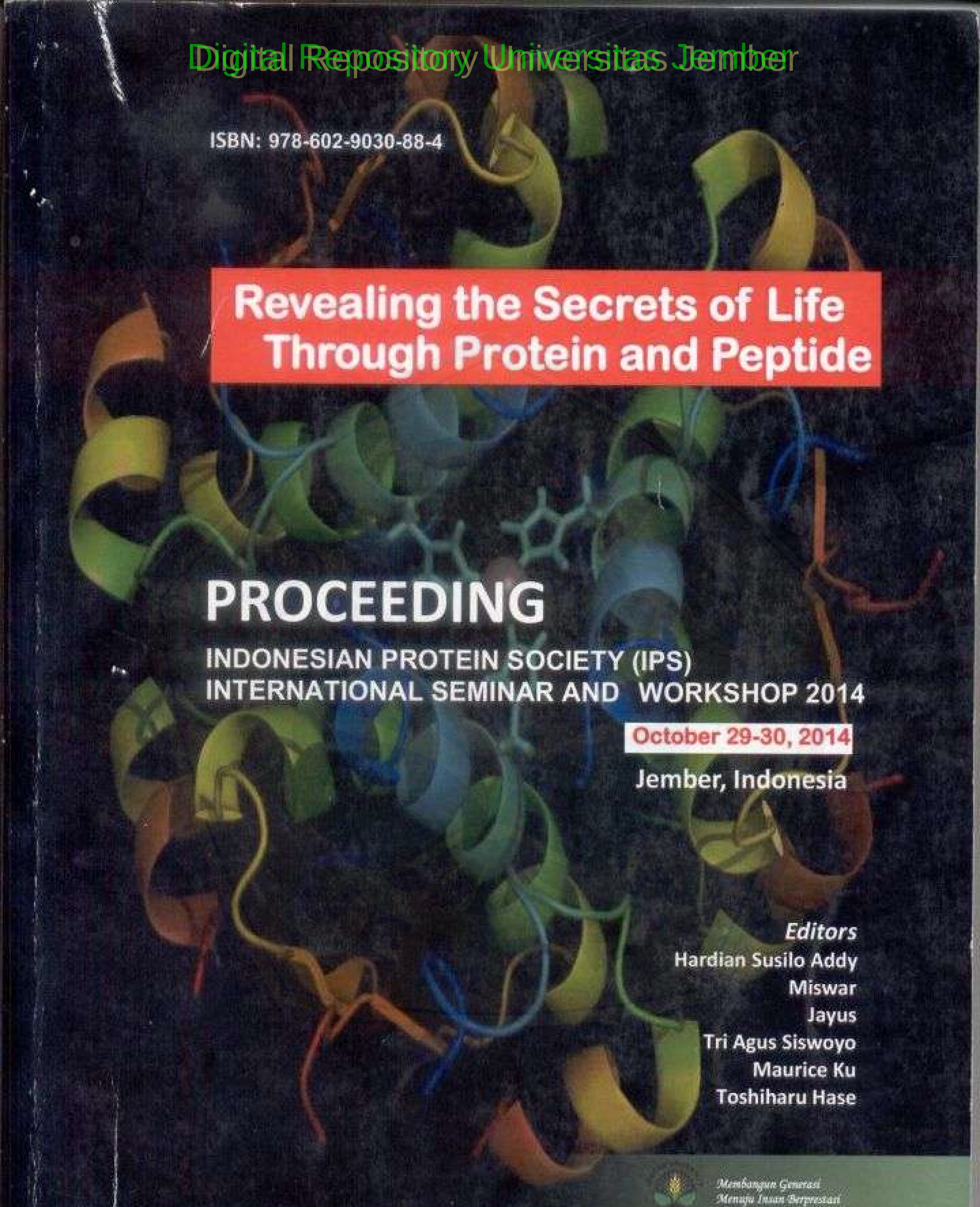

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Revealing the Secrets of Life Through Protein and Peptide

PROCEEDING

INDONESIAN PROTEIN SOCIETY (IPS) INTERNATIONAL SEMINAR AND WORKSHOP 2014

October 29-30, 2014

Jember, Indonesia

Editors
Hardian Susilo Addy
Miswar
Jayus
Tri Agus Siswoyo
Maurice Ku
Toshiharu Hase

Membangun Generasi Menuju Insan Berprestasi

Center for Development of Advanced Sciences and Technology, University of Jember

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Table of Contents

INDONESIAN PROTEIN SOCIETY
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Research Article

