Aloe vera L. powder processing using spray drying method for coating material of agriculture products

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Abstract. Alternatives that can be done to reduce the damage to agricultural products after harvest is the application of coatings. The coating produces a film on the surface of the fruit to protect the product from environmental influences that cause damage. Besides gel form, aloe vera can be processed in the form of powder, which has advantages compared to gel form. The research purpose was to study the making of aloe vera powder using a spray drying method with the treatment of drying temperature and determine the best process base on the characteristic of powder solution and form of film as a coating result. Aloe vera powder making using a spray dryer with the outlet temperature of 60 °C and 80 °C, determine the best drying temperature base on the characteristics of powder solution and film formed. Films made from aloe vera powder solution with a concentration of 10%, 15%, and 20%. The result of this research showed that the powder produced by a temperature of 60 °C was better than that done of 80 °C with the yield produced was 2.72%, and the pH value was 3.512. While for making the best film was obtained from the concentration of 20% powder solution with a viscosity value of 4.126 mPa.s, film thickness 0.321 mm, L value of films color 87.632, film water content 12%, film solubility 99%, and water vapor transmission rate 6.540 g/hour.m².

1. Introduction
Aloe vera in the form of a gel as a coating material has been widely researched with a good result. Aloe vera gel applied as a coating material on rambutan fruit ([1],[2],[3]), papaya fruit ([4],[5]), and cherry tomatoes [6] can maintain the quality and prolong the shelf life. These results indicate the potential of aloe vera gel as a coating material to maintain the quality of fruits. However, there are some weaknesses of the gel as a coating preparation material, such as a gel that is easily damaged, easily formed sediment, and the viscosity is easy to decrease due to the process of sugar hydrolysis [7]. Making aloe vera in powder form is intended to make the coating material more durable, easy to store, and easy to apply. Therefore, the objective of this research was to study the process of making aloe vera powder with a spray drying method by treating various temperatures and determine the formulation of the powder solution that produces the best film character as coating materials.

2. Material and Methods
2.1. Sample preparation
Aloe vera was harvested from the farmers in Parung region, Bogor District, West Java. The harvest age is 8-10 months (estimated by farmers), the length of leafs 45-48 cm, the width of the base leafs 7-8.5 cm. Leaf washed thoroughly with running water to remove the soil and air drying.
2.2. Gel preparation
Aloe vera leaves were peeled, and the transparent part (fillet) washed using running water, then it was soaked in the citric acid solution for 30 minutes. After soaking, the fillets were washed using running water and continue soaked in ascorbic acid for 15 minutes, washed again with running water and finally washed with distilled water. The gelling process was carried out using a blender of fillets at low speed for 30 seconds and followed by a refinement process using a modified mixer with a speed of 7000 rpm for 30 minutes at 5°C. The gel was diluted and mixed with maltodextrin as a filler material. The mixing process was done by dissolving maltodextrin 15% in aquadest 15%, then added with aloe vera gel 70% and stirred at a speed of 10000 rpm for 30 minutes to make a homogeneous solution.

2.3. Aloe vera powder processing
Aloe vera powder was made by using a mini spray dryer (BUCHI 190; technical specification of tool is shown in table 1) with two outlet temperature treatments, which were 60 °C and 80 °C at an inlet temperature set at 140 °C. Aloe vera gel solution (feed) is sprayed in the direction of the flow of heating air in the drying chamber, the evaporation process occurs and produces dry powder, then sifted it to obtain the particles with a uniform size of 150 microns. Aloe vera powder produced was analyzed using 3 parameters that were yields, polysaccharide content, and viscosity to determine the best process. The viscosity test was carried out by dissolving aloe vera powder concentration of 10% with aquadest.

