Environmental Friendly Packaging based on Liquid Whey as Edible Film: A Feasibility Study

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Abstract. Tofu is one the most common foodstuff consumed mainly in developing countries. Yet, tofu waste produced is also quite large in each process. Tofu liquid waste is the most obtained waste in making tofu and can still be utilized as a base material in making edible films. This study aims to determine the characteristics of edible films including thickness, tensile strength, elongation and water vapor transmission rate with the addition of glycerol and find out the best formulations made for edible film using whey as material bases. This study used a completely randomized design (CRD) with three treatments (addition of glycerol with variations of 0.5%, 1.5% and 2.5% respectively) and three replicates. The parameters tested were thickness, tensile strength, elongation and water vapor transition rate. Data from this study indicate that the value of thickness edible film obtained is about 0.078-0.095 mm, the tensile strength value is around 56.9832 kgF/cm²-59.3125 kgF/ cm², elongation between 170.58-208.5533% and the rate water vapor transmission around 6.21-12.02 g / m²/ hour. The addition of glycerol variations did not have a significant effect (p> 0.05) on the value of thickness, tensile strength, elongation and water vapor transmission rate. A good glycerol formulation to produce edible film based on whey is a concentration of 0.5%.

1. Introduction
Tofu is one the most consumed and popular foodstuff for people worldwide especially in the developing countries. Tofu is easy to process and simply to cook as additional food. However, following waste produced is also quite large in tofu processes. Generally, many tofu producers and factories still dispose their wastewater carelessly around factory environment and have the potential to pollute the environment, cause foul odors and can be harmful to human’s health of the surrounding community.

Edible films are common packaging used to coat products in order to maintain product’s qualities. Forming materials for edible film can be obtained from animal and plant sources such as animal tissue, milk, eggs, grains, gelatin, whey protein isolates, jackfruit seed starch and many other ingredients. The constituent components of edible film consist of hydrocolloids (proteins, polysaccharides), lipids and composites two or more ingredients. The results of previous studies showed that edible films made from standalone whey did not produced superior characteristics, such as being not transparent, easily brittle and not elastic [1]. The addition of hydrocolloid in the process of making edible film can provide synergistic interaction so that the characteristics of edible film become much better [2]. The hydrocolloids added
to edible films can increase weight loss and are used as inhibitors of fruit ripening processes. One disadvantage of edible film is that it is brittle and does not have good elasticity.

Plasticizer is a material that is often added when making edible films, which can improve the characteristics of edible films to be not easily brittle and elastic. The more use of plasticizers, the more solubility will be due to plasticizer properties to the hydrophilic [3]. The glycerol and sorbitol are one of the plasticizers used in making edible films. Glycerol is one of the plasticizers that is often used in making edible films. Glycerol has a low molecular weight and is hydrophilic. The main aim of this present research is to develop the edible films as an environmental friendly packaging used to maintain foods and agricultural products qualities.

2. Research Methods

2.1. Time and venue
This research was conducted at the Laboratory Analysis of Food and Agricultural Products, Department of Agricultural Product Technology, Syiah Kuala University, Material Physics Laboratory, Department of Physics, Faculty of Mathematics and Natural Sciences, Syiah Kuala University. Industry Standardization Research and Center Banda Aceh, Indonesia.

2.2. Materials and Equipment
The Equipment used in this study include scissors, beaker glass, measuring cups, measuring pipettes, petri dishes, spatulas, hotplates, magnetic stirrers, timers, ovens, thermometers, Teflon, analytical scales, freezers, desiccator, filter paper, cutter, ruler, micrometer screw, and tensile strength test equipment (Autograph Type-HT 8503 Hung Ta brand). The materials used in this study include liquid tofu (whey), glycerol, aquades, Carboxy Methyl Cellulose, silica gel, tissue, aluminum foil and plastic.

2.3. Data Analysis
This study used a non-factorial Completely Randomized Design (CRD) for estimating glycerol concentration. Glycerol concentration factor consists of three levels: glycerol 0.5%, glycerol 1.5% and glycerol 2.5% of the total volume of the solution film-maker by using 3 replications.

2.4. Research Procedure
This study began by dissolving distilled water with whey and determining the concentration of distilled water and wastes whey required. Then proceed with the manufacture of edible film with the addition of additives in the form of hydrocolloid and plasticizer and determination of concentration. The solution edible film was heated to reach 90°C, then printing using Teflon and carried out drying for 15 hours with a temperature of 55°C. The final stage was testing the thickness, tensile strength, elongation and Rate of Water Vapor Transmission (WVTR) against edible film used.

