

The effect of glycerol concentration and breadfruit flour mass on edible film characteristics

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Abstract. Breadfruit flour is one of basic ingredient in edible films making. Poor properties of edible film produced from natural starch can be improved by adding glycerol, as plasticizer that can improve its elasticity, and chitosan as hydrophobic substance that can increase its moisture resistance. While the amount of starch raw materials can improve film's compactness. This research is held to discover the effect of glycerol concentration and breadfruit flour mass on edible film characteristics. This research variates the amount of raw materials (6 grams; 8 grams; 10 grams; 12 grams) and glycerol concentrations (20 percent; 25 percent; 30 percent; 35 percent (w/w)). The characteristics of edible films observed in this research are tensile strength and Water Vapor Transmission Rate (WVTR). Almost all research products have tensile strength and WVTR value that meet grade 4 and grade 5 Japanese Industrial Standard (JIS) for edible film. The best tensile strength value (93.432 kgf/square cm) was obtained when the amount of breadfruit flour is 10 grams and glycerol concentration 20 percent, while the best WVTR value (3.210 gr/square m.hour) was obtained when the amount of breadfruit flour is 12 grams and glycerol concentration 20 percent.

1. Introduction

Edible film is a thin layer of edible material that can be placed on the surface of food products to provide barrier to moisture, oxygen, and transfer of solids from these foods [1]. There are components in edible film making: hydrocolloids, fats, and composites [2]. Starch is hydrocolloid group which is an easy-to-obtain material, cheap, and has a variety of types in Indonesia. Breadfruit is one of the most widely grown plants in Indonesia and can grow well throughout the year. Based on Horticultural Production Statistics released by the Ministry of Agriculture Directorate General of Horticulture, total breadfruit production in Indonesia is 103,483 tons by 2014. Starch contents in breadfruit is quite high at 89% [3]. To anticipate the abundance of breadfruit during its harvest time and to extend its shelf life, breadfruit is processed into flour. Breadfruit flour can be used to make edible film because its starch contents (61.75%) [4]. Starch-based edible film has weaknesses such as low resistance to water, low barrier properties to water vapor. Those weaknesses will shorten the food's shelf life because water vapor and microbes may enter and damage the food. To improve starch film's characteristics, it is necessary to add biopolymer or other materials which has hydrophobic and or antimicrobial properties. One of biopolymer that has those properties are chitosan [5].

Research on edible film making from breadfruit flour has been done in here [6] and have best characteristics of tensile strength value of 16.34 MPa and percent elongation of 6% obtained from raw



materials with composition ratio of breadfruit starch and chitosan of 6:4. However the product still has pores and cracks on its surface, therefore, plasticizer is needed to minimize cracking. The kind of plasticizer that can be used in making edible films are glycerol and sorbitol [7-12].

Research result in here [13] shows that increasing raw material mass can increase edible films tensile strength. Research conducted in here [14] variates glycerol concentration as plasticizer in edible film making and shows that greater glycerol concentration used has effects on higher water vapor transmission, smaller tensile strength, and greater percent elongation.

Specifically, there has not been any research that already variates glycerol concentration and breadfruit flour mass on edible film making. This paper will describe the effects of glycerol concentration and breadfruit flour mass variation on edible film characteristics.

2. Methodology

This research is carried out at laboratory scale which consist of five stages: preparation of research equipment and raw materials, creation of chitosan solution, making of edible film, moulding of edible film, and characteristic testing of edible film. Breadfruit flours are initially sized using 120 mesh sieves, while chitosan solution created using formula in here [3]. Edible film making is carried out using formula in [6]. The formed film solution is then poured onto the mould, in the form of plastic sheet, then flattened using stirring rod. The film sheet then dried in 50°C until its weight is constant. The film then desiccated to room temperature. Edible film then tested for its thickness, tensile strength, percent elongation, and water vapor transmission rate (WVTR). Variation for edible film composition is shown in Table 1. Edible film characteristics are then compared with Japan Industrial Standard for Edible Films as shown in Table 2.

Table 1. Edible film samples.

Sample	Glycerol Concentration (%)	Breadfruit Flour Mass (gram)	Sample	Glycerol Concentration (%)	Breadfruit Flour Mass (gram)
S1	20	6	S9	20	10
S2	25	6	S10	25	10
S3	30	6	S11	30	10
S4	35	6	S12	35	10
S5	20	8	S13	20	12
S6	25	8	S14	25	12
S7	30	8	S15	30	12
S8	35	8	S16	35	12

Table 2. Edible film characteristics based on standards [15].

