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Production and Evaluation of Properties of Edible Starch Film Containing Bene (*Pistacia atlantica*) Gum Essential Oil

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Abstract

Pistacia atlantica is the dominant species of Pistachio in Iran. Mastic Gum is a resinous gum, which is called Saghghez in Iran. Firstly, the essential oil (EO) of *Pistacia atlantica* gum was extracted by hydrodistillation method, then the starch film containing *Pistacia atlantica* essential oil at 0, 0.5, 1 and 2% (V/V) were prepared applying casting method and their physicochemical, mechanical, permeability properties were evaluated.The results showed that the incorporation of EO caused a significant increase (P<0.05) in thickness of films and also caused a significant decrease in solubility in water and tensile strength (TS) of films, although no significant decrease was observed in elongation at break (E). Color of the films were also significantly affected by essential oil and total color difference (ΔE) significantly decreased. Despite the fact that water vapor permeability (WVP) of films containing EO increased in comparison with the control film, the increase was not significant at different levels of the EO (P<0.05). In the films containing EOs, increasing the concentration of essential oils did not cause a significant effect on oxygen permeability. To study the microstructure of the films, further analysis was provided by the scanning electron microscope (SEM), the results of this test indicate the production of uniform and without crack films and also confirming the results of the permeability tests.

Keywords: Bene Gum, Edibel Film, Essential Oil, Mechanical Properties, Starch

Introductıon

Edible films and coatings are proposed to be used for food product protection, improving quality and shelf life without impairing consumer acceptability (Baeva & Panchev, 2005). Edible antimicrobial films and coatings have shown to be an efficient alternative in controlling food contamination. Durango *et al*., (2006) reported that the growth of both deteriorating and pathogenic microorganisms may be prevented through the incorporation of antimicrobial agents into edible films. In the last years, research has been performed concerning the use of edible films for surface application of natamycin, benzoate, and potassium sorbate (Barzegar *et al*., 2014) and for slow release of lysozyme and nisin (Park *et al*., 2004).

Methods

Essential Oil of *Pistacia atlantica* gum (EOP) were extracted by hydrodistillation method (British pharmacopoeia, 1988).

The films were prepared as described in our previous studies with slight modifications (Barzegar *et al*., 2014). Briefly, 4 g starch was added to 100 mL distilled water, which contained 0.3 g glycerol/g starch and gelatinized in 90 °C for 10 min. Finally, the obtained solution was spread onto Plexiglas plates and dried for 18 h at 30 °C. The films containing EOP were prepared by an Ultra-Turrax T-25 homogenizer at 9500 rpm for 3 min. The next steps process was achieved similar to the starch films.

Film thickness was measured with a handheld digital micrometer having a sensitivity of 0.001 mm (Barzegar *et al*., 2014).

The tensile strenght (TS) and elongation at break (E) of the films were measured with Texture Analyzer according to ASTM standard method D882 (ASTM-D882, 2001). Equilibrated film strips (at 53% RH for 48 h) were fixed between the grips with an initial separation of 50 mm and the cross-head speed was set at 50 mm/min. TS was calculated by dividing the maximum force by the initial area of the film and E% was calculated by dividing the extension at the moment of specimen rupture by the initial gauge length and multiplying by 100.

The WVP of the films was determined at according to the ASTM-E96 (1995). The test cups containing anhydrous calcium chloride (0% RH) were sealed by the test films, then were placed inside a desiccators containing sodium-chloride-saturated solution (75% RH). Weight gain of the cups along time were recorded periodically and plotted as a function of time. Water vapor transmission rate or WVTR ($g/m^2.h$) and WVP ($g.mm/m^2.h.kpa$) were calculated using these Equations:

$$WVPR = \frac{\Delta m}{\Delta t \times A} \quad (1)$$

$$WVP = \frac{WVPR \times X}{\Delta p} \quad (2)$$

$\Delta m/\Delta t$: the weight of moisture gain per unit of time (g/h), X: the average film thickness (mm), A: the area of the exposed film surface (m^2) and Δp: is the water vapor pressure difference between the two sides of the film (kPa).

The oxygen permeability (OP) of the films was determined indirectly according to the method described by Zahedi *et al*., (2010). Cells were filled with sunflower oil, then covered with the films. The peroxide values of the oil reported as the OP index.

The microstructure of films were observed by a Scanning Electron Microscope, at 26 kW (Salarbashi *et al*., 2013).

