Iranian Journal of Organic Chemistry Vol. 14, No. 2 (2022) 3343-3347

Mechanical properties of sago starch film incorporated with euparin extract of *Petasites hybrids*

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Received: February 2022; Revised: March 2022; Accepted: March 2022

Abstract: The mechanical and barrier properties of sago starch film incorporated with different percentages of euparin (0.02, 0.04, 0.06, 0.08, and 0.1) were evaluated. With regard to mechanical properties, tensile strength and Young's modulus increased when the percentage of extract Elongation at break (%) decreased. and increased with the increasing percentage of extract from 0.02 to 10.1,

Keywords: Tensile strength, Elongation at break, Youngs modulus

Introduction

The development of starch-based bioplastics has been given considerable attention as an environmentally friendly biodegradable alternative to hydrocarbon-based plastics [1]. When starch films are used for food packaging it is required to have good transparency, sufficient strength and low moisture absorption so as be able to improve the shelf life of food. Solution casting is one of common method for preparing starch film, especially at the laboratory level. During this preparation, some defects resulting in inhomogeneous structures may occur. These inhomogeneous structure results from incompletely soluble starch granules often called ghosts [2]. This can decrease the transparency of starch film [3]. Ghost formation is a result of cross-linking of polysaccharide chains within swollen granules [4]. Previous studies found that ultrasonication is effective in reducing insoluble and agglomerated starch [5-6].

This is because sound energy from ultrasonication produces acoustic cavitation: the formation, growth, and collapse of starch granules within the liquid matrix [7-8].

Physical and mechanical properties of a maize starch film after ultrasonication of the starch gel improve due to an increase in homogeneity of the structural starch film resulting in increased transparency and tensile strength of the film along disappearance of the ghosts [9-10]. In contrast, another previous study claimed that a high ghost phase fraction enhanced the tensile (elongation at break and tensile stress) properties of corn starch film [11-14]. These dissimilarities in results could be due to differences in the starch sources used for preparing starch films. To the best of our knowledge, there is no publication in the literature related to the mechanical properties of edible films incorporated with euparin. Therefore, the objectives of this research were to characterize the mechanical and barrier properties of sago starch-based film incorporated with euparin.

Materials and methods

Purification of phycocyanin

Petasites hybridus dried roots (1 kg) were cut into small pieces and extracted with a mixture of MeOH:THF (1:1) for 5 h. Next, the solvent was evaporated under reduced pressure and euparin was obtained as yellow needle crystals [14].

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Chemicals and reagents

Sago starch with approximately 12% moisture, glycerol, sorbitol and the other chemicals were supplied by Sigma-Aldrich.

Film preparation

2.2.1 Sago starch –based film was explained [15]. First 4% (w/w) sago starch was added to distilled water and followed by heating to 90 ◦C for gelatinization of starches and stirred continuously for 45 min to complete homogeneity and gelatinization in solution. A mixture of plasticizer (sorbitol: 3/glycerol: 1) that was previously reported as having the best heat seal ability at 40%, was also added. This mixture was cooled to 40–45 ◦C. Different amount of suspension euparin dissolve in methanol (0.0 2, 0.0 4,0.0 6, 0. 08, and 0.1 w/V) was added into the mixture of EU1, EU2, EU3, EU4, and EU 5 films respectively. Film without the addition of EU (EU0) served as control. Each suspension was cast on Perspex plates and fitted with rims to yield a 16 cm × 16 cm film-forming area. Then the films were dried in the oven at 40 ◦C for 20 h and peeled off after drying, and kept at,23 ± 2 ◦C and the dried and peeled were film put into a desiccator with 50% relative humidity until further analyses.

Mechanical properties

The mechanical properties of were films were determined using ASTM D882 [22-24] with a slight modification. Film strips were cut into 100 mm × 20 mm sections and were kept for 48 h at 23 ◦C and 53% RH to be conditioned. The mechanical properties were then measured using a universal testing machine (SANTAM)in an initial grip separation with crosshead speeds of 50 mm/s and 1 mm/s. Deformation and force were recorded by the software during extension and expressed in graph format. Elongation and tensile strength at breaking as well as Young's modulus were calculated. At least five replicates were carried out for each sample

