THE INFLUENCE OF SOME PRESERVATIVES (GA3, 1-MCP AND CACL2) ON DELAYING PEEL COLOUR DEGRADATION AND MAINTAINING QUALITY OF SEEDLESS LIME FRUIT (CITRUS LATIFOLIA) DURING COLD STORAGE

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ABSTRACT

The study was conducted to survey the influence of some preservatives (GA3, 1-MCP and $CaCl_2$) on the ability to maintain peel green colour and quality of seedless lime fruit during cold storage. Harvested limes were treated with $CaCl_2$ solution (1; 2; 3%/ 2 minutes), GA3 solution (50; 100; 150 ppm/ 2minutes) and 1-MCP (0.5; 1; 1.5 ppm/ 6 hours) whereas untreated lime fruits were regarded as control. Afterwards the fruits were packed in perforated PE packs and stored at 8°C. Quality assessments were performed from 4 weeks to 10 weeks with 2 weeks intervals. The results indicated that 1-MCP 1-1.5 ppm/6 hours could retain the quality of seedless lime fruit up to 8 weeks of storage at 8°C in terms of retarding in yellowing of the peel, reducing disease and maintaining physico-chemical properties.

***Keywords:** 1-MCP, $CaCl_2$, GA3, lime, storage.*

TÓM TẮT

Khảo sát ảnh hưởng của một số chất bảo quản (GA3, 1-MCP VÀ $CACL_2$) đến khả năng duy trì màu xanh vỏ quả và chất lượng của chanh không hạt trong quá trình tồn trữ lạnh

Chanh không hạt là loại cây có giá trị kinh tế cao ở nước ta, tuy nhiên, một trong những vấn đề làm giảm giá trị thương phẩm của chanh không hạt sau thu hoạch là màu xanh vỏ chanh bị chuyển màu. Vì thế, để duy trì màu xanh vỏ cũng như chất lượng sau thu hoạch của chanh không hạt, "khảo sát ảnh hưởng của một số chất bảo quản (GA3, 1-MCP và $CaCl_2$) đến khả năng duy trì màu xanh vỏ quả và chất lượng của chanh không hạt trong quá trình tồn trữ lạnh" được thực hiện. Chanh được nhúng trong dung dịch $CaCl_2$ nồng độ 1, 2, 3% trong thời gian 2 phút, dung dịch GA3 nồng độ 50, 100, 150 ppm trong thời gian 2 phút, xông 1-MCP nồng độ 0,5; 1; 1,5 ppm trong 6 giờ và đối chứng (không xử lý). Sau đó chanh được bao bằng bao PE đục lỗ và bảo quản ở 8°C. Chất lượng chanh bảo quản được đánh giá sau 4, 6, 8 và 10 tuần bảo quản. Kết quả cho thấy xử lý chanh bằng 1-MCP 1-1,5 ppm trong 6 giờ có thể trì hoãn sự chuyển vàng của vỏ quả, hạn chế bệnh và duy trì chất lượng đến 8 tuần bảo quản ở 8°C.

***Từ khóa:** 1-MCP,bảo quản, chanh, $CaCl_2$, GA3.*

1. Introduction

Seedless lime (*Citrus latifolia*) is one of the citrus trees that have high economic value in Vietnam. Although this is a relatively new imported lime variety originated from California, America, the cultivated area of seedless lime has rapidly increased due to its superior plant pathogen resistance characteristics compared with other citrus species and high yield. One of the reasons which reduced commercial value of postharvest seedless lime fruit was the loss of peel green colour (Rivera-Cabrera *et al.*, 2010).

The loss of peel green colour relates to ethylene gas. Ethylene is a natural plant hormone that induces ripening, senescence process of fruits and vegetables since ethylene relates to biosynthesis process of many kinds of enzymes such as protopectinase enzyme hydolyzing protopectin into soluble pectin leading to soften fruit, oxidation of chlorophyll by chlorophylase enzyme causing loss of peel green colour,... ethylene also increases sensitive characteristic of fruits and vegetables to pathogen.