Physical Properties of Gel and Edible Plastic from Whey and Tapioca in Various Ratio and pH Value

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ABSTRACT

Edible plastic usually made from hydrocolloids and could be produced by solvent casting method whereas gel was made before casting. Potential of whey protein combined with tapioca as edible plastic based component was studied at this research. pH of solvent could affect interaction of whey and tapioca during gel preparation. The gel's characters affected on plastic's characters . The research objectives were to study effect of whey and tapioca ratio and pH of solvent on physical properties of gel and edible plastics. Randomized Factorial Block Design were used. The two factors were porpotion of whey protein-starch mixture (0%, 20%, 40%, 60%, 80%, 100%) and pH of solvent (4, 7 and 9). Increasing of whey porpotion could increase solubility of gel but decrease gel's lightness and texture. Increasing of pH could increase gel's solubility and decrease lightness and texture. There was significant effect ($p \leq 0,05$) of whey porpotion and pH interaction on gel's characters. Increasing of whey porpotion could increase tensile strength and decrease elongation and solubility of edible plastics but the increasing of tensile strength was not significant ($p \geq 0,05$). Increasing of pH could increase elongation and decrease tensile strength and plastic's solubility. There wasn't significant effect ($p \geq 0,05$) of whey porpotion and pH interaction on edible plastic's characters. The result showed that whey addition had decreased plastic's characters even at 100% whey ratio tensile strength and elongation value were zero, edible plastic could not be produced from 100% whey.

Keyword: texture, solubility, elongation, tensile strength, interaction

INTRODUCTION

Indonesian as agricultural country has abudant source of biological polymer that coud be explore as edible plastic. Edible plastic could be made from hydrocoloid such as polysacaride and protein. Previous study (Lindriati dkk, 2007a, 2007b; Lindriati dan Arbiantara, 2011) showed that combination of protein and carbohydrate would increase physical and mechanical character of edible plastic.

Many researches into edible films has involved the production of films from the method of solvent casting. Solvent casting method usually use water as solvent to disolve edible plastic based component and to gelatinize by heating the mixture. After gelatinitation the mixture was casted in order flat and transparant edible plastic could be produce. Properties of edible plastics that were produce from solvent casting method depend on the gel characters.

In this research tapioca and whey protein were used as edible film based component. Tapioca already widely used in food industry as edible/biodegradable plastic because of renewable, inexpensive and could produce good physical and mechanical characters (Bourtoom, 2007). Whey protein could result in plastics that were transparent , soft, flexible, odorless, colorless and has the aroma barrier properties. Plastics from whey protein have much disulfide bond so the plastic was not easily soluble in water (Wieddyanto, 2007).

Carbohydrate-protein interactions in the gel influences quality of edible plastics. Such interactions could be influenced by the composition and pH of the solvent. According to Graham (1977) and Zayas (1997), at pH where isoelectric point occur, protein solubility is low and if the pH above isoelectric point, soubility of protein could increase. The solubility of proteins would certainly affect the interaction of the protein with carbohydrates in edible plastic.

The aims of this research were to study effect of whey protein proportion and pH of solvent on edible plastic properties. Outcomes of this research is expected to provide a preliminary understanding of protein-carbohydrate interactions in edible plastic.

MATERIAL AND METHOD

Material

Tapioca and whey protein (industrial grade) were used as edible plastic based component was obtained from local market. The composition of the whey protein powder was reported as 76,97% protein, 10% carbohydrate, 6,36% fat and 6,67% ash. The composition of tapioca was reported as 4% protein, 93% carbohydrate, 2% fat and 1% ash. Glycerol was used as plasticizer that was p.a grade (merck). NaOH 0,2 M and HCl 0,2 M were used to control pH of solvent.

Gel and edible plastic preparation

Gel was made by solubilizing 10 grams mixture of whey protein and tapioca into 100 ml aqudest with variation of whey protein proportion (0%, 20%, 40%, 60%, 80% and 100). pH of aquadest was adjusted 4, 7 and 9 by using NaOH 0,2 M and HCl 0,2 M. 2.5 g of glycerol was added in to the mixture and then stirred for 10 minutes. The mixture was heated with steam (100°C) for 20 minutes to gelatinize. 10 gr gel was casted into 10 x 10 cm^2 plat porcelain and then dried in regulating oven at 50°C for 20 hours. Plastics were produce by peeling from plat porcelain and stored in desicator filled with silica gel for 24 hours. For gel observation, the gel was pour in to a cup (50 ml) and than stored in a refrigerator (4°C) for 24 hours and gel's parameters was observed.