No.	Characteristics	Value
1.	Thickness (mm)	≤ 0.25
2.	Percent Elongation (%)	≥ 70
3.	Tensile Strength (Kgf/cm ²)	≥ 40
4.	WVTR (g/m ² .h)	
	Grade 1	<0.0416
	Grade 2	0.0416-0.2083
	Grade 3	0.2084-0.8333
	Grade 4	0.8334-4.16
	Grade 5	>4.16

3. Result and discussion

3.1. Effect of glycerol concentration and breadfruit flour mass on edible film tensile strength

The effect of glycerol concentration and breadfruit flour mass on Edible Film tensile strength is shown on Figure 1 and 2. This tensile strength value needs to be known to see how strong the edible film can withstand the load of the product being packaged because the tensile strength value can reflect the mechanical strength of the edible film.

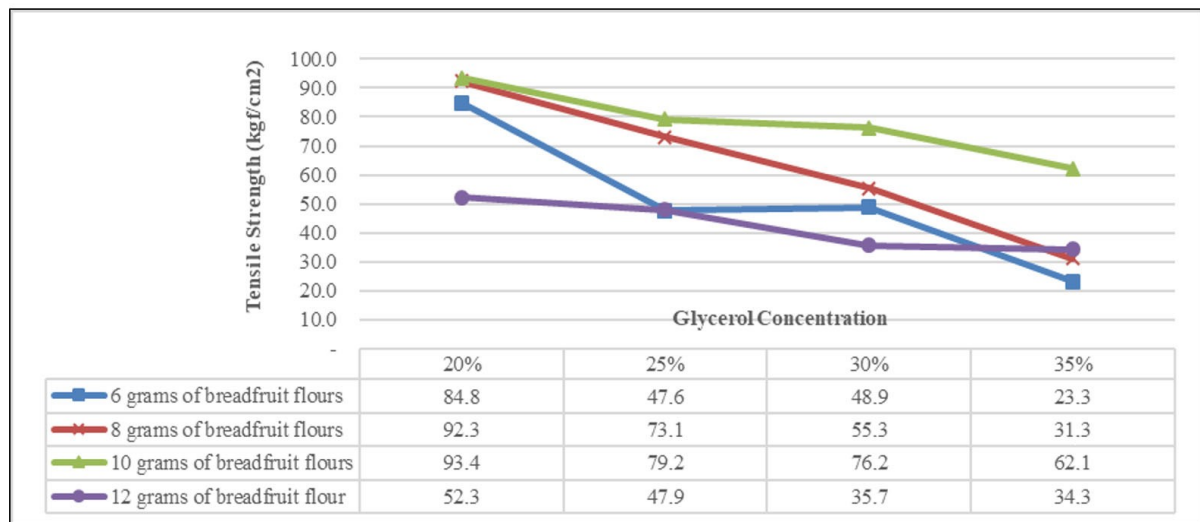


Figure 1. Effect of glycerol concentration on edible film tensile strength.

Based on Figure 1, it can be observed that Edible Film tensile strength is decreased with increasing of glycerol concentration. The highest values (93.432 kgf/cm²) were obtained in samples with glycerol concentration of 20% and breadfruit flour 10 gr. The decrease in tensile strength of edible films occurs due to the addition of glycerol which causes hydrocolloid interactions in the form of hydrogen bonds to be disrupted because the energy needed for molecules to make movement decreases and the intermolecular tensile strength of adjacent polymer chains so that the stiffness of edible films decreases and becomes more elastic.

