The Casting of Glycerol, Carboxymethyl Cellulose, and Jicama (*Pachyrhizuserosus* (*L.*) *Urban*) Starch for Edible Film

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Abstract

Producing films from pristine Jicama (Pachyrhizuserosus (L.) urban) starch will face difficulties because starch in general is brittle and uneasy to handle. Applying biopolymer in the film formula was expected to modify the starch by chemically synthesized. This work aimed to study the effect of casting carboxymethyl cellulose (CMC), glycerol, and jicama starch-based composite on the mechanical properties, water vapor transmission rate (WVTR), thickness, absorption, total plate count (TPC), and organoleptic of the edible film. From the research work, it was found that water absorption can be suppressed by the glycerol addition (2.49 %), where glycerol does not rule out the film thickness. The synergetic with CMC has successfully thinned the films (0.00062 m), and the high concentration of glycerol to CMC does not necessarily lead to an elasticity if made equal where it was found higher. The red ginger (Zingiber officinale) extract was solely added proportionally to the increase of glycerol for the inhibition of microbial growth purposes.

Keywords: Carboxymethyl cellulose, edible film, ginger extract, glycerol, jicama starch

I. INTRODUCTION

In general, foodstuffs are easily damaged by the influence of environmental, chemical, and microbiological. Food quality is much affected by the presence of oxygen, temperature, and light [1]. The major function of food packaging is to control moisture loss and the reduction rate of adverse chemical reactions[2]. It would become unsettling if packaging was made up of plastics as referred to the estimation of 40%of 380 million tons of world plastic production [3]. In addition, of is harmful tothe environment [4],[5]. One alternative for a plastic substitute is from edibles, which can be enhanced as active packaging to inhibit the migration of moisture, oxygen, and carbondioxide [6],[7]. The main ingredient for making edible films was starchorginally from Indonesia were abundantly and diverse. Jicama was one type of starch with an amylose content of 20.72% [8], and forms a strong bonds thin layer [9]. Adding an active component to edible film increases function [10], like ginger extract rich in phenolic for antimicrobials [11],[12]. The effort to improve the functional properties can be done by blending the starch to cellulose-based fibers because its chemical

similarities to plant fibers[13], [14], likecarboxymethyl cellulose (CMC) has carboxymethyl group (-CH_2-COOH) in their structure if interacted to hydroxyl (OH)group of starch improved the water resistance [15], and also improved mechanical properties of the film because the multi carboxyl of CMC perform ascrosslinker and also holding FDA.approval [16]. This work aimed to studythe effectof the casting CMC, glycerol, jicama starch with the addition of ginger for film composite to the mechanical properties, water vapor transmission rate (WVTR), thickness, absorption, total plate count (TPC), and organoleptic.

II. METHODOLOGY

2.1 *Sourcing and Preparation*

The fresh jicama and red ginger were purchased from the market 2-3 km away from the laboratory. The starch was obtained from jicama using an extractionmethod. Firstly, the jicama was peeled and washed to remove the remaining dirt. The tuber was weighed then filtered and deposited. Proceed to the boiling process using water for 30 minutes to facilitate the cutting into small pieces using a knife.

Then blend until it forms a slurry, filtered for 24 hours to separate the dregs from the filtrate until the starch settled. Driedunder the sun. The amylose of jicama precipitated as starch. The ginger extract was prepared by maceration method, a solvent interaction with secondary metabolites by the function of time [17]. The ginger was cleaned, then dried under the sun, or can be dried in an oven with a temperature of approximately ± 40ºC to result simplicia, then soaked in 96% ethanol. It was done repeatedly until the filtrate obtained was clear. The precipitate was then concentrated by a rotary evaporator or a hotplate until it reaches approximately 10% of the previous volume.

2.2 Experiment

Thus, limited to our study three formula was designated.Excel 17 was used for Analyses of variance (ANOVA) and Duncan means with a significance level of 0.05.

2.2.1 The Film Fabrication

Fabricating the film composite by gelatinizing the starch molecules [18] into ginger extract for the matrix formation in the existence of CMC and glycerol for attaining the ultimate properties of film composite. The films were fabricated by using jicama starch 25; glycerol 41.67: CMC: and ginger 8.33 (%,w/w) as named to the symbol of J25Gly42C25G8, the formula to jicama starch 30; glycerol 30; CMC 30: and ginger10 (%,w/w) to the symbol J30Gly30C30G10, and jicama starch 41.67: glycerol 25: CMC 25: and ginger 8.33 (%,w/w) to the symbol J42Gly25C25G08. The jicama starch was dissolved into 100 mL of distilled water andheated at 100℃. The CMC wasweighedand then dissolved in 75 mL of distilled water, heated and stirred until thickened and sieved, then blended into the starch with the specified concentration of ginger extract and glycerol. The composite was poured into 20x20 cm^2 laminated plastic, let it flattened then heat at 80℃ in an oven for 4 hours. Let it cool to room temperature. Gently remove the edible film from the laminated plastic. Each product were prepared in three replications.

