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Characterization of the mechanical properties of sago polymer films incorporated with the Flax seed extract, nano Zinc-oxide and nanozinc oxide-cadmium

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Abstract: Today, the tendency to use biodegradable packaging, including coatings and edible films, is increasing day by day in the industry due to the fact that they are free from synthetic chemicals and do not cause environmental pollution. In this regard, the use of combinations of plant extracts can greatly improve the efficiency of this type of packaging. The purpose of this research is to investigate the effect of alcoholic extracted from flax seed on the mechanical properties of sago starch edible film. In the research biofilm based on sago starch incorporated with the flax seed alcoholic extract (2, 4, and 6) grams , using nano zincoxide and nano zincoxide-Cds5% its property the mechanical Tensile strength(TS) and Elongation at break (EAB) and mechanical properties were evaluated with an increase in the content of the extract. The best results for the concentration of 6gram extract mixed with 0.01gram nanoparticle zinc oxide-Cds5%. Which is the lowest tensile strength and highest elongation at break

Keywords: Sago, Tensile Strength, Elongation at the break, Zinc Oxide-Cd, Flax Seed

Introduction

Quality and appearance of food is very important for consumers. Food quality changes easily and quickly due to microbial and chemical degradation and this can happen during handling, transportation, and storage [1,2]. The oxidation reaction of lipid is the main cause of spoilage. Therefore, preventing microbiological and chemical deteriorations are critical challenges for the food industry. Several innovative packaging techniques have been produced with the goal of both maintaining the quality and prolonging the shelf life of foods. Packaging is used for protecting the food from the outside environmental and preventing contamination. In recent years, so-called active packaging has emerged as an alternative method for protecting food.

Antimicrobial and/or antioxidant packaging are the main systems that effectively kill or suppress microbial growth and delay the oxidation of pigments and lipids present in food [3,4]. This technology actually incorporates active agents into the packaging materials, which provides antimicrobial and/or antioxidant properties that do not exist in traditional packaging starch alone as a packaging material has many limitations due to its hydrophilic nature and poor mechanical properties (for example brittleness). Therefore, starch is often modified Starch-based films have no color, odor, and taste and in comparison with plastic films that

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have good barrier properties and have good mechanical and barrier properties [5,6]. The oxygen barrier property of fresh products such as fruits, meats, and salads has an important role on their preservation. Starch films have a selective permeability to some substances such as oxygen which can make it as a very good modified atmosphere packaging (MAP) [7-9]. The water vapor barrier shows the volume of water vapor that pass from a packaging material. It is very important to prevent dehydration in fresh foods [10-14]. Mechanical properties of films such as tensile strength and elongation at break are important for proper function of packaging materials and may be influenced by interaction between polymer and chemical compounds [15] Most food contaminations exist on the food surface; therefore, packaging has an important role to control food contamination [16-20].

To the best of our knowledge, there is no publication in the literature related to mechanical properties of edible films incorporated with Flaxseed extract (FS), Zinc oxide nanoparticles (ZNPs) and Zinc oxide –cadmium 5% nanoparticles (ZNP-Cds5%). Therefore, the objectives of this research was to characterize the mechanical and barrier properties of sago starch-based film incorporated with FS, FSZNPs and FSZNP-Cds.

Results and Discussion

Tensile strength and elongation at break

The incorporation different concentration FS, FSZNPs and FSZNP-Cds5% into the sago film increased the thickness. the sago starch-based films was ranging from 0.22 mm to 0.30 mm for FS (2.0 and 6.0) and 0.34mm for FSZNPs and 0.35 mm for FSZNP-Cds5% and may be associated with different crosslinks established between the Sago and the FS, FSZNPs and FSZNP-Cds5%[25]