Table 1. Technical specification of spray dryer BUCHI 190

| Item Description          | Criterion               |
|---------------------------|-------------------------|
| Voltage                   | 240V/50 Hz              |
| Power                     | 2900 W                  |
| Electric Current          | 12 A                    |
| Maximal Temperature Drying| 220 °C                  |
| Maximal debit flow         | ca 45 m³                |
| Pressure flow sprayer     | 5 - 8 bar               |
| Dimension (L/W/H)         | 50 × 60 × 100 cm        |
| Volume                    | ± 0.8 m                 |
| Diameter chamber          | 0.1 m                   |
| High chamber              | 0.8 m                   |
| Temperature inlet         | 140 °C                  |
| Temperature outlet        | 60 °C and 80 °C         |
| Type nozzle               | Two-fluid nozzle atomization |
| Debit low of cyclone      | 600 m³ per hour         |

2.4. Film-making
As a coating material, the aloe vera powder produced was tested with its characteristics in films formed. The film was made by dissolving the aloe vera powder with aquadest and added a 10% of glycerol. The concentration of powder solution will affect the characteristics of the film formed. In this research, the solution concentration of 10%, 15%, and 20% was studied. The film was made by pouring 12 grams of solution into a petri dish of an 8.5 cm diameter, then air-dried with a fan until it can be detachable from the petri dish.

2.5. Aloe vera powder characterization
The yield value, polysaccharide content, and viscosity used to characterize the powder produced by two temperature treatments. The yield is calculated based on the ratio of the weight of powder produced to the weight of gel (feed) that sprayed in the process of spray drying. Polysaccharide content was calculated by proximate analysis where % KH (wb) = [100 – (water+ash+lipids+protein)] %. Viscosity measurement was
done using a solution with a concentration of 10% powder in the aquadest. The instrument that was used is the Rheometer (Anton Paar, Physica MCR 301, Austria). A sample of 3-5 ml was poured into a cone container. Viscosity measurements carried out in the range of shear rate 0.1-500/s with the results of measurements in a unit of mPa.s. All the measurement was made with three replications.

2.6. Aloe vera solution characterization

The stability, pH value, and viscosity were the characteristics of powder solution to determine the best concentration as a film-making material. The stability was calculated based on the height of the sediment formed. The characterization of the aloe vera powder solution was studied for three concentrations, namely 10%, 15%, and 20%.

2.7. Film characterization

Twelve grams of the solution was poured into a petri dish of 8.5 cm in diameter. The film characteristics were thickness, solubility in water, color, and water vapor transmission rate (WVTR). The thickness of the film was measure using a thickness gauge with an accuracy of 0.001 mm at five different points in one sheet of film. The solubility test of the film was carried out by making a sample film size 1 cm x 4 cm, weighed, dissolved in 50 ml of distilled water at 25 °C for 24 hours, then dried in an oven at 105 °C until constant weight. The solubility value was the ratio of the initial weight sample by the final weight sample after drying. The color (lightness:L) measured using chromameter at five different points on each sheet of film. The water vapor transmission rate (WVTR) was measured with the gravimetric method. The sample films were cut according to the diameter of the cup surface used (25 mm). The cup was added with 1 gram of CaCl₂, and then the film is glued as a cup cover. The sample was placed into a controlled desiccator container which is containing 40% of NaCl, RH 75% at room temperature for 24 hours. The water vapor transmission rate (g/m² hour) was the slop value of the linear function of weight gain and time (g/hour) divided by the surface area of the film that covers the cup.

2.8. Research Design and Data analysis

The effect of temperature on the powder produced was analyzed using ANOVA with the complete randomized trial design (CRD) with two temperature levels were 60°C and 80°C. The effect of concentration (10%, 15%, 20%) on the characteristics of the solution and the film formed was analyzed using ANOVA and DUNCAN further test with the reliance level (α) of 0.05%. This research was carried out also with CRD

