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ORIGINAL ARTICLE

Evaluation of Nanocomposite-based Packaging to prolong the Shelf-life of Sweet cherry (*Prunus avium* cv. Syahe Mashhad) during storage

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ABSTRACT
In order to investigate the effects of postharvest application of nanocomposite packaging on shelf life and quality characteristics of sweet cherry (Prunus avium cv. Syahe Mashhad) fruit, a factorial experiment was conducted with two factors, including conventional polymer packaging (control) and nanocomposite in four types (nanosilver based on polyethylene, nano-silver based on polypropylene, nano-silicate based on polyethylene, nano-silicate based on polypropylene) and time of storage in four levels (at the beginning 22 and 45 days after storage) in a completely randomized design with four replications at agricultural College and School of Medical Sciences, Urmia University. Result showed that using of nanocomposite compared whit conventional polymeric packets, increased the firmness of sweet cherry fruits during of storage. Catalase activity and weight of cherry fruit were decreased with the passage the storage period. PPO enzyme activity and weight of fruits storage in nanocomposites packages was significantly reduced. pH values increased during storage period in sweet cherry fruit

Keywords: *Antioxidant enzyme, Nano-composite, Polyphenoloxidase, Sweet Cherry, Weight*

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INTRODUCTION

Sweet cherry due to the high value of vitamin C and antioxidant properties. Improved methods for using sweet cherry fruit storage containers nano-composites will be able to maintain the food quality during a period of increased supply in the market. The use of protective coatings and suitable packaging by the food industry has become a topic of great interest because of their potentiality for increasing the shelf life of many food products [12]. The high surface to volume ratio of the radius of the spherical particles has a direct relationship them. With reduction particle size in the nanometer range, power, activity level, increased material and material surroundings to increase the reaction rate is more surface active sites [9]. Novel and efficient polymeric materials for food packaging based on nanotechnology can be presented as a new innovation that can be as solutions to enhance performance polymer more safety, economic and environmental benefits reduced to zero percent, an increase of food safety and human health, avoid wasting energy, transport and storage Mani, prevent the entry of gases and light, reducing the volume of waste material that is disposed of in landfills is helping to reduce CO_2 emissions [7]. Sweet cherry fruit postharvest storage period affected by a series of factors including dehydration, reduced fruit firmness, surface spots of sweet cherry, brown stem (tail up), reduce postharvest decay of color is limited [21]. Nanotechnology is a promising area of science that could offer new materials and new techniques to prolong food shelf life [10]. The use of nanoparticles in food packaging plastics can be improved permeability properties [17]. Particles to prevent the passage of oxygen, carbon dioxide and humidity are also packages to the transparency [6]. Silver nano particles bind to the surface of the cell membrane, the respiratory system interact with the respiratory chain enzymes that destroy bacteria by Ag^+ [28]. Also

