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Pectin-honey coating as novel dehydrating bioactive agent for cut fruit: Enhancement of the functional properties of coated dried fruits

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ABSTRACT

In this paper, a novel and sustainable process for the fruit dehydration was described. Specifically, edible coatings based on pectin and honey were prepared and used as dehydrating and antimicrobial agents of cut fruit samples, in this way promoting the fruit preservation from irreversible deteriorative processes.

Pectin-honey coating was tested on apple, cantaloupe melon, mango and pineapple. The analysis were performed also on uncoated dehydrated fruits (control). The coated fruit evidenced enhanced dehydration percentage, enriched polyphenol and vitamin C contents, improved antioxidant activity and volatile molecules profile. Moreover, the antimicrobial activity against *Pseudomonas* and *Escherichia coli* was assessed. Finally, morphological analysis performed on fruit fractured surface, highlighted the formation of a non-sticky and homogeneous thin layer. These outcomes suggested that the novel fruit dehydration process, performed by using pectin-honey coating, was able to both preserve the safety and quality of dehydrated fruits, and enhance their authenticity and naturalness.

1. Introduction

Dehydration of fruit is one of the oldest techniques of food preservation consisting essentially in a decrease of water content with following increase in solute concentration (Chen & Mujumdar, 2008; Kudra & Mujumdar, 2009).

Almost all industrial devices used as fruit dryers are convective type with either hot air or combustion gases as heat transfer media; anyway, in the last year, novel drying methods exploiting microwave or ultrasound approaches, high electric field, heat pump drying and refractance window drying technology are used to improve the dehydration process by reducing the energy consumption and, at the same time, preserving the quality of the dried products (Zarein, Samadi, & Ghobadian, 2015; Sabarez, Gallego-Juarez, & Riera, 2012).

Moreover, the fruit dehydration processes are usually supported by the addition of chemical additives, such as ascorbic acid, citric acid, glucose oxidase-catalase and sodium bisulfite that, in the last few decades, has increased to a great extent, since they represent a common approach to ensure the reduction or elimination of sanitary risks and microbiological contamination, while preserving, at the same time, the food sensorial characteristics (Bourdoux, Li, Rajkovic, Devlieghere, & Uyttendaele, 2016).

Anyway, the upcoming concept of “green foods” quality is oriented toward a reduced content of chemical additives since their ascertained healthy toxic effects on human immune system, leading to various disorders and diseases, not least, to serious risk of cancer (Dar, Shivani, Karishma, Azam, & Anupam, 2017).

Finally, since the increasingly concern related to harmful environmental impact of the high greenhouse gases emission during the food drying methods (Mujumdar & Law, 2010), the applicative science research and the industrial technologies have being focusing their attention on new eco-friendly fruit drying methodologies able to drastically reduce the energy consumption while preserving the safety and quality of dehydrated fruits, by enhancing their authenticity and naturalness.

A novel approach, exploited in the frame of this paper, can be represented by the use of edible coatings. They are defined as thin layers of edible material applied to the surface of a food, which provides a

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barrier against migration of moisture, oxygen, carbon dioxide, aromas, lipids, and other solutes (Castilho Garcia,Cássia Caetano, de Souza Silva, & Aparecida Mauro, 2014; Lago-Vanzela, Nascimento,Fontes, & Mauro, Kimura, 2013).

An edible coating must be eaten as part of the whole product. Therefore, the composition of edible coatings must be conform to the regulation applied to the food product (Vargas, Pastor, Chiralt, Mc Clements, & Martinez, 2008).

Several studies reported that polysaccharides from different sources are promising materials for the preparation of films and coatings with tailored behavior (Chengcheng, Pollet & Averous, 2017). This is not surprising considering that they are natural, nontoxic, biodegradable polymers. Among polysaccharides, pectin is of worthy interest as a potential coating component, because of its unique colloidal properties. This biopolymer is mainly obtained from citrus peel or apples pomace and contains smooth (linear) regions and hairy, branched regions. Its chemical structure is widely reported in literature and will not be discussed here (Ström et al., 2007; Nesic et al., 2017).

Its efficiency in enhancing food protection has been well recognized by many research groups, as shown by Laurienzo, Di Stasio, Malinconico, and Volpe (2010). In their paper, the authors showed that pectin edible films could preserve some volatile components and free sugar content of dried fruits, controlling the gas exchange, the moisture transfer and the oxidation processes (Laurienzo et al., 2010).

In addition, the development of functional edible coatings with inherent active ingredients represents an upcoming technological challenge for the food industry. Indeed, several compounds, such as antioxidants, antimicrobials, flavors and probiotics, can be incorporated into the polymeric formulations and consumed with the food, by enhancing its safety, nutritional and sensorial attributes (Rojas-Graü, Soliva-Fortuny, & Martín-Belloso, 2009; Robles-Sánchez, Rojas-Graü, Odriozola-Serrano, González-Aguilar, & Martin-Belloso, 2013).