2.9. Determination the Best of Powder Process and Solution Concentration Using Weighting Method

The Weighting method was used for choosing the best result of the spray dryer temperature and the solution concentration to produce the film. This method starts by determining the weighting factor. The weighting factor is obtained from comparing the level of importance between quality variables. The stability value, viscosity, and pH as solution quality variables, while the thickness, solubility, color, and WVTR values as film quality variables were compared to each other. The more important quality variable is given a value 1 and the other 0. The result was the weight value of each quality variable. The second step was the equalization of each quality variable. The equalization was done by giving the number 1 (equality number) for the best value for each quality variable. The equality number for other treatments was obtained by dividing the value of the treatment with the best value. The equality number between 1-0. The final value is totaled of the weight value multiplied by the quality number of each quality variable. The largest value was stated as the best treatment that produces powder and film.

3. Results and Discussion

3.1. Effect of spray dryer outlet temperature on the characteristics of powder produced

The yields, polysaccharide content, and viscosity of the powder produced from two drying temperatures (60°C and 80°C) were shown in table 2.
Table 2. The characteristic of aloe vera powder with a temperature of 60 °C and 80 °C

| Quality Variable                  | Drying temperature |
|----------------------------------|--------------------|
|                                  | 60 °C              | 80 °C              |
| Yields (%)                       | 2.72 a             | 2.69 a             |
| Polysaccharide content (%)       | 93.17 ± 0.13 a     | 95.78 ± 0.26 a     |
| Viscosity (mPa.s)                | 1.315 ± 0.084 a    | 1.342 ± 0.006 a    |

Note: The viscosity of the powder was measured in the form of a solution with the concentration of 10% in aquadest. The same letter index shows no significant difference with α = 5%.

Statistically, the three characteristics of powder (yield, polysaccharides, and viscosity) were not significantly different. It means that the outlet temperature does not affect the characteristics of the powder. A higher yield value and lower polysaccharide content in the powder produced with an outlet temperature of 60 °C due to differences in water content. The high water content will produce the percentage of ingredients in powder was lower. Aloe vera, in the form of a gel with the water content of 98.25%, has a polysaccharide content of 1.39% [8]. However, the texture of powder produced from the treatment temperature of 80 °C was more sticky, and the resulting film was more brittle than the film made from powder with a treatment temperature of 60 °C. The resulting film of each treatment, as shown in figure 1. Based on these characteristics, the drying temperature of 60 °C and inlet temperature of 140 °C was selected as the best process.

![Figure 1. Visual of film that produced from a 10% Aloe vera powder solution](image)

(a) Powder that dried with an outlet temperature of 60 °C  
(b) Powder that dried with an outlet temperature of 80 °C

3.2. Solution characterization

The solution used to make films was a mixture of aloe vera powder (spray drying process with 60 °C outlet temperature), 10% glycerol, and distilled water. The concentration of the solution will take effect to the film produced. There were three concentrations studied, namely 10%, 15%, and 20%. The results of the characterization of the three solutions were shown in table 3.

The viscosity solution experienced increased due to the increasing concentration of the solution, as well as the sedimentation. However, sedimentation can be homogenized again by handshaking and can be used to make films with good results. The shelf life of the solution, which can still be used as film-making material was two days if stored at 10 °C. Viscosity will affect the ease of dipping and dry duration in the coating application [9] and the thickness of the film layer on the product surface. There was no standard or
reference viscosity of the solution for good film-making so that further research is needed for the application of the selected concentration in the product.

Table 3. Values of viscosity, pH and stability at three concentrations of solutions

| Solution Characteristics         | Treatment of Concentration |
|----------------------------------|----------------------------|
|                                  | 10%            | 15%            | 20%            |
| Viscosity (mPa.s) *              | 1.937±0.036 a  | 2.465±0.050 b  | 4.126±0.006 c  |
| pH                               | 3.552±0.007 c  | 3.536±0.001 b  | 3.512±0.002 a  |
| High of sediment day-1 (cm)      | 0.15           | 0.3            | 0.5            |
| High of sediment day-2 (cm)      | 0.35           | 0.35           | 0.5            |

Note: * measured at a shear rate of 20 (1/s) with a spindle speed of 15.5 rpm

The graph of apparent viscosity and shear rate relationship in figure 2, shown the type of fluid flow of the solution for three concentrations were shear-thinning. Shear-thinning is a fluid that has the property of getting thinner when subjected to rotational speed or greater stirring [10].

