IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372.Volume 5, Issue 2 (Sep. - Oct. 2013), PP 83-88
www.iosrjournals.org

Delay Ripening Treatments to Maintain Quality of Lime Fruit (*Citrus aurantifolia*) In Two Different Harvest Time

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Abstract : *In Indonesia lime is a widely consumed and economically significant crop. Lime would be harvest when development of fruit is optimum but still have greenish peel color (Murata, 1997 ; Thompson, 2003). Customers tend to prefer lime fruit that is green instead of yellow (Thompson, 2003). The main problem of lime is yellowing. The most visible is loss of peel greenness that usually cause by Chlorophyll degradation (Drazkiewice, 1994; Srilaong et al., 2011). The prevention of the degradation of chlorophyll can be done by way of delay maturity, such as by using a hot water treatment, $KmnO_4$, and waxing. The result showed that delay ripening treatments could maintain physical and chemical quality of lime fruit during storage compared with control. The treatments also could prolong the shelf life of fruit up to 20 days after treatment, compared with control which only reaches 15 days. HWT 40^o;2mnt;6 mafi s the best treatment in every parameters, include chlorophyll content 1.94 mg/l, weight loss 2.30 %, vitamin C 59 mg/100ml, total acidity 0.76 %, and juice content 19 ml. Time harvest 6 months after flowering has the ability to maintain physical and chemical quality of fruit when compared with 5 months after flowering.*

Keywords: *: Lime (Citrus aurantifolia), delay ripening*

I. INTRODUCTION

One of the major commodities that have the potential fruits worthy to be developed in Indonesia is lime fruit. Lime has high potential because the demand for lime production is likely to increase from year to year. Lime fruit is harvested when the fruit development have been perfect but still green (Kluge *et al*., 2003 ; Thompson, 2003). The main standards are selling lime fruit weighs 35-45 grams per fruit, fruit juice content reaches 30-40% of the weight of the fruit, and the tolerance of yellow color on the skin surface of the fruit of two thirds or less than 30% of the total surface color.

The main problem is readily degradable green color on the skin surface of the fruit. Color degradation can occur during storage and marketing. The loss of green color on the skin surface due to the degradation of chlorophyll (Drazkiewice, 1994 ; Srilaong *et al*., 2011).

The prevention of the degradation of chlorophyll can be done by way of delay maturity, such as by using a hot water treatment, the use of ethylene absorbent material using KMnO4 and coating method with the use of a layer of wax. Hot water immersion method with an impact on the prevention of loss of product quality after harvesting (Schirra and D'hallewin, 1998). Combination of temperature and dipping duration is an important factor in the hot water immersion method because if the temperature is too high and the duration is too long, the product can suffer a heat injury.

Treatment with hot water immersion method known to effectively maintain the quality of broccoli at 45 ° C for 4 min (Dong, 2004). Ethylene absorbent and method of use wax coating can be done to extend the shelf life. Ethylene absorbent used is $KmnO_4$ while the wax coating method is used for beeswax. Both methods are closely linked to the process of respiration, where it is known that orange juice is the fruit of non climacteric.

II. Material And Method

2.1 Plant material

The Materials are lime fruit that has harvesting time 5 months after flowering and six months after flowering, with the characteristic of the fruit surface smooth, bright green color that dominates. Uniform, unblemished, equal size and colored fruit in hands were selected and cleaned. Each fruit group was subjected to one of following treatments : HWT 40^o C;2 mnt;5 maf, HWT 40^{o}C;7.5 mnt;5 maf, HWT 50^o C;2 mnt;5 maf, HWT 50^{o}C;7.5 mnt;5 maf, $KMnO_4$;5 mag, waxing;5 maf, HWT 40^o C;2mnt;6 maf, HWT 40^{o}C;7.5 mnt;6 maf, HWT 50^o C;2 mnt;6 maf, HWT 50^{o}C;7.5 mnt;6 maf, $KMnO_4$;6 maf, waxing;6 maf (HWT: Hot Water Treatment, mnt: minutes, maf: months after flowering).

2.2 Hot water treatment

Fruit were dipped in water at 40˚C for 2 and 7.5 minutes and 50˚C for 2 and 7.5 minutes. Fruits were not dipped in hot water were used as control. Fruit were storage at temperature room with plastic packaging.

2.3 $KMnO_4$ application

On the use of ethylene absorbent material, the material used is $KMnO_4$ by 4 gr for 15 kg of lime fruit. lime which has been placed into a plastic container, labeled according to treatment after, then enter into the cardboard. KMnO4 which has been wrapped with filter paper placed in a cardboard box containing fruit and cardboard covered with plastic sheets.

2.4 Wax coating

Coating with beeswax done by first mixing beeswax with 120 gr of Triethanolamine as much as 40 ml, 20 ml Oleic Acid, and distilled water which had been heated (> 60˚ C) of 820 ml. Lime that has been prepared, then dipped for 30 seconds, then drained to further air-dried, then put in a plastic container and labeled.

2.5 Determination of chlorophyll content

A 5 g sample of peel skin of lime was homogenized with 20 ml of 80% acetone. The fusion was filtered with Whatman no. 2 filter paper, then adjusted to 100mL volume with 80% acetone, spectrophotometer reading at 663 nm and 646 nm.

2.6 Determination of weight loss (%)

The determination of weight loss was doing by formula :

$$\frac{BA - BK}{BA} \times 100\%$$

Note : BA : initial weght
BK : final weight

2.7 Determination of vitamin C

Vitamin C analysis was done by titration Iodometry. Squeezed lime juice then it taken by about 30 ml. Distilled water was added until the volume reaches 100 ml, and then filtered with a filter paper. 20 ml of the filtrate was taken and put in a 125 ml Erlenmeyer and then added 2 ml of 1% amilum solution. The next stage is the standard titration with 0.01 N iodine solution is made of KI and iodine until the solution become blue.

