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Effect of 1-MCP on Vase Life and Other Postharvest Qualities of Patumma (*Curcuma alismatifolia*) cv. Chiang Mai Pink

P. Chutichudet, B. Chutichudet and K. Boontiang
Department of Agricultural Technology, Faculty of Technology, Mahasarakham University, Mahasarakham 44000, Thailand

Corresponding Author: Dr. Benjawan Chutichudet, Department of Agricultural Technology, Faculty of Technology, Mahasarakham University, Mahasarakham 44000, Thailand

ABSTRACT

The objective of this study was to extend patummas shelf life by using a substance against ethylene action, 1-Methylcyclopropene (1-MCP). The experiment was arranged in a Factorial in completely randomized design, composed of two factors : 1-MCP concentration at four levels (0, 300, 600 or 900 ppb) and period of fumigation at two levels (4 or 8 h) in a hermetically sealed plastic bucket (50 L) at 25°C. Afterwards, the treated and untreated flower stems were dipped in a plastic bottle filled with distilled water and stored in ambient temperature (27.5°C, 91% R.H.). Each treatment consisted of 10 replicates, one flower per replication. The experiment was carried out from June to August, 2008 at the laboratory of the Division of Agricultural Technology, Faculty of Technology, Mahasarakham University, in the Northeast of Thailand. The results showed no obvious differences in shelf life, except that the flower-treated with 600 ppb of 1-MCP for 8 h had the least storage life of 6.40 days. Treatment with 1-MCP had no effect on water uptake, rot appearance and wilting percentage. In addition, flower-treated with 1-MCP at 600 and 900 ppb for 4 and 8 h retained a higher content of anthocyanin by 26.57 and 16.32 mg/100 g Fresh Weight (FW) by 4 and 10 days after vase life (DAV), respectively.

Key words: 1-MCP, anthocyanin content, *Curcuma alismatifolia*, flowers, vase life

INTRODUCTION

Patumma (*Curcuma alismatifolia*), or Siam Tulip, is an annual monocotyledon crop which is considered a perennial like ginger in Zingiberaceae. In Thailand, this plant is widely grown and no less than 30 species have been found. *Curcuma alismatifolia* is regarded as an attractive local plant and a popular cut flower with high commercial demand. Patumma typically form a lotus-like structure, containing a small flower bud and open flower surrounded by a large attractive bright pink bract (Olarn *et al*., 2007). Olarn *et al*. (2007) reported that after the flower was cut from its plant, the display life is a relatively short at only seven days. Furthermore, patumma flowers rapidly lose their attractive color appearance after cutting. Such changes have a major negative impact upon the sale value at market. Generally, post-harvest senescence of flower has been attributed mainly to ethylene. In the presence of ethylene, it led to flower senescence, shortening of life and loss bright color (Jiang, 2000). Bunya-Atichart *et al*. (2004) indicated that the shorthened vase life of *Curcuma alismatifolia* var. Chiang Mai Pink may be related to ethylene. In order to extend storage life of patumma flower it is necessary to control ethylene production and

perception (Macnish *et al.*, 2004). Recently, an ethylene action inhibitor, the compound 1-methylcyclopropene (1-MCP) has been reported to prolong the display life of several horticultural commodities (Honghem *et al.*, 2007) by acting as a competitor with ethylene for the binding site on the ethylene receptor. These inhibit ethylene responses in various cut flowers (Sisler *et al.*, 1996). Furthermore, 1-MCP has been considered as non-toxic for humans and the environment (Blankenship and Dole, 2003). Thus, 1-MCP is currently being viewed as a strong potential alternative to apply in commercial use for cutflowers (Feng *et al.*, 2000) included asiatic lilies (*Lilium*) Cordelia and Elite and Easter lily (*Lilium longiflorum*) Lorena (Elgar *et al.*, 1999), petunia (*Petunia hybrida*) Pink Cascade (Serek *et al.*, 1995c), cut carnation Sandra (Serek *et al.*, 1995a), holiday cactus (*Schlumbergera*) (Serek and Sisler, 2001) and Dendrobium orchid inflorescence (Uthaichay *et al.*, 2007). At present, there is still a need for more information of 1-MCP applications on the postharvest of the patumma flower. Thus our hypothesis was that 1-MCP application had some effects to shelf life and other postharvest qualities of patumma flower. This experiment aims to investigate the effectiveness of exogenous 1-MCP as a postharvest tool for extending the potential vase life and other characteristics of patumma flower.

