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Characterization of the mechanical properties of the sago polymer films incorporated with the *Abelmoschus esculentus* extract nano Zinc-oxide and nanozincoxide-cadmium

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Abstract: Sago starch polymer is widely used in food, pharmaceutical, textile, etc industries. Their combination with other materials such as sorbitol and glycerin increases their mechanical properties. Mechanical properties are important for edible films. Mechanical tests of the films were performed in accordance to the standard methods. In this regard, the use of various herbal extracts can greatly improve the efficiency of the packaging.
In the research biofilm based on the sago starch incorporated with the Abelmoschus esclentus alcoholic extract (2, 4, and 6 grams) and Sorbitol/glycerol was used as a plasticizer and films were prepared under controlled conditions by the casting method using nano zinc oxide and nano zincoxide -Cds5% its properties the mechanical tensile strength (TS) and elongation at break (EAB) and mechanical properties were evaluated with a decrease in the content of the extract. The best results for the concentration of 2gram extract mixed with 0.01gram nanoparticle zinc oxide-Cds5%. Which is the lowest tensile strength and highest elongation at break.

Keywords: Sago, Tensile, Elongation, Nano Zinc oxide, Nano Zinc Oxide-Cd, Abelmoschus

Introduction

Non-biodegradable packaging waste accumulation and pollution the environment as well as low percentage recycling synthetic materials have motivated researchers to focus on natural resources as an alternative to synthetic plastic packaging [1]. Sustainable and environmental friendly materials for industrial applications are being developed world-wide. In recent decades, bio-based polymers, such as gelatin and starch, have been studied as alternative packaging films with comparable physicochemical, barrier, and mechanical properties [2]. Indeed, for fresh foods, biodegradable polymers can be more suitable because they have potential carrier of bioactive component for playing a role as active packaging [3]. Sago starch among the starch materials is relatively un-known.

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It is easily extracted from sagu palm tree at a very low cost compared with other starches. The functional properties of sago starch are between potato and cereal starches [4–7]. The starch popularity in biopolymer science is related to its relatively low cost, abundancy, and renewability [8]. However, starch alone as an alternative in polymer packaging material has some limitations such as brittleness and hydrophilic nature. Plasticizers or other additives are often combined with starch to overcome brittleness of starch [9]. But unfortunately, incorporation of plasticizers to structure of biopolymers decreases the mechanical properties [10]. Incorporation of the *Abelmoschus esculentus* alcoholic extract (2, 4, and 6)(Ae) grams , nanozincoxide (ZnO NPs) and nano zinc-Cd5% (ZnO NPs-Cds) 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 2-gram extract mixed with 0.01-gram nanoparticle zinc oxide-Cd5%. Which is the lowest tensile strength and highest elongation at break.

Materials and methods

Sago starch with approximately 12% moisture, glycerol, sorbitol, *Abelmoschus esculentus*, 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 Ae extract by weight of sago and 1 mL of Abelmoschus *esculentus* alcoholic extract (Ae) were added to the mixture Film Ae1, Ae2 and Ae3, respectively. Film without the addition of Ae is (Ae 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 [11-14].

2.1.2. Synthesis of Zinc oxide nanoparticles (ZNPs) was prepared by following the established protocol [15]. 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 (AeZNPs). 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 (AeZNP-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 [16-20].

Mechanical properties

The mechanical properties of the films was determined using ASTM D882 [21-24] 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

