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Full Length Research Paper

Physical and mechanical study on Tilapia's skin gelatine edible films with addition of plasticizer sorbitol

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The first objective of this research is to study the mechanical and physical characteristic of edible films from tilapia skin gelatin with sorbitol as plasticizer. Second objective is to identify the effect of gelatin and sorbitol concentration level on the mechanical and physical characteristic of the edible films produce. This study uses a complete randomized design with 2 factors and treatments. The first factor was the concentration of gelatin with 3 levels: 5, 7.5, and 10%. The second factor was the concentration of sorbitol with 3 levels: 2.5, 5, and 7.5%. Observations were done on the physical characteristic of film thickness and mechanical tensile strength, percent elongation, water vapor transmission and oxygen gas. The results showed that the physical and mechanical characteristics of edible films produced are influenced by the interaction of gelatin and sorbitol concentration levels. Edible films produced from various concentrations of gelatin and sorbitol treatment has a range of thickness 74 to 220 μm, tensile strength 54.33 to 211.33 kgf/cm^2, elongation 34.33 to 170%, and rate water vapor transmission 953.2 to 1229.02 g/m^2/24 jam while the oxygen transmission rate 0 ml/ m^2/24 h.

Key words: Gelatin, sorbitol, edible films, mechanical, physical.

INTRODUCTION

These days, human awareness on plastic waste pollution made from petro-chemical polymer was increased so it brings the development of economically organic renewable packaging. One of environmental friendly packaging is edible packaging. Edible packagings preeminent are for the protection of a food product, originality on product performance, edible and safe for the environment (Olivas and Barbosa-Canovas, 2008).

Edible group types could be divided to a function as edible coating and secondly as the edible films itself. Edible coating uses for frozen meat coating, intermediate moisture foods, confectionary product, frozen chicken meat, seafood product, sausage meat, fruits, medicine especially for capsule facing. Edible films is a thin layer which can be eaten, made from food components and have mass transferred resentencing function (for example, moisture, oxygen, fats and other dissolved materials) and also as food carrier or addictive and also for the food handling material (Bertuzzi et al., 2007).

Edible film must have the same characteristic with the other packaging material such as plastic, which is: water holder characteristic, selective permeable against certain gases, controlling the suspended solid changes. Edible films commonly used for food packaging such as: sausage meat packaging, fruits, fresh vegetables to prevent quality degradation because the edible films prevent carbon dioxide and oxygen diffusion and water evaporation and flavor contamination with other products. Other benefits from edible films are to extend the storage period and friendly environment of products since edible films can be eaten along with its product (Du et al., 2008).

One of the materials to make edible films is gelatin. Gelatin is a hydrocolloid compound that resulted from the collagen hydrolysis of animal and fish skin. Tipalpia's fish skin is the most common skin found i n the fillet industry

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Table 1. Edible film thickness (µm) based on the combination of gelatin and sorbitol concentration.

Sorbitol (S)	Gelatin (G)		
	5% (G1)[a]	7.5% (G2)[b]	10% (G3)[c]
2.5% (S1)	74	125.33	172.67
5% (S2)	130.33	147.67	206
7.5% (S3)	165	186	220

Note: Small alphanetical letter means that no significant differences among treatment based on Duncan multiple range test on 95% of confidence interval.

as a waste and has a potential for gelatin source. Gelatin from Tilapia's skin can be use for edible films. On edible films processing one of the plasticizer is sorbitol. Sorbitol additive use for the edible film processing is made from Tilapia's skin gelatin. Edible films used as packaging materials rely on its physical and mechanical characteristic. Those characteristics have an effect on the type of hydrocolloids and hydrocolloids material, hydrocolloids and plasticizer concentration and edible films drying process. Based on those characteristics, the problem that could be encountered is the lack of knowledge of the extent at which the mechanical and physical characteristic of edible films is made from Tilapia's skin with sorbitol additive as its plasticizer.

The purpose of this research is: first, to find the mechanical and physical characteristic of edible films made from Tilapia's skin gelatin with sorbitol additive as the plasticizer and secondly, to find the influence of gelatin concentration level and sorbitol as material source against mechanical and physical characteristic of its edible films.