MATERIALS AND METHODS

Patumma flowers (*Curcuma alismatifolia*) cv. Chiang Mai Pink harvested at the commercial stage were purchased 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. After they arrived the laboratory, the flowers were selected again for the uniformity in size, shape, initial bract colour and freedom from external damage before being placed into the chambers for fumigating with 1-MCP. Each flowering stem was recut with stainless steel scissors into 30 cm in length. The experiment was carried out from June to August 2008 at the Division of Agricultural Technology, Faculty of Technology, Mahasarakham University, in the Northeast of Thailand. A factorial in compeletly randomized design was arranged and composed of two factors: concentration of 1-MCP four levels (0, 300, 600 or 900 ppb) with two periods of fumigation time (4 or 8 h). While control flowers were sealed in identical chambers without added 1-MCP, different concentrations in combination with fumigation periods were used as treatments: 0 ppb 4 h (T_1), 0 ppb 8 h (T_2), 300 ppb 4 h (T_3), 300 ppb 8 h (T_4), 600 ppb 4 h (T_5), 600 ppb 8 h (T_6), 900 ppb 4 h (T_7) and 900 ppb 8 h (T_8). Each treatment was carried out in ten replicates, one flower per replication. All treatments were taken in sealed 50 L plastic buckets of 50 L capacity containing distilled water and exposed to different concentrations of 1-MCP (0, 300, 600 or 900 ppb) with two periods of time (4 or 8 h) at 25°C. After the period of exposure, each flowering stem end was subsequently stood in 500 mL plastic bottle containing distilled water and stored in ambient temperature (27.5°C, 91% R.H.). The following determinations were recorded every other day for assessments of (1) fresh flower weight (g), (2) water uptake by flowering stalk, (3) vase life (days) was considered terminated when 30% of the flowers had withered, (4) percentage of decay incidence was assessed visually on individual flower and scores were given ranging from 0 to 100%, (5) wilting was assessed as percentage by visual mean and scores were given ranging from 0 to 100% and (6) total anthocyanin content was determined according to the method of Ranganna (1997) that compared with absorbance value at wavelength of 535 nm at 530 nm by the use of spectrophotometer model V-325-XS, from China. Total anthocyanin content was expressed as mg per 100 g fresh weight. The collected data were statistically analysed using the SPSS Computer Program, Version 6 (SPSS, 1999).

RESULTS AND DISCUSSION

After exposure with different concentrations of 1-MCP (0, 300, 600 or 900 ppb) and various periods of time (4 or 8 h) and then kept in plastic bottle containing distilled water stored at ambient temperature, the recorded data composed of:

Flowering stalk weight: All patumma flowers decreased their weight as storage time prolonged. There were significant effects on flowering weight exposed to 1-MCP at different concentrations and fumigation periods. The minimum weight of flowers treated with 1-MCP at 600 ppb for 8 h and 300 ppb for 4 h were observed by 32.17 and 23.59 g by 6 and 14 DAV, respectively (Table 1).

Water uptake: For combination of 1-MCP concentrations with periods of fumigation, the results showed highly significant differences in the water uptake by flowering stalks. The differences were observed only by the initial 2 and 4 DAV. Flower-treated with 1-MCP at 900 ppb for 4 h uptook the maximal amount of distilled water (3.50 and 8.90 mL by 2 and 4 DAV, respectively) (Table 2).

Shelf life: Exposure to different concentrations and fumigation periods of 1-MCP had no significant effect on the vase life of flowers except 600 ppb of 1-MCP for 8 h. This treatment had the least shelf life only 6.40 days (Table 3).

