Substrate Reactivity of Polyphenol Oxidase and Browning Inhibition of Fresh-cut ‘Nam Dok Mai Si-Thong’ Mangoes by Protein-based Sericin Coating

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Recent studies aimed to investigate five phenolic substrates’ reactivities in terms of PPO activity compared with browning symptom occurrence, as well as the efficiency of sericin extracted from ‘Nam Dok Mai Si-Thong’ mango in vitro on polyphenol oxidase (PPO) activity, and the efficiency of sericin coating on browning inhibition of fresh-cut ‘Nam Dok Mai Si-Thong’ mango during storage. The specificity of PPO activity was determined using various substrates such as caffeic acid, catechol, chlorogenic acid, 4-methylcatechol and pyrogallol. PPO extracted from ‘Nam Dok Mai Si-Thong’ mango was more actively specific to catechol and 4-methylcatechol than other substrates that revealed a darker browning color on mango pieces. In vitro, sericin inhibited the activity of PPO reacted with catechol and 4-methylcatechol substrate in mango extracts. The efficiency of sericin coating on browning inhibition of fresh-cut mangoes was then investigated. Application of a 2% sericin coating maintained the visual appearance including the L* value, browning index, browning score, and inhibited enzymatic browning incidence by lowering the increases in total phenol and PPO activity compared to the control during storage at 10°C for 4 days. However, sericin seemed to have no influence on phenylalanine ammonia-lyase (PAL) activity. Moreover, sericin coating enhanced the antioxidant activity of fresh-cut mango when compared to the control. In conclusion, we found that sericin coating is an effective option to maintain the visual appearance, and inhibit the enzymatic browning incidence, of fresh-cut ‘Nam Dok Mai Si-Thong’ mangoes during registered storage.

Key Words: enzymatic browning, fresh-cut mangoes, nam dok mai mango, sericin, phenolic substrates.

Introduction

Mango (Mangifera indica Linn.) is an important commercial fruit in Thailand, and the ‘Nam Dok Mai Si-Thong’ variety (Golden variety) is grown for domestic and export markets. The skin of the ‘Nam Dok Mai Si-Thong’ mango is yellow and it turns golden-yellow with ripening. This variety has fragrant, sweet, juicy flesh with no fibrous tissue.

Nowadays, the demand for fresh-cut products has increased in response to the demand for quality and the modern lifestyles of consumers. Tesco, one of the largest fresh-cut retailers in the global market, reported that the demand for healthy fruit snacks such as melon and mango ‘fingers’ has increased by 400% over the
last two years (Tesco PLC, 2017). Notwithstanding the wide appeal, fresh-cut processing of mango increases the risk of browning, dehydration, and quality loss during storage. Browning and a water-soaked appearance are reportedly the main factors that limit the shelf-life of fresh-cut ‘Nam Dok Mai Si-Thong’ mangoes during storage (Poubol and Izumi, 2005). Browning incidence in fresh-cut mango is caused by the enzymatic activities of phenylalanine ammonia-lyase (E.C. 4.3.1.5, PAL) and polyphenol oxidase (EC 1.14.18.1, PPO) (Alberio et al., 2015). PAL catalyzes the transformation of phenylalanine into trans-cinnamic acid which, in subsequent reactions, is transformed into other phenolic compounds such as chlorogenic acid, a substrate of PPO. The latter enzyme oxidizes compounds synthesized by PAL to quinones that spontaneously polymerize, resulting in enzymatic browning (Ke and Saltveit, 1989). PPO activity is influenced by substrate type and displays a cultivar-specific logarithmic increase during the postharvest ripening of mango (Vásquez-Caicedo et al., 2007; Cheema and Sommerhalter, 2015). Previous research studied PPO in several mangoes. However, this is the first report using the mango ‘Nam Dok Mai Si-Thong’.

The use of synthetic chemicals to treat fresh-cut products has become unpopular due to growing concerns about food safety. For this reason, research is being conducted to develop alternative methods to control browning in minimally processed products. For example, studies have demonstrated the browning-inhibiting and quality-maintaining potential of natural agents such as honey (Jeon and Zhao, 2005; Supapvanich and Boonyaritthongchai, 2016), aloe vera (Alberio et al., 2015), whey protein (Yi and Ding, 2014), and rice bran extracts (Sukhonthara et al., 2016). Previous research studied PPO in several mangoes. However, this is the first report using the mango ‘Nam Dok Mai Si-Thong’.

