Degreening Peel Color and Improving Fruit Quality of 'Ponkan' Mandarin (*Citrus reticulata* Blanco) by Preharvest Bagging and 1-Methylcyclopropene Treatments

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Key word: 'Ponkan' mandarin fruit, 1-Methylcyclopropene, Preharvest bagging fruit

Summary

The purpose of this study is to evaluate the effects of preharvest bagging fruit treatment, cold quarantine treatment and 1-MCP treatment on the peel color change and fruit quality of the 'Ponkan' mandarin fruit. For the 2011 experiment, the 'Ponkan' mandarin fruits were treated with black-paper bagging treatment comparing to black-plastic bagging treatment for seven weeks before harvest. The preharvest bagging fruit treatment improved the coloration of fruit peel and increased chlorophyll degradation. Total soluble solids and titratable acidity content were not affected by both treatments. After that, fruits were transferred to five different temperatures of storage for further investigation on fruits quality, results showed that total soluble solids and titratable acidity content were not significant different between control and bagging treatments. For the 2012 experiment, 'Ponkan' mandarin fruits were treated with black-paper bagging alone treatment comparing to a treatment of black-paper bagging combines with 0.2 g 1-MCP (14 hours) for four times. The black-paper bagged fruits were significant lower in total chlorophyll content than the fruits bagged with black-paper combined with 1-MCP and control fruit. The black-paper bag fruits induced the chlorophyllase activity during initial stage of development and tended to decrease in later stages. The total soluble solids of the combination treatment, bagging with 1-MCP, were significant lower and titratable acidity were higher than the control after bagging for seven weeks.

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Introduction

The colorful of 'Ponkan' mandarin fruit peel is important to consumer. In Taiwan, Hong Kong, Japan and other country, 'Ponkan' mandarin usually is used as the gift in New Year. Therefore, the 'Ponkan' mandarin fruit must be generally harvested early, before they are fully colored. The results of early harvest are poor quality, and poor color. To maintain quality of fruit, we used the bagging technique. Because of bagging fruits, not only protect fruit from diseases, but also change the microenvironment during fruit development, which exerts multiple effects on the growth and quality of fruits.

Moreover, bagging fruit produces high quality unblemished fruits (Kitagawa *et al*., 1992) and promotes fruit coloration (Jia *et al*., 2005). Temperature management is the most important environmental factor used to maintain quality of fresh horticultural produce after harvest. The low temperatures reduce respiration and ethylene production rates, water loss, pathogen growth, and decay incidence (Kader, 2002; Thompson *et al*., 2001).

1-methycyclopropane (1-MCP) used as a synthetic plant growth regulator that is structurally related to the natural plant hormone ethylene. 1-MCP is used commercially to slow down the ripening of fruit and maintains the freshness of cut flowers (Serek *et al*., 1994; Sisler *et al*., 1996). The purpose of this study is to evaluate the effects of preharvest bagging fruit, postharvest temperature treatment, and 1-MCP treatment on 'Ponkan' mandarin fruit peel color turning, chlorophyll content, chlorophyllase activity and fruit quality.

Materials and methods

Plant materials

Mature green of 'Ponkan' mandarin (*Citrus reticulata* Blanco) fruits on tree in the citrus orchard of Mr. Zeng’s at latitude 24.153°N and longitude 120.830°E, Jhonghe Village, Xinshe District, Taichung City, Taiwan, were selected for uniformity of color and size.

Experiment 1: Preharvest bagging treatment and postharvest additional storage of 'Ponkan' mandarin fruit

The experiment in 2011, mature green of 'Ponkan' mandarin fruits were bagged by two types of bags (black paper bag, and black plastic bag; 50 fruits of control, 50 fruits of bagging with black paper bag, and 10 fruits of black plastic bag) seven weeks before harvested. After harvest, fruit were packed by plastic bag and storage at 1℃ for 14 days and measured fruit quality in each treatment (10 fruit per each treatment). Afterwards, the remained fruits were transferred to 12, 15, 20, and 25℃, step by step, 7 days for each temperature and fruits were measured at day 7 after storage in each temperature.