Table 1: Weight of patumma flowering stalk during vase life

	Flowering stalk weight (g) at DAV				
Factor 1-MCP conc. (ppb)	6	8	10	12	14
0	36.81	34.65	33.05	31.65	28.38
300	36.37	34.59	32.23	29.85	26.04
600	34.81	34.06	31.59	30.87	27.25
900	39.86	37.27	34.85	33.31	29.71
F-test	ns	ns	ns	ns	ns
CV (%)	15.72	16.08	16.21	14.09	16.36
LSD	1.2994	1.4222	1.3435	1.3271	1.3640
Fumigation time (h)					
4	37.22	35.41	33.00 3030.91	30.91	27.66
8	36.70	34.80	32.85	31.81	27.81
F-test	ns	ns	ns	ns	ns
CV (%)	16.30	16.19	16.38	14.38	16.86
Conc. X fumigation time					
0 ppb 4 h	36.78abc	36.05	34.66a	34.57a	31.91a
0 ppb 8 h	36.84abc	33.05	31.19abc	29.21ab	25.45bc
300 ppb 4 h	34.24bc	31.90	29.22bc	26.59b	23.59c
300 ppb 8 h	38.50ab	37.57	35.57a	32.38ab	27.95abc
600 ppb 4 h	37.45ab	35.62	33.15ab	30.82ab	27.23abc
600 ppb 8 h	32.17c	30.16	27.70c	31.22ab	27.44abc
900 ppb 4 h	40.41a	38.17	35.29a	32.99a	29.37abc
900 ppb 8 h	39.31ab	35.75	34.11ab	33.63a	30.05ab
F-test	*	ns	*	*	*
CV (%)	15.39	15.32	15.10	12.78	15.22
LSD	1.7990	1.9927	1.8402	2.0503	2.1609

Letters within columns indicate least significant differences (LSD) at *p = 0.05, NS: Non significant

Table 2: Water uptake by flowering stalk of patumma during vase life

Factor	Water uptake (mL) at DAV				
1-MCP conc. (ppb)	2	4	6	8	10
0	2.40	5.25	6.25	4.73	2.73
300	2.60	6.75	5.00	6.40	4.40
600	2.95	4.65	6.20	4.85	3.77
900	2.40	6.10	6.30	4.88	3.65
F-test	ns	ns	ns	ns	ns
CV (%)	15.58	16.90	16.17	14.51	13.23
LSD	0.2984	0.7236	0.6130	0.8068	0.6792
Fumigation time (h)					
4	2.85	7.05a	6.15a	4.76	3.57
8	2.33	4.33b	5.73b	6.04	3.86
F-test	ns	**	**	ns	ns
CV (%)	20.63	22.62	26.36	25.95	23.86
Conc. X fumigation time					
0 ppb 4 h	2.00 bc	6.60ab	6.50	4.50	3.13
0 ppb 8 h	2.80 ab	3.90cd	6.00	5.00	2.29
300 ppb 4 h	2.70 ab	6.70ab	4.70	4.60	2.80
300 ppb 8 h	2.50 ab	6.80ab	5.30	8.20	6.00
600 ppb 4 h	3.20 a	6.00bc	7.70	5.44	4.22
600 ppb 8 h	2.70 ab	3.30d	4.70	3.50	2.75
900 ppb 4 h	3.50 a	8.90a	5.70	4.50	4.10
900 ppb 8 h	1.30 c	3.30d	6.90	5.43	3.00
F-test	**	**	ns	ns	ns
CV (%)	27.00	24.30	25.08	28.49	22.03
LSD	0.3846	0.8867	0.8465	1.1364	0.9465

Letters within columns indicate least significant differences (LSD) at **p = 0.01, NS: Non significant

Rot appearance: There was gradual increment in rot occurrence of the patumma flower and it coincided with an increase in degree of storage. After the initial ten DAV, rot was not evident in any of the patumma flowers. Afterwards, all treatments began to decay on their bracts but the percentage of decay showed no significant differences. Rot appearance of patumma flower showed similar patterns in the 1-MCP-treated and the control flowers (Table 4).