The Tensile strength (TS) and elongation at break (EAB) of films with different concentration of are shown in fig1,2. The TS of the sago film FS (0) is 3.92 MPa, while that of the FS (2.0) film value of 5.77 MPa, for FS (4.0) value 5.53 MPa, for FS (6.0) value 5.17 MPa, value of for 2.78 MPa FSZNPs (0.01) and value of 3.05 MPa for FSZno-Cd5%(0.01). The EAB of the FS (0) film 21.78%, for FS (2.0) film value of 19.59%, for FS (4.0) 43.12%, for FS (6.0) 62.56%,FSZNPs (0.01) value 39.04 and for FSZNP-Cds5%(0.01) 41.64 %.that as higher concentration of FS was incorporated into the sago starch-based films, The enhanced tensile strength was probably due to intermolecular interactions between FS extract and sago could tighten polymeric chain-to-chain interactions, making Sago/Fs extract films more resistant to mechanical stress The decreasing trend in TS with higher concentration FS , FSZNPs and FSZNP-Cds could be attributed by the weakened interfacial hydrogen bonds between hydrophilic sago starch and hydrophobic Fs. Besides that, it might also be due to the less compact inner structure of FS-containing films especially the films incorporated with higher concentration and impact with ZNP-Cd nanoparticle [26-27].

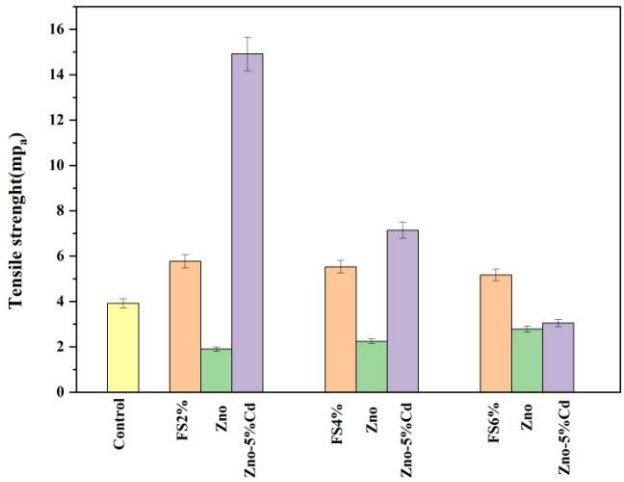

Fig. 1. Tensile strength of sago starch films incorporated FS , FSZNPs and FSZNP-Cds Bars represent mean (n = 10) ± SD.

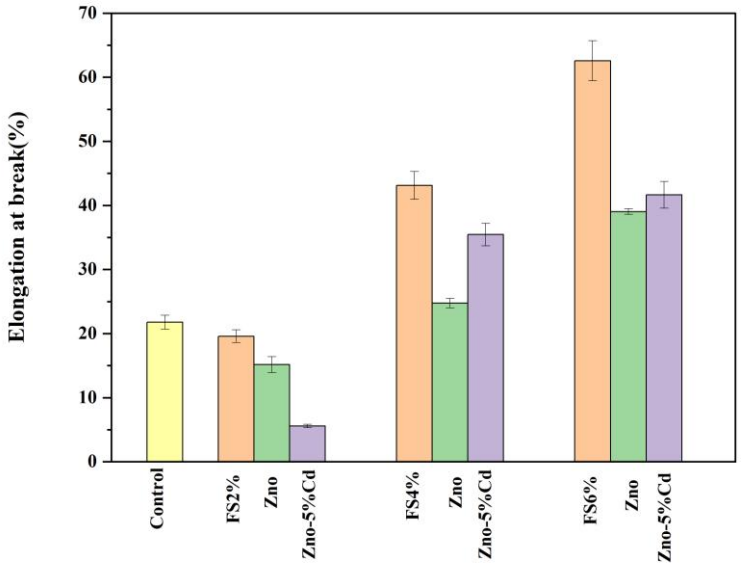

Fig. 2. Elongation at break of sago starch films incorporated FS , FSZNPs and FSZNP-Cds Bars represent mean (n = 10) ± SD.