Experiment 2: Preharvest bagging and 1- MCP treatments of 'Ponkan' mandarin fruit

The experiment in 2012, 'Ponkan' mandarin fruits on tree in the citrus orchard were bagged with black paper bag and treated with the 1- MCP for 4 times on 19 Sept., 26 Sept., 10 Oct., and 24 Oct. 2012. Each fruit (bagged with black paper bag) was enclosed in plastic bag (low-density polyethylene, 29 cm × 57 cm), contained 0.2 g 1-MCP mixed with 1 mL distilled water just before the fruit were bagged and removed after 14 hours. Fruits after treated with 1-MCP were harvested (10 fruits of 1-MCP and 10 fruits of control) on 19 Sept., 26 Sept., 10 Oct. 24 Oct., and 5 Oct. They were placed in paper box that were labeled accordingly and immediately transported back to the postharvest laboratory, National Chung Hsing University for further analyses.

Color measurement

The color of the fruit was measured with a Lab Scan XE DP-9000 colorimeter (Hunter Associates Lab II, Preston VA). The 'Ponkan' mandarin fruit samples consisted of two measurement spots of approximately 1 cm from the exterior of the fruit (on peel). The values of L* (lightness), a* (redness to greenness), b* (yellowness to blueness), C (Chroma), and H° (Hue angle) were recorded for each sample.

Total soluble solids (°Brix)

The total soluble solids (TSS) of samples were measured with a Digital Refractometer (Atago PR-32, Atago Co., Ltd., Tokyo, Japan) and expressed as a percentage. Juice sample were prepared by thoroughly mixing 'Ponkan' slices (four segments for 'Ponkan' mandarin fruits).

Titratable acidity (TA %)

The titratable acidity was determined by titration to pH 8.2 with 0.1 N NaOH, using phenolphthalein as an indicator and expressed as g of citric acid per 100 mL of juice. Each measurement comprised ten fruits per treatments.

Extraction and measurement of chlorophyll

Chlorophyll content was measured according to Moran and Porath, (1980). Five flavedo disks (11 mm in diameter) were immersed overnight in 5 ml of *N*, *N*-dimethylformamide at 4℃ and the chlorophyll content was determined spectrophotometrically for wavelengths ranging from 647 to 664.5 nm.

Calculated;

$Chl\ a = 12.70 \times A_{664.5} - 2.79A_{647}$;

$Chl\ b = 20.70 \times A_{647} - 4.62A_{664.5}$;

$Total\ Chl = 17.90 \times A_{647} + 8.08A_{664.5}$;

Unit of Chl = µg per mL

Unit of Chl =µg per g^{-1}FW (Chl × 5 ÷ FW)

(Inskeep and Bloom, 1985)

Determination of chlorophyllase activity

Chlorophyllase activity was determined according to the method of Amir-Shapira *et al*., (1987) by some modifications. The outer, colored layer of citrus fruit peel removed and homogenized in ice-cold 50 mM Tris-HCl, at pH 8.0, of 400 mM sucrose. Floating chloroplast pellets were subsequently homogenized at -15℃ in acetone for the preparation of acetone powders. Acetone powder 500 mg was extracted by stirring with 10 ml of 5mM phosphate buffer, pH 7.0, 50 mM KCl, and 0.24% Triton X-100 for 60 min at 30℃. The extract was filtered through glass wool and centrifuged at 12,000 ×g for 10 min at 4℃ for the enzyme assays supernatant. The protein content of the enzyme extract that contained Triton X-100 was determined by the biuret method. Enzymatic assay reaction mixture contained 5 ml of 100 mM phosphate buffer (pH 7.0), 0.24% Triton X-100, 1.0 mL of enzyme extract, and 0.2 ml of diethyl ether containing 0.7 µmole of chlorophyll a, which is dissolved in the aqueous solution by vigorous shaking the incubated in a shaking bath at 35℃. Aliquots, at 1 mL, were transferred into centrifuge tube containing 11 mL of acetone/ hexane/10 mM KOH, 4:6:1 (vol/vol). The mixture was shaked vigorously and centrifuged at 12,000 ×g for 10 min to separate the phases. Chlorophyllide was determined in the acetone phase spectrophotometrically by using an extinction coefficient of $7.49 \times 10^{-2}\ M^{-1}\ cm^{-1}$ at 667 nm. The enzymatic reaction progressed linearly for 30 minutes. The activity was calculated according to the 10-min readings.