To constrain the negative impact of ethylene, some methods such as dispelling or adsorption of ethylene, inhibition of the ethylene production or inactivation of ethylene action have been used . In recent years, there have been many research on 1-methylcyclopropene (1-MCP) to preserve fruits and vegetables such as research of Jomori *et al.* (2003) on reduction loss of peel green colour of lime fruits, research of Rosa *et al.* (2014) on reduction loss of peel green colour of oranges, research on preservation of mandarin conducted by Duangsuphan and Shiesh (2013), etc. Gibberelic acid (GA3) also inhibited action of chlorophyllase enzyme caused by ethylene and helped to reduce the change in peel colour from green to yellow in tangerine fruits (Ritenour *et al.*, 2005; Fuji *et al.*, 2008). $CaCl_2$ also reduced the loss of peel green colour of tangerine fruits (Nguyễn Thị Tuyết Mai *et al.*, 2012) and change of flesh colour in apricot (Saba *et al.*, 2016). Seedless lime is a relatively new crop in Vietnam and mostly changes peel green colour after harvest, hence, the study "The influence of some preservatives (GA3, 1-MCP and $CaCl_2$) on delaying peel colour degradation and maintaining quality of seedless lime fruit (*Citrus latifolia*) during cold storage" was carried out to maintain peel green colour and quality of postharvest seedless lime fruits grown in Vietnam.

2. Materials and methods

2.1. Materials

Seedless lime fruits were harvested at proper maturity index from an orchard in Long An province. Packaging materials were polyethylene (PE) bags with 4 perforated holes (Φ 6 mm/ hole).

Utensils were baskets, secateurs and other essential ones. Chemicals included $CaCl_2$, GA_3, 1-MCP.

2.2. Methods

2.2.1. Experimental designs and treatments

Procured seedless lime fruits were transported to laboratory of Postharvest Technology Department and sorted, trimmed, washed by water, dried by fan.

The fruits were divided into 10 groups, each group contained 144 fruits and were treated as the following designed experiment as follows dipping in $CaCl_2$

solutions (1, 2, 3%/ 2 minutes), GA3 solutions (50, 100, 150 ppm/2 minutes), treating by 1-MCP (0.5, 1, 1.5 ppm in closed chamber for 6 hours at 20°C) and untreated ones (control). Then the fruits were dried by fan and packed in PE bags, 12 fruits/pack and stored at 8±1 °C, RH=80-90%.

After 4, 6, 8 and 10 weeks storage duration, 3 packs of each treatment were taken out for quality assessments.

2.2.2. Physicochemical attributes

Peel colour was evaluated around the equator for each fruit by using a Minolta CR-400 chromameter (Japan) and the colour was expressed as L*, a* and b*. Disease percentage was the percentage of number of disease fruit with total observed fruits. Weight loss was the percentage of the loss of weight with the original weight, using electric balance. Firmness of fruit was assessed by using Guss fruit texture analyzer (German). The fruit juice was collected for determination of total soluble solids (TSS), titratable acidity (TA) described by AOAC (2005) and vitamin C ascribed by Silva *et al.* (1999).

2.3. Statistical analysis

The obtained data were analyzed of variance (ANOVA) according to one factorial completely randomized design, using SAS sofware, version 8.1. Treatments were compared by Duncan test at a significance level of $p<0.05$.

3. Results and discussion

3.1. Fruit peel colour

Fruit peel colour is one of the major criteria to assess the quality of seedless lime fruit (Table 1). Results showed that the lightness of peel colour (L* value) of seedless lime fruit in all treatments tended to increase during storage duration, corresponding with the gradually brightening of peel colour. The differences in brightness (L* value) of all treatments were statistically significant after 10 weeks storage duration at 8°C. Similar to the brightness (L*), a* and b* (peel yellow colour) increased with the increase of storage duration which indicated that peel colour of seedless lime has tendency to change to yellow with the increase of storage duration. The loss of peel green colour was caused by the action of chlorophyllase enzyme which related to the production of ethylene during storage duration of the fruit. Seedless lime fruits in control treatment possessed the highest values of L* (brightness), a* and b* (yellow colour) in all evaluated storage duration at 8°C. Treating seedless lime fruits by $CaCl_2$ (1, 2, 3% for 2 minutes), GA3 (50, 100, 150 ppm for 2 minutes) and 1-MCP (0.5, 1, 1.5 ppm for 6 hours) could inhibit the respiration rate, action of ethylene participating in physiological process of fruit hence reduced activity of chlorophyllase enzyme (Serek *et al.*, 1995; Fuji *et al.*, 2008; Nguyễn Thị Tuyết Mai *et al.*, 2012). The loss of peel green colour in seedless lime fruits in 1-MCP 1.5 ppm for 6 hours treatment was the least, the second one was in seedless lime fruits in 1-MCP 1 ppm for 6 hours.