Color Measurement (Colour Reader Minota CR-10)

Determination of color was performed by touching the lens of color reader as close as possible to the surface of material whereas white paper was lied under the plastic . The data obtained was Lightness value (L). Measurements were performed on each sample gel from 5 different point.

Texture Measurement (RheoTex, Type SD-700, Ogawa Seiki)

Depth which needle penetrate sample were set 12 mm and the load required to puncture was value of texture (gr/mm.detik). Measurements were made at 5 points on each sample. The scale on the monitor was proportional to the force required to penetrate the material and it was proportional to the hardness of the material.

Degree of solubility (Dahle, 1971)

Measurement of solubility of gel was done by measuring the absorbance by spectrofotometry, the value of absorbance depend on amount of ingredients that were dissolved. The measurement procedure begins by weighing 0.5 grams of samples put in centrifuge tubes and 15 ml of distilled water was added. Centrifuge was operated in 1200 rpm for 5 minutes. The absorbance of resulting supernatant was observed by spectrofotometry at 650 nm wave length.

Measurement of Water Holding Capacity (WHC) (AACC, 1991, modified)

WHC measurements was done by weighing the centrifuge bottle as a gram, then added ± 0.5 gram sample. Sample and bottle was weighed as b gram. Distilled water was added 7 times of the material weight (3.5 g). The mixture was homogenized by vorteks at room temperature for 5 minutes, then centrifuged at 2000 rpm for 5 minutes. The supernatant was discarded slowly and precipitate was weighed as c gram.

$$WHC = \frac{(c-a)-(b-a)}{(b-a)} \times 100\%$$

Tensile strength and elongation (according to ASTM standards D638-94 in Chang et al, 2000)

Pieces of edible plastic with a width of 10 mm and a length of 80 mm may be stored in a jar containing silica gel for one day. Then the tensile strength was measured using a Universal Testing Machine (Shimadzu). The size of the specimen can be seen in Figure 1

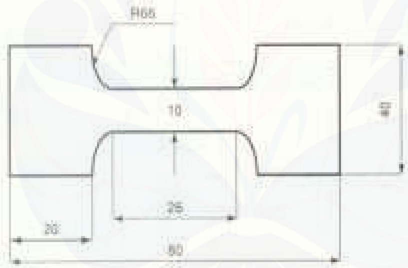

Figure 1. Tensile Test Specimens (according to ASTM D638-94 in Chang et al, 2000)

The tensile strength can be calculated with this formula:

$$\sigma = \frac{F}{A}$$

σ = tensile strength (N / mm 2); F = tensile force (N); A = area of work (mm2).

In accordance with tensile strength procedure, strain measurement was done using Universal Testing Machine. The strain can be formulated:

$$\varepsilon = \frac{\Delta l}{l_0}$$

ε = Strain (%); Δl = length addition (mm); l0 = Initial length (mm)

Solubility of edible plastic (Gontard et al., 1992)

Measurement of solubility of edible film in water based on percentage of initial dry material that dissolves. Pieces of edible film with a size of 2.5 x 5 cm were dried in an oven 105°C for 24 hours, then weighed (a gram). After drying edible film was soaked in 30 ml of distilled water and placed in a container that was covered with plastic and then stored at room temperature for 24 hours. Pick up the resembled pieces and then dried in an oven at 105°C for 24 (b gram). Solubility value is g/g calculated by (a-b)/a or ((a-b)/a) x 100% if the units was % .

RESULT AND DISCUSSION

Properties of edible plastic's gel before casting

The results of lightness measurements were from 25.30 to 51.10. Completely Radomized Design showed that lightness was significantly (α = 5%) affected by pH of solvent, proportion of whey protein and interaction of these two parameters. The results of measurements of lightness (L) gel as a variation of solvent composition and pH are presented in Figure 2.

