Edible Films of Blended Cassava Starch and Rice Flour with plasticizers and Their Mechanical Properties

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Abstract

In this study, the effects of cassava starch and rice flour blending compositions and additional of sorbitol as plasticizer on mechanical properties (tensile and folding resistance) of edible film blends were studied. The suitable ratio of cassava starch and rice flour to water at 10 % w/v was used for film forming solution through the experiment. Addition of plasticizer up to 30 % w/w of blending compositions trended to improve mechanical properties of films. The mechanical properties of edible blended films with 30% plasticizer were strongly dependent on the blending composition. The experimental results indicated that cassava starch and rice flour blends at ration 70:30 with sorbitol 30%w/w of blending composition gave the best tensile and folding resistance.

Introduction

Nowadays, about 150 million tons of plastics are annually produced all over the world and the plastic production as well as consumption continually increased. This has stimulated researchers to synthesize new polymer that can be returned to the biological cycle after use. Therefore, the use of agricultural biopolymers that are easily biodegradable not only would solve this problem, but would also provide a potential new use for surplus farm production. Edible and biodegradable polymers based on natural polysaccharides, particularly starch, can be produced at low cost and at large scale. Because the wraps are eaten, they produce no waste to harm the environment. Eco-efficient products are the new generation of biobased products prepared with sustainable materials, which agree with ecological and economic requirements including environmentally acceptable disposal of post-user waste.

Starch is a polysaccharide which consists of the linear D-glucan amylose and the highly branched amylopectin. Although most of the recent research has been focused on the conversion of starch into thermoplastic material by the extrusion process, another means of preparing films, i.e. from solution or gel, has been used (Bader and Göritz, 1994; Lourdin et al., 1995) as an attractive alternative. Owing to the hydrophilic properties of starch, it provides a minimal barrier to water (Kestera and Fennema, 1986). Nevertheless, starch film possesses good barrier properties to oxygen, carbon dioxide and lipids and protect against lipid oxidation (Banker, 1966). Films from polysaccharides are also stronger and more extensible than proteinaceous films (Krochta and De Mulder, 1995).

Rice and cassava are the economically crucial crops in Thailand. Rice and cassava flours are efficient thickeners and binding agents, they are used mainly and extensively in the production of soups, sauces, pastry filling, etc. In the recent studies, cassava and rice flours or starches were used to produce the edible films and plasticized with glycerol and sorbitol (Laohakunjit and Noomhorm, 2004; Phan et al., 2005). Cassava starch based film plasticized with glycerol showed interesting mechanical properties. It is transparent, clear, homogeneous,
flexible, and easily handled. Whereas rice starch based films plasticized with glycerol was relatively brittle and have a low tension resistance (Phan et al., 2005). The tensile strength of glycerol-plasticized rice starch film was significantly lower than that of sorbitol-plasticized rice starch film, but its elongation was larger (Laohakunjit and Noomhorm, 2004).

In recent year, many researches reported the mechanical properties of starch film but there is no information of mechanical properties of cassava starch and rice flour blended films with plasticizer. Therefore, the objective of this study is effect of blending ratio of cassava starch and rice flour with plasticizer on the mechanical properties of the edible films.

Materials and Methods

Preparation of cassava starch film by various amount of sorbitol for mechanical testing

Effect of plasticizer on cassava starch film on mechanical properties was investigated. Cassava starch film solution (concentration 10% w/v) was heated at 60°C, stirred, and sorbitol (0, 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 w/w of cassava starch). The mixture was still stirred for 10 minutes and cooled down to room temperature (27-30°C). Film solution was casted by tape casting machine with speed 20 rpm. Casted film was leaved at room temperature for 24 hours. Dried cassava film was peeled off for thickness measurement, tensile strength, %elongation at break and folding endurance test. The results revealed that cassava film added with sorbitol 30% w/w gave the best tensile strength and folding endurance. Therefore, this amount of plasticizer ration (30% w/w) was used to investigate the effect of blending composition of cassava starch and rice flour on mechanical properties.

Preparation of cassava starch/rice flour film blends with 30% sorbitol (w/w) by various blending composition for mechanical testing

Effect of blending composition of cassava starch/rice flour film on mechanical properties of film blends was investigated. Film solution was prepared at concentration of 10 % w/v by various ration of cassava starch/rice flour at 100:0 90:10 80:20 70:30 60:40 50:50 40:60 30:70 20:80 10:90 and 0:100 (%w/w). Film solution was stirred at 60 °C and 30% w/w of sorbitol was added in to the solution. The film solution mixture was casted as discuss above. Dried cassava starch/rice flour film blends was peeled off for mechanical testing in the next step. The result showed that ratio of cassava starch/rice flour blended film at 70:30 provided the best tensile strength and folding endurance. Therefore, the ration of 70:30 was used for studying the effect of amount of sorbital in cassava starch/rice flour film blends for mechanical testing.

Preparation of cassava starch/rice flour film blends at 70:30% w/w by various sorbital (w/w) for mechanical testing

Effect of amount of plasticizer on mechanical properties of cassava starch/rice flour ratio at 70:30 was studied. Film solution (10% w/v) of blended cassava starch/rice flour ratio at 70:30 was added with plasticizer (0, 10, 20, 30, 40 and 50%w/w). The blended film solution with plasticizer was casted as discussed above. All film was kept for mechanical testing.