Wilting: Patumma began to show marked bract wilting, as measured by visual means, on the first two days. From Table 5, the results showed that the wilting of the patumma flower was similar upon ambient storage, except for flowers-treated with 1-MCP at 600 ppb for 8 h appeared to have the maximal wilting percentage of 23.50 and 39.70 by 4 and 6 DAV, respectively (Table 5).

Anthocyanin content: The results presented in Table 6 showed that anthocyanin content gradually decreased both in control and 1-MCP treated flowers throughout the storage. The highly significant difference in anthocyanin content, between treated flower and control, was presented after storage. Flower-treated with 600 ppb of 1-MCP for 4 h showed the highest anthocyanin content (26.57 mg/100 g fresh weight) by the initial 4 DAV, while flower-treated with 900 ppb of 1-MCP for 8 h consisted of the maximum anthocyanin content (16.32 mg/100 g fresh weight) by 10 DAV (Table 6).

Table 3: Vase life of patumma after fumigation with 1-MCP

Factor 1-MCP conc. (ppb)	Vase life (days)
0	11.65ab
300	13.35a
600	9.15b
900	12.05a
F-test	*
CV (%)	16.93
LSD	0.9537
Fumigation time (h)	
4	Z2.38
8	10.73
F-test	ns
CV (%)	18.14
Conc. X fumigation time	
0 ppb 4 h	12.50a
0 ppb 8 h	10.80a
300 ppb 4 h	12.90a
300 ppb 8 h	13.80a
600 ppb 4 h	11.90a
600 ppb 8 h	6.40 b
900 ppb 4 h	12.20a
900 ppb 8 h	11.90a
F-test	**
CV (%)	15.53
LSD	1.2976

Letters within columns indicate least significant differences (LSD) at *p = 0.05, **p = 0.01, NS: Non significant

The effects of different concentrations in combination with fumigation periods of 1-MCP to vase life and other postharvest characteristics was investigated in patumma Chiang Mai Pink. The results revealed that the effects of 1-MCP in this study were quite invariable among the treatments. Many reasons for these may be due to the fact that the patumma flower was cut at a young stage. At this stage, Nakano *et al.* (2003) cited that ethylene production was induced within a few days of detachment in all flower tissues and led to a burst of ethylene production. These brought about a hastening of the senescence of the flower (Abeles *et al.*, 1992). The effectiveness of 1-MCP to protect flowers from ethylene also depended on 1-MCP application. Blankenship and Dole (2003) found that the concentration of 1-MCP gas in fumigated plant material declined with time. In addition, the patumma flower is considered as inflorescent on the cut stem which 1-MCP may only partially protect, presumably due to different tissue ages (Sisler *et al.*, 1996; Newman *et al.*, 1998). However, mechanisms of 1-MCP for inhibiting ethylene production in cut patumma have not been determined.

The relationship between different concentrations and application times of 1-MCP did not show significant interaction between the two except for anthocyanin content in the bract as shown in Table 6. This may be due to the exposure times to 1-MCP at different concentrations and that there may be insufficient time to block the production and action of ethylene because the effects of 1-MCP depend on the plant species (Serek *et al.*, 1995c). These corresponded to the results of Jeong *et al.* (2002) who cited that an exposure 1-MCP for 6 h at 0.45 μL L^{-1} was not enough to control ethylene production in avocado. While, Blankenship and Dole (2003) reported that effective durations for

Table 4: Rot appearance of patumma during vase life

	Rot appearance (%) at DAV (days)		
Factor 1-MCP conc. (ppb)	12	14	16
0	5.60	4.44	5.71
300	6.19	6.36	5.00
600	7.75	9.00	3.29
900	4.00	2.60	-
F-test	ns	ns	ns
CV (%)	13.66	15.39	18.96
LSD	1.3140	1.9310	2.8704
Fumigation time (h)			
4	5.60	4.84	2.00
8	6.05	7.47	6.82
F-test	ns	ns	ns
CV (%)	15.06	12.06	14.53
Conc. X fumigation time			
0 ppb 4 h	4.20	3.20bc	2.00
0 ppb 8 h	7.00	6.00abc	10.67
300 ppb 4 h	4.86	1.25c	0.00
300 ppb 8 h	7.22	9.29ab	7.50
600 ppb 4 h	8.43	11.60a	3.33
600 ppb 8 h	3.00	-	-
900 ppb 4 h	4.33	5.75abc	-
900 ppb 8 h	3.60	2.60c	3.25
F-test	ns	*	ns
CV (%)	13.89	17.49	15.77
LSD	2.2285	2.2025	4.0675

