to day 5. The treatment of edible film and storage days significantly affected the hardness value of jackfruit. This is indicated by the results of ANOVA analysis with probability values $p < 0.05$, namely 0.000 for days factor and 0.036 for ZnO concentration. As can be observed from Table 1, the hardness of jackfruit with edible film was significantly lower than that of control. The effect of ZnO addition at various concentration, however, is not statistically different.

3.3. Total Dissolved Solids

The total dissolved solids (TDS) determines the sugar content in the fruit. The higher the total soluble solids value of the fruit, the sweeter the fruit taste will be. The results of the measurement of total dissolved solids of minimally processed jackfruit with edible film packaging at various concentrations of ZnO can be seen in Figure 3. It shows the value of the total soluble solids of jackfruit with ediblefilm treated with ZnO 12% at room temperature, the increase in value was slower than the control treatment, ZnO 0%, ZnO 3%, ZnO 6%, ZnO 9% and ZnO 12%. This happens because the treatment given with edible film can protect the surface of the jackfruit so that it inhibits the respiration process in the fruit and causes the formation of sugar to be inhibited. The total soluble solids value of jackfruit in the control treatment at room temperature had a higher value the next day compared to other concentrations. This is because the control treatment is not coated with edible film so that the ripening process of jackfruit is not hampered so that the formation of sugar occurs more quickly. During the ripening process, TDS of fruit will increase due to the increasing concentration of dissolved compounds in fruit, especially sugar (Latifah, 2000). This is in accordance with the statement of Pujimulyani (2009) which states that when fruit ripens, the dissolved solids will increase. This increase will be sharper if there is a very fast transpiration. This means that the edible film treatment in this study is able to coat minimally processed jackfruit to reduce the rate of respiration and transpiration processes so that it can inhibit a significant increase in TDS content, this is in line with the statement of Widaningrum *et al.* (2015) which states packaging or coating able to inhibit the rate of respiration in minimally processed fruit.

The TDS value of minimally processed jackfruit at room temperature can only be observed on day 0 only, for the next day the jackfruit has been damaged, rotten and has fungal growth. This is because storage at room temperature will speed up the process of respiration in the fruit will also take place quickly. The minimally processed

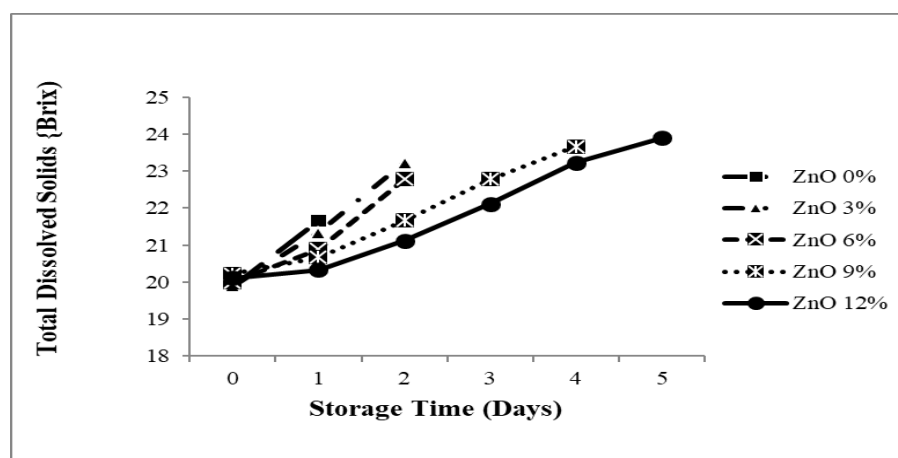


Figure 3. Total dissolved solids of jackfruit using edible film corn starch with variation of ZnO

jackfruit that was given the control treatment could only be observed on day 0, because on day 1 it smelled bad and was moldy. Minimally processed jackfruit treated with 0% ZnO had a shelf life of up to day 1. Minimally processed jackfruit treated with 3% and 6% ZnO had a shelf life of up to day 2, while minimally processed jackfruit treated with 9% ZnO had a shelf life of up to day 4. The minimally processed jackfruit with the longest shelf life was found in the 12% ZnO treatment, which is up to day 5. The treatment of ZnO concentration and storage days did not significantly affect the TDS value of jackfruit. ANOVA analysis reveals that the treatment of ZnO edible film has p value $0.600 > 0.05$ (H_0 was accepted and H_1 was rejected). This indicates that the storage day has no significant effect on the TDS of the jackfruit. Similarly, the ZnO concentration treatment has a p value of $0.784 > 0.05$ (H_0 was accepted and H_1 was rejected), indicating that the concentration of ZnO has no significant effect on the TDS of minimally processed jackfruit.