Serincin is a natural macromolecular and water-soluble protein that is derived from silkworm and can be used as an edible coating for fresh-cut products. It consists of 18 amino acids, of which 30–33% is serine (Kato et al., 1998), and its effectiveness is due to the presence of a high concentration of hydroxyl groups. Serincin and its derivatives have been included in the “Generally Recognized as Safe-GRAS” list (Food and Drug Administration (FDA), 2001). Kato et al. (1998) demonstrated that serincin can inhibit the activity of tyrosinase (polyphenol oxidase; PPO), which is responsible for the browning reaction of various food products. Besides, it has been globally utilized in cosmetic and pharmaceutical applications due to its unique, non-toxic biocompatibility with human skin tissue. Peptide fractions of serincin have long term anti-aging benefits.

Therefore, in this study, we investigated the effects of various PPO substrates’ responses in terms of the browning reaction in ‘Nam Dok Mai Si-Thong’ mangoes. In addition, the efficacy of serincin as an edible coating agent that can be used for browning inhibition of fresh-cut mangoes was also examined.

**Materials and Methods**

**Materials**

‘Nam Dok Mai Si-Thong’ mangoes were obtained from an export company located in Prachuap Khiri Khan province, Thailand. The fruit were harvested at the full mature stage (85 days after anthesis).

Serincin powder was produced under control by Assoc. Prof. Dr. Theppanya Charoenrat from the Department of Biotechnology, Faculty of Science and Technology, Thammasat University, Thailand. The serincin powder was produced by the degumming method using heat under high pressure at 121°C for three hours followed by filtering to remove fibroin. The filtrate was centrifuged and the supernatant collected. Precipitation protein from the supernatant was then obtained. The supernatant was dialyzed for 24 hours and then centrifuged at 6,000 × g for 20 min. at 4°C. The precipitate was washed and freeze dried and serincin powder was obtained; this serincin was of a food-grade level.

Authentic phenolic compounds (PPO substrates), such as 4-methylcatechol, catechol, pyrogallol, caffeic acid, and chlorogenic acid, were obtained from Sigma-Aldrich, USA.

**Sample preparation**

Mangos, selected based on being free from physical damage or infection and uniform in size, were transported to a laboratory. The fruit were washed with tap water, dipped in 400 μL·L⁻¹ ethephon to induce ripening and stored at room temperature (28 ± 2°C) for 3 days. Ripened mangos with a firmness of 10–12 N were collected for the experiment. The fruit were immersed in 100 μL·L⁻¹ of sodium hypochlorite for 5 min and dried at room temperature (25°C).

**PPO and PAL extraction**

PPO was extracted according to Jiang (2000) with some modifications. Five grams of cut-surface from the fresh-cut mangoes were homogenized with 10 mL of 0.05 mM sodium phosphate buffer (pH 7) with 0.50 g polyvinylpyrrolidone (PVPP) on ice. The homogenate was centrifuged at 15,000 rpm for 20 min at 4°C, and the crude enzyme extract (supernatant) was used to determine the PPO activity. The protein content in the supernatant was determined according to the method of Bradford (1976), using bovine serum albumin as a standard. PAL extraction was determined by mixing mango flesh (2 g) with 20 mL of 50 mM sodium borate buffer (pH 8.8) and 50 mM β-mercaptoethanol. The extract was filtered with cheesecloth, centrifuged at 15,000 rpm for 30 min at 4°C, and the crude enzyme (supernatant) was then collected.
**PPO substrate reactivity**

*In vivo substrate reactivity of mango fruit cubes*

Mangos were peeled and cut into cubes (2 × 2 × 2 cm, approximately). Different PPO substrates, including caffeic acid, catechol, chlorogenic acid, 4-methylcatechol, and pyrogallol were used. The five phenolic substrates were selected because they have been used as substrates for browning in many mango fruit research papers (Mayer et al., 1990; Palma-Orozco et al., 2014; Cheema and Sommerhalter, 2015). Freshly prepared substrates, 50 mM each, were used for the experiments. The substrates (300 μL) were separately dropped onto the surface of mango cubes, and distilled water was used as a control. These samples were exposed to room temperature (25°C) for 45 min. A photograph of each sample was taken, and the browning assessment was conducted using a browning score (BS).