The pH value of the solution is very important as a coating material because it will affect the level of microbial contamination. [8] shown that the lower the pH value (base), so the greater the microbial contamination. A solution with a pH of 4.495 has a microbial contamination value of 6.280 x 10^4, while a solution with a pH of 3.602 has microbial contamination of 9.500 x 10^3. The pH of the solution in the research result was still within safe limits because it was within the standard range was 3.5-5.0 (the acidity level set by Terry Lab. United States). The concentration treatment significantly affected the pH value of the solution, the higher concentration of the solution will cause the lower of pH value.

The stability of the solution was indicated by the presence of sediment or separation of the material that floats on the surface. The sediment which formed faster and higher showed an unstable solution [11]. In a 10% solution, a separation is formed on the surface, and the sediment is produced at the bottom. In contrast, at a concentration of 15% and 20%, the only sediment appears at the bottom of the solution. The higher concentration, the more unstable the solution formed. However, the homogeneity of the solution can be improved again by manually shaking either or stirring using a stirrer.

3.3. Film characterization

The film was made from aloe vera powder solution with a concentration of 10%, 15%, and 20%. Each of the solutions was added with 10% of glycerol as a plasticizer. A 12-grams of a solution was poured evenly
on an 8.5 cm diameter petri dish and dried at the room temperature then removed. The characteristics of the film that was studied were thickness, color, solubility in water, water vapor transmission rate. The results of the film characterization for the three-solution concentration studied were presented in Table 4.

Table 4. Characteristics of films produced by three concentrations of solution (10%, 15%, and 20%)

| Remarks       | 10%                      | 15%                      | 20%                      |
|---------------|--------------------------|--------------------------|--------------------------|
| Thickness (mm)| 0.1753±0.0150 a          | 0.2926±0.0147 b          | 0.3213±0.0084 b          |
| Color (L)     | 88.958±0.050 b           | 88.942±0.115 b           | 87.632±0.499 a           |
| Solubility (%)| 94.875±4.716% a          | 95.801±3.425% a          | 99.944±0.34% a           |
| WVTR (g/hour.m²) | 7.014 a                  | 6.560 a                  | 6.540 a                  |

Note: The same letter index showed no significant difference in the Duncan test (α = 5%)

The concentration influenced the thickness of film. The higher concentration causes the film thicker. Statistically, only 10% showed significantly different, while the concentration of 15% and 20% were not different. The addition of plasticizer (glycerol) makes the starches bond replaced by the starch-glycerol-starch bond will cause an increase in film thickness [12]. The increase of solution concentration makes starch content in the solution is getting increased. The maximum standard film thickness according to the Japanese Industrial Standard is 0.25 mm, which is satisfied with a solution of 10% concentration.

The concentration of aloe vera powder solution has a significant effect on the color of the film. The L value decreased along with the increasing concentration of the solution. The higher concentration of a solution made the color of the film to be more turbid and uneven. The solution that produces the film with the best brightness value was a concentration of 10%

Film solubility is one of the important parameters for the application of film as a coating for fresh fruits. Fresh fruits respiration will produce heat and water vapor that forms water droplets on the surface of the fruit. Low solubility values were expected to increase product integrity and water resistance. Although the solubility value of the film produced from the solution concentration of 10%, 15%, and 20% was not statistically significantly different, the lowest solubility was that of the films produced from a solution with a concentration of 10%. Besides the solution concentration, the addition of glycerol is indicated to affect the solubility value. This was stated by [13], that the highest solubility of the film was obtained in the treatment of glycerol of 15%, which was 74.20 ± 5.33%. Besides glycerol, the filler material of powder also affects the solubility of the film. Maltodextrin has high solubility properties so that the film formed will be dissolved easily in water. Therefore, we need a study of the right filler material of powder when used as a coating material.