3.4. Microorganisms Test

Microorganisms in fruits are generally concentrated on the skin that is bruised or deformed during harvest. According to [Leksono \(2001\)](#), at the beginning of storage the microorganisms found in fruits were relatively similar, but these microorganisms would increase over time during storage. This is because the environment can affect the growth of microorganisms to the maximum. The results of the minimally processed microbial test of jackfruit with edible film packaging at various concentrations of ZnO can be seen in Figure 4.

According to [Leksono \(2001\)](#), at the beginning of storage the microorganisms found in fruits were relatively similar, but these microorganisms would increase over time during storage. This is because the environment can affect the growth of microorganisms to the maximum. The results of observations of jackfruit microorganisms using corn starch ediblefilm with varying concentrations of ZnO can be seen in Figure 4 which shows that the total microbe of minimally processed jackfruit that was given corn starch edible film with various concentrations of ZnO increased during storage at room temperature. [Rochman \(2007\)](#) stated that the increase in total microbes was due to the fruit containing nutrients that can be used for the growth of microorganisms. During respiration, carbohydrates are broken down into simple sugars. These simple sugars are used as substrates for the growth of microorganisms.

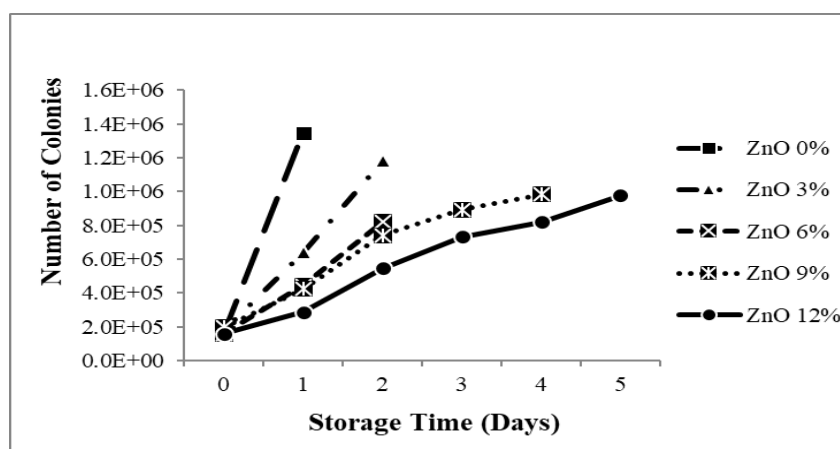


Figure 4. Microbial test of jackfruit using edible film corn starch with variation of ZnO

The total microbial increase in minimally processed jackfruit that was given edible film during storage was lower than that of minimally processed jackfruit that was not given edible film (control). Observations of total microbes were carried out after 24 hours of storage. The lowest total increase in microbial growth was found in jackfruit coated with edible film with 12% ZnO concentration. This proves that corn starch edible film with ZnO concentration can inhibit the increase of microbes in minimally processed jackfruit. The main application of zinc oxide nanoparticles in food packaging can be found in the manufacture of edible films. Nano-sized fillers greatly affect the properties of the edible films produced, including zinc oxide nanoparticles which have an important role in reducing the risk of pathogen contamination and increasing the shelf life of food (Espitia *et al.*, 2012). In the food sector, ZnO is a nano material that is often used because it is safe to eat and easily decomposes into ions after entering the body.

The minimally processed jackfruit that was given the control treatment could only be observed on day 0, because on day 1 it smelled bad and was moldy. Minimally processed jackfruit treated with 0% ZnO had a shelf life of up to day 1. Minimally processed jackfruit treated with 3% and 6% ZnO had a shelf life of up to day 2, while minimally processed jackfruit treated with 9% ZnO had a shelf life of up to day 4. The minimally processed jackfruit with the longest shelf life was found in the 12% ZnO treatment, which is up to day 5. The treatment of ZnO concentration and storage days affected the total microbial growth in jackfruit as indicated in Table 1. Based on the results of data analysis, it can be seen that the storage day treatment and the concentration of ZnO edible film have a significant value < 0.05 (H_0 is rejected and H_1 is accepted). This value indicates that the storage day and the concentration of ZnO edible film affect the total microbial growth of minimally processed jackfruit. Table 1 shows that edible film treatment still have higher microbial as compared to control. However, the values are lower than the standard value. Based on the Regulation of the Food and Drug Supervisory Agency of the Republic of Indonesia (BPOM, 2019), the number of colonies on fruit that is not suitable for consumption is 1×10^6 colonies, meaning that until the fifth day, jackfruit treated with edible film with a concentration of 12% ZnO is still suitable for consumption. The results showed that jackfruit without edible film (control) on the second day had too much total plate count that it could not be counted, while the jackfruit coated with edible film and 12% ZnO concentration was able to prolong the shelf life. Store up to 5 days with a total number of bacteria 9.8×10^5 colonies.