Letters within columns indicate least significant differences (LSD) at *p = 0.05, NS: Non significant

1-MCP application should be 12-24 h to achieve a full response. Thus, patumma may be required to apply 1-MCP for the higher concentrations or longer durations to prevent the ethylene effects.

The results on postharvest qualities of patumma were similar to Sisler *et al.* (1996), who reported that 5 nl L^{-1} 1-MCP for 6 h prevented the effects of ethylene and stored carnation flowers for 10 days at room temperature. While, these results are in contrast to Macnish *et al.* (2004), who found that the flower longevity, fresh weight loss, floret wilting and flower senescence in several Australian native cut flowers, may have declined by 1-MCP application. These indicated that 1-MCP did not completely eliminate the effect of ethylene (Serek *et al.*, 1995b). In addition, this may be derived from the fact that 1-MCP binds temporarily to receptors after treatment and the new receptor sites of ethylene may be resynthesized after further storage and then the flower eventually senescence. These revealed that 1-MCP may not completely eliminate the effect of ethylene (Serek *et al.*, 1995b). While Honghem *et al.* (2007) studied the effect of exposure duration of 1-MCP on the postharvest quality and display life of Mokara Jairak Gold by fumigating with 1-MCP at 250 nl L^{-1} for 3, 6 and 12 h. The result revealed that flower treated with 1-MCP at all treatments maintained the quality and had significantly longer display life than the control. However, at present there is not any research that has determined the effectiveness of 1-MCP to eradicate the ethylene production in cut patumma.

Table 5: Wilting appearance of patumma during vase life

Factor	Wilting percentage (%) at DAV				
1-MCP conc. (ppb)	2	4	6	8	10
0	0.10	5.80ab	13.95ab	9.60	11.71b
300	0.00	1.40b	5.05b	6.63	11.00b
600	0.95	13.20a	24.65a	15.62	27.92a
900	0.00	5.80ab	6.40b	10.18	15.33b
F-test	ns	*	**	ns	*
CV (%)	14.19	18.28	15.48	15.30	18.13
LSD	0.2795	2.7430	4.3501	2.4289	4.1021
Fumigation time (h)					
4	0.05	2.75b	7.70b	11.05	16.91
8	0.48	10.35a	17.33a	8.78	14.42
F-test	ns	**	*	ns	ns
CV (%)	14.77	17.13	16.27	18.26	10.56
Conc. X fumigation time					
0 ppb 4 h	0.20b	3.50b	14.90b	10.00	9.71
0 ppb 8 h	0.00b	8.10b	13.00b	9.14	13.71
300 ppb 4 h	0.00b	0.70b	2.30b	7.30	11.88
300 ppb 8 h	0.00b	2.10b	7.80b	5.89	10.22
600 ppb 4 h	0.00b	2.90b	9.60b	13.11	27.78
600 ppb 8 h	1.90a	23.50a	39.70a	21.25	28.33
900 ppb 4 h	0.00b	3.90b	4.00b	13.80	16.00
900 ppb 8 h	0.00b	7.70b	8.80b	5.00	14.57
F-test	**	**	**	ns	ns
CV (%)	14.07	17.89	15.76	13.96	10.68
LSD	0.3736	3.5604	5.7673	3.4894	6.3071

Letters within columns indicate least significant differences (LSD) at *p = 0.05, **p = 0.01, NS: Non significant

The weight of the patumma flower steadily declined throughout its display life. The results from Table 1 showed that there was marked effect of 1-MCP on flower weight. This was probably due to the fact that the patumma flower is a perishable product and susceptible to readily loosing a lot of water through transpiration immediately after cutting (Nakano *et al*., 2003). In addition, Landrigan *et al*. (1996) cited that weight loss was concomitant decline in water potential of fresh-cut products. As water potential decreased, cell turgor also declined leading to a loss of turgor and eventually decreased weight loss. Porat *et al*. (2001) also found the similar effect on Oroblanco pummelo after exposing to 1-MCP at 2000 nl L^{-1} resulted in greater weight loss than in control fruit. This may be due to 1-MCP treatment at high concentrations imposing a stress on the tissue and this coupled with the excessive water loss, caused the deleterious results and led to the eventual weight loss (Ben-Yehoshua and Cameron, 1989).

