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Influence of True Flower Thinning and 1-MCP on Postharvest Changes of 'Chiang Mai Pink' Patumma Cut Flower

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ABSTRACT

Patumma flower is one of the new exported cut flower that faces with the poor vase life affecting to this flower's price after cutting. Effects of true flower thinning in conjunction with 1-MCP fumigation at 0, 100 and 300 ppb on postharvest changes and vase life of patumma flower 'Chiang Mai Pink' was studied at ambient conditions (27°C, 91% RH). A Factorial in Completely Randomized Design was arranged with two factors: flower thinning and 1-MCP concentrations. The experiment was conducted from May-September 2011 with four replications and ten flowers per replication. Flowering weight loss, water uptake, bract color and vase life were recorded every other day. The results showed that treatments with true flower thinning, irrespective of 1-MCP application, caused the least flowering weight loss and maintained the highest bract color in terms of L* and a*. In addition, deflowered flowers with no treatments with 1-MCP had maximal vase life of 20.10 days.

Key words: True flower thinning, 1-MCP, patumma, bract color, vase life

INTRODUCTION

Several species of cut flowers that originate in tropic zones have become important commercial exports, including the patumma flower. Chutichudet *et al.* (2011a) cited that the patumma is one of the most popular exported cut flowers in Thailand due to its attractive large pink bracts. The patumma (*Curcuma alismatifolia*) crop is widely grown in the warm and wet climate zone of Thailand where no less than 30 species have been found (Chutichudet *et al.*, 2011a). Generally, it is regarded as an appealing local ornamental plant and a popular cut flower with high popular commercial demand from foreign markets. Patumma typically form a lotus-like structure, containing a small true flower bud surrounded by a large attractive bright pink bract (Olarn *et al.*, 2007). By nature, the patumma flowers contain one to six flowers on each inflorescent and opens from the base upwards, with oldest flowers at the bottom and youngest flowers at the distal end (Ascough *et al.*, 2008). Halaba and Rudnicki (1986) cited that the flower senescence processes usually occurs very quickly because flowers are composed of many organs and they are not adapted to long term storage after cutting. Due to the fact that the flower is a complex organ, interrelationships between different portions can affect the senescence of the flower (Jambor-Benczur *et al.*, 2010). In addition, the greatest effect on cut flowers is caused by ethylene (Satoh *et al.*, 2005). Ethylene is a plant hormone which plays a crucial role especially in accelerating the flower senescence leading to a shortened vase life in many cut flowers

(Nowak and Rudnicki, 1990; Woltering and van Doorn, 1988; Van Doorn, 2001; Serek *et al*., 2006). Natural pollination in cut flowers affects to advance an increase in ethylene production. Nichols (1977) also reported that senescence in some flowers can be accelerated as a result of pollination. It is known that pollination induces to enhance ethylene production and induces significant changes in cut flowers (Halevy, 1995) like dianthus (Nichols *et al*., 1983), petunias (Whitehead *et al*., 1984) and carnations (Nichols, 1980; Satoh *et al*., 2005). In the absence of pollination, the flowers of carnation, petunia, orchids and cyclamen have a relatively long life span (Woltering and van Doorn, 2009; Halevy *et al*., 1984). Streif *et al*. (2010) reported that 1-methylcyclopropene (1-MCP), is a gaseous compound considered for commercial use (Blankenship and Dole, 2003) that interacts with ethylene receptors by blocking the ethylene binding sites and thereby inhibiting the effects of ethylene action (Serek *et al*., 1995), including maintaining the flower quality and extending the storage life in several cut flowers (Sisler and Serek, 2001; Honghem *et al*., 2007). At present, very little information is available on deflowering treatments combined with 1-MCP application in order to extend the patumma vase life after cutting. Thus, this experiment aimed to investigate the effectiveness of true flower thinning and exogenous 1-MCP as a postharvest tool for extending the vase life and maintaining the quality characteristics of *Patumma* cv., Chiang Mai Pink, in order to assess the potential of these treatments as a pretreatment to extend the flower longevity and improve the qualities of this flower under the ambient temperature conditions.