*In vitro substrate reactivity and PPO activity*

Mangos were peeled and quickly cut into small pieces. Flesh samples were immediately dipped in liquid-nitrogen and stored at −80°C until analysis. Following the extraction of a crude enzyme, the PPO reactivity to the substrates caffeic acid, catechol, chlorogenic acid, 4-methylcatechol and pyrogallol was determined according to Jiang (2000) with some modifications. The reaction medium in a quartz cuvette contained 1 mL of 0.05 mM phosphate buffer (pH 7), 1 mL of 10 mM of substrate, and 1 mL of crude enzyme extract, giving a reaction volume of 3 mL. The reference control sample contained the reaction mixture without the enzyme, which was replaced with the buffer. PPO activity was determined by measuring the increase in absorbance at 420 nm and recorded automatically at 3 min intervals at 25°C using a spectrophotometer (UV-1800; Shimadzu). Data are expressed as OD 420 per min per milligram of the protein in the enzyme extract.

Effect of sericin solution on PPO activity

Following the extraction of a crude enzyme, the sericin solution’s effects on PPO reactivity to the substrates caffeic acid, catechol, chlorogenic acid, 4-methylcatechol, and pyrogallol were determined according to Jiang (2000) with some modifications. The crude enzyme (1 mL) was mixed with 1 mL of 2% sericin solution dissolved in 0.05 mM phosphate buffer (pH 7) and 1 mL of 10 mM of substrate, giving a total reaction volume of 3 mL. PPO activity was measured using a spectrophotometer (UV-1800; Shimadzu) at 420 nm. One unit of PPO activity was determined as a change in absorbance of 0.001 per min per milligram of the protein in the enzyme extract.

**Effect of sericin coating on browning and quality of fresh-cut ‘Nam Dok Mai Si-Thong’ mangos**

First, the fruit were peeled, halved along the longitudinal section and, cut three times along the cross section using a sharp knife. The coating solution was prepared by dissolving 2 g of sericin powder in water and heating the mixture at 105°C for 5 min using an autoclave. Each longitudinal half of the fresh-cut mango was separately dipped in the sericin solution and distilled water (control). The fresh-cut mangos were then placed in rigid-plastic boxes and stored under a browning accelerating temperature condition (10°C) and 85–90% RH for 4 days.

**Browning incidence**

Browning of mango flesh was assessed using the CIE LAB system expressed as the L* value, browning index (BI), sensory browning score (BS), and browning pigment concentration. The L* value, an indicator of lightness, was recorded using a Minolta DP-301 colorimeter (Konica Minolta Sensing, Tokyo, Japan). BI was calculated according the equation described by Palou et al. (1999).

\[
A = a^* + (1.75 \times L^*) \\
B = (5.64 \times L^*) + [a^* - (3.012 \times b^*)] \\
C = A/B \\
BI = [100 \times (C - 0.31)]/0.17
\]

The sensory browning score of the fresh-cut mangos was determined using a sensory evaluation based on a 9-point scoring test: 1 = no browning (excellent quality), 3 = slight browning (1–25%), 5 = moderate browning (26–50%), 7 = severe browning (51–75%), and 9 = extreme browning (76–100%). Ten trained panelists were used to evaluate the BS of fresh-cut mangos.

The browning pigment concentration was measured according to Supavpanich et al. (2011). Two grams of cut-surface of the fresh-cut mangos were homogenized in 65% ethanol (v/v) and incubated at room temperature (25°C) for 1 h. The extract was filtered using Whatman No.1 filter paper. The absorbance was measured at 420 nm wavelength using a spectrophotometer (UV-1800; Shimadzu). Data are expressed as OD 420 per g fresh weight.

**Enzymatic browning**

Browning enzymes were determined by PPO and PAL activity assays. The procedures used for extracting and determining PPO enzyme activity have already been described in the previous sections. Based on the preliminary results, 4-methylcatechol was used as a substrate.

The PAL activity was assayed according to Assis et al. (2001) with slight modifications. The crude enzyme (1 mL) was mixed with 2 mL of 50 mM borate buffer (pH 8.8) and 1 mL of 20 mM L-phenylalanine and incubated at 37°C in a water bath for 2 h. This reaction was stopped by adding 1 M HCl (1 mL). The absorbance was measured using a spectrophotometer (UV-1800; Shimadzu) at 280 nm. One unit of PAL ac-
Activity was determined as a change in absorbance of 0.01 per min per milligram of the protein in the enzyme extract.