3. Results and Discussion

3.1. Thickness of Edible Film
Thickness is one of the physical properties of edible film which can affect the value of water vapor transmission rate, tensile strength, elongation of edible film. Besides that, the thickness of the edible film produced is influenced by the large number of dissolved solids found in the film solution and the width of the film printing plate used. The average thickness of edible film with different variations of glycerol can be seen in Figure 1.
Figure 1. The average thickness of edible film using different glycerol concentrations

Figure 1, shows that the average thickness of edible film with the addition of glycerol concentration produces a thickness value that different, namely 0.078-0.095 mm. The thickness of the edible film produced is still relatively good because it is still below the maximum standard thickness of edible film according to Japanese Industrial Standard which is 0.25 mm. Whereas for coatings with thickness values (>0.25 mm) it is not good because it will limit the displacement of gas from respiration results and can cause the product to break quickly. The thickness of edible film obtained is thicker than the various results of research on edible film with different materials. This result is thicker than the results of [4] the study which mixed glycerol with different variations (10%, 20%, 30%, 40% and 50%) into the mixture whey and agar, with a thickness of about 0.032-0.036 mm. However, the results of this study were thinner than the best thickness standards from the results of the study by [5] made from leaf extract at 20% glycerol concentration of 0.18 mm.

3.2. Strong Pull (Tensile Strength) Edible Film
Tensile strength is the maximum pull that can be retained by the film until just before the film is torn or broken. The measurement of tensile strength aims to find out how strong the resulting film can hold the material being packed. The results of tensile strength is presented in Figure 2.

Figure 2. The average tensile strength of the thickness of edible film using different glycerol concentrations
Tensile strength obtained by treatment of glycerol concentration (0.5, 1.5, 2, 5%) around 0.5733-0.5933 kgf / mm² (57.3131 kgf / cm²-59.3125 kgF/cm²). This result has met the tensile strength standard based on Japanese Industrial Standard [9], that is, edible film maximum has a tensile strength value of 3.92 MPa (40 kgf / cm²). In this study, the best tensile strength value of the film was obtained at 2.5% glycerol concentration which is 0.5933 kgf/mm². This is because the 2.5% glycerol concentration is the maximum condition of the film to achieve maximum tensile [7]. Plasticizers can reduce the internal hydrogen bonds of molecules and cause weak intermolecular attraction of adjacent polymer chains thereby reducing breaking strength.

3.3. Elongation of Edible Film
Elongation is the percentage of lengthening film that is calculated when the film is withdrawn until it breaks. The average elongation of edible films produced by the addition of different glycerol concentrations is shown in Figure 3.

![Figure 3. Average elongation of the thickness of edible film using different glycerol concentrations](image)

Based on Figure 3, shows that the elongation value of edible film produced by the addition of 0.5% glycerol, 1.5% and 2.5% are 170.58-174.89%. These results have met the standard of elongation of edible films according to Japanese Industrial Standard (JIS) [9], namely with a minimum elongation value of 70%. Plasticizer is a material with a small molecular weight that can be joined into a matrix of proteins and polysaccharides to improve the flexibility and film forming properties [6].

3.4. Water Vapor Transmission Rate (WVTR) Edible Film
The rate of water vapor transmission is the rate of water vapor entering into edible film by seeping at certain temperatures and humidity. Data on the water vapor transmission rate of edible film at different glycerol concentrations can be seen in Figure 4.
The value of water vapor transmission rate edible film obtained is 6.21-12.02 g / m²/hour. This result is not good because it has not met the standard of the water vapor transmission rate (WVTR) based on Japanese Industrial Standard [9], that is, edible film maximum has a tensile strength value of 10 g / m²/hour. These results are also higher than edible films using teak leaf extract and the addition of 20% glycerol concentration is 11.63 g / m²/hour [5]. This result is lower than the standard vapor transmission rate of edible film made from apple peel pulp extract with 10% -30% glycerol concentration around 16-18 g / m²/hour [8]. Edible film with basic ingredients of tofu liquid waste (whey), at CMC concentrations of 3% and sorbitol concentrations of 1, 3, and 5%, obtained the value of water vapor transmission rates respectively, 2.60 g / m² / hour; 2.27 g / m² / hour and 3.25 g / m² / hour. Whereas at 5% CMC concentration the rate of transmission of water vapor was 1.78 g / m² / hour; 2.58 g / m² / hour; 2.92 g / m² / hour [10].

4. Conclusions and Suggestions

4.1. Conclusions
Based on the results of the research that has been carried out, the following can be concluded:

1. Based on the research that has been done, whey can be treated as edible film an environmentally friendly.
2. The characteristics of edible film produced after analysis of variants test, the best concentration of glycerol was 0.5% concentration with a thickness value of 0.072 mm, tensile strength 0.5733 kgf / mm², elongation of 174.89% and water vapor transmission rate of 6.21 g/m²/hour.
3. Different glycerol concentrations have no significant effect on the value of thickness, tensile strength, elongation and rate of water vapor transmission.

4.2. Suggestion
Based on the results of the research that has been carried out, suggestions that can be put forward for further research are:

1. It necessary to conduct research by adding solids (hydrocolloid) such as agar and others.
2. Further study needs to be performed by adding parameters edible film to be tested.
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