METHODS

The design of this research is completed randomized design with 2 (two) factorial treatment. The first factorial treatment is Tilapia's skin gelatin concentration level at 5, 7.5 and 10%. Second factorial treatment is sorbitol concentration as plasticizer with 3 levels: 2.5, 5 and 7.5%. Then, each factorial of treatment combined with 9 combinations of treatments. Each combination of treatments is repeatedly 3 times. This is research divided into 3 steps. First step is the gelatin processing. Second step is edible films processing and the third is the observation of the mechanical and physical characteristic of the edible films.

Gelatin processing step is as follows: Tilapia's skin are cleaned from meats, fats and scales of fish by soaking it in boiling water for 1 to 2 min, then the scales were scratched, cleaned and cut it into small cuts (3 to 5 cm) to increase the surface (Pelu et al., 1998). After the cleaning process, Tilapia's skin is soaked in acetate acid dissolved at 1% for 12 h. After soaking it in acetate acid, it was dissolved and then rinsed with pure water to 6 to 7 of pH (Astawan et al., 2002). After hydrolysis process, the Tilapia's skin is put into breaker glass with addition of fresh aqua water, and the ratio of b/b 1:3 was compared. The tilapia's skin is then put into water-bath for 4 h at 70°C of temperature. The Tilapia's skin was filtered with what-man filter paper and then put it into oven for 24 h with 50°C of temperatures. After that, grind the Tilapia's skin until it becomes a powder and ready to be the edible films material.

Edible film processing is as follows: sorbitols (as designed for the treatment) were dissolved with 600 ml of pure aqua water while stirring it using magnetic stirring, and was heated at 75°C of temperature. Gelatin (as designed for the treatment) to be dissolved together with glycerol-water for 30 min under 75°C of temperature. Add pure aqua water upto the volume reaches 1,000 ml and stirs it for 3 min. The Tilapia's skin solution to be mould into edible film-mould is made from glass with 20 × 20 cm^2 of shape and a glass thickness of 5 mm dry mould with more than 70% of moisture condition. After the edible film mould processing is finished then continues with measurement of the mechanical and physical characteristics. The observations of the mechanical characteristics are: tensile strength (ATSM D882, 1997), elongation percentage (ATSM D882, 1997), water evaporation transmission (ASTM E96, 1983) and the oxygen gases transmission ASTM (D3985 – 81, 1989).

RESULTS

Films thickness

Analysis result for the edible film's thickness is 74 to 220 µm of thickness. The thickest edible film resulted from (G3S3) treatment which is made from comparison of 10% gelatin and 7.5% sorbitol. The thinnest edible film resulted from treatment G1S1 with comparison of 5% gelatin with 2.5% sorbitol. Based on F test statistical analysis (analysis of variant) with 95% of confidence interval the edible film thickness are affected by gelatin concentration interaction with sorbitol. The higher the gelatin and sorbitol concentration, the higher the edible film thickness will be (Table 1). Edible film thickness (um) based on the combination of gelatin and sorbitol concentration.

Tensile strength

Approximate result of tensile strength is between 54.33 to 211.33 kgf/cm^2 of edible film from combination of gelatin and sorbitol concentration. The highest tensile strength came from experiment (G3S2) which is made from 10% of gelatin and 5% of sorbitol. The lowest edible film's tensile strength came from experiment (G1S3) which is made from 5% of gelatin and 7.5% of sorbitol.

Based on F test statistical analysis (analysis of variant)

Table 2. Edible film tensile strength (kgf/cm^2) resulted from combination od gelatin and sorbitol concentration.

Sorbitol (S)	Gelatin (G)		
	5% (G1)[a]	7.5% (G2)[b]	10% (G3)[c]
2.5% (S1)	79.67	167	194
5% (S2)	105	180.67	211.33
7.5% (S3)	54.33	71	89.33

Note: Small alphanetical letter means that no significant differences among treatment based on Duncan multiple range test on 95% of confidence interval.

Table 3. Edible fims elongation percentage (%) with gelatin and sorbitol concentration.

Sorbitol (S)	Gelatin (G)		
	5% (G1)[a]	7.5% (G2)[b]	10% (G3)[c]
2.5% (S1)	44.67	64.67	91
5% (S2)	126.67	147.67	170
7.5% (S3)	34.33	50.67	68.67

Note: Small alphanetical letter means that no significant differences among treatment based on Duncan multiple range test on 99% of confidence interval.

with 95% of reliance level edible film made from combination of gelatin and sorbitol concentration influent the tensile strength. As sample 5% of gelatin concentration (G1) and 5% of sorbitol concentration have the highest tensile strength compare with combination of 2.5 and 7.5% sorbitol. Based on Duncan multiple range test, edible film made from 5% of sorbitol was significantly different with 2.5 and 7.5% of sorbitol concentration (Table 2). Edible film tensile strenght (kgf/cm2) resulted from combination of gelatin and sorbitol concentration

Elongation percentage

Formulation form edible film based on gelatin and sorbitol concentration is different from elongation percentage result. The final result of elongation percentage for edible film based on gelatin and sorbitol concentrate combination.