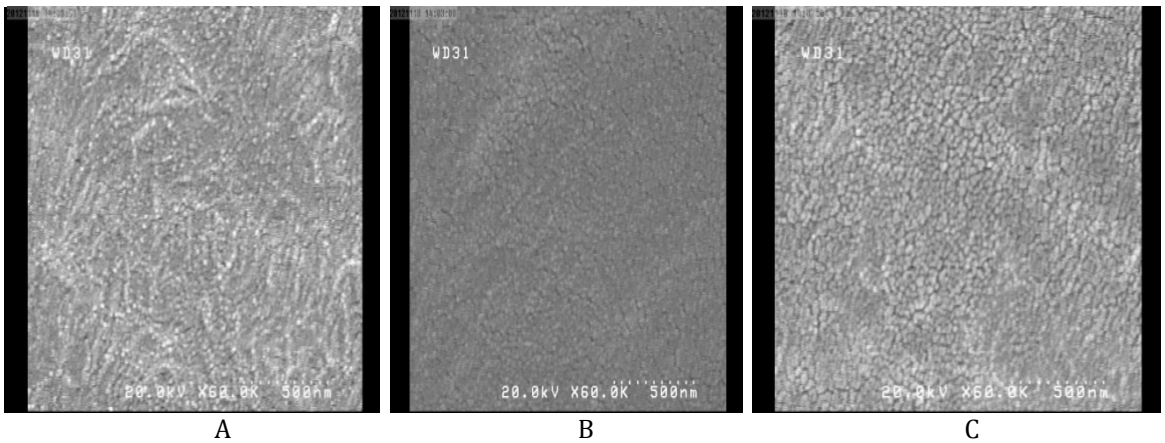
packages polyethylene packages containing silver nanoparticles compared regular beneficial effect on physical, chemical and sensory Chinese jujube has been shown [20]. Various applications of silver nanoparticles to vegetables [2,8,11,13] and dairy products [14] are reported in the literature.
Grapefruit Kiwi fruit cut into nano packages less weight than conventional polymer packages within 42 days of maintenance [25]. Yang et al [13] showed that the enzyme PPO in strawberry fruits packed in containers of silver nanoparticles decreases. Our previous study also showed that the nano-packing had quite beneficial effect on sensory, physicochemical, and physiological quality of fresh strawberry than polyethylene bags [32]. To the best of our knowledge, there are no published reports on the effect of nanocomposite-based packaging on preservation of sweet cherry. Therefore, the objective of the present work was to well understand the effect of this novel nanocomposite-based packaging material, the quantitative and qualitative characterization, antibacterial effect of the nanocomposite was conducted as well.

MATERIALS AND METHODS

In order to investigate the effects of postharvest application of nanocomposite packaging on shelf life and quality characteristics of sweet cherry fruit, a factorial experiment was conducted with two factors, including conventional polymer packaging (control) and nanocomposite in four types (nanosilver based on polyethylene, nano-silver based on polypropylene, nano-silicate based on polyethylene, nano-silicate based on polypropylene) and time of storage in four levels (at the 22 and 45 days after storage) in a completely randomized design with four replications at agricultural College and School of Medical Sciences, Urmia University. The sweet cherry fruits were harvested at the trade repining stage, shipped to the laboratory and up to the treatment and kept at the temperature of 0.5°C. Then, in 4 different combinations of nano-silver, nano-silicate clay and conventional polymer containers were considered as control samples, and were transferred to fridge (0.5°C and 90%- 95% relative humidity). FDA law states that nano-silver should be restricted in terms of consumption and its delivery rate. Besides, in short-term it should be near to 100 pbb, and in long-term around 1420 pbb. Therefore, we thought that seems necessary to create a barrier against passing oxygen and water. In fact, in this method, polymer nano-silica was designed and produced (ANSC-PE4 and ANSC-PP2) which belongs to Nano Bespar Aytech Company (Tehran, Iran).

Morphological investigations of nanocomposite-based packaging materials

Scanning electron microscopy (SEM) was applied for the investigation of the nanocomposite-based packaging. Gold was deposited on the cryogenic fracture surfaces of the samples. The SEM measurements were made on a scanning electron microscope (S-3000N, Hitachi High- Technologies Corporation, Japan) at an accelerating voltage of 20 kV (Figure 1).



A B C

Figure 1. SEM micrographs for the polypropylene and polyethylene nanocomposites containing A: nano silver, B: typical polymer C: nano-silicate.

Catalase activity

CAT activity was measured according to Beer and Sizer [5], with minor modifications. The reaction mixture (1.5 mL) consisted of 100 mmol L^{-1} phosphate buffer (pH 7.0), 0.1 mmol L^{-1} EDTA, 20 mmol L^{-1} H_2O_2 and 20 µL enzyme extract. The reaction was started by addition of the extract. The decrease of H_2O_2 was monitored at 240 nm and quantified by its molar extinction coefficient (36 $M^{-1}cm^{-1}$) and the results expressed as CAT units mg^{-1} of protein (U=1 mM of H_2O_2 reduction min^{-1} mg^{-1} protein).