3.2. Disease percentage

Results revealed that there was no detected disease of seedless lime fruit after 6 weeks storage duration at 8°C, however, after 8 weeks storage at 8°C, diseases occured in seedless lime fruit in all treaments except seedless lime fruits treated by 1-MCP 1.5 ppm for 6 hours which was non-significant difference with 1-MCP 1 ppm for 6 hours treatment but significant difference with other treatments (Table 2). After 10 weeks storage at 8°C, diseases appeared in all treatments and there were significant differences among the treatments. There was physiological changes and senescence in the fruit during storage duration, which were favourable conditions for the development of diseases (Prusky và Keen, 1993). The maximum values of disease percentage (19.44% after 8 weeks storage duration and 27.78% after 10 weeks storage duration) were recorded in control treatment. It was clear that treating seedless lime fruits by 1-MCP 1-1.5 ppm for 6 hours could reduce disease of seedless lime fruit because 1-MCP could maintain linkage of cell membrane of fruit, help to withstand the attack of fungal disease (Plainsirichai *et al.*, 2010).

Table 1: The influence of some preservatives (GA3, 1-MCP and $CaCl_2$) on peel colour(L*, a*, b*) of seedless lime fruit during cold storage

Treatments	L*				a*				b*			
	Storage duration (Weeks)				Storage duration (Weeks)				Storage duration (Weeks)			
	4	6	8	10	4	6	8	10	4	6	8	10
$CaCl_2$ 1%	53.62	54.40	54.58	56.32^{abc}	-20.54^{bc}	-19.86^{abc}	-19.50^{ab}	-19.33	43.33^{ab}	47.19	48.27	50.80^{abc}
$CaCl_2$ 2%	53.26	53.95	54.15	54.75^{abcd}	-20.63^{bc}	-20.03^{abcd}	-19.61^{abc}	-19.35	42.93^{abc}	47.11	47.13	50.00^{abc}
$CaCl_2$ 3%	53.19	53.51	53.66	53.93^{bcd}	-20.88^{bc}	-20.32^{bcd}	-20.07^{abcd}	-19.48	42.53^{bc}	47.05	47.05	49.48^{abc}
GA3 50 ppm	54.55	54.79	55.20	57.90^{ab}	-19.77^{ab}	-19.44^{ab}	-19.41^{ab}	-19.18	43.80^{ab}	47.35	48.99	53.82^{ab}
GA3 100 ppm	52.36	53.50	53.61	53.83^{bcd}	-20.96^{bc}	-20.45^{bcde}	-20.21^{abcd}	-19.48	42.24^{bc}	46.76	46.88	48.91^{abc}
GA3 150 ppm	52.15	52.79	53.24	53.33^{bcd}	-21.00^{bc}	-20.56^{cde}	-20.48^{bcd}	-19.58	42.07^{bc}	46.19	46.30	48.49^{bc}
1-MCP 0.5 ppm	51.61	52.05	52.60	52.97^{cd}	-21.02^{bc}	-20.57^{cde}	-20.88^{cd}	-19.65	42.06^{bc}	44.64	45.46	47.50^{c}
1-MCP 1 ppm	51.40	51.54	51.57	52.71^{cd}	-21.05^{c}	-20.98^{de}	-20.96^{cd}	-19.66	41.83^{bc}	44.47	45.27	47.10^{c}
1-MCP 1.5 ppm	50.51	50.93	51.22	51.23^{d}	-21.53^{c}	-21.46^{e}	-21.16^{d}	-19.69	39.63^{c}	44.23	44.44	46.01^{c}
Control	56.15	56.52	58.47	58.85^{a}	-19.30^{a}	-19.15^{a}	-19.02^{a}	-18.99	46.33^{a}	50.11	51.08	54.11^{a}
CV (%)	**3.60**	**4.50**	**4.46**	**4.69**	**3.14**	**2.71**	**3.55**	**2.34**	**4.41**	**5.45**	**5.76**	**5.72**
F	NS	NS	NS	*	*	*	*	NS	*	NS	NS	*