MATERIALS AND METHODS

Materials: Patumma flowers (*Curcuma alismatifolia*) cv., Chiang Mai Pink were harvested on September 11, 2011 at the commercial stage from a commercial garden in Chiang Mai, in the north of Thailand. Each flower was wrapped with a foam sheath and packed carefully in fiberboard cartons then transported in an air-conditioned vehicle to Mahasarakham University within twelve hours of harvest. During transport, buckets containing stems were covered with a plastic film shroud to minimize moisture loss. After they arrived at the laboratory, the flowers were selected again for uniformity of size, shape, initial bract color and freedom from external damage. The stem end of each flower was recut with stainless steel scissors into lengths of 30 cm.

Methods: The experiment was carried out from May to September 2011 at the Laboratory of the Division of Agricultural Technology, Faculty of Technology, Mahasarakham University, in the northeast of Thailand. The experiment was laid out in a Factorial in Completely Randomized Design and composed of two factors: true flower thinning (deflowering and non-deflowering) and fumigation with 1-MCP at three concentrations (0, 100 and 300 ppm) for 12 h, compared with Control. Each treatment was carried out in four replicates, ten flowers per replication. For deflowering, all true flowers were removed by using forceps to pull individual true flowers (tiny violet flowers emerge from bracts) out of each inflorescence. 1-MCP was applied to patumma flower by fumigation in a closed bin at 25°C for 12 h. Afterwards, all treatments were held in a bottle filled with distilled water 300 mL and stored at ambient temperature (27°C, 91% RH). The Control flowers were untreated with deflowering and 1-MCP fumigation and maintained under identical storage conditions. The following determinations were assessed at 2 day intervals: (1) weight loss of the flowering stalk was calculated as a percentage of the initial weight (%), (2) water uptake by the flowering stalk was measured as mL day^{-1}, (3) Bract color was measured by using a Hunter Lab Model No. 45/0 L, Serial No. 7092, USA. CIE color values L* (black = -100 and white = +100), a*

(redness) (- = green and + = red) and b* (yellowness) (- = blue and + = yellow) were measured to describe the color of the flower's bract and (4) Vase life (days) was judged to have terminated when 30% of the flowers had withered.

Data analysis: The collected data were statistically analyzed using the SPSS Computer Program, Version 6 (SPSS, 1999). Differences between means tested were using Least Significance Differences (LSD) (p = 0.01 and 0.05).

RESULTS

The recorded data, after removing the true flowers combined with 1-MCP fumigation at three concentrations on patumma flowers, were collected and demonstrated the following results.

Weight loss: Interaction of true flower thinning and 1-MCP application did not affect to the flowering weight loss on 2 and 4 days after vase life. There were major differences between treatments with respect to thinning effect and 1-MCP application since 6 days after vase life (DAV). The results from Table 1 revealed that treating with deflowering irrespective of using 1-MCP application showed the lowest flowering stem weight loss of patumma. While the highest weight loss of flowers treated with non-deflowering and receiving 300 ppb 1-MCP was significantly observed since 6-14 DAV. Thus, weight loss of patumma inflorescence was greatly affected by thinning treatment.

Table 1: Weight loss of at different DAV of patumma flowering stalk during vase life