Statistical analysis

The experiments were conducted in a complexly randomized design. The mean values were analyzed by SAS version 9.0 (SAS Institute Inc., Cary, NC, USA). Analysis of variance was performed; means were compared by the least significant and t tested (L.S.D) at significance levels of 0.05.

Results and discussion

Preharvest bagging treatments

The bagging creates an environment that generally reduces contents of sugars, or soluble solids, and titratable acidity (Niu *et al*., 2003). Sugar content was not significantly affected by bagging fruits with bag < 10 - 70% light transmittance (Yang *et al*., 2009). Kim *et al*. (2000) reported that titratable acidity tend to increase by bagging with yellow paper of low light transmittance, while our results showed that total soluble solids content and titratable acidity was not significantly affected by bagging materials (Table 1). Similar results also found in 'Keitt' mango (Hofman *et al*., 1997). These results indicated that preharvest bagging treatment did not influence 'Ponkan' mandarin fruit total soluble solids content and titratable acidity.

Color is one of the parameter qualities for fruit. In this studies, the lightness, chroma, hue angle, a* value, and b* value showed significant differences between control and bagged (Table 2). The bagged 'Ponkan' mandarin fruit until harvest made the skin brighter, yellowy-looked and good color (Fig.1). Similar results were also found for 'Meirensu' and 'Yunhongli' on red Chinese sand cultivars of pear (Huang *et al*., 2009). Mars *et al*. (1994) noted that the skin color of citrus fruit was affected by bagging and depth of fruit within the canopy. In addition, fruit bagging stimulated degradation of chlorophyll in fruit peel (Fig.2).

Fig. 1. Appearance of 'Ponkan' mandarin fruits after bagged with different materials for 7 weeks.

Table 1. Effect of preharvest bagging on the TSS and TA of 'Ponkan' mandarin fruits after harvest

Treatments	TSS[y]	TA[y]
Control	9.54 a[z]	0.44 a
Black paper bag	9.46 a	0.45 a
Black plastic bag	9.24 a	0.43 a

[z]Mean separation within columns were by Least Significant Different test (L.S.D) at 5% level.
[y]TSS = Total soluble solids (°Brix), TA = Titratable acidity (% as citric acid)

Table 2. Effect of preharvest bagging on the peel coloration of 'Ponkan' mandarin fruits after harvest.

Treatment	Peel color				
	Lightness	Chroma	Hue angle	a*	b*
Control	48.58b[z]	43.89b	90.88a	-0.30b	43.53b
Black paper bag	61.79a	61.91a	78.78b	12.03a	60.69a
Black plastic bag	60.25a	59.90a	78.80b	11.46a	58.71a

[z]Mean separation within columns were by Least Significant Different test (L.S.D) at 5% level.

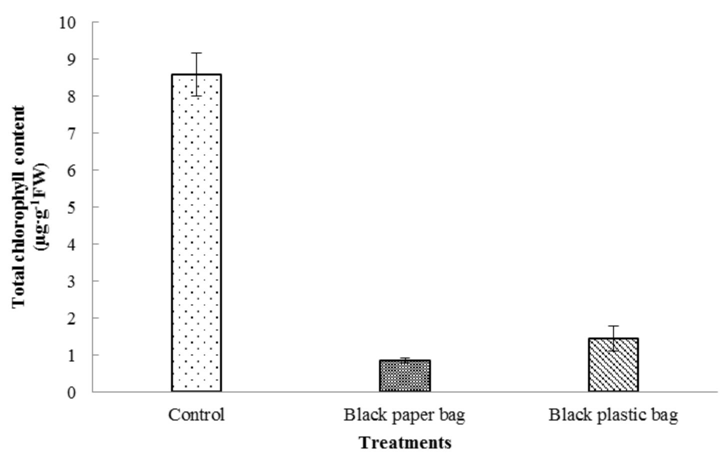

Fig. 2. The total chlorophyll content of 'Ponkan' mandarin peel after bagged with different materials for 7 weeks.