Fruit weight loss

Fruit weight loss was done with a digital scale CANDGL 300 model for this purpose, fruit weight were measured after storage [23]. Percentage weight loss was calculated as follows:

Percentage weight loss =Weight secondary / 100 × (secondary weight - initial weight)

Polyphenol oxidase activity

The sweet cherry slices (0.5 g) freezing in liquid nitrogen followed by grinding with 1 mL extraction buffer (50 mM phosphate buffer, pH= 6.8 containing 0.5 mM EDTA and 6 % PVPP (w/v). Homogenate was centrifuged for 15 min at 14000 rpm and the supernatant used to determine enzymes activity. Monophenolase and diphenolase activity of PPO was assessed with different substrates according to the method of Vidhan Ara and John [29] with some modification. 200 µL of crude enzyme extract was added to 200 µL Pyrogallol 0.02 M and 2100 µL phosphate buffer solution (0.1 M, pH=7.2). Absorbance was read at 420 nm every 5s up to 3 min. The activity is expressed as unite per mg fresh weight. Diphenolase activity of PPO was determined by two different substrates. The first, the pyrocatechol substrate solution was prepared by adding 300 µL pyrocatechol to 3 mL Distilled Water. Monophenolase activity of PPO was determined spectrophotometrically by adding 200 L of enzyme extract to 300 µL pyrocatechol 0.5 M and 2500 µL phosphate buffer solution (0.1 M, pH=7.2). Absorbance was read at 420 nm and the activity is expressed as unite per mg fresh weight.

The second, 10 µL of enzyme extract was added to 500 µL dopamine hydrocholoride solution 60 mM with MBTH 5 mM, %2 (v/v), phosphoric acid % 5 and 490 µL phosphate buffer solution (0.1 M, pH=7.2). Absorbance for dopamine hydrocholoride substrate was read at 475 nm every 5 s up to 3 min according to Juan et al. [15]. The activity is expressed as unite per mg fresh weight. All enzymes determinations were performed in triplicate.

Determination of firmness

Samples firmness was measured using a Texture Analyzer (Model TA-XT Plus, Surrey, UK). The puncture diameter was 3 mm with a travel distance of 10 mm and test speed of 1 mm s^{-1}. The maximum force needed to puncture each sample was measured. Altogether, 10 slabs were used per treatment. The mean value of firmness for each treatment was then calculated, and the results were expressed in N mm^{-1}.

pH

Measure the pH of fruit juice extract was used filtered using a Model 411 pH meter at 20 °C was read.

Statistical analysis

Analysis of variance was performed using SAS version 9.1 (SAS Institute Inc., Cary, NC, USA). The data were presented as the means for each treatment. Differences among the means were analyzed using the least significant difference (LSD) test with a confidence interval of 95%. ($P \leq 0/05$).

RESULT AND DISCUSSION

Firmness

Firmness of sweet cherry fruits was improved using nano-composite containers containing silicate and silver and at 22 and 45 days after of storage (Figure 2). The results showed that there were no significant differences between nano-composite containers containing silicate and silver in terms of firmness (Figure 2). Biochemical basis associated with the softening of the fruit is not quite clear [19]. According to the research by Manning [22] fruit softening is due to the degradation of cell wall components, mainly pectins, by the action of specific enzymes, such as polygalacturonase. Li et al [20] indicated that nano-packing material had a quite beneficial effect on physicochemical and sensory quality compared with normal packing material. Maintaining lower fruit temperatures immediately after harvest results in firmer fruit with reduced decay and greener stems [26].

Catalase activity

Catalase activity of cherry fruit was decreased with the passage the storage period. The highest activity of catalase was observed at nano-silver based on polypropylene and 22 days after storage (Figure 3). The lowest catalase activity was observed at conventional polymer and 45 days after storage. It has been reported that 1-MCP treatment maintained significantly higher levels of superoxide dismutase, peroxidase, catalase and ascorbate peroxidase activities in pear fruit [18]. Vilaplana et al. [30] also observed that 1-MCP induced a significant rise in catalase and peroxidase activities, which implied greater resistance to senescence development in apple fruit. Catalase, which is located in peroxisomes, glyoxysomes and mitochondria, and is apparently absent in the chloroplast, dismutates mostly photorespiratory or respiratory H_2O_2 into water and molecular O_2 [3].