Tensile strength and percent elongation

Film samples were cut to 25mm x150mm test specimens. Film samples were preconditioned at 27±2°C with 65±2% relative humidity at least 24 h. Tensile strength (TS) were measured using Instron Universal Testing Machine Model 1000 (H1K-S, UK) according to ASTM Method (ASTM, D882-80a, 1995a). Ten samples were tested.

Folding Endurance

Film samples were cut to 15mm x 140 mm test specimens and preconditioned at 27±2°C with 65±2% relative humidity at least 24 h. Folding endurance was performed according to ASTM D2176-97a (2002) using MIT folding endurance tester (MIT Folding
Endurance Tester Model Spring System Tokyo Seiki Seisakusho Ltd. Model: HT-60147 2001.4) with a 500 g load cell, angle 135° and 175 times/min).

**Results and Discussion**

**Effect of plasticizer (sorbital) on cassava starch film on mechanical properties**

Effect of sorbital (0, 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 w/w of cassava starch) on cassava starch film on mechanical properties was studied. Film appearance was transparent. Addition of sorbital from 0 to 30 w/w improved flexibility of cassava starch film (Figure 1). However, film added with sorbital more than 30%w/w was hard to peel off. Film was so sticky and stick to itself. Therefore, film with sorbital above 30%w/w could not be tested. Interestingly, addition of sorbital in cassava film improved in tensile strength (Figure 1) and folding endurance (Figure 2) comparing with cassava film without sorbital (control sample). Tensile strength and folding endurance of cassava film with sorbital tended to increase. This result was opposite to the mechanical properties of cassava starch film plasticized with glycerol (Alves *et al.*, 2007). According to Garcia *et al.* (2000), sorbitol has higher interaction with starch chains causing higher strength because sorbitol is more similar to the structure of glucose units than glycerol.

Therefore, cassava starch film with sorbital of 30%w/w was selected for studying the effect of blending composition of cassava starch/rice flour on mechanical properties.

**Effect of blending composition of cassava starch/rice flour on mechanical properties of film blends with 30% sorbitol w/w**

Effect of blending composition of cassava starch/rice flour on mechanical properties of film blends with 30% sorbitol w/w was studied. Appearances of cassava starch film and cassava film blend containing with rice flour 0 to 30%w/w were transparent. The opacity of film blends increased as addition of rice flour increased above 40%w/w. Rice flour film had the most opaque. As shown in Figure 3, tensile strength of blended film increased as amount of rice flour increased and reached to maximum at 20 and 30% of rice flour, and then tensile strength decreased as rice flour increased above 30%. Moreover, tensile strength of blended film at ratio of rice flour above 50% dramatically decreased. Tensile strength of film containing with rice flour from 60 to 100% slightly decreased as increasing amount of rice flour. The results of folding endurance of film blends (Figure 4) provided the similar trend as tensile strength. Cassava starch film blends with 30% rice flour gave the highest both tensile strength and folding endurance. The processing temperature of this study was 60-70°C which was in the range of gelatinization temperature of cassava starch, but rice flour had
gelatinization around 60-82°C (Sermsirisophon and Kongkiattikajorn, 2005). Gelatinization temperature of cassava starch was lower than rice flour; therefore, amylose in rice flour suppressed swelling of granule and increased the strength of film. Addition rice flour more than 30% in film blends was lower gelatinization. Film appearance was opaque and increased surface irregularity. Therefore, film blend of cassava starch/rice flour ratio at 70:30 was selected for studying the plasticizer effect.

**Effect of plasticizer on mechanical properties of cassava starch/rice flour ratio at 70:30**

Effect of amount of plasticizer (10, 20, 30, 40 and 50% w/w) on mechanical properties of cassava starch/rice flour ratio at 70:30 was studied. Appearance of all film blends with various plasticizers was transparent. Addition of sorbitol from 0 to 30 w/w improved flexibility of cassava starch film. However, film added with sorbitol more than 30% w/w was hard to peel off. Film was so sticky and stick to itself. Film with 30% sorbitol had the highest tensile strength (Figure 5). This result agreed with the effect of plasticizers on mechanical and barrier properties of rice starch film (Laohakunjit and Noomhorm, 2004). Folding endurance of film increased as amount of sorbitol increased from 10% to 30% (w/w) and then folding endurance of film decreased when amount of sorbitol 40-50% (w/w) added. Addition sorbitol 30% (w/w) to blended film had the highest folding endurance which related to tensile strength of the films.

**Conclusion**

Effect of sorbitol on cassava starch film was investigated. Addition of sorbitol 30%w/w in cassava film had the best tensile strength and folding resistance. Effect of blending composition of cassava starch/rice flour on tensile strength of film blends with 30% sorbital w/w was also investigated. The ratio of cassava starch and rice flour at ration 70:30 with sorbitol 30% (w/w) gave the best mechanical properties.
Figure 5 Effect of sorbital on tensile strength of cassava starch/rice flour ratio at 70:30.

Figure 6 Effect of sorbital on folding endurance of cassava starch/rice flour ratio at 70:30.

References