Low temperature storage has the additional benefit of protecting non-appearance quality attributes; texture, nutrition, aroma and flavor because of low temperatures can reduce respiration and ethylene production rates, water loss, pathogen growth, and decay incidence (Kader, 2002; Thompson *et al*., 2002). 'Ponkan' mandarin fruits are chilling sensitive, and need to be stored at relatively moderate temperature to prevent development of chilling injuries. In this study, we used postharvest simulation of low storage temperature to higher storage temperature during storage period. Results showed significant differences on coloration between fruit at harvest except to L* and a* value on black paper bag treatment (Table 5). It seems that postharvest simulation of low temperature may improve peel color in fruit of early-harvest, as a result of chlorophyll degradation (Fig.3 and Table 5). There changed slightly on total soluble solids content and titratable acidity during storage period (Table 3, and Table 4). Thus low temperature treatment in 'Ponkan' mandarins fruits improved peel color to a level comparable with that of commercial ethylene degreening. Similar results also found for 'Nules Clementine' mandarin, and the same studies, low temperature or cold shock of 'Navel' oranges treatment was unsuccessful and no color improvement was found (Barry and Wyk, 2006). Nevertheless, the fruit after storage showed fruit decay. These results indicate that in different cultivar showed difference response on low storage temperature of citrus fruit.

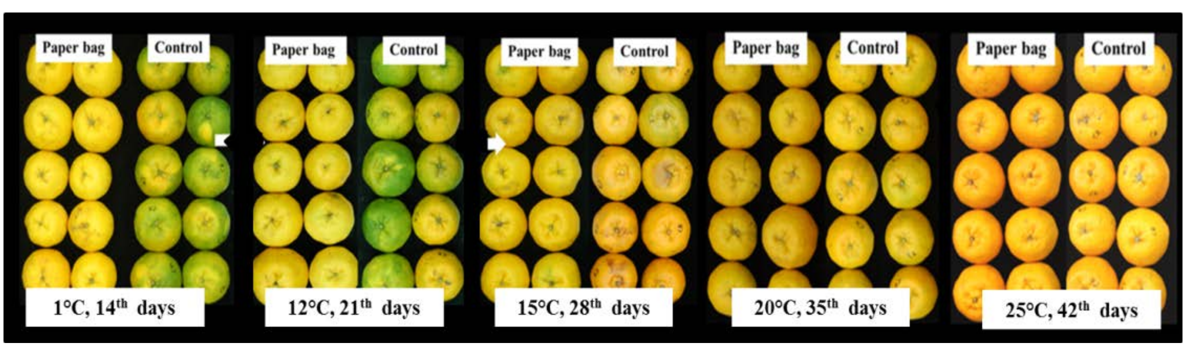

Fig. 3. Appearance of bagged or non-bagged of 'Ponkan' mandarin fruits at various stages of storage.

Table 3. Changes in the total soluble solids (°Brix) of bagged 'Ponkan' mandarin fruits during additional storage .

Storage procedure [z]	Total soluble solids (°Brix)	
	Control	Black paper bag
After harvest	9.54 a[y]A	9.46 bA[x]
1℃ for 14 days	9.76 aA	10.03 aA
12 ℃ for 7 days	9.18 aA	9.33 bA
15 ℃ for 7 days	9.12 aA	9.32 bA
20 ℃ for 7 days	9.47 aA	9.10 bA
25 ℃ for 7 days	9.17 aA	9.06 bA

[z] Total of storage time : 14 days (cold quarantine treatment at 1℃) + 7 days (at 12℃) + 7 days (at 15℃) + 7 days (at 20℃) + 7 days (at 25℃) = 42 days.