The results of water uptake by flowering stalk showed a similar trend during vase life. This may be due to after detaching, the flowers have no renewable source of water to compensate for that lost through transpiration. Detached flowers therefore experience water stress, which might be involved in ethylene induction and led to eventually senescence (Apelbaum and Yang, 1981).

For shelf life, flower longevity of patumma in this study showed no significant difference, except that treatment with 1-MCP at 600 ppb for 8 h significantly hastened the decrease in vase life to only 6.40 days (Table 3). From the results of this study the range of dosage and period of fumigation pre-treatment with 1-MCP would not seem to be effective in extending the shelf life of

Table 6: Anthocyanin content of patumma during storage

Factor	Anthocyanin content (mg/100 g FW) at DAV				
1-MCP conc. (ppb)	2	4	6	8	10
0	17.41b	18.40b	15.91b	13.95	11.25b
300	16.65b	19.12b	16.43b	14.87	13.11ab
600	23.52a	25.13a	18.17a	15.63	14.00a
900	17.90b	18.52b	17.47ab	15.90	14.13a
F-test	**	**	*	ns	*
CV (%)	13.11	8.94	11.73	13.53	19.53
LSD	0.85	0.52	0.58	0.59	0.74
Fumigation time (h)					
4	17.41	20.24	16.21b	14.25b	11.87b
8	16.65	20.35	17.78a	15.93a	14.37a
F-test	ns	ns	**	**	**
CV (%)	16.28	16.62	11.71	13.00	18.72
Conc. X fumigation time					
0 ppb 4 h	19.75cd	17.21d	13.99d	11.78c	8.05e
0 ppb 8 h	22.73bc	19.59c	17.83ab	16.12a	14.45b
300 ppb 4 h	21.83bc	19.70c	17.04abc	16.29a	14.95b
300 ppb 8 h	21.40bcd	18.54cd	15.83cd	13.44b	11.27d
600 ppb 4 h	28.14a	26.57a	17.54abc	14.33b	12.53c
600 ppb 8 h	24.14b	23.69b	18.80a	16.93a	15.46ab
900 ppb 4 h	18.62d	17.47d	16.27bc	14.58b	11.95cd
900 ppb 8 h	22.32bc	19.56c	18.68a	17.22a	16.32a
F-test	**	**	**	**	**
CV (%)	11.44	7.22	9.48	8.23	7.85
LSD	1.04	0.60	0.66	0.51	0.42

Letters within columns indicate least significant differences (LSD) at *p = 0.05, **p = 0.01, NS: Non significant

patumma. Honghem *et al.* (2007) reported a similar effect of 1-MCP on the displayed-life of *Mokara* Jairak Gold by fumigating at 0 (control), 250, 500 and 1,000 ppb for 1.5 h. The results revealed that the displayed life was not significantly different between treatments. These implied that the effects of 1-MCP in this study may act as a non-competitive inhibitor of ethylene action and are not effective in blocking the action of ethylene (Serek and Sisler, 2001). Baker (1987) also reported that after fumigating, 1-MCP was rapidly depleted so as if to have no effect on increasing display life. This is in line with Blankenship and Dole (2003) studies on the inhibiting influence of 1-MCP on the mechanism of ethylene action. They observed that it may not completely block ethylene action in some species of cut flowers. This result is consistent with the findings of Valentines *et al.* (2005) who showed that a pre-treatment with 1-MCP at 1 nl L^{-1} for 12 h was sufficient to protect Lollypop flowers against ethylene for only 4 days. While opposite results were found, Sisler *et al.* (1996) revealed that treatment with 5 nl L^{-1} 1-MCP for 6 h allowed carnation flowers to still prevent the effects of ethylene because 1-MCP appeared to be permanently bound to the carnation tissue.