Results and discusions

Mechanical properties

The influence of EOP incorporation on thickness, TS, E, WVP and OP of films can be seen in Table (1). The addition of EOP caused a significant decrease (P<0.05) in TS althogh no significant effect on E was observed. Sanchez- Gonzalez *et al*., (2013), reported that the addition of tea tree oil (0.5-3% w/w) caused a significant decrease in the TS and elastic modulus (EM) of HPMC films, although with no significant effect on E.

Table 1. Physical and mechanical properties of films

Film	Thickness (mm)	WVP ($g.mm/m^2.h.kPa$)	OP ($meqO_2/kg$ oil)	TS (Mpa)	E (٪)
Control	0.090 ± 0.001^c	0.884 ± 0.017^b	28.668 ± 1.470^a	4.9053 ± 0.783^a	38.223 ± 11.818^a
EOP 0.5	0.100 ± 0.004^c	1.052 ± 0.031^a	28.000 ± 0.730^a	3.2759 ± 0.187^b	37.467 ± 7.904^a
EOP 1.0	0.115 ± 0.004^b	1.041 ± 0.051^a	27.800 ± 1.200^a	2.1957 ± 0.272^c	31.840 ± 9.948^a
EOP 2.0	0.147 ± 0.008^a	1.005 ± 0.000^a	25.000 ± 0.516^b	1.4090 ± 0.217^d	27.201 ± 5.440^a

Barrier properties

Water vapor permeability

The WVP of biocomposite films added with EOP at various amounts is shown in Table (1). In general, the incorporation of EOP into Starch films leads to an increase in WVP values from 0.88 to 1 $g.mm/m^2.h.kPa$. The similar trend has been found in fish gelatin films containing bergamot essential oil (Ahmad *et al*., 2012) and chitosan-based films incorporated with basil essential oil (Bonilla *et al*., 2012). According to Bonilla *et al*., (2012) this may be ascribed to the discontinuities caused in the polymer network by lipid droplets, in provoking a loss in film cohesion and consequently enhancement of transport phenomena through the film. Furthermore, the hydrophilic-hydrophobic ratio of the film constituents has a direct influence on the water vapor transfer process in the films.

Oxygen permeability

A big advantage of starch films for the protection of food is their ability to act as oxygen barriers, and to control oxygen transport, thus extending the shelf life of the food. Increase the amount of EOP to 1%, no significant effect on the OP. But, in films containing 2% EOP significantly reduced permeability (Table 1).

Filmmicrostructure

In order to provide a better insight into the structure-property relationships of biocomposite films, scanning electron microscopy (SEM) analysis was performed. SEM micrographs of the surface and cross-section of starch films incorporated with EOP at different levels are illustrated in Figure (1). The control film (without essential oil) showed relatively uniform and continuous surface (Figure 1-a), comparable with the results reported by Souza *et al*., (2014). In contrast, the film contains essential oils, uneven surface was observed. Acosta *et al*., (2013) reported that, drops of essential oil creates a film with a rough surface and fine pores.

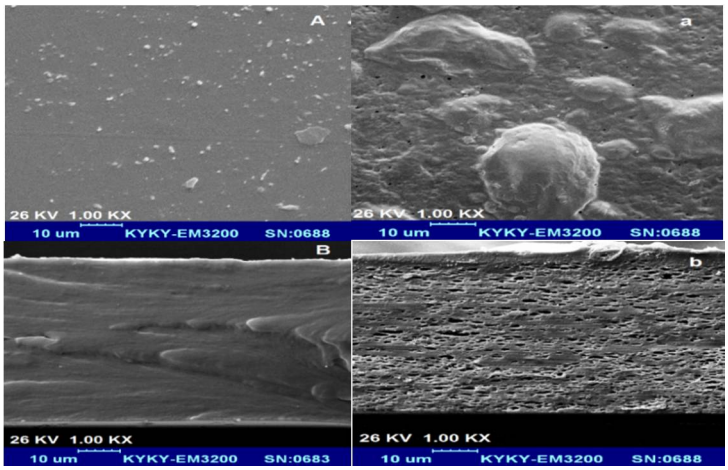

Figure 1. SEM micrographs of the surface and cross-section of starch films containing 0 (a,b) and 2 ٪ (v/v) EOP (a,b), respectively.

Conclusion

Adding EOP to the starch films cause increase of film thickness and WVP, decrease of tensile strength, but had no significant effect on elongation at break of films. Addition of high amounts of EOP cause decrease in oxygen permeability of the films, the SEM images confirm the results.

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