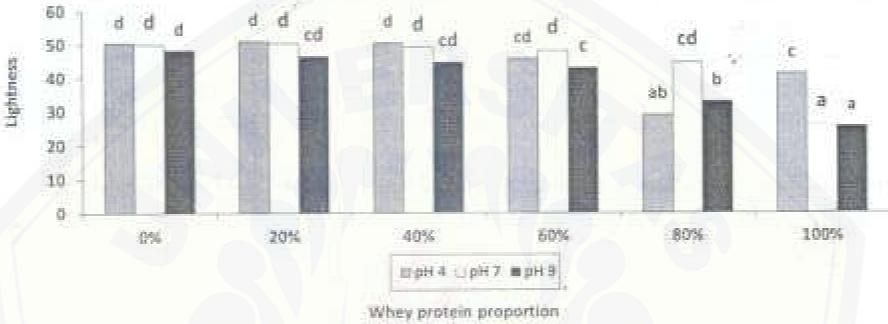

Figure 2. Result of lightness measurement as variation of whey protein proportion and pH of solvent.

Figure 2 showed that increasing in whey addition would decrease lightness because whey protein resulted in opaque color gel that affected the value of lightness. Decreasing in tapioca proportion would decrease the clear-colored of starch gel.

On porportion of whey 0%, 20%, 40% lightness value was not affected by pH of solvent. Increasing of pH at proportion of whey 60% and 100% would decrease lightness value, it was due to an increase in pH increased protein solubility resulted in formation of a homogeneous gel so the color of whey would dominate the gel's color. Whey protein proportion at 80% increased pH from 4 to 7 would increase lightness, while when pH increased from 7 to 9 would decreased lightness. This was probably because a unique carbohydrate protein interaction during gel preparation at pH 7.

Results of texture measurements ranged from 0.00 to 0.41 g / mm. Variation of solvent's pH, proportion of whey and interaction of these two parameters had significant effect on texture of gel (α<5%). Figure 3 showed result of texture measurement in variation of pH and whey proportion.

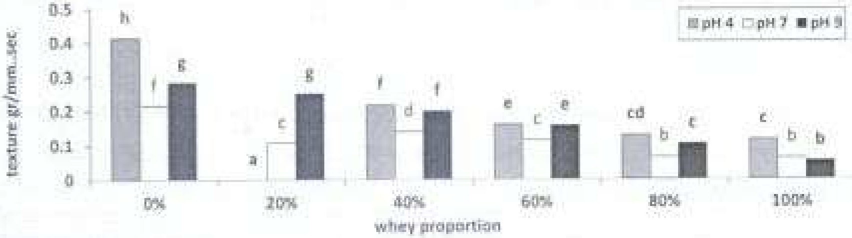

Figure 3. Result of texture measurement as variation of whey protein proportion and pH of solvent.

Figure 3 showed that increasing of whey proportion would decrease gel texture. Wheywould soften the gel and gel of starch when cooled will turn into a hard and rigid. Increasing of pH generally would decrease texture, especially when pH increase from 4 to 7. The pH of 4 is isoelectric point, where protein has lowest solubility therefore protein matrix could reinforces the gel matrix of starch-protein resulting in increasing texture value. While at pH 9 the highest protein solubility allowing co-solubility interaction between starch and protein molecules that was why increasing pH from 7 to 9 would increase texture value. Proportion of whey 100% , increasing pH from 4 to 9 would decrease texture, increasing pH would increase protein solubility, without starch there are no carbohydrate protein interaction could be involved. The results of absorbance measurements to measure the solubility ranged from 0.01 to 1.08 . Variation of solvent's pH, proportion of whey and interaction of these two parameters had significant effect on texture of gel ($\alpha = 5\%$). Figure 4 showed result of texture measurement in variation of pH and whey proportion.

Based on figure 4 showed that increasing of whey protein porpotion would increases the mean absorbance value of more soluble gel. That is because the protein gel would softened and more easily to solubly. Generally increasing pH would increase solubility presumably because of increasing protein solubility.

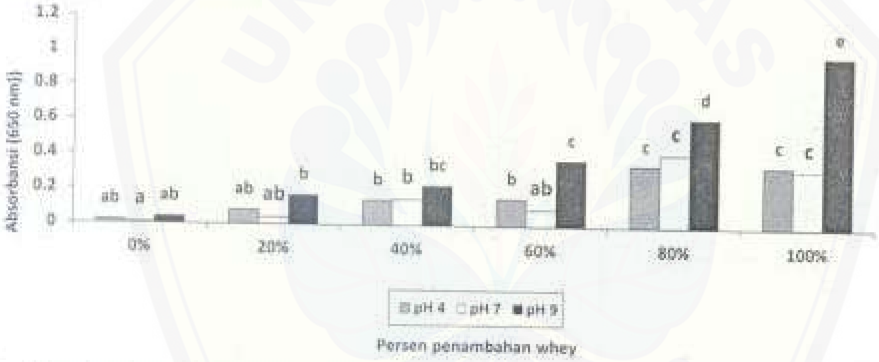

Figure 4. Result of texture measurement as variation of whey protein proportion and pH of solvent .

