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Influence of edible coatings chitosan/PVP blending with salicylic acid on biochemical fruit skin browning incidence and shelf life of guava fruits cv. 'Banati'

A.A. Lo'ay[a,*,1], Mohamed A. Taher[b,1]

[a] Pomology Department, Faculty of Agriculture, Mansoura University, El-Mansoura, P.O. Box 35516, El-Mansoura, Egypt
[b] Agricultural Chemistry Department Faculty of Agriculture Mansoura University, El-Mansoura, P.O. Box 35336, El-Mansoura, Egypt

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ABSTRACT

The effect of chitosan/poly-vinyl-pyrrolidine (CS/PVP) combined with a salicylic acid (SA) at different concentrations (0, 1, and 2 mM) of 'Banati' guava fruits were harvested at three color maturity development stages (M1; green, M2; green-yellow, and M3; yellow). the experiment was carried out during seasons 2016–2017 in a commercial orchard near Damietta Gov., Egypt. Fruits were coated by consolidated biopolymer CS/PVP-SA to minimize browning spots during shelf life at room temperature (27 ± 1 °C and air relative humidity 48 ± 2%) for fifteen days. The measurements were estimated each three-day interims to assess physical and chemical quality attributes. The physical estimations, for example, water loss rate, fruit peel color hue angle (h°), fruit skin browning index, and fruit firmness. The chemical properties, total soluble solids (SSC%), fruit acidity (TA%), and SSC/TA-ratio. The browning parameters were studied such as total phenolic compounds (TP), polyphenol oxidase (PPO; EC:1.14.18.1), and phenylalanine ammonia-lyase (PAL; EC:4.3.1.24). Furthermore, cell wall degradation enzyme activities were determined such as cellulase (CEL; EC: 3.2.1.4), lipoxygenase (LOX; EC: 1.13.11), and pectinase (PT; EC: 3.2.1.15). Furthermore, cell wall degradation enzyme activities were determined such as cellulase (CEL; EC: 3.2.1.4), lipoxygenase (LOX; EC: 1.13.11), and pectinase (PT; EC: 3.2.1.15). The changes in browning and cell wall degradation enzymes activities during shelf life are related to the presence of SA in biopolymer (CS/PVP) to fruits were delayed. The CS/PVP-SA treatment could be improved the antioxidant activities. It is, therefore, possible to point out that the treatment of guava fruits with CS/PVP-SA $_{2\,Mm}$ treatment after harvesting can be considered as a tool to reduce browning in fruit skin.

1. Introduction

Guava (*Psidium guajava* L.) is frequently called to as 'Apple of the tropics' as it possesses a comparable sweetness and culinary usage and nutritional significance. It is rich in containing fiber, ascorbic corrosive and pectin (Anon., 2015). Guava considered a climacteric fruit subsequent to harvesting (Eliane et al., 2005), and it has a short postharvest life amid timeframe of realistic usability or showcasing inside a couple of days (Hashem and Alamri, 2009). Botanically, it has a place with Myrtaceae family. These days, it planted in various regions (tropical and sub-tropical) of the world including, Algeria, Brazil, California, China, Columbia, Egypt, Florida, Hawaii, India, Peru, Malaysia, Mexico, South Africa, and west India (Singh et al., 2016). It is considered highly profitability fruit and postharvest loss during shelf life about 3.4 - 15.1% (Madan and Ullasa, 1993). The most remarkable degeneration is because of it contains a high measure of water and thin delicate skin. Thusly, organic products are shown the higher rate of transpiration, breath, aging and enhancing other physiological procedures after harvesting.