*Total phenols and antioxidant capacity (FRAP)*

Total phenols and FRAP of the extract were determined according to Swain and Hillis (1959) with some modifications. 5 g of cut-surface tissue of fresh-cut mangoes was homogenized in 25 mL of methanol with a homogenizer (Heidolph SilentCrusher M). The homogenate was kept at 4°C for 12 h, then centrifuged at 15,000 rpm for 20 min. The supernatant was collected and stored at −20°C until analysis.

The total phenols were determined by the Folin-Ciocalteu method, whereby 150 μL of supernatant, 2400 μL of distilled water, and 150 μL of 0.25 N Folin-Ciocalteu were thoroughly mixed in a test tube with a vortex. The mixture was allowed to react at room temperature for 2 h. A spectrophotometer (UV-1800; Shimadzu) was used to measure the absorbance at 725 nm, and the result was converted into gallic acid equivalents (GAE) mg/100 g fresh weight using a gallic acid (0–0.1 mg·mL⁻¹) standard curve. Methanol was used as a blank. Data are represented as milligrams (GAE) mg/100 g fresh weight.

The FRAP assay followed the method of Benzie and Strain (1996) and Thaipong et al. (2006). The stock solutions were prepared with 300 mM acetate buffer, pH 3.6, 10 mM TPTZ (2,4,6-tripyridyl-s-triazine) solution in 40 mM HCl, and 20 mM FeCl₃·6H₂O solution. The working solution was obtained by mixing 25 mL acetate buffer, 2.5 mL TPTZ, and 2.5 mL FeCl₃·6H₂O and then warming to 37°C before use. The FRAP was determined by using 150 μL of mango extracts that were allowed to react with 2850 μL of the FRAP solution. The solution was mixed well and incubated under dark conditions at room temperature (25°C) for 30 min. Then, the absorbance was taken at 593 nm using a spectrophotometer (UV-1800; Shimadzu) and the standard curve was linear between 25 and 800 μM using a Trolox. Methanol was used as a blank. Results are expressed in milligrams Trolox equivalent (TE) per 100 grams fresh weight basis (FW).

**Statistical analysis**

Data were subjected to analysis of variance (ANOVA) using the general linear models procedure of the SPSS software (version 15.0; IBM Crops, White Plains, NY, USA), generating a completely randomized design for the experiments. Each treatment contained four replicates. Significance was tested at $P \leq 0.05$ using Duncan’s multiple range test.

**Results and Discussion**

*Substrate reactivity in ‘Nam Dok Mai Si-Thong’ mango*

In *in vivo* and *in vitro* substrate and sericin effects on enzymatic browning reactivity

The browning severity of fresh-cut ‘Nam Dok Mai Si-Thong’ mangoes after treatment with various phenolic compounds (PPO substrates) is shown in Figure 1A. Browning started 5 min after treatment and we found that browning incidence of fresh-cut mangoes with phenolic compounds was completed within 45 min and then remained relatively constant. This was in agreement with Gomes et al. (2014) who demonstrated that most browning occurred within the first 30 min after applying phenolic compounds to the surface tissue of pear slices at room temperature (24°C) with browning remaining constant thereafter. ‘Nam Dok Mai Si-Thong’ mango cubes revealed different browning color intensity after being dropped with different PPO substrates. The highest browning color intensity was found in catechol-treated mango cubes followed by 4-methylcatechol and pyrogallol, respectively, while chlorogenic acid, and caffeic acid treated mango cubes had a light brown color (Fig. 1A). It is commonly acknowledged that the browning incidence of cut tissue of plant organs is mainly due to oxidation of oxidizable o-diphenols to reddish-brown o-quinones (Mayer et al., 1990). Therefore, the different intensities of browning color and PPO reactivity depend on phenol substrates. A recent result revealed that in crushed apple, the o-
quinone of chlorogenic acid was more intensely colored than the quinones derived from catechin and 4-methylcatechol (Mayer et al., 1990). We found that PPO activity in extracts from 'Nam Dok Mai Si-Thong' mangoes was highly specific to catechol and 4-methylcatechol.

