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EFFECT OF WHEY PROTEIN ON THICKNESS, WATER VAPOUR TRANSMISSION RATE, AND WATER CONTENT OF GELATIN FILM

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Abstract: Packaging is a tool used to protect products from physical damage; edible films can improve food quality and reduce plastic-based packaging materials. This study aimed to determine the effect of adding whey protein concentration on gelatin edible film thickness, water vapour transmission rate, and moisture content. This research used a completely randomized design with 4 treatments and 3 replications. The treatments consisted of P0 (0 g whey: 2 g gelatin), P1 (0.05 g whey: 2 g gelatin), P2 (0.10 g whey: 2 g gelatin), P3 (0.15 g whey: 2 g gelatin). The addition of whey protein had a significant effect ($P<0.01$) on the thickness of the gelatin film. However, no significant effect ($P>0.05$) was found on the water vapour transmission rate and moisture content. Nonetheless, employing whey protein can reduce the water vapour transmission rate and increase the moisture content of edible gelatin film. The findings suggest that incorporating whey protein can enhance the physicochemical properties of gelatin films. Using whey protein at a concentration of 0.05 g is deemed the optimum treatment.

Keywords: *Edible Film, Gelatin, Packaging, Whey Protein*

INTRODUCTION

Packaging is a tool used to protect products from physical damage. The most widely used material for packaging food is synthetic packaging due to its low production cost and excellent product protection [1]. However, as these plastics are synthetic compounds with a biodegradation time of 100-700 years, their use raises severe ecological concerns, such as the ecological problems released during manufacture and incineration and the formation of non-biodegradable waste [2]. As an alternative, edible packaging has been developed in recent years that can be made from biopolymers such as proteins [3–5], carbohydrates [6], lipids [7], or mixtures thereof [8–13].

This type of raw material includes various by-products of previous technological processes related to food processing [14]. One of the materials that can be utilized to make edible films is gelatin. Gelatin is a protein of animal origin, mainly obtained from bovine by-products. Gelatin protein is used in various applications in the food industry due to its abundance and functional properties as a thickener stabilizer and capacity to form biodegradable films [12].

Other proteins, such as whey, can provide a wider range of functional film properties such as transparency, odourlessness, tastelessness, good gas barrier, and mechanical properties [3]. Whey proteins include globular proteins. However, β-lactoglobulin is the major protein in whey that dominates the aggregation and glassing phenomena of whey protein solutions [15-16]. However, whey has little water resistance, tends to have higher water vapour permeability than other biopolymers, and lacks antimicrobial properties [17]. The protein content of whey affects water absorption, resulting in a more hygroscopic water vapour transmission rate in whey-edible film composites as opposed to those with low protein content [9]. The water vapour transmission rate depends on the protein content and plasticizer employed in creating edible films manufactured from gelatine. An increased quantity of protein in the edible film will result in greater water uptake from the surroundings [18].

An effective strategy to overcome this limitation is to improve the functional properties of the film by blending gelatin and whey protein. These packaging materials can be produced using different techniques. The casting method is usually preferred for films, consisting of evaporating the solvent from the film-forming solution [19]. In addition, it is also necessary to use plasticizers to increase the elasticity of a film, one of which is sorbitol. This plasticizer can produce good oxygen permeability, reduce brittleness, and increase the film's flexibility and durability when stored at low temperatures [20]. Moisture content is a crucial factor in determining the plasticizing impact of biopolymer films, with high water levels in edible films being conducive to an increase in thickness [18]. This study aimed to determine the effect of using different concentrations of whey protein on the thickness, water vapour transmission rate, and moisture content of the gelatin-based edible film.

RESEARCH METHODS

Tools and Materials

The tools used in this research include a hot plate stirrer, magnetic stirrer, Petri dish, measuring tube, measuring cup, thermometer, Erlenmeyer, micrometre screw, desiccator, and digital scales. The materials used included gelatin, whey protein, sorbitol, silica gel, distilled water, and label paper.

Preparation of Edible Film Solution

The edible film solution was prepared based on modified methods [21-22]. Gelatin with whey protein was mixed according to the treatment, and distilled water solution was added until the volume of the film solution reached 20 ml. The film solution that has been mixed is then heated using a hot plate stirrer at 90ºC and stirred using a magnetic stirrer (speed 250 rpm) for 30 minutes. The finished film solution was then poured into a Petri dish and kept at room temperature for 24 hours before testing.