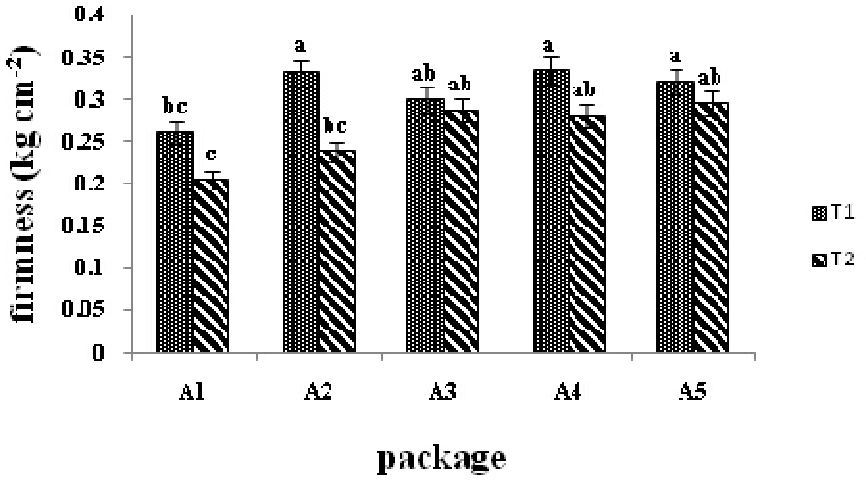


Figure 2- Interaction effect of containers of packaging and time of storage on firmness of sweet cherry fruits: A1:conventional polymer, A2: nano-silver based on polypropylene, A3: nano-silver based on polyethylene: A4: nanosilicate based on polyethylene A5: nano-silicate based on polypropylene. T1: 22 days after storage, T2: 45 days after storage. Means with the same letter for each stage are not significantly different (P≤0.05).

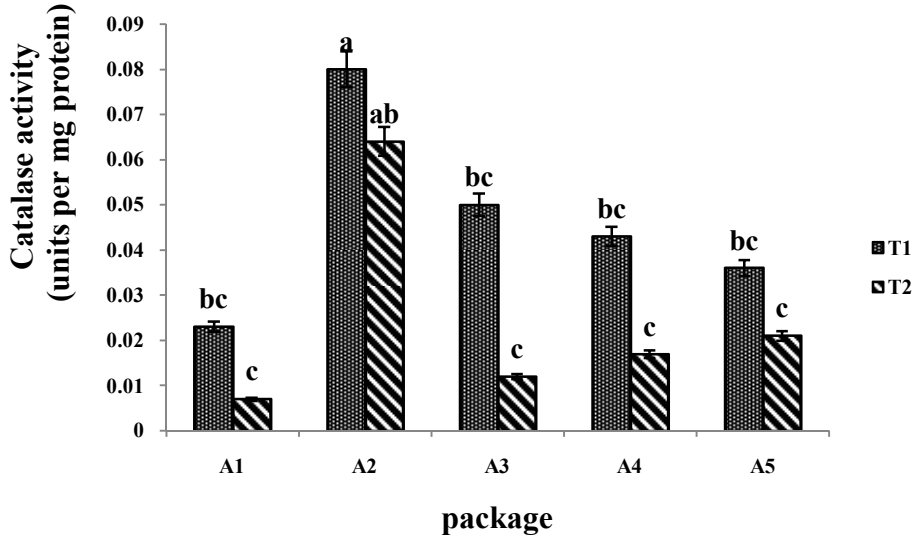


Figure 3- Interaction effect of containers of packaging and time of storage on catalase activity of sweet cherry fruits: A1:conventional polymer, A2: nano-silver based on polypropylene, A3: nano-silver based on polyethylene: A4: nan-osilicate based on polyethylene A5: nano-silicate based on polypropylene. T1: 22 days after storage, T2: 45 days after storage. Means with the same letter for each stage are not significantly different (P≤0.05).