[xy] Mean separation within columns (small letters) and within rows (capital letters) were by Least Significant Different test (L.S.D.) at 5% level.

Table 4. Changes in the total soluble solids (°Brix) of bagged 'Ponkan' mandarin fruit during additional storage.

Storage procedure [z]	Titratable acidity (%)	
	Control	Black paper bag
After harvest	0.44 a[y]A	0.45 abA[x]
1 ℃ for 14 days	0.39 abA	0.42 abA
12 ℃ for 7 days	0.39 abA	0.46 aA
15 ℃ for 7 days	0.41 abA	0.42 abA
20 ℃ for 7 days	0.41 abA	0.47 aA
25 ℃ for 7 days	0.36 bA	0.37 bA

[z] Total of storage time : 14 days (cold quarantine treatment at 1℃) + 7 days (at 12℃) + 7 days (at 15℃) + 7 days (at 20℃) + 7 days (at 25℃) = 42 days.

[xy] Mean separation within columns (small letters) and within rows (capital letters) were by Least Significant Different test (L.S.D.) at 5% level.

Table 5. Changes in the coloration and chlorophyll degradation of bagged 'Ponkan' mandarin fruit during additional storage.

Storage procedure [z]	L*values		Hue angle		Chroma		a*values		b*values		Chl a ($\mu g \cdot g^{-1}FW$)		Chl b ($\mu g \cdot g^{-1}FW$)		Total Chl ($\mu g \cdot g^{-1}FW$)	
	CK	PB	CK	PB	CK	PB	CK	PB	CK	PB	CK	PB	CK	PB	CK	PB
After harvest	48.58 c[y]B	61.79 aA[x]	90.88aA	78.78aB	43.89cB	61.91eA	-0.30 dB	12.03 dA	43.53 cB	60.69 dA	6.72aA	0.35aB	1.85aA	0.49aB	8.57aA	0.84aB
1°C for 14 d	54.40 bB	67.76 aA	89.00aA	77.69aB	50.26bB	70.59aA	0.98 dB	15.03 cA	49.99 bB	68.92 aA	7.13aA	0.19bB	1.74aA	0.29bcB	8.88aA	0.48bB
12 °C for 7 d	55.24 bB	66.85 aA	85.56abA	76.80aB	54.22bB	68.77bA	2.47 dB	15.61 cA	53.53 bB	66.86 bA	6.55aA	0.18bB	1.40aA	0.32bB	7.95aA	0.51bB
15 °C for 7 d	61.71 aB	66.08 aA	81.51bA	73.50bB	59.44aB	66.04cA	8.94 cB	18.73 bA	58.40 aB	63.25 cA	2.13bA	0.14bcB	0.55bA	0.22dcB	2.68bA	0.36bcB
20 °C for 7 d	62.02 aB	64.81 aA	75.72cA	71.68bcB	62.47aB	66.21cA	15.38 bB	20.79 abA	60.43 aB	62.79 cA	0.87bA	0.12cB	0.41bA	0.18dB	1.28bA	0.30cB
25 °C for 7 d	64.48 aA	64.53 aA	71.11cA	69.89cA	63.70aA	63.75dA	20.53 aA	21.87 aA	60.18 aA	59.83 dA	0.38bA	0.11cB	0.19bA	0.18dA	0.57bA	0.29cA

[z] Total of storage time : 14 days (cold quarantine treatment at 1 °C) + 7 days (at 12 °C) + 7 days (at 15 °C) + 7 days (at 20 °C) + 7 days (at 25 °C) = 42 days.

[xy] Mean separation within columns (small letters) and within rows (capital letters) were by Least Significant Different test (L.S.D.) at 5% level.