The highest elongation percentage is 170% of edible film came from experiment (G3S2) with 10% of gelatin and 5% of sorbitol concentration. The lowest elongation percentage is 34.33% of edible film came from experiment (G1S3) (Table 3). Edible film elongation percentage with 5% of gelatin and 7.5% of sorbitol concentration.

Water evaporation transmission rate

Lowest water evaporation transmission rate resulted from experiment (G3S1) composition of 10% of gelatin and 2.5% of sorbitol. Highest water evaporation transmission rate resulted from experiment (G1S3) composition of 5% gelatin and 7.5% sorbitol (Table 4).

Based on statistical analysis of variant, edible film water evaporation transmission rate are influenced by sorbitol and gelatin interaction. The interaction shown on increasing the gelatin concentration will decrease the water evaporation transmission rate. By increasing the sorbitol concentration will increase the edible film water evaporation transmission rate level.

Oxygen transmission rate

Oxygen measurement result from edible film interaction of gelatin and sorbitol concentration is 0 g/m^2/24 h. This result shows that the edible film cannot be passed by oxygen molecule. As reported by Noviariansyah (2004) that edible films made from gelatin in various concentrations (5 to 10%) and 5% of glycerol concentration has 0 of oxygen transmission rate.

DISCUSSION

Films thickness

The higher the sorbitol and gelatin concentration produces, the higher the edible film thickness. Total dissolved concentration will increase gelatin and sorbitol concentration. Same pattern from this research show that the thicker on edible films makes the higher sorbitol and gelatin concentration. Noviariansyah (2004) reported that edible film made from 10% of gelatin is thicker than 7.5 and 5% with concentration of 5% gelatin as plasticizer.

Table 4. Edible film water evaporation transmission rate (g/m^2/24 h) combination between gelatin and sorbitol.

Sorbitol (S)	Gelatin (G)		
	5% (G1)[a]	7.5% (G2)[b]	10% (G3)[c]
2.5% (S1)	1023.41	1012.53	953.2
5% (S2)	1152.04	1093.94	1001.70
7.5% (S3)	1229.02	1162.92[b]	1130.24

Note: Small alphanetical letter means that no significant differences among treatment based on Duncan multiple range test on 95% of confidence interval.

Another research reported by Wahyuni (2001) show that edible film made from 6% of glycerol concentration is thicker than that made from 4 and 2% with 10% concentration of gelatin type B as its hydrocolloid.

Tensile strength

The higher the gelatin concentration at a constant sorbitol concentration, the more tensile strength of edible film produce. This condition is the result of gel concentration in gelatin. Dianti (2008) reported that gel concentration in gelatin increases the tensile strength of the edible film. The findings of Suryani (2009) showed that when gel tensile strength is directly proportional with gelatin concentration, the higher gelatin concentration increases the tensile strength.

Krochta and Johnston (1997) showed that the edible film's tensile strength was influenced by the gelatin concentration because of the increase of the inter-molecule force in the film's polymer chains; as such, the polymer decreased or the primary molecule decreased and the edible film's tensile strength increased. Yang and Wang (2009) also find that gelatin's inter-molecule force is caused by hydrogen chain bound with hydroxyl cluster. Addition of sorbitol concentration with constant gelatin concentration will increase the tensile strength of the edible film. Addition of sorbitol concentration will decrease the tensile strength. The maximum result for tensile strength from this research is at level 5% of sorbitol concentration. Mc Hugh and Krochta (1997) finds that sorbitol as plasticizer could make edible film more flexible to use and at the same time decrease the tensile strength of the edible films, mechanical characteristic is influential by the biopolymer characteristic and the plasticizer concentration. Lai et al. (1997) also finds that increasing the plasticizer will decrease the tensile strength of the edible films.

