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Utilization of mango peel extracts on the biodegradable films for active packaging

A. Nor Adilah[a], B. Jamilah[a,b], M.A. Noranizan[a], Z.A. Nur Hanani[a,b,*]

[a] Department of Food Technology, Faculty of Food Science and Technology, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia
[b] Halal Products Research Institute, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

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ABSTRACT

Mango peels extract (MPE) was incorporated into fish gelatin films to determine their physical, barrier, mechanical and antioxidant properties for active food packaging. Films with three different concentrations of MPE (1–5%) were prepared by solution casting method. Films incorporated with MPE showed a decrease ($P > 0.05$) of water vapor permeability (WVP) and lower ($P \leq 0.05$) films solubility. High level of MPE films also exhibited more rigid and less flexible film formation. Colored tint films and a reduction in transparency were due to the hydrogen bond linkages between fish gelatin molecules and phenolic content within the film matrix. Higher free radicals scavenging activities also observed for films with higher concentrations of MPE. This study reveals the benefits of mango by-products incorporated into gelatin based films as a potential material for active packaging.

1. Introduction

Synthetic antioxidants are widely used in the food industry to inhibit oxidation of food products. Butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) are some examples of common synthetic antioxidants used in food commodities. However, some added artificial additives into foods could alter the food flavors and give a distinctive taste (Kuorwel, Cran, Sonneveld, Miltz, & Bigger, 2011). Also, consumers nowadays prefer minimal to no synthetic additives in their food due to their concern on adverse effects on human health. Natural sources such as green tea extract (Li, Miao, Wu, Chen, & Zheng, 2014; Siripatrawan & Harte, 2010; Wu et al., 2013), mango kernel extract (Maryam Adilah & Nur Hanani, 2016), murta fruit extract (López de Dicastillo, Bustos, Guarda, & Galatto, 2016), plant extracts (Bonilla & Sobral, 2016), hemp and sage oils (Mihaly Cozmuta et al., 2015), ginger essential oil (Alexandre, Lourenço, Bittante, Moraes, & Sobral, 2016) and plant oils (Nur Fatin Nazurah & Nur Hanani, 2017) are some examples of plant extracts and essential oils that have been used in food packaging development due to their antioxidant properties.

Development in food packaging with the concept of incorporating active compounds into packaging materials or its surrounding conditions which referred as 'active packaging' evolved progressively today (Camo, Beltrán, & Roncalés, 2008; Realini & Marcos, 2014). This innovation has gained interests among researchers due to demand for prolong food shelf life, maintenance of food quality and food safety and enhanced food organoleptic properties. Moreover, environmentally friendly active packaging and natural preservatives could be better options to overcome health concerns and environmental issues.

The inclusion of natural compounds in biopolymer formulations had been suggested to improve the functionality of the packaging (Valdés, Mellinas, Ramos, Garrigós, & Jiménez, 2014). Natural components recovered from wastes and by-products can be alternative sources for bio-based packaging production. For example, mango peels are considered as by-products from industrial processing or consumption of the fruit itself. The skins contribute about 7–24% from the whole fruit weight (Iqbal, Saeed, & Zafar, 2009). Utilization of mango by-products will help in reducing the waste and environmental contaminants. Furthermore, mango peels are known for their source of dietary fibers and high valuable compounds that benefit human health as well as a functional ingredient. Mango peels contain higher phenolic compounds and flavonoid content compared to papaya and pineapple peels (Ayala-Zavala, Rosas-Domínguez, Vega-Vega, & González-Aguilar, 2010). Sultana, Hussain, Asif, and Munir (2012) also reported that mango peels contained higher bioactive compounds compared to the leaves, kernel and stem bark from two different varieties of mangoes. The antioxidant and functional properties of mango peels are from the high presence of polyphenols, carotenoids, phytochemicals, enzymes, vitamin C and vitamin E (Ajila, Naidu, Bhat, & Rao, 2007). In spite of high antioxidant properties in mango peels compared to other fruits, no studies have been conducted to develop this by-product as one of the 'active' elements in packaging material.

* Corresponding author at: Department of Food Technology, Faculty of Food Science and Technology, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia.
E-mail address: Hanani@upm.edu.my (Z.A.N. Hanani).

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Fish gelatin is derived from hydrolysis of fibrous insoluble protein which is also known as collagen and can be obtained from the waste generated from the fish processing line (Nur Hanani, Roos, & Kerry, 2014). Fish gelatin is unique as it can substitute mammalian species gelatin due to its unique properties, overcoming the issues of halal or kosher gelatin and bovine spongiform encephalopathy (BSE) and having some technological advantages over mammalian gelatins. Fish gelatin is widely used as biopolymer material due to its great film forming properties (Pérez-Gago, 2012) and one of the proposed carrier materials of active compounds (Gómez-Guillén, Giménez, López-Caballero, & Montero, 2011). Films produce from gelatin are also transparent and show good gas barrier property (Nur Hanani et al., 2014).

Therefore, the objectives of this research were to develop bioactive films by incorporating mango peels extract (MPE) into fish gelatin films and evaluate the effect of different MPE concentration on the physical, barrier, mechanical and antioxidant properties of the films.