	Weight loss (%)						
Factor	2 DAV	4 DAV	6 DAV	8 DAV	10 DAV	12 DAV	14 DAV
Flower thinning							
No thinning	5.66	15.18	23.83^{a}	28.65^{a}	42.75^{a}	72.55^{a}	87.02^{a}
Thinning	6.90	11.69	16.01^{b}	18.40^{b}	22.89^{b}	27.40^{b}	33.04^{b}
F-test	ns	ns	*	*	*	*	*
CV (%)	5.15	4.85	3.94	4.50	6.78	9.04	7.65
1-MCP conc. (ppb)							
0	4.01	13.00	19.01	22.75	29.13	41.29^{b}	57.55
100	8.49	14.29	20.88	24.09	36.87	55.69^{a}	58.42
300	6.33	13.03	19.86	23.73	32.46	52.95^{a}	64.12
F-test	ns	ns	ns	ns	ns	*	ns
CV (%)	6.30	5.94	4.82	5.56	8.30	11.07	9.37
LSD	3.13	2.95	2.39	2.74	4.13	5.49	4.65
Flower thinning×1-MCP (ppb)							
No thinning×0	1.51	13.70	21.34^{ab}	26.88^{a}	35.65^{b}	55.71^{b}	84.71^{ab}
No thinning×100	9.92	16.62	25.48^{a}	30.38^{a}	51.19^{a}	82.64^{a}	81.50^{b}
No thinning×300	5.54	15.24	24.66^{a}	28.70^{a}	41.42^{ab}	79.31^{a}	94.85^{a}
Thinning×0	6.51	12.30	16.69^{b}	18.62^{b}	22.61^{c}	26.87^{c}	30.39^{c}
Thinning×100	7.07	11.96	16.29^{b}	17.81^{b}	22.55^{c}	28.73^{c}	35.34^{c}
Thinning×300	7.12	10.82	15.06^{b}	18.77^{b}	23.50^{c}	26.60^{c}	33.39^{c}
F-test	ns	ns	*	*	*	*	*
CV (%)	8.92	8.39	6.82	7.80	11.75	15.66	13.24
LSD	4.43	4.17	3.38	3.87	5.83	7.77	6.58

Values followed by different superscripts are significant, Least significant differences (LSD) at *p = 0.05, ns: Non significant, DAV: Day after vase life

Table 2: Water absorption of patumma flowering stalk during vase life

	Water absorption (mL)						
Factor	2 DAV	4 DAV	6 DAV	8 DAV	10 DAV	12 DAV	14 DAV
Flower thinning							
No thinning	4.38	4.43	4.71^{b}	4.93	4.87	5.47	5.19^{a}
Thinning	4.38	4.36	4.82^{a}	4.84	4.86	4.94	4.74^{b}
F-test	ns	ns	*	ns	ns	ns	*
CV (%)	1.81	1.29	1.98	2.49	1.12	9.27	2.72
1-MCP conc. (ppb)							
0	4.39	4.37^{b}	4.78	4.87	4.89^{a}	4.94	4.87^{b}
100	4.39	4.44^{a}	4.76	4.89	4.87^{ab}	5.58	4.88^{b}
300	4.36	4.38^{b}	4.76	4.89	4.83^{b}	5.08	5.14^{a}
F-test	ns	*	ns	ns	*	ns	*
CV (%)	1.81	1.29	1.98	2.49	1.12	9.27	2.72
LSD	0.04	0.03	0.05	0.06	0.03	0.50	0.07
Flower thinning×1-MCP (ppb)							
No thinning×0	4.36	4.38^{abc}	4.68^{c}	4.91	4.87^{abc}	4.96	4.96^{c}
No thinning×100	4.40	4.47^{a}	4.79^{abc}	4.96	4.92^{a}	6.22	5.17^{b}
No thinning×300	4.39	4.43^{ab}	4.66^{c}	4.92	4.83^{c}	5.24	5.46^{a}
Thinning×0	4.42	4.35^{bc}	4.88^{a}	4.83	4.92^{a}	4.93	4.79^{cd}
Thinning×100	4.38	4.42^{ab}	4.73^{bc}	4.83	4.82^{c}	4.95	4.60^{d}
Thinning×300	4.33	4.33^{c}	4.87^{ab}	4.87	4.84^{bc}	4.92	4.83^{c}
F-test	ns	**	**	ns	**	ns	**
CV (%)	1.81	1.29	1.98	2.49	1.12	9.27	2.72
LSD	0.06	0.04	0.07	0.09	0.04	0.71	0.10

Values followed by different superscripts are significant, Least significant differences (LSD) at **p = 0.01, *p = 0.05, ns: Non significant, DAV: Day after vase life

Water uptake: With respect to water uptake by the flowering stem, the results revealed a significantly higher capacity of water uptake from the flowers treated with non-deflowering with 100 ppb 1-MCP on 4 and 10 DAV. While treatment of true flower removal, patumma treated with 100 ppb of 1-MCP, showed the least water uptake since 10-14 DAV (Table 2).