2.3 Product characterization

2.3.1Mechanical Properties

Tensile strenght, elongation, and elasticity was evaluated by ASTM D-412 type C method. The tensile strength was to determine the magnitude of the force to achievemaximum tension in each unit area of the film. Elongation is the change in the maximum length of the film before breaking. The elasticity isexpressed in Megapascals (MPa) with the formula (E) = ($\Delta\sigma$) change in stress/($\Delta\epsilon$) change in strain.

2.3.2 Film Thickness and Water Absorption Test

The film thickness test was done by cutting the edible film in the form of dumbbells and placing it on the grip of the thickness meter with an accuracy of 0.01 mm, the data obtained was the mean of three random positions. The water absorption test Water (%) was the ratio of the weight of the initial film sample (W) and weight after soaking in distilled water for one minute to the initial weight.

2.3.3 Water Vapor Transmission Rate (WVTR) Test

The WVTR method measures the amount of water vapor passed through the packaging layer. This would beneficial for the film itself because related to shelf life. The low WVTR value was much expected by applying the calculations of WVTR = slope/film surface area.

2.3.4 Total Plate Number Test (TPC)

Every viable cell develops a single colony. The number that appeared was an index of viable microorganisms in the sample. The plate count agar (PCA) media was done by weighing 22.5 g of PCA media, dissolved in 1 L of distilled water, and sterilizing using an autoclave at 121 ^{0}C for 15 minutes. Cool tothe range temperature of 45-50^{0}C, and 20 mL of media was poured into a sterile petri dish. Let it solidify. The analysis processTPC was carried out in the petri dish containing media and inoculated the pure culture of *Staphylococcus aureus* using the streak plate. Incubated at 35^{0}C for 48 hours. Observe the results.

2.3.5Organoleptic Test

An organoleptic test was conducted on the film using sight, smell, and touch, and interprets reactions from the effects of the sensing process. In this study, wehave focused on the observation for 10 days at room temperature.

III. RESULTS and DISCUSSION

3.1. Mechanical Properties

Adding glycerol to the film formula was meant to avoid brittleness, increasing the glycerol concentration will increase the flexibility of the starch-based film. The tensile strength of edible using formula J42Gly25C25G8 was (11.58 MPa) was found higher than the value of tensile strength formula J25Gly42C25G8 (10.27 MPa) and formula J30Gly30C30G10 (9.37 MPa). It was founded a 25% of glycerol concentration was the maximum limit of reaching the highest tensile strength synergetic to an equal concentration of CMC surfactant concerning

starch content. The tensile strength will decline if the glycerol concentration continued to be added though it were counter by the same portion concentration of CMC. According to the research conducted by Arnon*et. al*, the glycerol concentration in the film formula was recommended at the maximum level of 20% (w/w), while if exceedingly will form phase separation with a bit of sticky [1] and physical exclusion of glycerol [19].The results of the percent elongation test on edible films show that the greater the addition of glycerol, the percent elongation will also increase. The glycerol function as a plasticizer which reduces the mechanical cohesion bonds between polymers so the film formed was more flexible [20]. Glycerol has a small molecular weight if combined in the film matrix increased film flexibility [21]. However, in this research wefound the the concentration of surfactant much affected to the film elongation, it was proven the glycerol has to be made proportional to surfactant concentration. The highest percent elongation value in the formula (J25Gly42C25G8) treatment were compared to J30Gly30C30G10 and J42Gly25C25G8. The percentage elongation in the film were categorized as bad if the value was less than <10% and is categorized as good if the percentage of elongation exceeds 50% [22].Based on this study,the percent elongation results ranged from 20.95-24.1%, it can be concluded the percent elongation valuewasnot bad but also not good.The interaction between glycerol and surfactants in the film will affect to the mechanical properties. Theaddition of glycerol concentration can result in a decrease in tensile strength but an increase elongation. The addition of CMC was able the film becomes slightly brittle. If the composition of glycerol and CMC was made the equal 25:25 (%, w/w) it will result in a certain elasticity, but if the glycerol concentration was increased, namely glycerol: CMC (30:30) (%, w/w). It was found the increase in glycerol concentration does not prove to increase elasticity because the same concentration of CMC to glycerol has contributed to reducing the elasticity which tends to be brittle. Moreover, increasing the glycerol to 1.7 times from the previous with the ratio of glycerol: CMC as 4.2:2.5 (%, w/w), did not also increase [19], even though the concentration of CMC was made half of the glycerol. The small molecules of surfactant were between starch chains such as glycerol, which causes an increase in mobility of the plastic effect. From the test results, it was found that the elasticity of J4.2Gly2.5C2.5G0.8 (12.61) MPa) was higher followed by J3Gly3C3G1 (11.17 MPa) and J2.5Gly4.2C2.5G0.8 (10.62 MPa).The mechanical property of the edible film on depicted in Table 1.