Chl = Chlorophyll content; Unit: μg/g, CK = Control, PB = Fruit bagged with black paper bag

Preharvest bagging fruit and 1-MCP treatments

'Ponkan' mandarin fruits were bagged with black paper bag and treated with 1-MCP at the green mature stage on the tree. There are made any difference on the total soluble solids content and titratable acidity during fruits development on the tree (Table 6 and 7). The total soluble solids content constantly increased when the periods of bagging time was prolonged (Table 6). It seems that the total soluble solids content decreased when compared with the control fruit. Titratable acidity showed no significant difference during development when compared with the control fruit, except at seven weeks, on 5 Nov. 2012, but the 1-MCP treated fruit harvested at seven weeks were significantly higher than control fruit (Table 2). Seven weeks, on 5 Nov. 2012, after fruits were bagged with black paper bag and treated with 1-MCP, the fruits showed green color while fruits were bagged with only black paper bag showed yellow color (Fig.4). Similar to Win *et al*. (2006) who reported the delayed yellowing in West Indian limes.

The green color of the fruit peel is related to the presence of chlorophyll. In citrus fruit, chlorophyll degradation occurs during leaf senescence and fruit ripening. Chlorophyll degradation is associated with carotenoid synthesis (Lizada, 1991). Additionally, the reduction of chlorophyll in 'Ponkan' mandarin fruit peel may allow carotenoid pigments to become more visible. Peel color of 'Ponkan' mandarin fruit is green when unripe, and gradually turns yellow when ripe. Preharvest bagging fruit and treated with 1-MCP delayed chlorophyll degradation by showing the green color on peel, but fruit without 1-MCP application in black paper bag showed yellow color on peel (Fig.4). This result suggested that 1-MCP treatment might inhibit the ethylene synthesis in 'Ponkan' mandarin fruit bagged with black paper bag during developed on the tree.

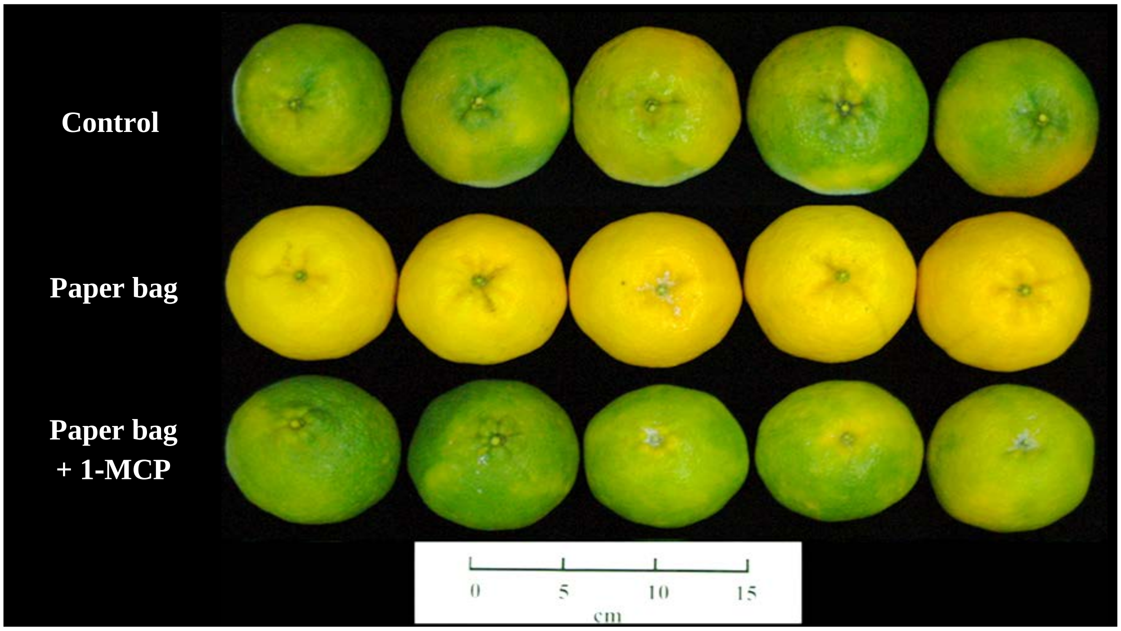

Fig. 4. Effect of preharvest 1-MCP treatment on the peel color and appearance of 'Ponkan' mandarin fruits harvest on 5 November 2012.