These varieties inspire to expand fruit quality losses in short period and rich them unmarketable. Expanding in physiological responses, for example, expanding fruit softening, diminishing corrosiveness and ascorbic acid during marketing (Deepthi et al., 2016). Moreover, fruit at this stage is more Vulnerable to microbial contamination brings about the short time span of usability (El-Anany and Hassan, 2013). Consequently, it is critical to making sense of a diminishment of physiological and concoction disintegration to improve the capacity shelf life of guava fruits. Numerous investigations focused on the timeframe of shelf life phase of guava fruits can be stretched out by low temperature, appropriating distinctive palatable covering, or utilizing diverse

* Corresponding author.
E-mail addresses: Loay_arafat@mans.edu.eg (A.A. Lo'ay), Mohamedtaher@mans.edu.eg (M.A. Taher).
[1] www.mans.edu.eg

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concoction medications (pre-and post-reap), to manage fruit quality amid taking care of. These chemicals, for example, GA3 (Pila et al., 2010), salicylic acid (Lo'ay and El-Khateeb, 2011), or utilizing potassium permanganate (Bal and Celik, 2010), and boric acid application (Kaur et al., 2016). The prior substance applications plan to incorporate diverse physiological procedures, for example, water vanishing, respiration, the aging of fruit and delay in an internal ethylene blend (Singh et al., 2017).

However, the coating application strategy, for example, starch, protein, lipid, and mixes of these biopolymers. Edible coatings are drilled as a film for an whole fruit to safeguard/increment fruit quality for the market duration (Maria et al., 2009). Normally, chitosan is second at the biggest natural polysaccharide after cellulose found. It is non-dangerous, sustainable and dissolvable in low causticity water arrangements. Moreover, it is assessed a perfect biodegradable issue that can be discarded effectively amid common flow without changing on the environment (Yeh et al., 2006). Another biopolymer, a water polymer, poly-vinyl-pyrrolidine (PVP), has likewise useful effects on insurance, thickness, retentiveness, solubilization, and buildup. It has low poisonous quality and is used in board fury of zones, for example, medicinal, food, corrective, and wellbeing related spaces (Chin, 1998). However, salicylic acid (SA) is admitted an endogenous, phenolic nature plant development controller. It plays huge physiological capacities in the plant control development and expands plant force under biotic and abiotic stresses (Hayat et al., 2010). Besides, it assumes a basic part in changing organic product quality, for example, appearance, flavor, astringency, and bitterness (Chamkha et al., 2003), and declining fruit softening (Shafiee et al., 2010). Essentially, SA has hopefully effect on diminishing fruit respiration and ethylene biosynthesis rates (Srivastava and Dwivedi, 2000), and incorporating fruit water loss, microbial contamination and keeping up fruit firmness between storage and shelf life of usability (Lo'ay, 2017).

The goal of this examination assessed the potential effects of chitosan/PVP intensified with salicylic acid at various concentrations as a coating blend on three fruit color maturity development phases of 'Banati' CV guava fruits. Likewise, assess browning manifestations on fruit skin spots that identified with chemicals action during shelf life.

2. Materials and methods

2.1. Fruit material and experimental setup

The experiment was carried out on guava (*Psidium guajava* L. cv 'Banati') planted in loam soil in a commercial orchard near Damietta Gov., Egypt during two seasons 2016-2017. Fruit samples were harvested at three different maturities stages according to color (hue angle). The fruit maturities were defined into three classes (Palette 1) are M1 (green: fruits are completely green color, hue angle 121), M2 (yellow-green: fruits have more yellow color than green, hue angle 95), and M3 (yellow: fruits are completely yellow, hue angle 83) (Lo'ay and El-Khateeb, 2011; Mondal et al., 2009). Fruits were transported at low-temperature 13 °C with two hours. Upon arrival to Lab, fruit samples (2160 fruits) were divided into two main batches. The first batch contains 1080 fruits that allocated over four treatments. Each treatment contains 270 fruits which are distributed on three fruit maturities, only every 90 fruits. The second batch (1080 fruits) also arranged as described previously for non-destructive measurements such as skin spots browning index, color hue angle and water loss percentage.