Bract colour: Color measurements of patumma bract were expressed in terms of L* a* and b* values as followed:

L*: Effects of interaction between thinning treatment with 1-MCP concentrations was also significant on L* values. Complete true flower removal, irrespective of 1-MCP concentration, resulted in maintaining more L* values since 12 DAV. While the L* value of flower treated with no-thinning in combination with 1-MCP application at 300 ppb showed the significant decrease in L* was observed on 12 DAV and 14 DAV. The results suggested that removal of true flowers on patumma inflorescence resulted in the more color bract brightness (Table 3)

a*: All a* value, representing the 'red' section of the bract color, the results showed that flowers treated with true flower thinning, regardless of 1-MCP concentration, resulted in maintaining the highest level of bract redness, especially the long lasting since 12 DAV. While non-removal of true flowers and received 1-MCP at 100 and 300 ppb had lower bract redness (Table 4).

Table 3: L* of patumma flower during vase life

	L*						
Factor	2 DAV	4 DAV	6 DAV	8 DAV	10 DAV	12 DAV	14 DAV
Flower thinning							
No thinning	54.39	54.69	57.02	54.25	50.62	43.12	29.65^{b}
Thinning	56.31	52.31	56.71	54.62	48.78	50.75	47.76^{a}
F-test	ns	ns	ns	ns	ns	ns	*
CV (%)	6.76	13.90	5.16	9.22	12.32	13.50	14.48
1-MCP conc. (ppb)							
0	52.80^{b}	52.79^{ab}	56.46	54.38	51.94	48.44	46.82^{a}
100	57.17^{a}	50.94^{b}	57.50	54.59	50.88	49.96	35.67^{ab}
300	56.08^{a}	56.76^{a}	56.64	54.32	46.27	42.41	33.64^{b}
F-test	*	**	ns	ns	ns	ns	**
CV (%)	6.76	13.90	5.16	9.22	12.32	13.50	14.48
LSD	1.18	2.35	0.93	1.59	3.35	5.41	5.56
Flower thinning×1-MCP (ppb)							
No thinning×0	49.97^{b}	54.93^{ab}	55.84	52.68	51.33	53.84^{a}	52.18^{a}
No thinning×100	57.17^{a}	51.36^{ab}	58.45	55.78	51.66	45.48^{a}	21.88^{b}
No thinning×300	56.03^{a}	57.77^{a}	56.77	54.28	48.85	30.04^{b}	14.90^{b}
Thinning×0	55.64^{a}	50.64^{b}	57.07	56.09	52.54	43.03^{ab}	41.45^{a}
Thinning×100	57.17^{a}	50.53^{b}	56.54	53.41	50.10	54.43^{a}	49.46^{a}
Thinning×300	56.13^{a}	55.75^{ab}	56.51	54.36	43.68	54.78^{a}	52.37^{a}
F-test	*	**	ns	ns	ns	**	**
CV (%)	6.76	13.90	5.16	9.22	12.32	13.50	14.48
LSD	1.67	3.33	1.31	2.25	4.74	7.66	7.87

Values followed by different superscripts are significant, Least significant differences (LSD) at **p = 0.01, *p = 0.05, ns: Non significant, DAV: Day after vase life

These results indicated that true flower thinning was extremely effective in maintaining the redness of patumma cut flower. Due to the thinning effect significantly maintained the a* values in bract color

b*: There was no difference of bract color in term of b* values among treatments after 2 and 4 days of vase life. The results showed b* value measured from patumma bract exhibited significant levels since 6 DAV as shown in Table 5. The trends of higher mean b* value ($p<0.01$) over the vase life period was observed from deflowered flower since 6 DAV. Significantly ($p<0.01$) higher mean b* values were observed for thinned flowers treated with 1-MCP at three concentrations on 6 DAV and the lowest mean b* value were observed for no-thinned flowers in combination with 1-MCP. The increase in b* value indicated that patumma bract from deflowered flowers become less yellow, with a subsequent increase as they age and senescence