The sensory browning scores (BS) of fresh-cut mangoes treated with various phenolic compounds are shown in Figure 1B and clearly indicate the color changes occurring on the surface tissue. The browning score was concomitant with the browning appearance as shown in Figure 1A. The highest BS was found in mango cubes treated with 4-methylcatechol and catechol, followed by pyrogallol, while the browning scores of caffeic acid, chlorogenic acid and the control were low and showed no significant difference.

Figure 2 shows the efficacy of sericin solution on PPO activity in extracts from 'Nam Dok Mai Si-Thong' mangoes by using various phenolic compounds as substrates. In vitro, PPO activity of mango extracts was the highest when treated with the 4-methylcatechol substrate followed by catechol, pyrogallol, and chlorogenic acid, respectively. Sericin treatment significantly reduced the activity of PPO with 4-methylcatechol, catechol and pyrogallol as the phenolic substrates. Similarly, ‘Manila’ mango PPO showed the highest affinity to pyrogallol, 4-methylcatechol and catechol (Palma-Orozco et al, 2014). However, Cheema and Sommerhalter (2015) reported that the ‘Ataulfo’ mango exhibited PPO activity with pyrogallol, 3-methylcatechol, catechol, gallic acid, and protocatechuic acid. Recently, Puangphet et al. (2015) reported that sericin hydrolysate showed an ability to reduce PPO activity to a greater extent than citric acid on PPO from apple and banana flowers, whereas the opposite result was observed for bean sprouts. It seems that the PPO substrate effect depends on the mango variety and the inhibition of PPO activity varied depending on the phenolic compound used as a substrate. The sericin solution also affected enzymatic browning inhibition of PPO from ‘Nam Dok Mai Si-Thong’ mangoes, so we investigated the “the efficacy of sericin coating on physical and biochemical changes of fresh-cut mangoes”.

Effect of sericin coating on browning alleviation of fresh-cut ‘Nam Dok Mai Si-Thong’ mangoes

Visual appearance and color attributes

The preliminary experiment varying the concentration of sericin from 0–5% showed that 2% sericin was suitable to reduce browning symptoms in fresh cut ripe mangoes. In the preliminary experiment, we checked the visual appearance (browning symptom). We also found that the physical properties of sericin solution were glue-like and sticky. If the concentration of sericin was higher than 2%, the fresh cut mango appeared abnormal, similar to the water soaking symptom. ‘Nam Dok Mai Si-Thong’ mangoes sensitive to browning based on the preliminary experiment were chosen for this study, and the fruit were treated with 2% sericin; this was predetermined to be optimal for delaying browning in fresh-cut mangoes (data not shown). Figure 3 shows the visual appearance of fresh-cut ‘Nam Dok Mai Si-Thong’ mangoes treated with 2% sericin compared with the control samples during storage. It was found that the 2% sericin coating retarded the browning incidence of the cut surface tissue of the fresh-cut mangoes during storage for 4 days at 10°C. The browning incidence of control samples clearly occurred after storage for one day, while the 2% sericin-coated fresh-cut mangoes had no browning incidence on the cut surface tissue over the same storage period. This was concomitant with the changes in color attributes of the fresh-cut mangoes during storage, as shown in Figure 4. At the beginning of storage, the L* values for control and sericin coated fresh-cut mangoes were comparable (Fig. 4A). Afterwards, the L* value of the 2% sericin-coated fresh-cut mangoes was found to be significantly higher than that of the control throughout the storage period (P ≤ 0.01). This result corroborates
the finding of Thongsook and Tiyaboonchai (2011), who reported that the $L^*$ values of apple slices coated with sericin were higher than those of uncoated samples during storage. Similarly, this result is comparable with that of the browning index (BI) and browning pigment concentration as shown in Figure 4B, C, respectively. The BI and browning pigment concentration of control samples were higher than that of 2% sericin-coated fresh-cut mangoes throughout the storage period. Sericin application retarded the increase in browning pigment concentration of the fresh-cut mangoes during storage, unlike the control. As shown in Figure 4D, no surface browning incidence occurred in the fresh-cut mangoes on the first day of storage. The browning score (BS) increased during storage, but decreased significantly in fresh-cut mango fruit coated with 2% sericin ($P \leq 0.01$), which had BS ranging from 1.0–3.80 (1.0 score indicates a no-brown symptom, and a 3.80 score indicates light brown) compared to the browning scores of 3.0 (light brown) and 9.0 (dark brown) in the control. Similarly, samples coated with 2% sericin had significantly higher $L^*$ values (Fig. 4A) and lower BI and browning pigment concentrations than control samples. Puangphet et al. (2015) reported a similar result, in which sericin hydrolysate delayed the changes in the $L^*$ value and browning incidence of fresh-cut apples and eggplants during storage. The current results suggest that 2% sericin could maintain the visual appearance and inhibit browning incidence of fresh-cut ‘Nam Dok Mai Si-Thong’ mangoes during storage.