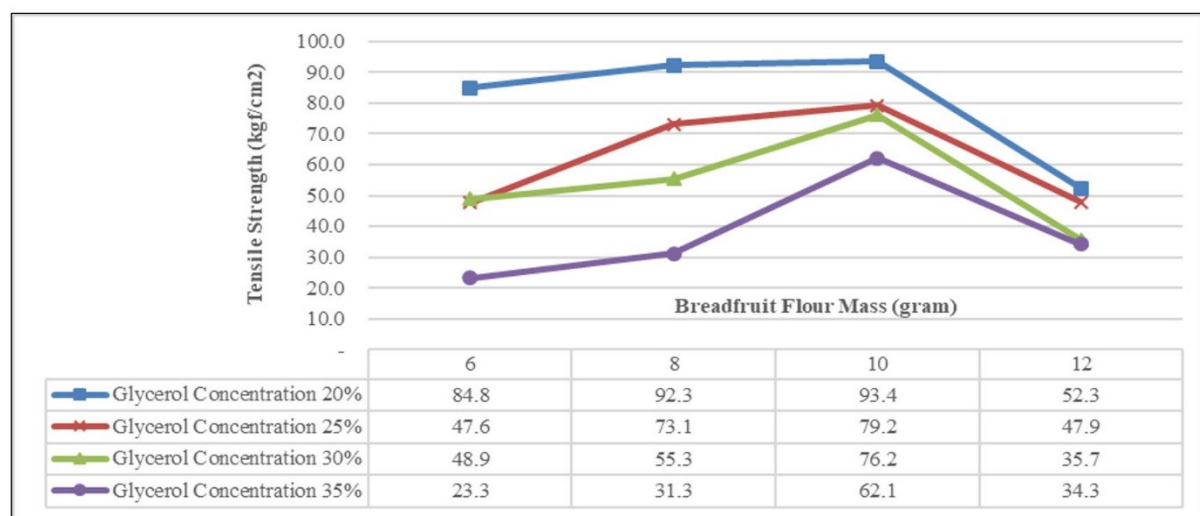


Figure 2. Effect of breadfruit flour mass on edible film tensile strength.

Based on Figure 2 it can be observed that the value of tensile strength has a tendency to increase along with the increase of breadfruit flour mass. This is due to the presence of amylose in the starch. The higher amylose content in the starch will make more matrixes formed between polymers and increase hydrogen bonds between molecules in the polymers. The bonds will make the force needed to break the film greater. This are consistent with the result in here [16] that tensile strength will increase with the increasing number of edible film polysaccharides. This polysaccharide also serves to maintain the stability and compactness of edible films.

There are some anomalies related with samples with 12 grams of breadfruit flour. The decrease in tensile strength of this sample is caused by gelatinization process that is not going well. A good gelatinization process is influenced by starch's water absorption. The starch needs to be heated to a maximum swelling temperature or gelatinization temperature and need some excess water. Sample with 12 grams breadfruit flour did not get enough water to experience maximum swelling so that the starch granules did not break, and the gelatinization process does not work perfectly.

3.2. Effect of glycerol concentration and breadfruit flour mass on edible film WVTR.

The effect of glycerol concentration and breadfruit flour mass on Edible Film WVTR can be seen in Figure 3 and 4. WVTR value shows the ability of edible film to hold water vapor. Smaller WVTR value means that the water vapor will be more difficult to pass through so that the shelf life of the product will be longer.

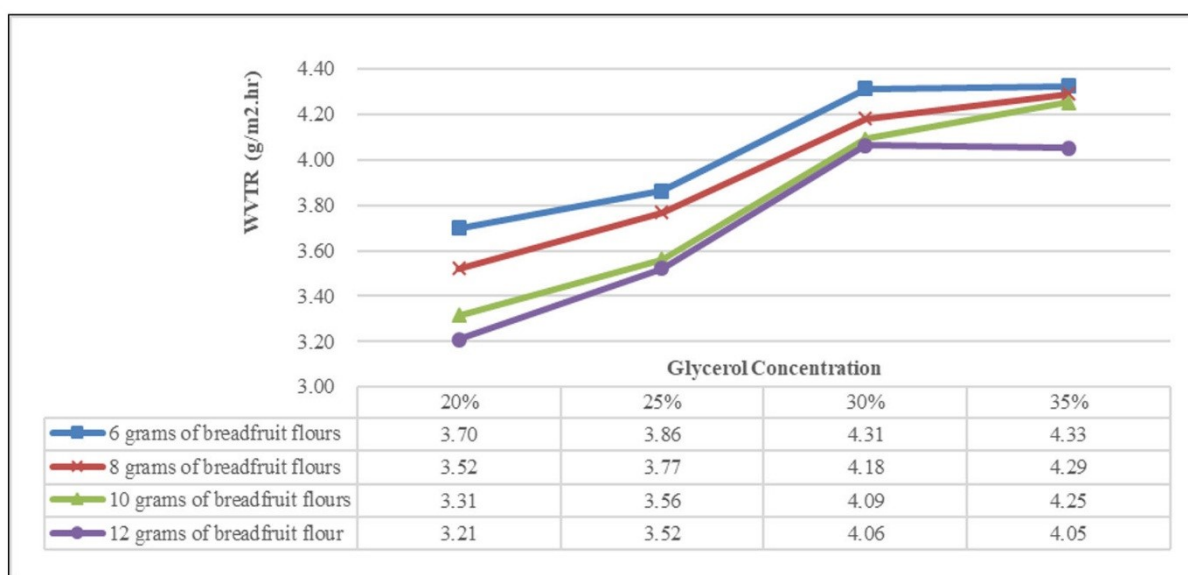


Figure 3. Effect of glycerol concentration on edible film WVTR.