Data shown in the table are mean values of thrice replications; in the same column, means within a column followed by the same letter are not significantly difference at $p<0.05$, "": significant difference, "NS": non-significant difference*

Table 2: The influence of some preservatives (GA3, 1-MCP and $CaCl_2$) on disease percentage of seedless lime fruit during cold storage

Treatments	Disease percentage (%)	
	8 Weeks	10 Weeks
$CaCl_2$ 1%	16.67 (0.42)^{ab}	19.44 (26.06)^{abc}
$CaCl_2$ 2%	13.89 (0.38)^{ab}	16.67 (24.09)^{bcd}
$CaCl_2$ 3%	11.11 (0.34)^{b}	16.67 (24.09)^{bcd}
GA3 50 ppm	16.67 (0.42)^{ab}	22.22 (28.03)^{ab}
GA3 100 ppm	13.89 (0.38)^{ab}	16.67 (24.09)^{bcd}
GA3 150 ppm	11.11 (0.34)^{b}	13.89 (21.66)^{cd}
1-MCP 0.5 ppm	11.11 (0.34)^{b}	13.89 (21.66)^{cd}
1-MCP 1 ppm	2.78 (0.21)^{c}	11.11 (19.22)^{de}
1-MCP 1.5 ppm	0.00 (0.17)^{c}	5.56 (14.51)^{e}
Control	19.44 (0.45)^{a}	27.78 (31.75)^{a}
CV (%)	**17.27**	**13.54**
F	*	*

Data shown in the table are mean values of thrice replications; in the same column, means within a column followed by the same letter are not significantly difference at $p<0.05$, "": significant difference*

3.3. Weight loss

Table 3: The influence of some preservatives (GA3, 1-MCP and $CaCl_2$) on weight loss of seedless lime fruit during cold storage

Treatments	Weight loss (%)			
	4 Weeks	6 Weeks	8 Weeks	10 Weeks
$CaCl_2$ 1%	0.69^{ab}	0.82^{a}	1.17^{b}	1.31^{bc}
$CaCl_2$ 2%	0.65^{ab}	0.81^{a}	0.96^{c}	1.23^{bcd}
$CaCl_2$ 3%	0.59^{abc}	0.79^{a}	0.90^{cd}	1.00^{cde}
GA3 50 ppm	0.71^{a}	0.82^{a}	1.30^{b}	1.47^{b}
GA3 100 ppm	0.56^{abc}	0.71^{ab}	0.89^{cd}	0.98^{cde}
GA3 150 ppm	0.50^{abc}	0.68^{ab}	0.86^{cd}	0.92^{de}
1-MCP 0.5 ppm	0.47^{abc}	0.64^{ab}	0.86^{cd}	0.89^{de}

Treatments	Weight loss (%)			
	4 Weeks	6 Weeks	8 Weeks	10 Weeks
1-MCP 1 ppm	0.42^{bc}	0.64^{ab}	0.79^{d}	0.84^{e}
1-MCP 1.5 ppm	0.36^{c}	0.53^{b}	0.77^{d}	0.84^{e}
Control	0.75^{a}	0.86^{a}	1.58^{a}	2.41^{a}
CV (%)	**25.32**	**15.75**	**8.38**	**16.05**
F	*	*	*	*

Data shown in the table are mean values of thrice replicates; in the same column, means within a column followed by the same letter are not significantly difference at p<0.05, "": significant difference*

