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Mechanical properties of sago starch film incorporated with Cydonia oblonga extract

Seyed Amirhossein Salimbahrami[a], Masoumeh Hosseinzadeh[a]*, Sadegh Salmanpour[a]

[a] *Department of Chemistry, Sari Branch, Islamic Azad University, Sari, Iran*
[b] *Department of Chemistry, Qaemshahr Branch, Islamic Azad University, Qaemshahr, Iran*

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Abstract: The mechanical and barrier properties of sago starch film incorporated with different percentages of Cydonia oblonga (0.2, 0.4, 0.6, 0.8, and 1.0) were evaluated. With regard to mechanical properties, tensile strength and Young's modulus decreased when the percentage of extract Elongation at break (%) increased. and increased percentage of extract from 0.2 to 0.1,

Keywords: Tensile strength, Elongation at break, Youngs modulus

Introduction

The increase in plastic pollution has raised the interest to develop alternative materials. Thus, researchers have focused on studying biopolymers to partially or completely replace the existing plastics. Starch has been considered an attractive alternative due to its eco-friendly character, abundance, and low-production cost at a large scale. However, starch-based films have limited functional properties (barrier and mechanical) and different strategies such as chemical modification (crosslinking, oxidation, esterification) or the combination with macromolecules (proteins and polysaccharides), and nanoparticles (nano clays, cellulose, and carbon tubes) have been used to improve them [1–6]. Nevertheless, starch-based films still cannot mimic the functional properties of films from conventional plastics. The oxygen barrier property of fresh products such as fruits, meats, and salads has an important role in their preservation.

Starch films have a selective permeability to some substances such as oxygen which can make it a very good modified atmosphere packaging (MAP) [7-9].

*Corresponding author: Tel: 0098-9111251481; Fax: 0098-112145047, E-mail: ma_hosseinzadeh@yahoo.com

The water vapor barrier shows the volume of water vapor that pass from packaging material. It is very important to prevent dehydration in fresh foods [10]. Mechanical properties of films such as tensile strength and elongation at break are important for the proper function of packaging materials and may be influenced by interaction between polymer and chemical compounds [11-15] Most food contaminations exist on the food surface; therefore packaging has an important role to control food contamination [16-18].

To the best of our knowledge, there is no publication in the literature related to the mechanical properties of edible films incorporated with Cydonia oblonga extract. Therefore, the objectives of this research were to characterize the mechanical and barrier properties of sago starch-based film incorporated with Cydonia oblonga extract.

Materials and methods

Purification of Cydonia oblonga

Cydonia oblonga Mill collected from Mazandaran privence (Alborz mountain) in Iran. Peels were separated from the fruits and further used for the experiments. The powdered peels were extracted by stirring with 300 mL of water and ethanol, at room temperature, 150 rpm, for 24 h. The extract was filtered through Whatman No. 4 paper. The residue was then re-extracted twice with additional portions.

Chemicals and reagents

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

Film preparation

Sago starch –based film was explained [19-20]. 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 Cydonia oblonga dissolve in water (0. 2, 0. 4, 0. 6, 0. 8, and 1 w/V) was added into the mixture of CO1, CO2, CO3, CO4, and CO5 films respectively. The film without the addition of CO (CO0) 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 off film were put into a desiccator with 50% relative humidity until further analyses.

Mechanical properties

The mechanical properties of the films were determined using ASTM D882 [21-22] 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 [23]. 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 concentration the Cydonia oblonga increased tensile strength from 3.21±0.05 MPa to 9.45±0.125 MPa, probably caused by Cydonia oblonga 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 decreased to control.