Vase life: From Table 6, the effect of true flower thinning interaction with 1-MCP on the vase life was observed. The results suggested that the true flower removal in patumma can extend the postharvest life compared to non-deflowered flower. For 1-MCP application at three concentrations (0, 100 and 300 ppb), the results showed similar storage life (13.65-16.15 days). While the interaction of deflowering combined with 1-MCP application, the results revealed that deflowered flowers not receiving 1-MCP (0 ppb) had the maximal vase life of 20.10 days. For non-deflowering,

Table 4: a* of patumma flower during vase life

	a*						
Factor	2 DAV	4 DAV	6 DAV	8 DAV	10 DAV	12 DAV	14 DAV
Flower thinning							
No thinning	14.09	14.02	14.42^{a}	11.70	9.64	6.56^{b}	4.84^{b}
Thinning	14.44	13.45	13.22^{b}	12.11	9.24	10.47^{a}	11.83^{a}
F-test	ns	ns	*	ns	ns	*	*
CV (%)	12.98	17.83	11.26	12.53	14.91	14.94	14.59
1-MCP conc. (ppb)							
0	13.65	14.13	14.05	11.85	11.29^{a}	9.50^{a}	11.58^{a}
100	14.67	13.29	13.57	11.77	10.26^{a}	8.79^{ab}	6.35^{b}
300	14.47	13.78	13.84	12.10	6.78^{b}	7.24^{b}	7.08^{b}
F-test	ns	ns	ns	ns	*	*	*
CV (%)	12.98	17.83	11.26	12.53	14.91	14.94	14.59
LSD	0.58	0.77	0.49	0.47	1.31	1.10	1.28
Flower thinning×1-MCP (ppb)							
No thinning×0	13.09^{b}	14.79	14.61^{a}	11.13^{b}	11.83^{a}	8.24^{ab}	11.58^{a}
No thinning×100	14.37^{ab}	13.52	14.12^{abc}	11.96^{ab}	9.63^{abc}	7.24^{bc}	2.29^{b}
No thinning×300	14.88^{a}	13.76	14.52^{ab}	12.01^{ab}	7.46^{bc}	4.18^{c}	0.64^{b}
Thinning×0	14.28^{ab}	13.48	13.48^{abc}	12.57^{a}	10.74^{ab}	10.76^{a}	11.58^{a}
Thinning×100	14.97^{a}	13.06	13.01^{c}	11.58^{ab}	10.89^{ab}	10.34^{ab}	10.40^{a}
Thinning×300	14.07^{ab}	13.81	13.16^{bc}	12.18^{ab}	6.10^{c}	10.30^{ab}	13.52^{a}
F-test	*	ns	**	**	**	**	**
CV (%)	12.98	17.83	11.26	12.53	14.91	14.94	14.59
LSD	0.83	1.09	0.69	0.66	1.85	1.55	1.81

Values followed by different superscripts are significant, Least significant differences (LSD) at **p = 0.01, *p = 0.05, ns: Non significant, DAV: Day after vase life

irrespective of 1-MCP application, had similar shortest vase life varied from 10.40-12.40 days (Table 6). The results showed the effect of flower thinning on extending the longevity of patumma flowers.