Based on Figure 3 it can be observed that the value of WVTR has tendency to increase with increasing of glycerol concentration. Lowest WVTR value (3.210 gr/m².hour) was obtained in samples with 20% glycerol concentration and 12 grams of breadfruit flour. When glycerol concentration is higher, the intermolecular interaction will decrease and the molecule's mobility which will facilitate water vapor migration will increases. Glycerol also has hydrophilic properties which will add polar properties in the film. That properties which will increase intermolecular distance so that internal hydrogen bonds and intermolecular stresses on edible film matrix will decrease. The presence of that distance cause moisture to penetrate and increase permeability. This result is consistent with research in here [17] which state that water vapor will easily diffused by the formation of free space on the film matrix due to reduced molecular density caused the presence of hydrophilic groups on glycerol.

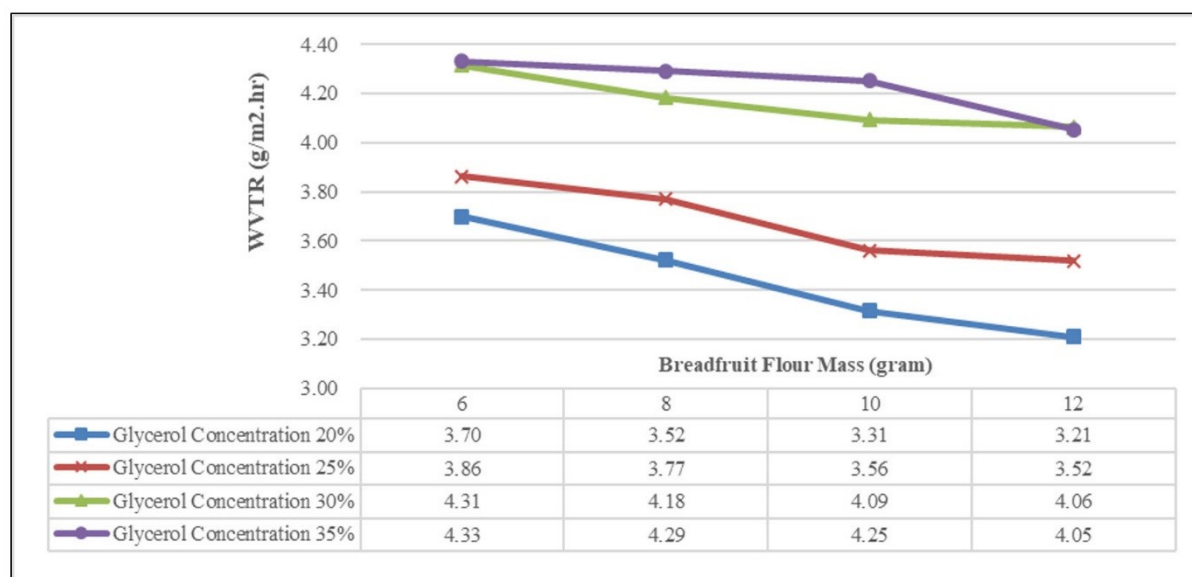


Figure 4. Effect of breadfruit flour on edible film WVTR.

Figure 4 showed that the value of WVTR has tendency to go down along with the increasing mass of breadfruit flour. This happen because the more flour in edible film will make the number of dissolved solids and amylose molecule's concentration increase. Increased amylose molecules concentration will form a stronger hydrogen bond so that the film formed will have more compact structure so that water vapor diffusion will be inhibited. This are consistent with the result in here [13] which states that the rate of water vapor transmission will decrease with increased thickness and density of the matrix formed on the edible film.

3.3. Comparison of Edible film products with Japanese industrial standard

This research produces edible film which has tensile strength value in the range of 23.28 to 93.43 kgf/cm² and WVTR value between 3.21 to 4.325 gr/m².hr. Compared with Japanese Industrial Standards (JIS), as stated in Table 2, most of the samples already met the standard of Edible Film tensile strength. While for its WVTR value, all the samples have already met the standard with different grade. Comparison of edible film sample's characteristic with JIS are shown in Table 3.

Table 3. Edible film characteristics compared with Japanese industrial standards.

Characteristics	Samples that met the criteria
Tensile Strength	S1, S2, S3, S5, S6, S7, S9, S10, S11, S12, S13 & S14
WVTR	
Grade 4:	S1, S2, S5, S6, S9, S10, S11, S13 S14, S15 & S16
Grade 5:	S3, S4, S7, S8 & S12

4. Conclusions

Some conclusions of this research, i.e., higher glycerol concentration will decrease edible film tensile strength and increase WVTR value, higher breadfruit flour mass will increase edible film tensile strength and decrease WVTR value, most of the samples have met JIS standard of edible film in its tensile strength characteristic and all the samples have met the standards for its WVTR value.

5. References

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