Results and Discussion

Tensile strength, elongation, at break and Youngs modulus

Tensile strength (TS) expresses the maximum force per area that the film can tolerance before breaking, while elongation at break (EB), elongation shows flexibility of the film when subjected to mechanical stress and tension and Young's modulus (YM) Films made from high amylose starches showed the highest values of TS and YM. Several studies have reported this behavior [16-17]. which has been attributed to the capability of linear amylose chains to interact through hydrogen bonds to a higher extent than the branched amylopectin chains Fig. **1** indicates that increasing the concentration of the euparin extract increased tensile strength from 6.98±0.05 MPa to 9.12±0.125 MPa, probably caused by the euparin coat formed on the surface reinforcing the films and increasing the tensile strength. Furthermore, the changes in the orientation of the helices of starch molecules within the semi-crystalline lamellae could have resulted in a compact structure which also increased TS but increased control.

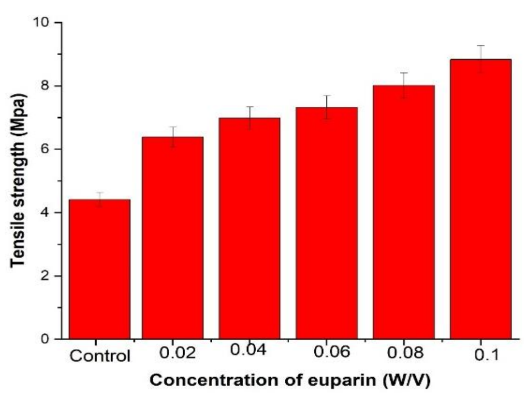

Figure 1. Tensile strength of sago starch films incorporated euparin Bars represent mean (n = 10) ± SD.

Elongation at break (%E) showed the opposite behavior of TS and YM in euparin films. %E values increased control when the concentration of euparin and Fig.**2** decreased the percentage of elongation at break from 19±0.07 to 11±0.705, decreased to control this result is consistent with several reports [18-19].

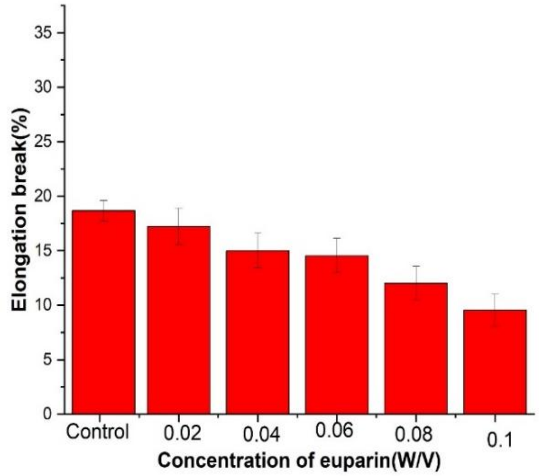

Figure 2. Elongation at break of sago starch films incorporated euparin. Bars represent mean (n = 10) ± SD.

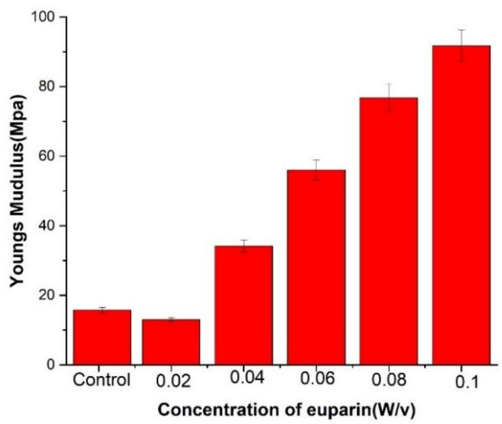

Figure 3. Young's modulus of sago starch films incorporated euparin. Bars represent mean (n = 10) ± SD.

Young's modulus was also improved by increasing the concentration of euparin as observed in Fig. **3**. Apparently, euparin increased the film rigidity as the short-range crystallinity increased resulting in higher YM values Results showed that by increasing the amount of euparin to film structure TS and YM significantly increased and EB of the sago starch films significantly decreased. It is likely that euparin plays a role as a plasticizing agent and improves the flexibility of the starch films. Such behavior of other EOs reported by other researchers [20-21].

Conclusion

The results demonstrated that films containing phycocyanin (0.2, 0.4, 0.6, 0.8 and 1.0) had a good tensile strength and Youngs modulus decreased and elongation at break increased when percentage of incorporated extract in the film increased.

Acknowledgements

The authors are thankful to the Islamic Azad University of Qaemshahr for their support.

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