Thickness

Film thickness was measured using a micrometre MDC-25M (Mitutoyo, MGF, Japan). The film thickness measurement was calculated as the average of 5 (five) different edible film areas, namely four edges and one centre of the film [22].

Water Vapour Transmission Rate

The water vapour transmission rate of the edible film was measured by putting the edible film into a desiccator filled with 3 g of silica gel, measuring the weight every 1 hour and lasting for the next 5 hours. The water vapour transmission rate is expressed in g/mm2/hour units using the formula [23].

$$\text{Laju Transmisi Uap Air} = \frac{n}{t\ x\ A}$$

Notes:
n: weight change of edible film (g)
t: time (hour)
A: surface area of edible film (mm^2)

Water Content

The moisture content of the edible film was calculated by heating a porcelain cup with a temperature of 100-105ºC for 1 hour. Then, the cooling process was done by putting it in a desiccator and weighing the porcelain cup (C). The edible film sample weighing 2 g (D) was put into a porcelain cup, and the drying process was carried out using an oven (105ºC) for 8 hours. Samples that have been dried are then cooled back into the desiccator and then weighed again (E) [24].

$$\text{Water Content} = \frac{C + D - E}{D}\ x\ 100\%$$

Statistical Analysis

Data analysis used a completely randomized design \ with 4 treatments and 3 replications. The treatments used in this study were P0 (0 g whey: 2 g gelatin), P1 (0.05 g whey: 2 g gelatin), P2 (0.10 g whey: 2 g gelatin), P3 (0.15 g whey: 2 g gelatin). Data were processed using ANOVA (Analysis of Variance) with the help of SPSS 16, and different treatments were further tested using the Duncan Multiple Range Test.

RESULTS AND DISCUSSION

Visualization of Gelatin-Whey Edible Film

Visualization of gelatin edible film with different concentrations of whey protein is shown in Figure 1. The edible film looks round following the mould container (using a petri dish), produces a good shape, is neat, does not tear, is elastic, and is in good condition (no mould, no smell).

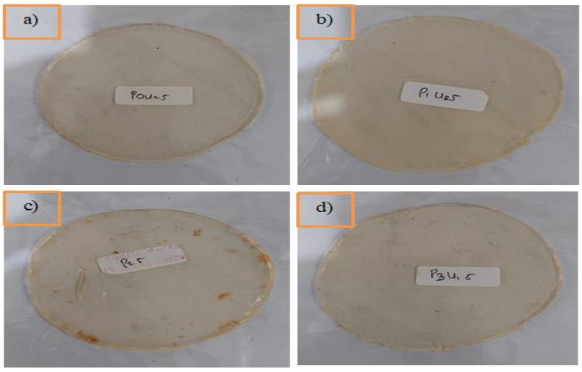

Figure 1. Visualization of gelatin edible film with different whey protein concentrations a) 0 g; b) 0.05 g, c) 0.10 g, and d) 0.15 g.

Thickness

The addition of different whey protein concentrations to the thickness of the gelatin edible film is presented in Figure 2.

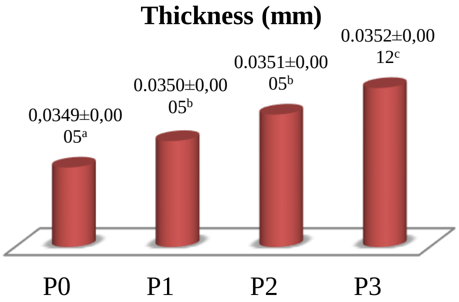

Figure 2. Thickness of gelatin edible film with the addition of different concentrations of whey protein

The analysis of variance shows that the addition of different concentrations of whey protein gives a very significant difference (P<0.01) to the thickness value of gelatin edible film. The higher the addition of whey concentration given, the higher the thickness of the resulting film. This is due to the composition of the constituent materials in the manufacture of edible film, so the addition of whey protein in the polymer matrix causes an increase in thickness. The film thickness depends on the solids content in the film-forming solution [25]. The components of the film-forming solution affect the alignment and solidification of these molecules during the film-drying process, which will cause differences in the thickness of the resulting film [26]. The thickness of edible film produced in this study has met the Japanese Industrial Standard [27] of 0.25 mm.

The use of sorbitol in the manufacture of the edible film contributes to the value of the thickness of the resulting film. This plasticizer functions as a destroyer and reconstitutor of the film network between molecules to create empty space, with the creation of this empty space, the plasticizer can enter the edible film matrix cavity so that it will also have an impact on the thickness of the resulting film [28-29].