Properties of edible plastic

Results of strain measurements in this study was 0.00% to 142.68%. Results of analysis of variance showed that variation of whey proportion and pH of solvent had significant effect on strain value ($\alpha < 5\%$). Figure 5 showed result of strain measurements as a function of whey propotion and pH of solvent.

Based on the data in figure 5 increasing of whey protein proportion would decrease strain of edible plastic. Plastic-based on proteins have a smaller strain than films made from tapioca other words edible film made from tapioca will result in a more elastic film. Lindriati et al (2007b) showed similar result where addition of protein from Cannavalia Ensiformis to the matrix of edible film from maizena decreased elongation. Research of Poeloengasih and Marseno (2003), also showed a similar trend, where the addition of protein fractions decreased elongation of edible film from tapioca starch.

Generally, figure 5 showed that the pH does not affect the value of the strain. The results of tensile strength measurements ranged between 0.00 MPa to 2.68 MPa. Results of analysis of variance showed that whey protein porpotion and pH of solvent had significant effect on tensile strength but interaction between this two parameters did not. Figure 6 showed result of strain measurements as a function of whey propotion.

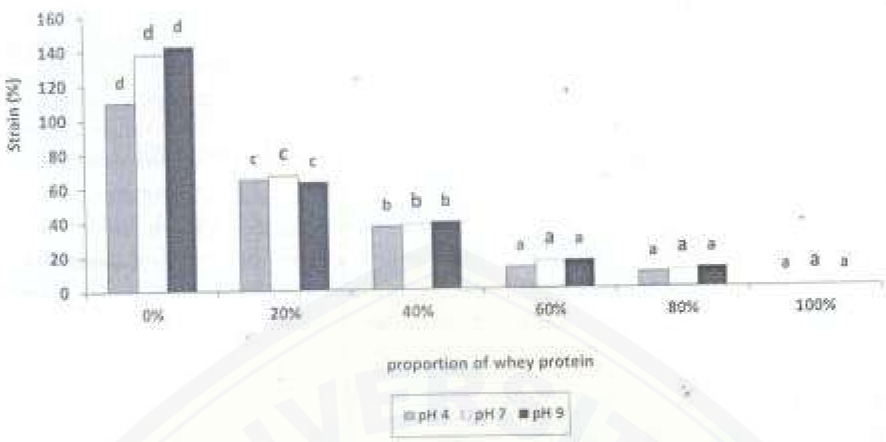

Figure 5. Result of strain measurement as variation of whey protein proportion and pH of solvent.

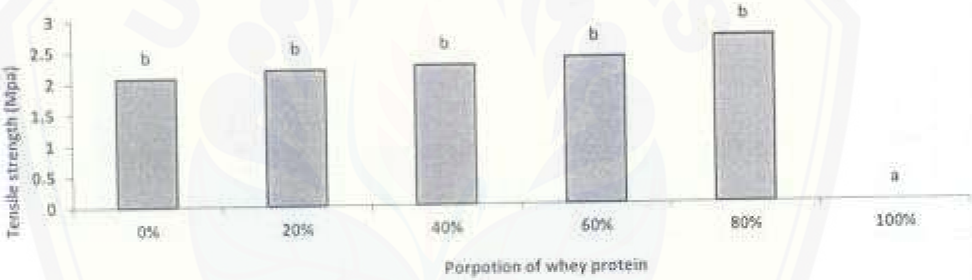

Figure 6. Result of tensile strength measurement as variation of whey protein proportion.

Based on the data in Figure 6 showed that increasing of whey porpotion would increase tensile strength. According to Guilbert and Graille (1994), generally, mechanical properties of edible films from protein better than the edible film of starch. This is because starch is a homopolymer, whereas the protein has a specific structure composed of at least 20 hydrogen bonds. Tensile strength measurement on 100 % whey was zero because plastic produce from 100% whey was brittle so the tensile test could not be performed.