DISCUSSION

With respect to weight loss, the flowering weight losses of patumma rapidly increased during postharvest life. The results showed that decreased flowering weight loss of patumma flower was more strongly correlated to deflowering treating than 1-MCP application. The results indicated that the deflowered flower, irrespective of 1-MCP at different concentrations, affected to lower flower weight loss in a similar manner throughout their vase life. In addition, these flower weight losses remained at low levels for the extended period. The most severe flowering weight losses from non-deflowered flowers received 300 ppb of 1-MCP were seen. These results suggest that deflowered treating, irrespective of 1-MCP application, can be viewed an effective method to maintain flowering weight loss occurring during vase stage. Nakano *et al.* (2003) and Bunya-Atichart *et al.* (2004) cited that patumma flower has fresh reproductive organs which are cut at a young stage and considered as a perishable product and susceptible to readily loosing a lot of water through transpiration immediately after cutting. These results may be due to true flower thinning that brings about having a relatively lower surface area and leads to less intense water loss through evapotranspiration after cutting (Paull *et al.*, 1981; Nakano *et al.*, 2003). This caused

Table 5: b* value of patumma flower during vase life

	b*						
Factor	2 DAV	4 DAV	6 DAV	8 DAV	10 DAV	12 DAV	14 DAV
Flower thinning							
No thinning	-7.41	-7.32	-7.84^{b}	-5.07^{b}	-0.53	0.11^{a}	0.77
Thinning	-7.10	-5.81	-3.94^{a}	-3.07^{a}	-1.13	-1.93^{b}	0.35
F-test	ns	ns	*	*	ns	*	ns
CV (%)	13.10	14.43	12.63	14.96	17.42	15.25	12.43
1-MCP conc. (ppb)							
0	-6.59	-6.63	-6.12	-4.20	-2.08	-1.35	-0.59
100	-8.03	-6.36	-5.62	-3.94	-0.97	-0.61	1.14
300	-7.13	-6.71	-5.92	-4.06	0.55	-1.76	1.13
F-test	ns	ns	ns	ns	ns	ns	ns
CV (%)	13.10	14.43	12.63	14.96	17.42	15.25	12.43
LSD	0.80	1.00	0.53	0.63	1.86	0.73	1.28
Flower thinning×1-MCP (ppb)							
No thinning×0	-6.21	-6.84	-7.82^{b}	-3.80^{ab}	-4.43^{b}	-2.34^{b}	-0.59
No thinning×100	-7.84	-7.30	-7.54^{b}	-5.66^{c}	0.13^{ab}	-1.28^{ab}	2.35
No thinning×300	-8.17	-7.82	-8.15^{b}	-5.73^{c}	2.71^{a}	-2.15^{b}	0.54
Thinning×0	-6.98	-6.42	-4.42^{a}	-4.61^{bc}	0.27^{ab}	-0.36^{ab}	-0.59
Thinning×100	-8.23	-5.41	-3.70^{a}	-2.22^{a}	-0.06^{ab}	0.06^{a}	-0.08
Thinning×300	-6.09	-5.59	-3.69^{a}	-2.38^{a}	-0.62^{ab}	0.63^{a}	1.72
F-test	ns	ns	**	**	**	**	ns
CV (%)	13.10	14.43	12.63	14.96	17.49	19.39	13.59
LSD	1.13	1.42	0.75	0.89	2.64	1.04	1.81

Values followed by different superscripts are significant, Least significant differences (LSD) at **p = 0.01, *p = 0.05, ns: Non significant, DAV: Day after vase life

advantageous results and led to show lower fresh weight loss on true flower thinned flowers. While Chutichudet *et al.* (2011b) found that patumma flowers treated with 300 ppb of 1-MCP for 15 h had the least weight loss of the flowering stem. However, the mechanisms of true flower thinning accounting for lower flowering loss in cut patumma have not been determined. Further work will be required to determine whether deflowering treating effects to reduce the flowering weight loss.