2. Materials and methods

2.1. Materials

Fish gelatin from Tilapia fish skin (~240 bloom) was purchased from Custom Collagen, (Addison, IL) whereas absolute ethanol and 2-phenl-1,1-hydrazine (DPPH) were obtained from Sigma Chemical Co. (St. Louis, MO). Folin-ciocalteau reagent, sodium carbonate, gallic acid, and glycerol were all of analytical grades from Merck (Darmstadt, Germany).

2.2. Preparation of mango peels

Mango peels (*Mangifera indica* L.) were collected from stall markets in Serdang, Selangor. The peels were washed with tap water and were rinsed with distilled water. The cleaned peels were dried at 35 °C in an oven (Memmert model UF110, Germany) for 24 h. After drying, the peels were ground into a powder by using an electrical blender (Panasonic model MX-J210PN, Japan). The ground peels were kept in a cool and dark condition at –18 °C in an airtight container until used.

2.3. Extraction of mango peels extract (MPE)

Dried ground mango peels were extracted by maceration method according to Sultana et al. (2012) with slight modifications. Samples were macerated in absolute ethanol (1:10) for 24 h. After that, the sample residues were macerated for the second time to maximize the extraction. Both supernatants obtained were combined and concentrated under vacuum using a rotary evaporator at 45 °C. The MPE was kept at –18 °C in a dark condition in an airtight container until used.

2.4. Preparation of films with MPE

The gelatin-MPE films were prepared by solution casting method according to the method Hosseini, Rezaei, Zandi, and Farahmandghavi (2015) with slight modifications. Fish gelatin (4% w/v) was dissolved in distilled water at 45 °C for 30 min with continuous stirring. Then, 30% of glycerol was added and heated at a constant temperature at 45 °C for another 15 min. Different concentrations of MPE (1, 3 and 5% w/w based on dry gelatin) were added to the solutions respectively, with continuous stirring for another 60 min. Film without MPE was prepared as a control. Lastly, 15 ml aliquots of film forming solutions were distributed in rimmed plastic plates (14.5 × 2.0 cm^2) and dried at 25 °C for 2 days. Prior to analysis, the films were conditioned at a temperature of 25 ± 2 °C with a relative humidity (RH) of 50 ± 5% for 48 h.

2.5. Morphology by scanning electron microscopy (SEM)

The surface area and cross sectional of the films were visualized at 1500 × magnification with 15 kV voltage by using scanning electron microscopy (JSM 6400, Jeol, Tokyo, Japan). The film samples were cut (1 × 1 cm^2) and mounted onto a bronze stub with double-sided tape. Prior to visualization, the films were spluttered with gold using Sputter Coater SCD 005 (BAL-TEC AG, Balzers, Liechtenstein).

2.6. Determination of film properties

2.6.1. Film thickness

The thickness of films was measured using a hand-held digital micrometer (Mitutoyo, Tester Sangyo Co. Ltd., Tokyo, Japan). The average values obtained from five different random positions on the films were used for the thickness determination.

2.6.2. Color measurement

The color of film samples was measured using a Hunter Lab Ultrascan PRO spectrocolorimeter (Model A60-1012-402, VA, USA). The measurement was taken at 5 random positions on the films. The L-, a-, and b- values which indicate the films lightness, greenness/redness and blueness/yellowness were recorded. White tile was used for calibration.

2.6.3. Film opacity

The film opacity was determined according to the method described by Siripatrawan and Harte (2010). The films were cut according to the test cell and were directly inserted. A blank test cell was used for reference. The films were measured at 600 nm by using a spectrophotometer (Shimadzu UV–vis 1601, Japan). The opacity of films was calculated by using Eq. (1):

$$T = Abs600/x \quad (1)$$

Where, T is the transparency of films, Abs600 is the value of absorbance at 600 nm and x is the thickness of films.

2.6.4. Water vapor permeability

The films water vapor permeability (WVP) was measured using a modified ASTM E-96 standard method (ASTM, 1990) according to Nur Hanani, Roos, and Kerry (2012). The test cup was filled with 6 ml of distilled water and the film sample was tightly fixed over the test cup opening with a rubber gasket. The RH and temperature conditions of the cups were controlled at 50 ± 5% and 23 ± 2 °C, respectively. The weight of test cups was recorded at a time interval of 1 h for 9 h. WVP was calculated using Eq. (2) below:

$$WVP = \frac{(\text{amount of permeant (g)}/\text{time (s)}) \times \text{film thickness (mm)}}{\text{film area } (m^2) \times \text{pressure difference (kPa)}} \quad (2)$$

2.6.5. Film solubility

The solubility of films was measured according to Nur Hanani et al. (2012) with slight modifications. Initially, the prepared films (1 × 4 cm^2) were dried in an oven at 100 °C for 24 h. Then, the dried films were immersed in 30 ml of distilled water overnight at a room temperature. The films were filtered through filter papers and re-dried at 100 °C for 24 h. The film solubility was calculated using the following Eq. (3):

$$\text{Film solubility} = \frac{\text{initial weight} - \text{final weight}}{\text{initial weight}} \times 100\% \quad (3)$$