**Browning enzymes activities, total phenols and antioxidant capacity**

The activities of browning-related enzymes of fresh-cut mangoes, PPO and PAL, during storage are shown in Figure 5A, B. 4-methylcatechol was used as a substrate to measure PPO activity due to its high specificity to browning symptoms in ‘Nam Dok Mai Si-Thong’ fresh-cut mangoes. At the beginning of storage, the highest PPO activity was found in the control (0.49 unit·mg$^{-1}$ protein). This rapidly decreased on day 2 of storage and slightly decreased until the end of storage. PPO activity with sericin treatment was almost unchanged during storage and was found to be significantly lower than that of the control ($P \leq 0.01$). The PPO activity in sericin-coated fruit was also positively related to the $L^*$ value, BI, BS and browning pigment concentration, as shown in Figure 4. It is commonly recognized that PAL plays a key role in phenolic compound biosynthesis through the phenylpropanoid pathway in which phenolic compounds act as the substrates for an enzymatic browning reaction. The PAL activity of coated and control samples ranged from 0.03–0.04 unit·mg$^{-1}$ protein during storage (Fig. 5B). The current result showed that the PAL activity of 2% sericin-coated fresh-cut mangos was significantly lower than that of the control ($P \leq 0.01$) on the third day of storage. This result was related to the total phenols (Fig. 5C) on the third day of storage; the total phenols in control fruit were higher than in sericin-treated mangoes. At the end of storage, there was no significant difference in the PAL activity with any treatment. PAL plays a significant role in browning as the O-diphenols formed by the phenylpropanoids pathway can be oxidized by PPO and polymerized into melanin pigments. Repressing the induction of PAL activity could also inhibit browning. An increase in total phenols of fresh-cut mangoes during storage is shown in Figure 5C. Higher total phenols may be due to the induction of phenolic biosynthesis that occurs under stress conditions such as wounding etc. (González-Barrio et al., 2005). On the third day of storage, the total number of phenols in 2% sericin-
coated samples (1.40 mg/100 g FW) was found to be significantly lower than that of the control \((P \leq 0.01)\) (1.83 mg/100 g FW) and this level was also found to be related to the PPO activity.

Similarly, the antioxidant capacity of cut-surface tissues of fresh-cut mangoes increased after one day of storage (Fig. 5D). After day 2 of the storage, the antioxidant capacity of the 2% sericin-treated fresh-cut mangoes continuously increased and was higher than that of control samples, in which a slight decrease was found until the end of storage. These results suggest that sericin coating could retard the enzymatic browning reaction. It is widely recognized that the enzymatic browning reaction is an oxidative reaction of phenolic compounds causing a browning pigment. Therefore, the reduced enzymatic browning reaction of fresh-cut mangoes coated with sericin, is considered to be due to its action as a peptide PPO inhibitor. Kato et al. (1998) and Puangphet et al. (2015) reported that sericin and hydrolysated sericin, which are non-dietary proteins and the major components of amino acids serine and aspartic acid, inhibited PPO activity and retarded browning in several fresh-cut products. Moreover, proteins and peptides such as sericin and hydrolysated sericin can be used to inhibit PPO action because they chelate copper at the active site of PPO, affecting o-quinones synthesis (Girelli et al., 2004).

In conclusion, the primary substrates of PPO in ‘Nam Dok Mai Si-Thong’ mangoes were 4-methylcatechol and catechol, followed by pyrogallol. The application of 2% sericin on fresh-cut ‘Nam Dok Mai Si-Thong’ mangoes maintained their visual appearance and reduced browning incidence and enzymatic browning reactions due to lower PPO activity and the higher phenolic compounds concentration. Moreover, the sericin coating also improved antioxidant capacity of the cut-surface tissue of fresh-cut ‘Nam Dok Mai Si-Thong’ mangoes during storage at 10°C for 4 days.

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