2.2. Biopolymer chitosan/PVA leaded with salicylic acid preparation

The following materials were used in this study: PVP (K-30 polymer; Ashland company, China), chitosan (CS) (MW 71.3 = kDa, the degree of deacetylation = 94%; Merck, Darmstadt Germany), salicylic acid was analytical grade. Chitosan (CS) solution (750 ml, 1% w/v) was prepared by dissolving 7.5 gram of CS in 750 ml of 2% (v/v) aqueous CH_3COOH hydrous solution for 8 h under magnetic stirring. The PVP solution (750ml, 1% w/v) was prepared by dissolving 7.5 gram of PVP in 750 ml distilled water. The solutions of PVP and CS were carefully mixed at a ratio of (1:1) and stirred for 2 h. Finally, the resultant solution (1500ml) was equally subdivided into three sets (500 mL in each one). The control set was not supplemented with any additive. Salicylic acid was dissolved and incorporated into the blended solutions of set 2 and 3 under magnetic stirring for 4 h at 25 °C at concentrations of 2 and 4 mM, respectively. The blended solutions were placed in conical flasks and stored at 4 °C till further analysis.

2.3. Treatment protocol

Fruit samples were picked to Pomology Department Faculty of Agriculture, Mansura University. The treatments were prepared as follow: control, CS/PVP-SA $_{0\,mM}$, CS/PVP-SA $_{1\,mM}$ and CS/PVP-SA $_{2\,mM}$. Fruits were immersed in CS/PVP-SA for five min. They were stored in ambient air (27 ± 1 °C and air humidity average during shelf life period 48 ± 2) for 15 days.

2.4. Non-destructive characteristics evaluation

Fruit quality factors were estimated such Water loss rate by determined on an initial weight basis and presented in percentage (Lo'ay and El-Khateeb, 2011). Skin spot browning index was measured and established in five levels: 1; no browning, 2; slight browning symptoms, 3; moderate, 4; sever browning symptoms, and 5; very severity browning (Lo'ay, 2009). While to fruit color, hue angle measurement was evaluated according to the RGB protocol (Lo'ay and Dawood, 2017b).

2.5. Destructive properties evaluation

Fruit samples were randomly picked from each treatment and divided into three replicates to measure soluble solid content (SSC%) using Cerlzesis hand refractometer. Total acidity (TA%) as a citric acid by titration with 0.1 N NaOH (A.O.A.C., 1995), and SSC/TA ratio was calculated as a percentage. The ascorbic acid content of fruit juice was recorded by 2,6-dichlorophenolindophenol visual titration as reported (Lo'ay, 2017). Fruit firmness was designated using fruit texture Effegi-penetrometer Supplemented with plunger 8 mm diameter penetrator which presented in N unit (Samaan et al., 2012). Total chlorophyll, two gram of guava fruit skin sample was dipped in 10 mL of N, N-dimethylformamide (DMF) for 16 hours to enable the DMF to extract the chlorophyll pigment. Finally, the extraction samples were centrifuged for 5 min at 15,000 rpm, then the clear supernatant was spectrophotometrically measured chlorophyll A and B at 663 nm and 646 nm, using spectrophotometer (UV-vis) and it exhibited in mg 100 g^{-1} FW (Lo'ay, 2005).

2.6. Browning enzymes activity, polyphenol oxidase (PPO, EC: 1.14.18.1) and phenylalanine ammonia-lyase (PAL, EC: 4.3.1.24), and total phenol content (TP)

Fruit peel (1 g) was added with Tris-HCl buffer 20 mM, pH 7.0 to assay polyphenol oxidase. the mix-up was centrifuged at 10,000 rpm for 5 min at 4 °C. The clear sample was collected at -20oC for testing PPO activity. 200 µL of The extract was immediately mixed with 3 mL of 20 mM catechol dissolving in 100 mM sodium phosphate buffer pH 7.0 (Jiang et al., 2002). The increase in activity was noted spectrophotometrically at wavelength 400 nm during 3 min. one unit of enzyme activity was defended as the number of enzymes that causes a change of 0.1 in absorbance min^{-1}.

PAL was estimated by appending 1 g of fruit peel sample to 4 mL of 50 mM of borate buffer (pH 8.5) containing 5 mM of 2-mercaptoethanol and 400 mg PVP (Ke and Salveit, 1986). The homogenate was