Based on the above considerations, and aimed to obtain a dehydrating and functional edible coating, a natural compound, honey, was included in pectin water formulations.

Actually, the high honey hygroscopicity and low pH (pH range 3.2–4.5) are the two key factors for the hampering of microorganism growth. Honey bactericidal activity against food spoilage and pathogenic organisms have been widely explored in numerous studies (Moundoi, Padilla-Zakour, & Worobo, 2004; Eteraf-Oskouei & Najafi, 2013).

Hence, the aim of the present work was to use a pectin-honey (PH) based coating as innovative eco-sustainable method for dehydrating selected kinds of cut fruits and contemporary preserving their safety and quality by exploiting the antimicrobial activity of honey. The dehydration process was carried out at low temperature; in this way, the nutritional and sensorial properties of dried fruit, not treated with sugar and/or chemical additives, could be maintained by providing a final high quality food. The effects of PH coating on fruits water content (dehydration process), total polyphenols and vitamin C amount, antioxidant activity, volatile molecules profile, microbiological quality and fruit surface adhesion were investigated. Uncoated dehydrated fruit slices were used as control reference.

2. Materials and methods

2.1. Materials

Fresh fruit samples of apple (Ap), cantaloupe melon (Cm), mango (Ma) and pineapple (Pi) slices were purchased from a local market and immediately stored at 4 °C, in order to avoid any fermentation process. Uniform sized, defect-free fruits were selected.

Citrus pectin (low esterification degree) was obtained from Herbstreight & Fox KG, Pektin-Fabriken (Germany). Honey was collected between May and July 2015 in the South of Italy (Benevento area) and stored in the dark, at room temperature.

2,2′-Diphenil-1-picryl hydrazyl (DPPH), gallic acid, Folin-Ciocalteau and ethanol were obtained from Sigma-Aldrich. Starch paste and iodine were purchased by Carlo Erba.

2.2. Films and cut fruit coating preparation

Low ester citrus pectin (2% wt/v) was dissolved in demineralized water at 100 °C, while stirring. After that, 10% w/w of honey was added in pectin solution and dispersed by magnetic stirring. After 30 min, 50 mL of neat pectin (P) and pectin/honey (PH) solutions were respectively casted on Petri dishes and allowed to dry at room temperature, under ventilated hood for 48 h up to obtain dried detectable films. Prior each measurements, all films were conditioned in climatic chamber at room temperature and 50% RH.

The fruit samples of Ap, Cm, Ma, and Pi were thoroughly washed, peeled, cut into sections of about 2 cm and dipped in PH solution for 30 s. The identification codes of coated samples used were ApPH, CmPH, MaPH and PiPH.

2.3. Dehydration process and determination of free water content

The coated samples, ApPH, CmPH, MaPH and PiPH and control samples Ap, CM, Ma, and Pi were placed on polypropylene grids and allowed to be slowly dehydrated by allocating them in a ventilated fridge at 4 °C and relative humidity of 40% for about 15 days. The free water content of the samples was evaluated as follows: all the fruit slices were periodically withdraw from refrigerator, weighted, put in an oven at 90 °C and re-weighted. This procedure was repeated up the reaching of dehydrated samples constant weight (%). For each kind of cut fruit, three specimens were used and the results were expressed as the average value of water losing percentage.

2.4. Extraction and determination of total polyphenol

The fruit samples were grounded into fine particles with a laboratory mixer (Ultraturrax T8, Ika-Werke, Germany). Aliquots of 0.5 g of selected kind of fruit were treated with 10 mL of ethanol–water mixture (50:50 v/v) for 30 min at room temperature (Soong & Barlow, 2004). The samples were centrifuged at 4000 rpm for 30 min by using a centrifuge (MOD. 4235, A.C.L. International S.r.L., Milano), and the supernatant was collected for the evaluation of total phenolic content and antioxidant capacity (see 2.6 paragraph) acid, Folin-Ciocalteau and ethanol were obtained from Sigma-Aldrich. Starch paste and iodine were purchased from Carlo Erba.

The total phenolic content was determined according to the Foline Ciocalteu procedure (Soong & Barlow, 2004). The absorbance was measured at 760 nm. Phenolic concentration was determined by comparing the absorbance of the samples with a standard. The results were expressed as milligrams of gallic acid equivalents in 100 g of dry fruit (mg GAE/100 g dry fruit). The measurement was perfomed in triplicate and the result was reported as the averaged value.

2.5. Antioxidant capacity

The antioxidant capacity of dehydrated fruit slices was studied according to the procedure described by Sànchez-Moreno, Larrauri, and Saura-Calixto (1998), (Sànchez-Moreno, et al., 1998).

The absorption of the samples was measured with a spectrophotometer UV–Vis (Beckman Coulter, mod. DU 730, Brea, CA, USA) at 515 nm against a blank of methanol without DPPH. The antiradical activity was expressed as percentage inhibition (%I) of the samples compared to the initial DPPH absorption (A_0), according to the following formula:

$$I(\%) = \frac{(A0-At)}{A0} \times 100 \quad (1)$$