Results were conformity with the results of Mendonça *et al.* (2003) that the weight loss of seedledd lime fruit increased with the increase of storage duration. Weight loss was caused by the evaporation of water from the respiration process of the fruit. The rate of evaporation was a function of the supply of water to the evaporating surface from inside the fruit, the vapour pressure gradient from the fruit to the air and the conductance of the surface of the peel (Plainsichirai *et al.*, 2010). There were significant differnces in weight loss among the treatments after 4, 6, 8, 10 storage duration at 8°C. The maximum values were noted in control treatment (0.75-2.41%) compared to others. It was clear that treating seedless lime fruit by $CaCl_2$, GA3 and 1-MCP reduced weight loss in seedless lime fruit compared to control because these preservatives could inhibit respiration process and retain integrity of cell membrane, reduce pressure gradient from the fruit and the air since then reduce evaporation of water, similar with the results of Babu *et al.* (2015) using $CaCl_2$ in loquat, Duguma *et al.* (2014) using GA3 in banana and Plainsirichai *et al.* (2010) using in Rose apple.

3.4. Firmness

Table 4: The influence of some preservatives (GA3, 1-MCP and $CaCl_2$) on firmness of seedless lime fruit during cold storage

Treatments	Firmness (kg/cm^2)			
	4 Weeks	6 Weeks	8 Weeks	10 Weeks
$CaCl_2$ 1%	10.15^{bc}	8.07^{ab}	7.43	7.27
$CaCl_2$ 2%	11.95^{abc}	8.12^{ab}	7.55	7.30
$CaCl_2$ 3%	12.16^{ab}	8.34^{ab}	7.56	7.37
GA3 50 ppm	10.10^{bc}	7.83^{b}	7.24	6.76
GA3 100 ppm	12.49^{ab}	8.75^{a}	7.62	7.60

Treatments	Firmness (kg/cm^2)			
	4 Weeks	6 Weeks	8 Weeks	10 Weeks
GA3 150 ppm	12.70^{ab}	8.79^a	7.85	7.70
1-MCP 0.5 ppm	13.20^a	8.82^a	7.85	7.71
1-MCP 1 ppm	13.25^a	8.84^a	7.96	7.84
1-MCP 1.5 ppm	13.29^a	8.94^a	8.15	8.14
Control	9.29^c	7.44^b	6.84	6.74
CV (%)	**12.34**	**5.69**	**8.20**	**7.77**
F	*	*	**NS**	**NS**

Data shown in the table are mean values of thrice replications; in the same column, means within a column followed by the same letter are not significantly difference at p<0.05, "": significant difference, "NS": non-significant difference*

Firmness of fruit is the linkage of cell wall polymers such as cellulose, hemicellulose and pectin. There were significant differences in firmness among the treatments of seedless lime fruit after 4 and 6 weeks storage at 8°C. The softening of fruit after harvest linked with enzymatic changes and textural modifications leading to breakdown of those polymers by enzymes (Chutichudet *et al.*, 2016). The activity of these enzymes increased related to the production of ethylene during storage duration of fruit. Firmness values in treatments with $CaCl_2$, GA3 and 1-MCP were higher than firmness value in control treatment. $CaCl_2$ was the component to built cell menbrane, helped to maitain structure and cell form (Lester and Grusak, 1999), GA3 increased linkage tissues (Ladaniya, 1997) and 1-MCP inhibited enzymed relating to degradation of cell (Álvarez-Herrera *et al.*,2016). Fimness value in seedless lime fruit by 1-MCP 1.5 ppm for 6 hours was highest (8.14 kg/cm^2) compared to others after 10 weeks storage at 8°C, the second high firmness value (7.84 kg/cm^2) was observed in seedless lime fruit by 1-MCP 1 ppm for 6 hours.