Table 1. Mechanical Property of Film

Treatment	Tensile Strenght (MPa)	Elongation (%)	Elasticity (MPa)
J2.5Gly4.2C2.5G0.8	10.27 ab	24.1 b	10.62 a
J3Gly3C3G1	9.37 a	20.95 a	11.17 ab
J4.2Gly2.5C2.5G0.8	11.58 b	21.93 ab	12.61 b

Note: followed very significantly at the 99% confidence level

3.3 Film Thickness and Water Absorption

Thickness of such cases of film product does not have to be thin because it will vanish before tasting.

The more thickness value of the edible film, the product becomes stiffer and harder. The package becomes more secure from outside influences. Due to theobservation conduct on this research, the mean thickness obtained from the threeedible films wereconducted three repetitive that were significantly different. We have found thegreatest thickness was 0.0063 m for (J42Gly25C25G8) following by 0.0039 m for (J30Gly30C30G10) and 0.00062 m for (J25 Gly42C25G8). According to Aisyah*et.al*, the thickness increases with the increase of glycerol in the edible film [23]. However glycerol does not rule outsolely, because there are some other factors that affect the thickness like the area of the mold, the volume of the solution, and the total amount of solids in the solution. [24].

Table 2 Physical Property of Edible Film

Treatment	Thickness (m)	Aw (%)
J2.5Gly4.2C2.5G0.8	0.00062a	2.49 a
J3Gly3C3G1	0.0039b	3.83 ab
J4.2Gly2.5C2.5G0.8	0.0063 c	6.67 b

Note: followed very significantly at the 99% confidence level

The low water absorption value or other words the ability of the film material to water resistency was expected to be low. According to the research findings, It can be concluded that the J4.2Gly2.5C2.5G0.8 treatment (6.67 %) was the highest percentage of water absorption followed by J3Gly3C3G1 (3.83 %) and J2.5Gly4.2C2.5G0.8 treatment (2.49 %). Based on the research conducted by Ismawanti*et.al*., the films product with the starch include in the compositions impervious to water [25]. However, in this research, we have found that excess glycerol concentration in jicama can suppress water absorption.

3.4 Total Plate Count

The total plate count (TPC) test aims to determine how the microbial colonies in numbers can grow on edible films. The microbial colonies on edible films greatly affect the decay process. The fewer the number of microbial colonies on the edible film, the better the edible film, because the grow the microbial is inhibited (Firdaus et al., 2022). The antimicrobial screening results are shown in Table 5 where the maximum against Staphylococcus aureus, the maximum was J4.2Gly2.5C2.5G0.8 (0.236x103)followed by J3Gly3C3G1 (0.208x103), and J2.5Gly4.2C2.5G0.8 (0.148 x 103) (colony/g) as can be seen in Table 3. Ginger functions as an antimicrobial, but the incorporation of glycerol into starch will affect the number of colonies.

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Table 3. The total Microbe during the 24-hour of observation

Type of Thin Film	Total of Microbe (Colony/g)	Images
J2.5Gly4.2C2.5G0.8	0.148 x 10 exp3	
J3Gly3C3G1	0.208 x 10 exp3	
J4.2Gly2.5C2.5G0.8	0.236 x 10 exp 3	
Blank	CBC	

* CBC: can not be counted

Theassumption of this study, theadditional concentration of glycerol into glycerol should be anticipated by increasing the ginger extract concentration proportionally.

3.5 Water Vapor Transmission Rate

The requirements must be owned by food packaging in this case edible film was the moisture decreased and the water vapor permeability made as low as possible. WVTR for formula made at 25% CMC concentration with the glycerol concentration made higher it shown the WVTR value was lowest 11.51 x 10^{-5} g m^{-1} h^{-1}, but if the glycerol concentration to CMC was made simmilar (25: 25) (%, v/ v) the WVTR value increased (11.71 x 10^{-5} g $m^{-1}h^{-1}$) and the value will increased if the simmilar concentration was made increased to (30: 30) (%, v/v) was 12.11 g m^{-1} h^{-1}. According to research of Siskawardani etl.al., the standard of WVTR is in the range of 21.73 - 31.54 g m^{-2} 24 $hours^{-1}$[9]. The research conclusion that the rising value of WVTR value directly proportional to glycerol concentration resulting moistureand low ability to r resist evaporation [26], it seems does not apply to this research, because the glycrol does not run solely but synergetics to CMC.