The results on rot appearance of patumma flower were quite similar during storage and relatively unaffected by treatment with 1-MCP. The appearance of rot on patumma flower began to develop slowly after 12 days of storage and showed similar patterns in 1-MCP-treated and control flowers. The effect of 1-MCP on decay has been inconsistent with results being species specific. In some cases 1-MCP treatment alleviates the decay, in apples (De Wild *et al.*, 2002), avocado (Pesis *et al.*, 2002), broccoli (Ku *et al.*, 1999), apricots (Dong *et al.*, 2002). The opposite results with

some species, included strawberry (Ku *et al.*, 1999), tomato (Diaz *et al.*, 2002), avocado (Hofman *et al.*, 2001) and orange (Porat *et al.*, 1999), treating with 1-MCP, these plant showed an increased incidence or severity of diseases. From this study, a possible explanation for these effects of 1-MCP may be that the blocking action of endogenous ethylene by 1-MCP might have rendered the flowers more susceptible to stresses such as pathogen attacks (Testoni *et al.*, 1992).

For wilting, the results showed that the freshness of the patumma flower was in accordance with the water uptake and the decrease of flower weight. A similar increase in wilting percentage of patumma flower was observed during vase life. This indicated that 1-MCP treatment could not effectively suppress the wilting occurrence of fresh patumma. Generally, bract wilting resulted from the failure of the cut stem to replace water lost mainly through the flower petals and was linked to a fall in water potential, reduced fresh weight and storage life (Bunya-Atichart *et al.*, 2004).

The results on anthocyanin content found that storage time was highly significant for anthocyanin content. From analyzing the anthocyanin content in patummas bract, it suggested that the content of anthocyanin decreased slowly during vase life. This indicated that anthocyanin had an important role in the flower's senescence after storage. Zhang *et al.* (2001) found that anthocyanins may be decolourised, to some degree, prior to the degradation as a consequence of increased vacuolar pH, which results to senescence process. In plant tissues, anthocyanins also can be degraded by enzymes, specially PPO (Francis, 1989). The results from Table 6 showed that application of 1-MCP clearly influenced anthocyanin degradation in patumma bract. 1-MCP at the concentrations of 600 ppb for 4 h and 900 ppb for 8 h had a positive marked effect in delaying anthocyanin degradation after 4 and 12 DAV, respectively. The reason for this may be derived from after cutting, the deterioration in membrane function of bract cell rapidly occurred (Jiang and Chen, 1995). These may result in loss of compartmentation between enzymes and their substrates and, thereby, led to anthocyanin degradation (Jiang *et al.*, 2004). Thus, pretreatment with 1-MCP would reduce the damage of membrane in fresh product, which is an important factor involved in retaining bract discoloration (Hershkovitz *et al.*, 2005). These results indicated that 1-MCP application was beneficial for commercial use to maintain the pink colour bract in the patumma flower. However, the mechanism by which 1-MCP exerts its activity may be through the direct inhibition of anthocyanin degradation is not clear, so properties of the 1-MCP involved in anthocyanin degradation require detailed characterisation. Thus, postharvest researches on combination of the upper 1-MCP concentrations with longer fumigation periods need to continue in order to learn how to effectively use 1-MCP to extend shelf life and retain the good qualities for cut flowers.

In conclusion, it was found that the application of 1-MCP in this study was not effective in extending the vase life of patumma flower. The flower weight, water uptake, decay appearance and wilting percentage were not affected by 1-MCP application. However, a pretreatment with 1-MCP at 600 ppb for 4 h and 900 ppb for 8 h was effective in retaining the anthocyanin content by 4 and 10 DAS. Thus, 1-MCP could be potentially considered for commercial application with patumma in controlling anthocyanin degradation. Work is in progress for further investigation of the possible role of 1-MCP in the response of patummas tissues to extend their storage life.

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