3.5. Total soluble solids

Total soluble solids of seedless lime fruits decreased with the increase of storage duration. There were significant differences among the treatments after 4, 6 and 8 weeks storage at 8°C, but after 10 weeks storage at 8°C, there were non-significant differences among the treatments. The lowest value in total soluble solids was recorded in control treatment. The results were in agreement with those obtained by Akhtar *et al.* (2010) using $CaCl_2$ in loquat fruit, Cao *et al.* (2011) using 1-MCP in loquat fruit, but not consistent with Sakhale and Kapse (2012) using GA3 in sweet orange. Ladaniya and Sonkar (1996) reported that total soluble solids in Nagpur mandarin reduced when fruits were stored at 4-6°C.

Table 5: The influence of some preservatives (GA3, 1-MCP and $CaCl_2$) on total soluble solids of seedless lime fruit during cold storage

Treatments	Total soluble solids (%)			
	4 Weeks	6 Weeks	8 Weeks	10 Weeks
$CaCl_2$ 1%	11.10^{de}	8.60^{b}	8.33^{ab}	8.03
$CaCl_2$ 2%	11.30^{cde}	8.63^{b}	8.53^{a}	8.07
$CaCl_2$ 3%	11.40^{cd}	8.80^{ab}	8.67^{a}	8.07
GA3 50 ppm	11.00^{e}	8.60^{b}	8.30^{ab}	7.83
GA3 100 ppm	11.40^{cd}	8.80^{ab}	8.70^{a}	8.30
GA3 150 ppm	11.60^{bc}	8.83^{ab}	8.77^{a}	8.40
1-MCP 0.5 ppm	11.90^{ab}	9.00^{ab}	8.83^{a}	8.57
1-MCP 1 ppm	12.10^{a}	9.03^{ab}	9.00^{a}	8.63
1-MCP 1.5 ppm	12.20^{a}	9.20^{a}	9.00^{a}	8.83
Control	8.53^{f}	8.00^{c}	7.77^{b}	7.67
CV (%)	**1.67**	**3.33**	**4.42**	**6.67**
F	*	*	*	**NS**

Data shown in the table is mean values of thrice replications; in the same column, means within a column followed by the same letter are not significantly difference at $p<0.05$, "": significant difference, "NS": non-significant difference*

3.6. Titratable acidity

Table 6: The influence of some preservatives (GA3, 1-MCP and $CaCl_2$) on titratable acidity of seedless lime fruit during cold storage

Treatments	Titratable acidity (%)			
	4 Weeks	6 Weeks	8 Weeks	10 Weeks
$CaCl_2$ 1%	6.85	6.43^{cd}	6.19^{cde}	6.17
$CaCl_2$ 2%	6.89	6.47^{cd}	6.41^{bcde}	6.28
$CaCl_2$ 3%	7.06	6.66^{bc}	6.47^{bcd}	6.30
GA3 50 ppm	6.72	6.43^{cd}	6.00^{de}	5.93
GA3 100 ppm	7.17	6.69^{abc}	6.53^{abc}	6.30
GA3 150 ppm	7.19	6.71^{abc}	6.61^{abc}	6.38
1-MCP 0.5 ppm	7.23	6.85^{abc}	6.61^{abc}	6.48
1-MCP 1 ppm	7.26	7.04^{ab}	6.82^{ab}	6.68
1-MCP 1.5 ppm	7.30	7.11^{a}	7.03^{a}	6.73

Treatments	Titratable acidity (%)			
	4 Weeks	6 Weeks	8 Weeks	10 Weeks
Control	6.68	6.21^{d}	5.93^{e}	5.89
CV (%)	**4.52**	**3.42**	**4.37**	**6.75**
F	**NS**	*	*	**NS**

Data shown in the table is mean values of thrice replications; in the same column, means within a column followed by the same letter are not significantly difference at p<0.05, "": significant difference, "NS": non-significant difference*

The results were in accordance with Paliyath and Murr (2008) that titratable acidity of fruit reduced during storage duration because titratable acidity participated in respiration process. There were significant differences among the treatments after 6 and 8 weeks storage at 8°C, but after 10 weeks storage at 8°C, there were non-significant differences among the treatments. Titratable acidity value in seedless lime fruit by 1-MCP 1-1.5 ppm for 6 hours was higher than other treatments during storage duration.