For water uptake, during vase life, water uptake by patumma flowers showed no marked decrease through the end of storage period. Water uptake of flowers treated with non-deflowering and 100 ppb of 1-MCP remained as the highest amount of water through their flowering stems at 4 and 10 DAV while the removal of true flowers, regardless of 1-MCP application, affected to reduce the water uptake by flowering stem. These results indicate that the degree of flowering weight loss of patumma is not proportional to the water uptake. Generally, change in the flower fresh weight is mainly due to a change in water content absorbed by the flowering stem (Halevy and Mayak, 1979; Itzhaki *et al.*, 1989). This is in agreement with Carpenter and Rasmussen (1974) who found that there is a close relationship between water uptake and transpiration. Similar results were reported by Watakoa and Mundia (2011) who investigated the effect of flower thinning on the quality of harvested moby dick flowers. They cited that thinning significantly influenced to lower water absorption by flowering stem. It also may be possible that thinning treatments tend to reduce the competition for supplies of assimilates thus resulting in lowering water uptake (Watakoa and Mundia, 2011). In addition, these results may be partially explained by the

Table 6: Significance of true flower thinning and 1-MCP concentration on vase life

Factor	Vase life (days)
Flower thinning	
No thinning	11.67[b]
Thinning	17.97[a]
F-test	**
CV (%)	20.81
1-MCP conc. (ppb)	
0	16.15
100	14.65
300	13.65
F-test	ns
CV (%)	29.43
LSD	0.9750
Flower thinning×1-MCP (ppb)	
No thinning×0	12.20[e]
No thinning×100	12.40[e]
No thinning×300	10.40[e]
Thinning×0	20.10[a]
Thinning×100	16.90[b]
Thinning×300	16.90[b]
F-test	**
CV (%)	19.67
LSD	0.9221

Values followed by different superscripts are significant, Least significant differences (LSD) at **p = 0.01, ns: Non significant. DAV: Day after vase life

development of the ovary. Matsushima *et al.* (2005) suggested that after pollination, the water uptake by cut carnation continued to increase because the ovary requires water to continue development. However, very limited research about the effect of deflowering practices on water uptake through the flowering stem has been conducted with the patumma flower. Further research is needed in order to have a better understanding of the reason for deflowering treating affects to reduce the water uptake in patumma flower.

For bract color, after applying true flower thinning and 1-MCP concentrations, color measurement data on patumma bract in terms of L*, a* and b* are shown in Table 3-5. The color measurement data collectively showed that the bract color is linked to deflowering treating. These observations indicated a direct involvement of true flower thinning on patumma inflorescence delayed dramatic changes in the bract color. Best results on bract color were attained with true flower thinning, irrespective of 1-MCP application. As the postharvest life progressed, a highly significant increase in bract lightness (L*), redness (a*) and yellowness (b*) were observed, with the highest mean values recorded from flowers treated with deflowering, irrespective of 1-MCP application. The results revealed that true flower removal treatments, irrespective of 1-MCP concentration, have advantageous effects by maintaining bract color in terms of L*, a* and b* values. These results indicated that the bract of deflowered flowers provides more brightness, redness and yellowness to the patumma bract. These data are consistent with those of Halevy (1995) who reported that non-pollinated cyclamen flowers produce very little ethylene synthesis during their whole life span. Consequently, non-pollination renders the flower tissues be less sensitive to ethylene and leads to preserve their bright colors (Jiang, 2000). This is in agreement

with Paull *et al.* (1981) who reported that removal of flowers had a delaying on the development of leaf blackening in *Protea*. Halevy (1995) also cited that non-pollinated cyclamen flowers produce very little ethylene and causes them to be insensitive to ethylene. Halevy (1986) cited that in many flowers pollination results in considerable enhancement of senescence, especially fading in carnation and petunia. In addition, the reason for this accounting may be due to the non-deflowering flowers losing their physical properties of membrane permeability rapidly during vase life. The changes in the physical properties of plant membrane lead in turn to overt signs of bract discolor (Barber and Thompson, 1980). These results were in line with Faragher *et al.* (1986) who found that changes in membrane permeability play a critical role in regulation of rose petal color. Faragher *et al.* (1986) also cited that the senescence of flowering bract leads to degradation of pigments and ultimately change to bract color. However, the role of true flower thinning on maintaining the bract color of patumma during the vase life is unclear. It is not fully established whether the bract color is controlled by the deflowering treatment. Further research is needed in order to have a better understanding of the effect of deflowering treatment on the bract color of patumma flower.