Weight loss

Nano-silicate beads on polyethylene and nano-silicate based on polypropylene containers have less weight loss compared with conventional polymer containers, hence the fruits were kept in the containers have more weight (Figure 4). Also, results showed that in terms of weight loss of sweet cherry fruits, there were no significant difference between nano silver based on polypropylene and nano silver based on polyethylene. This result indicated that the nano-packing had a greater effect in preventing weight loss of fruit, which could be attributed to its better barrier properties against H_2O [20]. Kiwi fruit and

grapefruit package insert polymer nano-loss less weight than a conventional package within 42 days of storage [24].

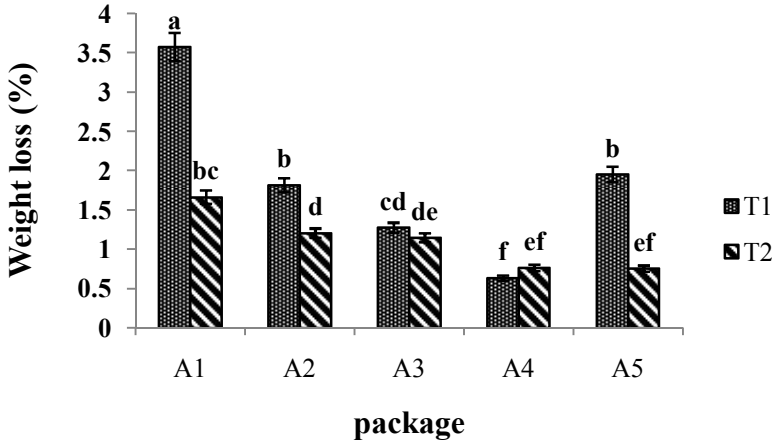


Figure 4- Interaction effect of containers of packaging and time of storage on weight of sweet cherry fruits: A1:conventional polymer, A2: nano-silver based on polypropylene, A3: nano-silver based on polyethylene: A4: nanosilicate based on polyethylene A5: nano-silicate based on polypropylene. T1: 22 days after storage, T2: 45 days after storage. Means with the same letter for each stage are not significantly different (P≤0.05).

Polyphenol oxidase enzyme activity

Polyphenol oxidase activity of sweet cherry fruits storage in nanocomposites packages was significantly reduced. Results showed that PPO enzyme activity was significantly reduced by nano silicate based on polyethylene at 45 days after storage (Figure 5). Yang and colleagues in 2010 showed that the polyphenol oxidase enzyme activities in strawberry fruits packed in containers of silver nanoparticles decreases. Also Qiuhui Hu and colleagues [24] showed that the polyphenol oxidase activity of packet nanocomposites or polyphenols oxidation rate by the fruit, kiwi fruit enzyme significantly reduced the nano packaging. According to Altunkaya's study, PPO and polyphenols are found in different organelles of plant cells [1]. When tissue is damaged, they meet and react with each other. Inhibitors such as ascorbic acid can be used to prevent browning of fruit. Higher ascorbic acid content, lower membranes damage and inhibited PPO activity of sweet cherry in nanocomposites packages contributed to better preservation quality of sweet cherry. PPO activity is reduced at low pH [16].