3.6 Organoleptic Test

Organoleptic testing is one of the important test methods to select and determine quality. The edible film layer serves to lower thediscoloration of thefruit caused by chlorophyll degradation and carotenoid synthesis. The organoleptic was summarized, and the tests were carried out describing the condition of the edible film in 10 days. There was no significant change of color. Meanwhile, the texture of the edible film on days 1 to 7 was still in fairly good condition comparedto the edible film on days 8 to 10. The aroma of the edible film on days 1 to 5 smells of ginger, but on days 5 to 10, the aroma is no longer visible.

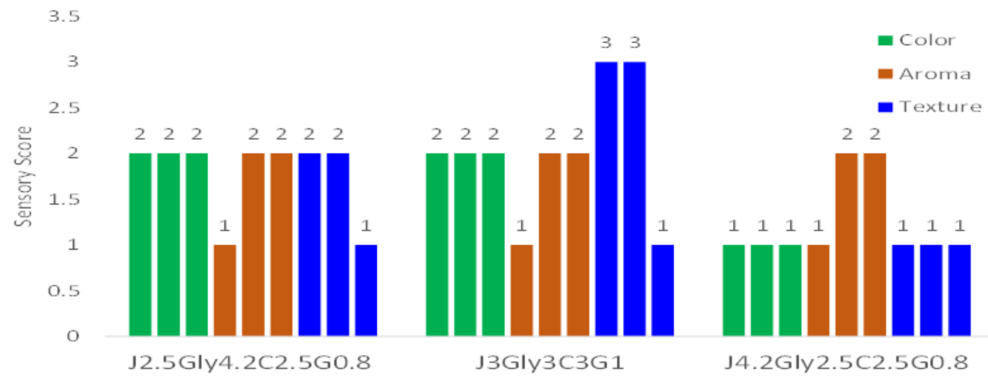

Figure 1a. Sensory of edible at Room temperature (day 1-3; day 4-7; day 8-10)

Day -1	Day - 2	Day -3	Day -4	Day -5
				
Day -7	Day -8	Day -9	Day-10	
				

Figure 1b. Visualization of organoleptic of ediblefilm in room temperature

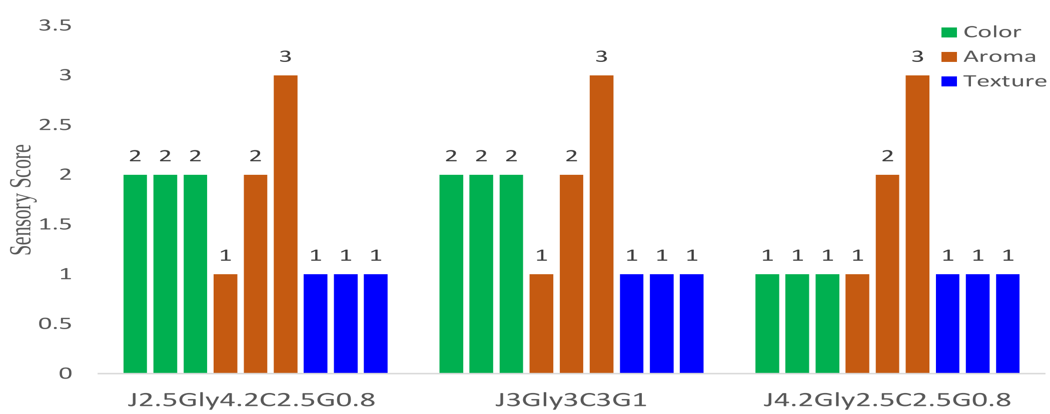

Figure 2a- Sensory of edible Film after Refrigeration (day 1-3; day 4-7; day 8-10)

Day -1	Day - 2	Day -3	Day -4	Day -5
				
Day -7	Day -8	Day -9	Day-10	
				

Figure 2b. Visualizationorganoleptic of ediblefilm afterrefrigerated

*The description of Figure 1 and Figure 2 were Color (1: clear, 2: slight yellow; 3: yellow) Aroma (1: ginger, 2: slight ginger, 3: no aroma) Texture (1: not sticky and hard, 2: slight sticky and hard, 3: Sticky and hard)

CONCLUSION

The addition of the concentration of jicama starch and glycerol affects the characteristics of the edible film. The addition of more starch can affect tensile strength and elasticity. While the addition of glycerol can affect the percent elongation and thickness ofthe edible film. Overview the starch was very good for the characteristic value of an ediblefilm, toavoid thelimitation of the starch-based film it can be applied to a dry environment.

Disclosure statement: *Conflict of Interest:* The authors declare that there are no conflicts of interest. *Compliance with Ethical Standards:* This article does not contain any studies involving human or animal subjects.

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