For vase life, the vase life duration of patumma flower at ambient temperature was apparently influenced by the deflowering without 1-MCP application. As can be seen in Table 6, the vase life of flowers treated with only deflowering increased to be the maximal vase life of 20.10 days. The results were consistent with the findings of Halevy (1986) who indicated pollination enhances the sensitivity of the flower to ethylene while non-pollinated cyclamen flowers are long-lived because they produced very little ethylene during the postharvest life of the flower. He suggested that pollination caused to induce abundant ethylene formation and led to hasten the flower senescence. While pre-treatment with 1-MCP alone and the combination of deflowering treating and 1-MCP were ineffective in terms of extending the postharvest life of patumma flower. These results revealed that treatment with deflowering treating significantly delayed the onset of flower senescence while the shortest mean of vase life were obtained with no thinning, irrespective of 1-MCP application. In addition, after cutting the flower, the natural supply of water, carbohydrates, hormones and other substances is cut off (Noordegraaf, 1999). Thus, senescence processes usually occur very quickly because flowers are composed of many organs and are not adapted to long term survival separate from the mother plant (Halaba and Rudnicki, 1986). It is evident that during vase life of the flower a considerable proportion of the food reserve is consumed when the flower is opening. This is in agreement with the previous data of Rudnicki *et al.* (1986) who cited that cut flowers do not have sufficient amounts of storage materials and endogenous sources of energy. In terms of storage conditions, the length of storage period depends primarily upon the food reserves. Thus, it may be possible that the removal of the true flower out of patumma inflorescence had better apparent food reserves than non-deflowered flower. Similar results were reported by Egli and Bruening (2003) who cited that the more food reserves response to removal the true flower might be the benefit effect to extend the flower's longevity. Thus, it may be suggested that deflowering treating in patumma can serve as strong sinks for food reserve when some reproductive structures are not allowed to develop. This implies that such deflowering practices dramatically increase the patumma's vase life, presumably because of the higher food reserves in flowering stem which lead to a progressive flower longevity (Burge *et al.*, 1996). It is probable; therefore, these significant changes that occur in the deflowering thinning in patumma are involved in delaying the senescence processes. Van der Meulen-Muisers *et al.* (1995) also suggested that a similar response was found after elimination of developing terminal flower buds by hand after harvest which significantly increased the longevity of the remaining flowers in

inflorescences of Asiatic Hybrid Lilies. They suggested that the increase in flower longevity of the remaining flowers after bud removal was mainly attributed to a decrease in sink strength within the harvested inflorescence. The opposite results were reported by Reid (1989) who cited that removal of the gynoecium from the carnation flower does not affect the timing of flower senescence. In addition, Hunter *et al.* (2004) found that non-pollinated Daffodil flowers produced negligible amounts of ethylene (<0.5 nL g^{-1} FW h^{-1}) throughout its display life which brings about to delay floral senescence. While the 1-day-old flowers were cross-pollinated, ethylene production in the flowers rose within 24 h to a broad peak at 48 h which coincided with acceleration of flower senescence (Kato *et al.*, 2002). For combination of deflowering treating and 1-MCP treatment, the results showed it was less effective than deflowering treatment alone. It is unclear why the combination of deflowering treating and 1-MCP treatment were less effective than deflowering treatment alone in controlling the physical changes of patumma flower. However, the specific mechanism of removal true flower in the physical changes and increased shelf-life of cut patumma flower is not fully understood. There is only limited information about the causes which deflowering treatment extends patumma vase life. Additional experiments are needed to further investigate the effects of removal of the true flower of patumma in the response to control the postharvest life and extend their storage life.

CONCLUSION

In conclusion, true flower thinning has been proved beneficial, as:

- True flower thinning treatments significantly improved the minimum flowering weight loss
- Postharvest true flower thinning treatment significantly maintained bract color in terms of L*, a* and b*
- Pretreatment with thinning true flower significantly improved patumma vase life of 20.10 days

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