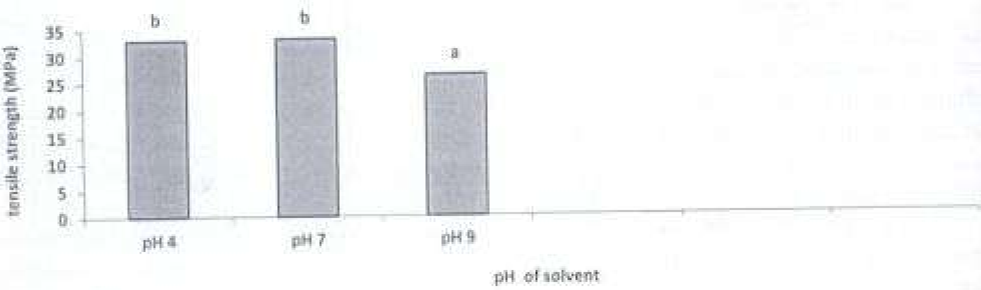

Figure 7. Result of tensile strength measurement as variation of pH of solvent.

The results of tensile strength measurements (Figure 7) showed that increasing of pH would decrease tensile strength of edible plastic, it was thought to relate with protein solubility. Increasing of pH would increase protein solubility. According to Mawarti et al. (2001), by decreasing pH value, effect of glycerol as a plasticizer was getting smaller, that cause of increase in tensile strength and decrease in extension.

The results of the solubility measurements ranged between 22.90% to 34.69%. Results of analysis of variance showed that whey protein porpotion and pH of solvent had significant effect on solubility but interaction between this two parameters did not. Figure 8 showed result of strain measurements as a function of whey propotion.

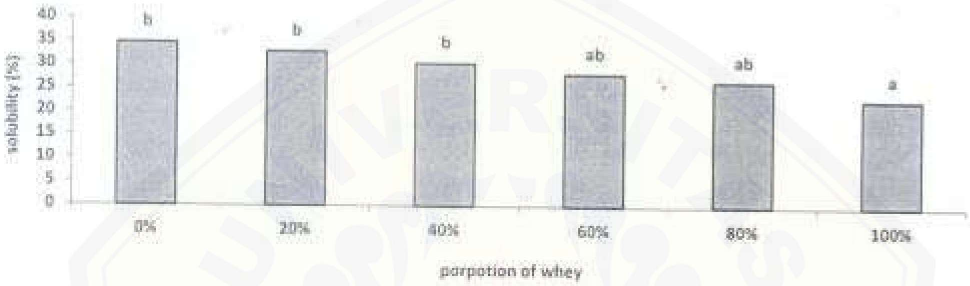

Figure 8. Result of solubility measurement as variation of whey protein proportion.

Figure 8 shows that increasing in whey porpotion would decrease of solubility. High solubility of edible plastic showed that it was easily soluble in water. During gel preparation, whey protein would be denatured when heated, whereas hydrophobic group was located outside and a hydrophilic group would be folded and more hydrophobic plastic could be produce.

The results of the solubility measurements as a function of pH is shown in Figure 9. The data showed increasing of solubility with increasing of pH. At pH 4 edible plastic had solubility in water less then plastic at pH 7 and pH 9. It was presumable there was plastic solubility depend on protein solubilty whereas at pH 4 near the isoelectric point protein had lowest solubility.

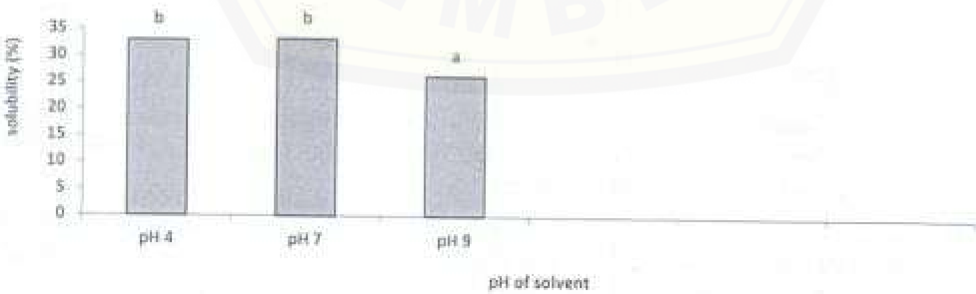

Figure 9. Result of solubility measurement as variation of pH of solvent.

CONCLUSION

Whey protein porpotion and pH of solvent had significant effect on gel's characters (lightness, texture and solubility) and edible plastic's characters (strain, tensile strength and solubility). Interaction of whey protein proportion and pH had significant affect on lightness, texture and solubility of gel and strain of edible plastic but had no significant effect on tensile strength and solubility. In this research edible plastic could not be produce from 100% whey protein.

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