Table 6. Effect of preharvest 1-MCP treatment on the total soluble solids (◦Brix) of 'Ponkan' mandarin fruit.

Time of harvest	Time of treatment	Total soluble solid content (◦Brix)		
		Control	Black paper bag	Bagged fruit +1-MCP
19 Sept.	-	8.86aD[x]	8.86 aD	8.86 aC
26 Sept.	19 Sept.	9.26 aC	8.90 abD	9.09 bBC
10 Oct.	19 Sept., 26 Sept.	9.76 aB	9.21 bC	9.55 aAB
24 Oct.	19 Sept., 26 Sept., 10 Oct.	10.09 aAB	9.71 aB	9.87 aA
5 Nov.	19 Sept., 26 Sept., 10 Oct., 24 Oct.	10.33 aA	10.03 abA	9.74 bA

[x] Mean separation within columns (capital letters) and within rows (small letters) were by Least Significant Different test (L.S.D.) at 5% level.

Table 7. Effect of preharvest 1-MCP treatment on the titratable acidity of 'Ponkan' mandarin fruit.

Time of harvest	Time of treatment	Titratable acidity (%)		
		Control	Black paper bag	Bagged fruit + 1-MCP
19 Sept.	-	0.82 aA[x]	0.82 aA	0.82 aA
26 Sept.	19 Sept.	0.69 aAB	0.60 aBC	0.64 aB
10 Oct.	19 Sept., 26 Sept.	0.67 aB	0.63 aBC	0.70 aAB
24 Oct.	19 Sept., 26 Sept., 10 Oct.	0.61 aB	0.69 aAB	0.73 aAB
5 Nov.	19 Sept., 26 Sept., 10 Oct., 24 Oct.	0.43 bC	0.50 bC	0.61 aB

[x] Mean separation within columns (capital letters) and within rows (small letters) were by Least Significant Different test (L.S.D.) at 5% level.

After seven weeks, fruits bagged with black paper bag were significant lower in total chlorophyll content than fruit bagged with black paper combined with 1-MCP treatment and control (Table 8). Fruit bagged with black paper bag (no 1-MCP) showed the highest hue angle value when compare to other treatments (Table 9).

Chlorophyllase is considered as first enzyme in the pathway of chlorophyll degradation (Matile *et al*., 1997; Hendry *et al*., 1987), and the activity of chlorophyllase tended to decrease during senescence (Minguez-Mosquera *et al*., 1996; Yamauchi and Watada, 1991). In addition, Jacob-Wilk *et al*., (1999) found that the chlorophyllase is constitutively expressed during citrus fruit development and its expression does not increase markedly towards the later stages of maturation and ripening. In this study found the 'Ponkan' mandarin fruit bagged with black paper bag and treated with 1-MCP or fruit bagged with black paper bag (no 1-MCP) both induced chlorophyllase activity during initial stage of development, and the chlorophyllase activity tends to decrease in a later stages, until fruits are yellowed (Table 10).

Table 8. Effect of preharvest 1-MCP treatment on the total chlorophyll content of 'Ponkan' mandarin fruit.

Time of harvest	Time of treatment	Total chlorophyll content (µg·g^{-1}FW)		
		Control	Bagged fruit	Bagged fruit + 1-MCP
19 Sept.	-	42.07 aA	42.07 aA	42.07 aA
26 Sept.	19 Sept.	45.17 aA	43.12 aA	38.11 aA
10 Oct.	19 Sept., 26 Sept.	26.18 aB	19.93 abB	18.32 bB
24 Oct.	19 Sept., 26 Sept., 10 Oct.	14.08 aC	8.28 bC	9.63 bC
5 Nov.	19 Sept., 26 Sept., 10 Oct., 24 Oct.	8.59aC	0.90 bD	6.27 aC

[x] Mean separation within columns (capital letters) and within rows (small letters) were by Least Significant Different test (L.S.D.) at 5% level.