Water Vapour Transmission Rate

The addition of different concentrations of whey protein on the value of the water vapour transmission rate of gelatin edible film is presented in Figure 3.

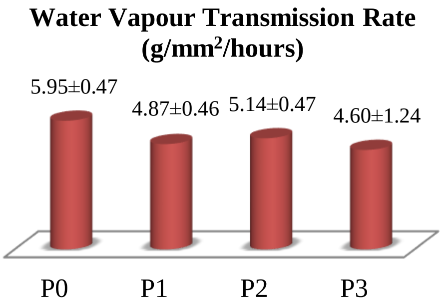

Figure 3. Water vapour transmission rate of gelatin edible film with the addition of different concentrations of whey protein

Based on the analysis of variance, the addition of whey protein concentration did not make a difference (P>0.05) to the water vapour transmission rate of gelatin edible film. Nevertheless, it demonstrated a tendency to reduce the water vapour transmission rate value, as the bonding between gelatin and whey polymers created a network structure that resisted the diffusion of water vapour through the film, thereby decreasing the water vapour transmission rate of the film. The resulting water vapour transmission rate values ranged from 4.60-5.95 g/mm^2/hour. The highest water vapour transmission rate value was obtained in the treatment without adding whey protein. This is because this treatment has a thin thickness compared to the other treatments. One of the factors affecting the water vapour transmission rate value of the film is the thickness of the film [30]. The thicker the film produced, the more complex and stiffer the film will be, so the ability to retain water will increase. Other factors that affect the water vapour transmission rate are the mobility of the polymer chain and the amount of plasticizer concentration used [31]. A small water vapour transmission rate value indicates that the edible film can prevent or resist the entry of high water vapour [32]. The water vapour transmission rate is related to the hydrophilic nature of the material used in the edible film manufacturing process. The Sorbitol plasticizer used in this study has hydrophilic properties. Sorbitol is a monosaccharide polyhydric alcohol compound, with the increase of hydrophilic components in the film matrix causing water vapour to easily penetrate the edible film so that it can affect the value of the resulting water vapour transmission rate [20]. Several research regarding this topic have produced varying results. For instance, [33] reported 7.63-7.96 g/mm-2, while [21] found a range of 7.64-8.45 g/mm-2 per day.

Water Content

The addition of different whey protein concentrations to the gelatin edible film's moisture content value is presented in Figure 4.

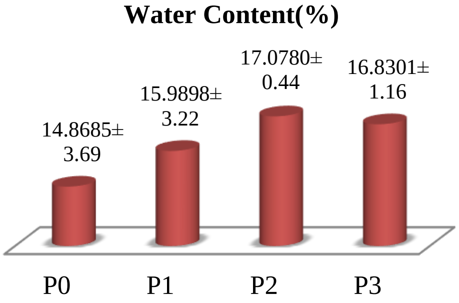

Figure 4. Water vapour transmission rate of gelatin edible film with the addition of different concentrations of whey protein

Based on the results of the analysis of ratios showed that the addition of different concentrations of whey protein did not make a difference (P>0.05) to the moisture content of gelatin film. The resulting moisture content ranged from 14.8685 to 17.0780%. The higher the addition of whey concentration, the higher the percentage of film moisture content produced. Gelatin and whey have hydroxyl properties that can bind water. The higher concentration of gelatin and whey mixture causes an increase in the number of polymers that make up the film matrix so that the hydroxyl groups of these polymers will be more excellent and able to absorb water in edible films [31]. The use of sorbitol plasticizer also plays an essential role in determining the moisture content value of the film. It is known that sorbitol has a lower ability to bind water than glycerol and polyethylene glycol plasticizers [34]. The moisture content of edible film will affect the durability of packaging a food product, where edible films with a lower water content can protect the packaged product compared to those with higher moisture content [18].

CONCLUSION

The research has determined that varying degrees of whey protein in gelatine film significantly impact film thickness, reduce the rate of water vapour transmission, and potentially raise the film's moisture content. The inclusion of whey protein presents a promising opportunity to enhance the physical and chemical characteristics of edible gelatine films. The application of whey protein at a concentration of 0.05 g resulted in a favorable value for the characteristic of the edible film, with a thickness of 0.0350 mm, a water vapour transmission rate of 4.87 g/mm2/h and a moisture content of 15.9898%.

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