3.5. Water Content

Water content is a parameter used in determining the freshness of an agricultural product. The results of measuring the water content of minimally processed jackfruit with edible film packaging at various concentrations of ZnO can be seen in Figure 5. It shows that the water content of minimally processed jackfruit that was given edible film of corn starch with various concentrations of ZnO decreased during storage at room temperature. This decrease in water content is caused by the process of respiration and transpiration that occurs in minimally processed jackfruit (Hartuti, 2006). Based on the graph, it can be seen that the water content of minimally processed jackfruit that was given corn starch edible film was higher than that which was not given edible film (control). The highest and lowest water content were found in the edible film treatment with 12% ZnO concentration and control, respectively. This proves that corn starch edible film can reduce water loss in minimally processed jackfruit. This is in line with the statement of Darmajana *et al.* (2017) which states that at the beginning of storage, the water content of the fruit and the coating material is relatively high. While the fruit ripening process begins,

there are two processes, namely the loss of water content from the material (control and treatment) and the ripening process of the fruit. In control, because there is no coating material, the process of water loss will be more (at the same time) and the process of physiological changes in fruit is also faster, such as respiration (more oxygen is available). From the research conducted, the higher the concentration of ZnO, the water content of the minimally processed jackfruit will be slower. This decrease occurs because the amount of solids in the solution that has a high concentration of ZnO NPs is greater than the solution with a low concentration. Thus, at the same volume of solution, there is less water in the film and the film will be thicker, this results in inhibition of water evaporation. At a fixed mass of biopolymer, there was a slow decrease in the water content value in cut kiwi due to an increase in the concentration of nanoparticles (Casariego *et al.*, 2009).

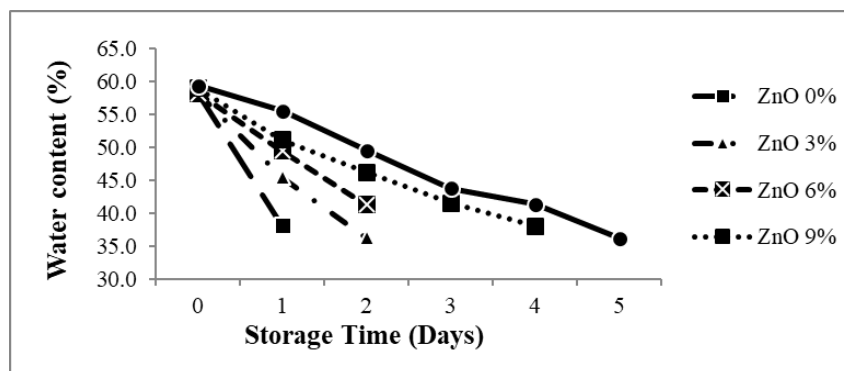


Figure 5. Water content of jackfruit using edible film corn starch_with variations of ZnO

The minimally processed jackfruit that was given the control treatment could only be observed on day 0, because on day 1 it smelled bad and was moldy. Minimally processed jackfruit treated with 0% ZnO had a shelf life of up to day 1. Minimally processed jackfruit treated with 3% and 6% ZnO had a shelf life of up to day 2, while minimally processed jackfruit treated with 9% ZnO had a shelf life of up to day 4. The minimally processed jackfruit with the longest shelf life was found in the 12% ZnO treatment, which is up to day 5.

Based on the ANOVA analysis, storage days had a p value $0.200 > 0.05$ (H_0 was accepted and H_1 was rejected). This value means that storage days have no significant effect on the water content of the minimally processed jackfruit. Similarly, the ZnO edible film concentration treatment had a p value $0.162 > 0.05$ (H_0 was accepted and H_1 was rejected), meaning that ZnO concentration has no significant effect on the water content of the jackfruit.

4. CONCLUSIONS

The application of corn starch edible film with ZnO to minimally processed jackfruit has an influence on the observation parameters, namely weight loss, hardness, total, microbial test, and minimally processed jackfruit color stored at room temperature. The best concentration of ZnO in maintaining quality and extending the shelf life of minimally processed jackfruit is corn starch edible film with a ZnO concentration of 12%, can extend the shelf life of minimally processed jackfruit until the 5th day at room temperature storage. Based on the research that has been done, the authors suggest optimizing the methods used in making edible films such as changing the type

of plasticizer or using a glycerol concentration with a concentration <50%, as well as increasing the concentration of ZnO used in the hope of perfecting the characteristics of edible films according to standards so that can be used on a large scale.

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