Conclusion

The results demonstrated that films containing FS (2, 4 and 6) had a decreased, FSZNPs increased and FSZNP-Cds5% decreased. elongation at break increased when percentage of incorporated extract FS, FSZNPs and FSZNP-Cds5% in the film increased.

Experimental

Materials and methods

Sago starch with approximately 12% moisture, glycerol, sorbitol, Flaxseed, Ethanol (absolute, ≥99.8%), and other chemicals were supplied by Sigma-Aldrich

Film preparation

2.1.1 Sago starch 4% (w/v) was added to distilled water, followed by heating to 90 ^{0}C for gelatinization of starches, and was stirred continuously for 45 min to complete homogeneity and gelatinization in the solution. A mixture of sorbitol and glycerol (3:1) was added for the dispersion of the solution reported these plastizers are the best heat seal ability at 40%. (w/w). This mixture was cooled to 40–45 ◦C. Different concentration 2.0% (w/w), 4.0% (w/w) and 6.0% w/w of FS extract by weight of sago and 1 mL of Flaxseed extract (FS) were added to the mixture Film FS1, FS2 and FS3, respectively. Film without the addition of FS is (FS 0%). Each suspension was cast in a petri dish (140 mm diameter). Then the films were dried in the oven at 40 ◦C for 24 h and peeled off after drying, and kept at 23 ± 2 ◦C and 50 ± 5%relative humidity (RH) until tested. The thickness of each film used to determine the thickness of films nearest 0.001 mm. All films include control films were prepared in four replicate and for each experiment new films according to the discussed method were prepared [21].

Synthesis of Zinc oxide nanoparticles (ZNPs) was prepared by following the established protocol. Concentration 0.01 gr of ZNPs was dispersed in 100 mL of distilled water and stirred using a magnetic stirrer hotplate at room temperature (28 ^{0}C) for 60 min then the ZNPs solutions were used to prepare aqueous 4% (w/v) sago starch dispersions. A mixture of glycerol and sorbitol (1:3) at 40% (w/ w) of the total sago starch was added to the dispersion. Sago starch nanocomposites were heated to 90 ± 2 °C and held for 45 min to accomplish starch gelatinization and a homogenized dispersion. Then cooling the dispersion to around 45 °C a

concentration (6.0 % w/w) of 1 mL of FS extract mixed for 60 min at the same temperature to achieve homogenized dispersions (FSZNPs). This suspension was cast in a petri dish (140 mm diameter). 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 50 ± 5%relative humidity (RH) until tested. The thickness of each film used to determine the thickness of films nearest 0.001 mm. The average thickness was determined at five random positions on the films.

Synthesis of Zinc oxide –cadmium 5% nanoparticles (ZNP-Cds5%) was prepared by following the established protocol [22] Concentration of 0.01 gr of ZNP-Cds%5 was dispersed in 100 mL of distilled water and stirred using a magnetic stirrer hotplate at room temperature (28 ^{0}C) for 60 min then the ZNP-Cds5% solutions were used to prepare aqueous 4% (w/v) sago starch dispersions. A mixture of glycerol and sorbitol (1:3) at 40% (w/ w) of the total sago starch was added to the dispersion. Sago starch nanocomposites were heated to 90 ± 2 °C and held for 45 min to accomplish starch gelatinization and a homogenized dispersion. Then cooling the dispersion to around 45 °C a concentration (6.0 %) of 1 mL FS extract mixed for 60 min at the same temperature to achieve homogenized dispersions (FSZNP-Cds%5). This suspension was cast in a petri dish (140 mm 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 50 ± 5%relative humidity (RH) until tested. The thickness of each film used to determine the thickness of films nearest 0.001 mm. The average thickness was determined at five random positions on the films.

Mechanical properties

The mechanical properties of the films was determined using ASTM D882 [23-24] with a slight modification. Film strips 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.

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