Results and Discussion

Tensile strength and elongation at break

The incorporation different concentration Ae, AeZnNPs and AeZnNPs-Cds5% into the sago film increased the sago starch-based films was ranging from 0.31 mm to 0.365mm for Ae (2.0 and 6.0) and 0.38 mm for AeZnNPs and 0.38 mm for AeZnNPs-Cds5% and may be associated with different crosslinks established between the Sago and the Ae , AeZNPs and AeZNP-Cds5% .The Tensile strength (TS) and Elongation at break (EAB) of films with different concentration are shown in Fig1,2. Mechanical properties of films containing plant extract

more depend on the polymers..The TS of the sago film Ae (0) is 3.92 MPa, while that of the Ae (2.0) film value of 2.83 MPa, for Ae (4.0) value 1.45 MPa, for Ae (6.0) value 0.435 MPa , value of for 3.40 MPa AeZNPs (0.01) and value of 0.791MPa for AeZNP-Cds5%(0.01). The EAB of the Ae (0) film 21.78 %, for Ae (2.0) film value of 66.06%, for Ae (4.0) 28.55%, for Ae (6.0) 10.39%, AeZNPs (0.01) value 45.17% and for AE ZNP-Cds5%(0.01)

146.09 %. The incorporation of Ae extract causes a decrease in the TS that of intermolecular interactions between polymer chains in film matrix.The results showed that incorporation of nanoparticles significantly decrease the moisture content of sago starch films. Moisture in the films plays a role of plasticizing agent and decreasing the amount of moisture content decreases the flexibility of sago starch films, thereby increasing TS and decreasing EAB [25]. Probably caused by Ae coat formed on the surface reinforcing the films and decreasing the tensile strength. and significant increases in EAB were [26-27].

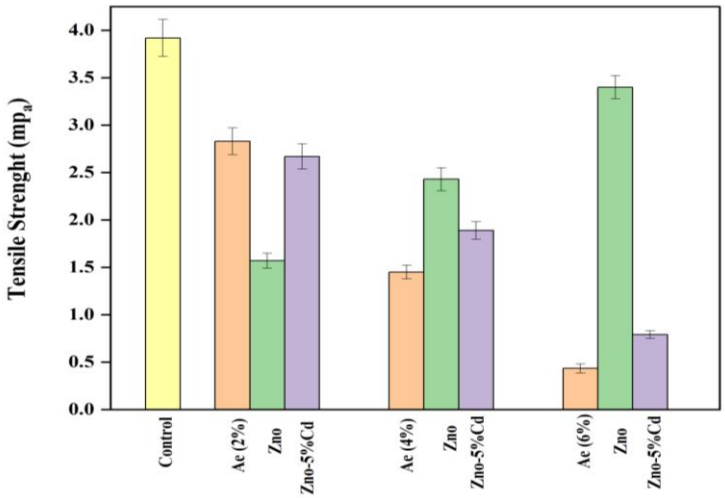

Fig. 1. Tensile strength of sago starch films incorporated Ae , AeZNPs and AeZNP-Cds Bars represent mean (n = 10) ± SD.

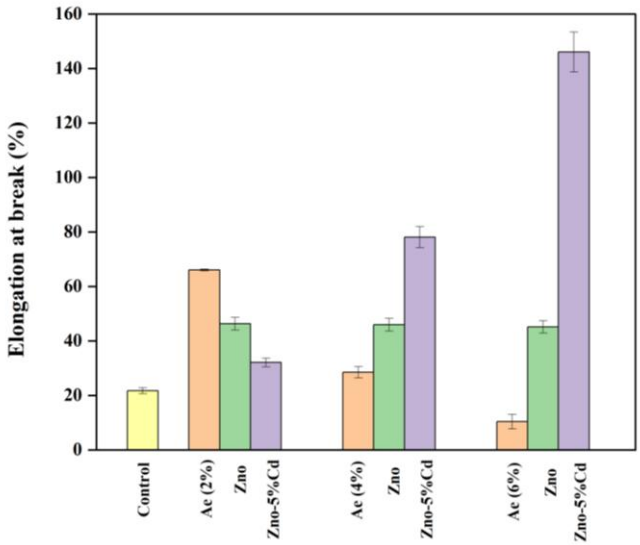

Fig. 2. Elongation at break of sago starch films incorporated Ae , AeZNPs and AeZNP-Cds Bars represent mean (n = 10) ± SD.

Conclusion

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

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