Table 9. Effect of preharvest 1-MCP treatment on the peel hue angle of 'Ponkan' mandarin fruit.

Time of harvest	Time of treatment	Hue angle value		
		Control	Black paper bag	Bagged fruit + 1-MCP
19 Sept.	-	109.86 aB[x]	109.86 aB	109.86 aA
26 Sept.	19 Sept.	152.16 aA	143.21 aA	110.46 aA
10 Oct.	19 Sept., 26 Sept.	106.13 aB	102.89 abBC	100.28 bB
24 Oct.	19 Sept., 26 Sept., 10 Oct.	103.81 aB	101.39 abBC	93.83 bC
5 Nov.	19 Sept., 26 Sept., 10 Oct., 24 Oct.	89.72 B	77.73 cC	95.02 aC

[x] Mean separation within columns (capital letters) and within rows (small letters) were by Least Significant Different test (L.S.D.) at 5% level.

Table 10. Effect of preharvest 1-MCP treatment on the chlorophyllase activity of 'Ponkan' mandarin fruit.

Time of harvest	Time of treatment	Chlorophyllase activity ($Units \cdot mg^{-1}$ protein)		
		Control	Black paper bag	Bagged fruit + 1-MCP
19 Sept.	-	1.57 aA[x]	1.57 aA	1.57 aA
26 Sept.	19 Sept.	0.92 bB	1.63 aA	1.94 aA
10 Oct.	19 Sept., 26 Sept.	0.61 aBC	0.62 aB	0.67 aB
24 Oct.	19 Sept., 26 Sept., 10 Oct.	0.37 aC	0.48 aB	0.47 aB
5 Nov.	19 Sept., 26 Sept., 10 Oct., 24 Oct.	0.30 aC	0.36 aB	0.38 aB

[x] Mean separation within columns (capital letters) and within rows (small letters) were by Least Significant Different test (L.S.D.) at 5% level.

Conclusions

In conclusion, our data indicate that fruit bagging with black paper or black plastic bags for 7 weeks can be improved the coloration of fruit peel by increased chlorophyll degradation. In addition, preharvest bagging fruit and 1-MCP combination treatment induced the chlorophyllase activity during initial stage of development and tended to decrease in later stages, until fruits are yellowed. This suggesting that 1-MCP treated fruits or fruits bagged with low light transmittance materials may induce the chlorophyllase activity in mature green of 'Ponkan' mandarin fruit and 1-MCP treated fruit may inhibit the ethylene synthesis.

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採前套袋及處理 1-MCP 促進'椪柑' (*Citrus reticulate* Blanco) 果皮褪綠提升果實品質

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關鍵字：椪柑、1-Methylcyclopropene、採前套袋

摘要：本研究目的為評估採前果實套袋、低溫檢疫與 1-MCP 處理對'椪柑'果實果皮轉色之影響。在 2011 年的試驗中，將'椪柑'果實於採前 7 週套上黑色紙袋或黑色塑膠袋，可加速葉綠素降解，促進果皮轉色，而全可溶性固形物及可滴定酸含量則不受影響。進一步實驗，將果實轉移到五個不同的貯藏溫度後調查品質，結果顯示果實貯藏後，對照組與套袋處理組之全可溶性固形物及可滴定酸含量並無顯著差異。在 2012 年的試驗中，'椪柑'果實在採前 7 週套上黑色紙袋或套黑色紙袋後，以 0.2 g 1-MCP 處理 4 次，每次處理時間 14 小時，套黑色紙袋處理之果實，葉綠素含量顯著較 1-MCP 處理及對照組低。套黑色紙袋可以提升果實發育初期的葉綠素分解酶活性，並縮短發育後期轉色的期間。套黑色紙袋並處理 1-MCP 的果實，套袋 7 週後，減緩轉色效果，其全可溶性固形物顯著較對照組低，可滴定酸則較高。

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