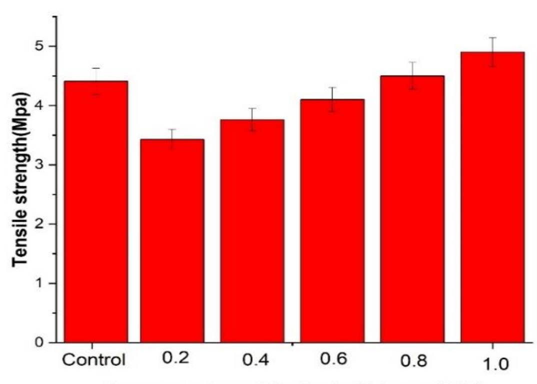

Figure 1. Tensile strength of sago starch films incorporated Cydonia oblonga Bars represent mean (n = 10) ± SD.

Elongation at break (%E) showed the opposite behavior of TS and YM in phycocyanin films. %E values increased control when the concentration of Cydonia oblonga and Fig.**2** while decreased the percentage of elongation at break from 43.98±0.07 to 25.12±0.705, increased to control increase flexibility of films. This result is consistent with several reports [24-25].

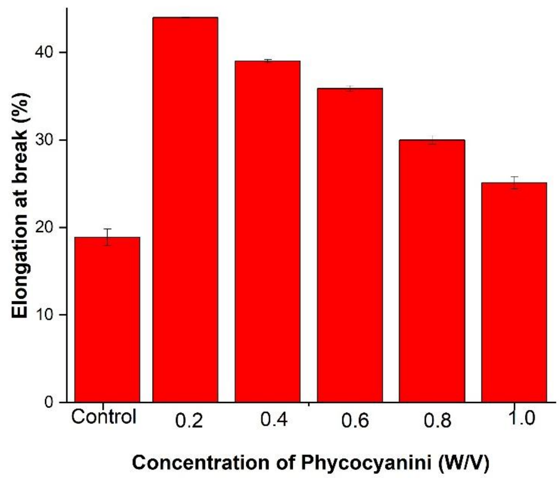

Figure 2. Elongation at break of sago starch films incorporated Cydonia oblonga. Bars represent mean (n = 10) ± SD.

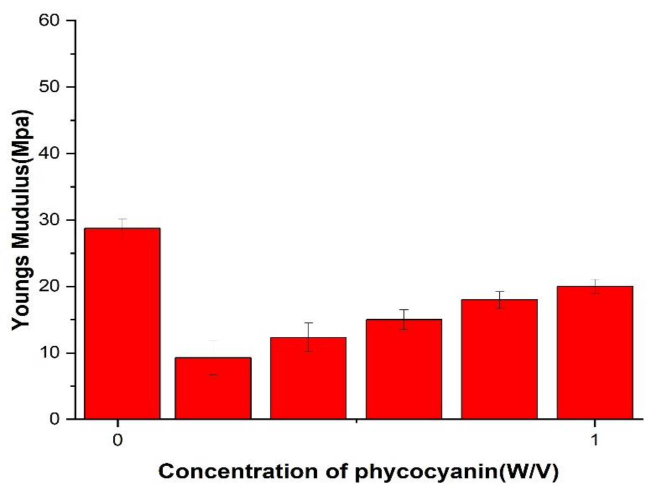

Figure 3. Young's modulus of sago starch films incorporated Cydonia oblonga. Bars represent mean (n = 10) ± SD.

Young's modulus was also improved by increase sing concentration of Cydonia oblonga as observed in Fig. **3**. Apparently, phycocyanin increased the film rigidity as the short- range crystallinity increased resulting in higher YM values Results showed that by increasing the amount of phycocyanin to film structure TS and YM significantly decreased and EB of the sago starch films significantly increased. It is likely phycocyanin plays a role as plasticizing agent and improves the flexibility of the starch films. Such behavior of other EOs reported by other researchers [26-28].

Conclusion

The results demonstrated that films containing Cydonia oblonga (0.2, 0.4, 0.6, 0.8 and 1.0) ad a good tensile strengthYoung'soungs modulus decreased and elongation at break increased when percentage of incorporated extract in the film increased.

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