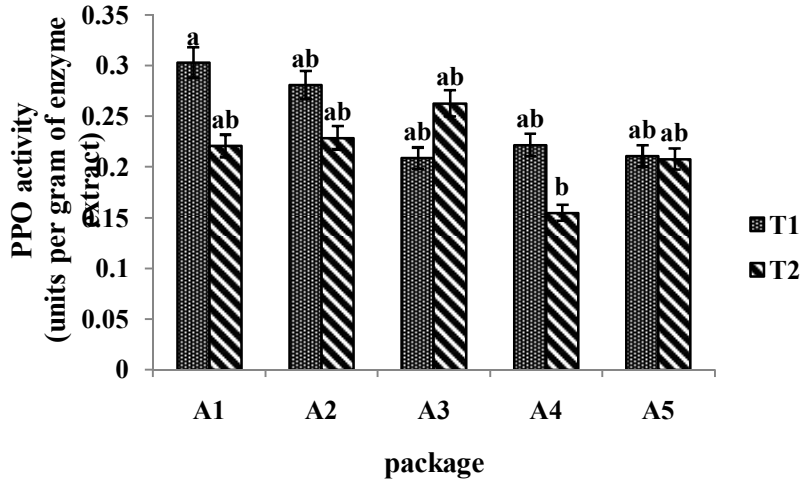


Figure 5- Interaction effect of containers of packaging and time of storage on PPO of sweet cherry fruits: A1:conventional polymer, A2: nano-silver based on polypropylene, A3: nano-silver based on polyethylene: A4: nanosilicate based on polyethylene A5: nano-silicate based on polypropylene. T1: 22 days after storage, T2: 45 days after storage. Means with the same letter for each stage are not significantly different (P≤0.05).

Acidity (pH)

Over time of storage of 22 to 45 days, sweet cherry fruits acidity was increased (Figure 6). But, acidity of sweet cherry fruits was not significantly affected by nanocomposites packages. It seems that decomposition of cell wall in the 45th day of storage causes to this irregular pattern. Our results confirmed other study results by day 9 [27]. Zandi et al [32] and Ayala-Zavala et al [4] reported that pH values increased during storage period in strawberry fruit. The increase in pH values seems to be normal during the postharvest life of strawberry fruit.

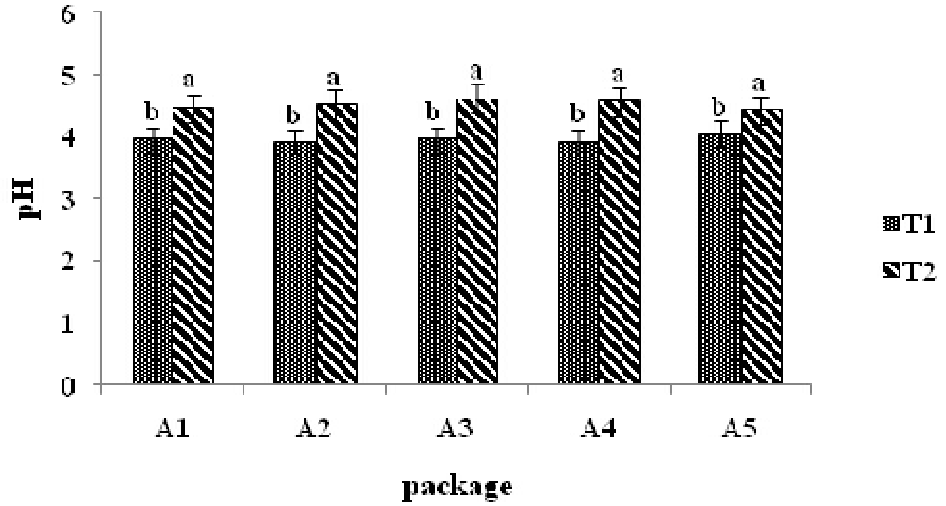


Figure 6- Interaction effect of containers of packaging and time of storage on pH of sweet cherry fruits: A1:conventional polymer, A2: nano-silver based on polypropylene, A3: nano-silver based on polyethylene: A4: nanosilicate based on polyethylene A5: nano-silicate based on polypropylene. T1: 22 days after storage, T2: 45 days after storage. Means with the same letter for each stage are not significantly different (P≤0.05).

CONCLUSION

The beneficial effects of nanocomposite packaging on quality of sweet cherry was manifested according to the obtained results, nanocomposite packaging was proven to be efficient prevent weight loss, antioxidant enzymes change (CAT and PPO) and improving of the firmness, thus delaying ripening and extending shelf-life of harvested of sweet cherry. Therefore, nanocomposite packaging could be new packaging strategies to retard ripening and improve preservation quality of sweet cherry.

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