3.7. Vitamin C

Table 7: The influence of some preservatives (GA3, 1-MCP and $CaCl_2$) on vitamin C of seedless lime fruit during cold storage

Treatments	Vitamin C (mg/100 ml)			
	4 Weeks	6 Weeks	8 Weeks	10 Weeks
$CaCl_2$ 1%	27.61^{bcd}	24.38^{cd}	22.93^{cd}	21.87
$CaCl_2$ 2%	30.03^{bcd}	24.87^{cd}	24.54^{bcd}	24.38
$CaCl_2$ 3%	31.32^{abc}	26.00^{bc}	25.19^{bcd}	24.54
GA3 50 ppm	26.16^{cd}	24.22^{cd}	22.93^{cd}	21.80
GA3 100 ppm	31.49^{abc}	26.96^{abc}	25.83^{abc}	25.19
GA3 150 ppm	32.29^{ab}	26.96^{abc}	26.16^{abc}	25.83
1-MCP 0.5 ppm	33.10^{ab}	28.26^{abc}	27.45^{abc}	26.16
1-MCP 1 ppm	33.26^{ab}	30.35^{ab}	29.06^{ab}	26.80
1-MCP 1.5 ppm	36.33^{a}	30.68^{a}	30.19^{a}	29.39
Control	24.87^{d}	21.15^{d}	20.67^{d}	20.34
CV (%)	**10.05**	**9.31**	**9.86**	**12.53**
F	*	*	*	**NS**

Data shown in the table is mean values of thrice replications; in the same column, means within a column followed by the same letter are not significantly difference at p<0.05, "": significant difference, "NS": non-significant difference*

Results also revealed that vitamin C content of seedless lime fruit decreased with the increase of storage duration. The vitamin C loss during storage was known to be due to its antioxidant activity and the respiration process of fruit under postharvest storage conditions (Li *et al.*, 2014). There were significant differences in vitamin C content among the treatments after 4, 6 and 8 weeks storage at 8°C, however, there were non-significant differences in vitamin C content among the treatments after 10 weeks storage at 8°C. Treating seedless lime fruit by $CaCl_2$, GA_3 and 1-MCP helped to reduce the loss of vitamin C content compared to untreated fruit (control). These preservatives could reduce respiration process and oxidative process of vitamin C in the cytosol. The results were in accordance with those explored by Selcuk và Erlan (2015) treating 1-MCP for medlar fruit, Li *et al.* (2014) treating 1-MCP and $CaCl_2$ for jujube fruit and Mahajan *et al.* (2011) treating $CaCl_2$ and GA3 for guava fruit.

4. Conclusions and recommendations

This work suggested that postharvest treating seedless lime fruit with 1-MCP 1-1.5 ppm for 6 hours at 20°C and then stored at 8°C could reduce the loss of peel green colour and maintain quality of the fruits up to 8 weeks.

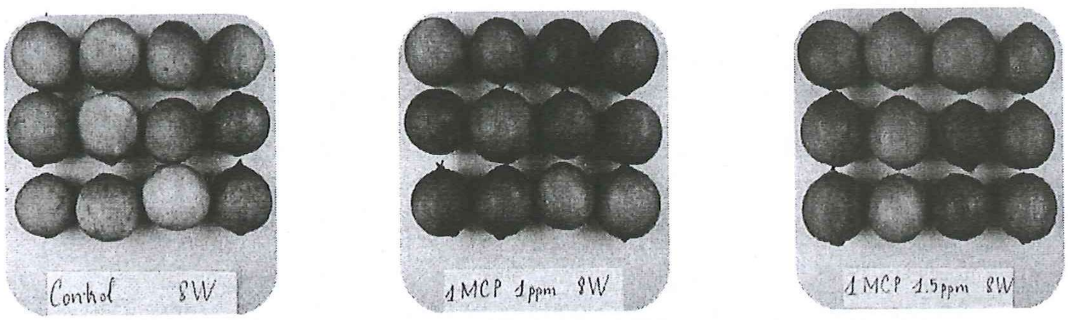

Figure 1: Photos of seedless lime fruits after 8 weeks storage at 8°C

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