Elongation percentage

Elongation percentage level influent by interaction between gelatin and sobitol concentration based on statistical analysis of variant. Interaction between 10% of gelatin (G3) and 5% of sorbitol (S2) with highest final elongation percentage result compare with 2.5 and 7.5% of sorbitol concentration. Based on Duncan multiple range test elongation percentage from 5% (S2) significantly different with 2.5 and 7.5% of sorbitol concentration.

The increasing numbers on edible film elongation percentage are parallel with the increase of the gelatin concentration with constant sorbitol concentration. The correlations between edible film elongation percentages with gelatin concentration level on this research have the same pattern with Noviariansyah (2008) research. Bigi et al. (2004) finds that the more used of the gelatin concentration, the more interaction between substituent clusters or functional cluster consisting carboxyl cluster, amino cluster, R-side chain cluster and hydrogen cluster on gelatin concentration produce more flexibility on edible film and increase the elongation percentage.

The increasing of sorbitol concentration with constant gelatin concentration will increase the edible film elongation percentage. Additional sobitol concentration will decrease the edible film elongation percentage. Maximum edible film elongation percentage produced from 5% of sorbitol in various gelatin concentration levels. Mc Hugh and Krochta (1994) said that sorbitol as a plasticizer makes edible film more flexible and Lai et al. (1997) finds that adding plasticizer in certain numbers can produce film with tensile strength opponent with the elongation percentage.

Water evaporation transmission rate

Ray et al. (2000), finds that influential factors on edible film water evaporation transmission rate are: film's thickness, water evaporation partial pressure, temperature, moisture, quantity of plasticizer been use. This research approaches are on film thickness and quantity of plasticizer uses influential against water evaporation transmission rate. Roy et al. (2000) also finds that edible film water evaporation transmission rate have an inversely proportional to edible film thicknesses. Thickness of a film is a distance for single water electron to evaporate and diffusion through film. Water evaporation process takes a period of time to diffuse through a film layer. The thicker the film the longer period needed for water to evaporate. The higher sorbitol concentration makes the water evaporation transmission rate higher as well. Julianti and Nurminah (2006) finds that polymer plasticization mechanism process as the result of plasticizer increments is to develop edible film inner-outer surface and its polymer structure become loosed and form holes that make water molecules fill the holes and diffused from that holes.

Oxygen transmission rate

Gontard et al. (1996) finds that edible films made from protein and polysaccharides is the best blocker material for oxygen. This condition caused by the two materials having a huge hydroxyl clusters. Those hydroxyl clusters create strong polymer chain interaction that makes polymer chain movement become limited and oxygen transmission rate limited too. Hydroxyl clusters came from sorbitol polymer chain, water and gelatin itself. The higher the sorbitol and gelatin concentration on edible film creating higher hydroxyl clusters, affecting the polymer chain interaction creating 0 oxygen transmission rate.

Permeate of a dissolved substance influent by its polymer and permeate characteristic from this substance. The dissolve differences of gases such as N_2, O_2 and CO_2 and water evaporation rate related with differences and temperature condensation capacity (Pascat, 1985). Edible film from this research can be pass through by water steam but cannot be pass through by oxygen, because oxygen are more difficult to condensate compare to water steam. Oxygen cannot be dissolved on this film polymer so the oxygen transmission rate is 0. Oxygen transmission rate is influenced by its film polymer chain density rate. High density came from simple straight polymer chain so that oxygen transmission rate becomes low. Permeable substance characteristic such as oxygen molecule is bigger than water steam molecule which makes its influential for it to pass through the film. Oxygen molecule weight is heavier than water steam molecule weight that so oxygen cannot pass through the film polymer matrix made from gelatin.

Conclusion

Mechanical and physical characteristic of the edible film form this research is influenced by gelatin and sorbitol concentration and interaction. Edible film thickness range was between 74 to 220 µm, tensile strength range is between 54.33 to 211.33 kgf/cm^2, elongation percentage was between 34.33 to 170% and water evaporation rate was between 953.2 to 1, 229.02 g/m^2/24 h with oxygen transmission rate as 0. The higher the gelatin concentration, the thicker the edible film produced, the more the tensile strength, the more the elongation percentage, but the lower the water evaporation rate. Furthermore, the higher the sorbitol concentration used for producing edible film, the thicker and higher the edible film on water evaporation.

RECOMMENDATION

From the result of this research, edible film can be used for packaging fish food products, such as tuna fish, and there is need for continuation of this research on its storage periods.

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