The water vapor transmission rate (WVTR) is the movement of water vapor over a certain area and time interval. The WVTR value indicates the film’s ability to retain water and can be used as a reference for determining the shelf life of the product. The higher the WVTR value, the easier water vapor passes through the film and shows the ability of the film is not good to retain the water vapor (Huseini 2016). Data from WVTR measurement shown that the higher the concentration aloe vera powder solution, the lowest the value of WVTR obtained. A high concentration of solution produces a thicker film so that less water vapor passes through the film. However, the WVTR value from the film produced is satisfactory because it fulfills the Japan International Standard (JIS) with maximum value was 10 g/hour m².

3.4. Selection of the best solution concentration as a film-making material

The characteristics of the film produced showed inconsistencies at the best solution concentration; therefore the rating method was used to determine the best concentration choice based on the score obtained by each concentration. The characteristics of the solution and film to be selected are high viscosity value, high solution stability with less sediment, low acidity level, film thickness, the color of the film that almost clear, low solubility, and low WVTR value. Film-making for coating material was greatly influenced by the
concentration of the solution of raw materials, in order to produce a special characteristics of the coating-film that will be applied to the surface of fresh fruits. The result of weighting for the solution, the film, and the total values of both are presented in Table 5.

| Concentration treatment (%) | Weighted index score | Total score |
|-----------------------------|----------------------|-------------|
|                             | Characteristics of solution | Characteristics of film |              |
| 10                          | 0.645                | 0.979       | 1.624       |
| 15                          | 0.729                | 0.858       | 1.587       |
| 20                          | 0.995                | 0.781       | 1.776       |

Based on the total score, the concentration of 20% solution has the highest score. Thus, the concentration of a 20% solution was selected as a material for making film-based aloe vera powder obtained from the drying process using a spray drying method with the inlet temperature of 140 °C, the outlet temperature of 60 °C and using 15% of maltodextrin as a filler material. Film produced from a solution with a concentration of 20%, which can retain the rate of water vapor well, the stability of the solution that has satisfactory results because it can last for 6 hours and has small sediment so that it is easy to make homogeneous again after stirring process. Also, the pH value is low enough to inhibit the growth of microorganisms. Visually of the film produced by three concentration of aloe vera powder solution (10%, 15%, and 20%) presented in Figure 3.

![Figure 3. Visual film produced by a solution of aloe vera powder; a) 10% concentration, b) 15% concentration, and c) 20% concentration](image)

4. Conclusion and Suggestion

4.1. Conclusion
Spray dryer with the outlet temperature of 60 °C and the inlet temperature of 140 °C with the maltodextrin as a material filler, produce aloe vera powder which can be used as a preparation of coating material. The coating material was made by dissolved aloe vera powder using aquadest with a concentration of 10%, 15%, and 20%, and added by 10% of glycerol as a plasticizer. The concentration of the solution that produced the best solution and film characteristics was a concentration of 20%. The solution and the film that formed have satisfactory solution stability, high viscosity, pH that is in the standard range, the color of the film is bright, and is the only concentration that can retain the water vapor transmission rate well.

4.2. Suggestion
The film produced from a solution of powder that added with 10% of glycerol is still not optimum to produce a film that was able to protect fresh agriculture products. The permeability of the film to water
vapor must be increased while the solubility in water must be decreased. For this reason, there must be more research needs to be done, which combines aloe vera with other fillers such as gum, carrageenan, and gelatin to improve the properties of the film produced.

5. Acknowledgement
Presented gratitude to The International Collaboration Office IPB University has been funded this paper presented in The 3rd International Conference On Agricultural Engineering for Sustainable Agricultural Production IPB International Convention Center, Bogor, 14-15 October 2019, and publish at IOP Publication.

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