2.8 Determination of total acidity

Total acidity (estimated as citric acid equivalent was determined by titration with NaOH and Phenolphthalein indicator.

2.9 Juice content

The juice was extracted from fruits with a motor-driven hand reamer. The juice content as a ml was recorded.

2.10 Data analysis

This research is using Randomized Block Design with three repetition. The data calculated on different parameters were subjected to Analysis of Variance (ANOVA) technique to observe the differences treatment as well as their interactions. In cases where the differences were significant, the means were further assessed for differences through Least Significant Difference.

III. Result And Discussion

3.1 Chlorophyll content

In the hot water immersion method, it appears that the use of the long immersion 40^o C for 2 minutes at time harvest 6 months after flowering cook (P7), has a high chlorophyll content compared with hot water immersion treatment and other fruit harvest (Table 1). According to Srilaong, *et al*., (2011) noted that the efficiency of the hot water immersion method depends on a combination of temperature and time of immersion of fruit. P7 is thought to be a combination of temperature and duration of soaking lime optimal compared to the others. Mechanisms of hot water immersion method is to retain the green color on the surface of the lime rind where the heat generated in the method may lead to its inactive enzymes involved in the degradation of chlorophyll. Chlorophyllase enzyme is one of the enzymes play an important role in the reduction of green in citrus fruits (Amir-Shappira *et al*., 1987).

On the provision of treatment KMnO4 as ethylene absorbent material at time harvest 5 months after flowering (P5) and 6 months after flowering (P11), it appears that KMnO4 proven effective in preventing chlorophyll content decreased drastically lime rind (Table 1). The use of ethylene absorbent material (KMnO4) can reduce levels of ethylene that can slow the rate of catabolism of the course work rate chlorophyllase enzymes including enzymes can also be slowed. This is consistent with the results of the study Siagian (2009) who stated that KMnO4 is an ethylene absorbent material is better than zeolites and activated carbon in a hamper of goodies banana maturity.

Wax coating method proved effective in preventing drastic reduction of chlorophyll content of lime rind. The optimal concentration of wax emulsions for citrus commodities is 12%. In this study, the ineffectiveness of the desired results because of the concentration of wax emulsions allegedly on lime fruit less than optimal, while providing a layer of wax should be as optimal as possible. If too thin then attempt to inhibit respiration and transpiration becomes less effective, however, if the layer is too thick then the chances are almost all the pores of the commodity will be closed.

Table 1. Chlorophyll content ($mg.l^{-1}$) at various delay ripening treatment on two different time harvest for 5, 10, 15, 20, and 25 days of storage.

	Storage duration (days)					
Delay ripening treatments	0 *)	5	10	15	20	25
P1 (5 MAF ; HWT 40° C ; 2 mnt)	8,23	4,86 c	4,37 b	3,62 c	2,88 c	1,89 c
P2 (5 MAF ; HWT 40° C ; 7.5 mnt)	8,45	2,69 b	2,22 a	1,85 ab	1,51 b	0,78 b
P3 (5 MAF; HWT 50° C ; 2 mnt)	8,04	2,07 ab	2,11 a	1,75 ab	1,42 ab	0,69 ab
P4 (5 MAF; HWT 50° C ; 7.5 mnt)	8,14	1,87 ab	1,79 a	1,58 ab	1,23 ab	0,40 ab
P5 (5 MAF ; $KMnO_4$)	8,23	2,97 b	2,59 a	2,13 b	1,86 b	1,05 b
P6 (5 MAF ; waxing)	8,11	1,66 a	1,58 a	1,30 ab	0,95 ab	0,30 ab
P7 (6 MAF ; HWT 40° C ; 2 mnt)	12,39	10,94 d	8,46 c	6,25 d	3,32 d	1,94 c
P8 (6 MAF ; HWT 40° C ; 7.5 mnt)	12,41	2,8 0 b	2,15 a	1,91 b	1,57 b	0,53 ab
P9 (6 MAF; HWT 50° C ; 2 mnt)	11,98	2,43 ab	1,74 a	1,38 ab	1,01 ab	0,35 ab
P10 (6 MAF;HWT 50° C ; 7.5 mnt)	12,06	2,10 ab	1,45 a	1,13 ab	0,91 ab	0,30 ab
P11 (6 MAF ; $KMnO_4$)	11,47	2,53 ab	2,26 a	1,79 ab	0,78 ab	0,65 ab
P12 (6 MAF ; Waxing)	11,47	1,74 ab	1,47 a	1,13 ab	0,82 ab	0,27 ab
Control	11,47	1,52 a	1,45 a	0,97 a	0,54 a	0,17 a
LSD 5%		1,02	1,19	0,89	0,92	0,52

Values followed by the same letter showed that not significant different by Least Significant Difference Test (LSD) at 5% level, MAF : month after flowering, HWT : hot water treatmet, mnt : minutes, *) Data obtained from observation day 0 after treatment.

3.2 Weight loss

In observation of weight loss seem that delay ripening treatment has significant effect in influencing the percentage of weight loss compared to control (Table 2). Lowest weight loss found in the hot water immersion treatment 40°C for 2 minutes with time harvest 6 months after flowering (P7) followed by hot water immersion treatment 40°C for 2 minutes with time harvest 5 months after flowering (P1). The amount of weight loss as a result of the loss of the water content of the fruit tissue and part of the process of respiration. With hot water immersion treatment can reduce the percentage of shrinkage caused by the melting of the fruit due to epicuticular wax content which then covered the stomata network. Stomatal closure can reduce the loss of fruit weight loss (Obeed, 2006). In addition to using hot water immersion at a certain temperature and duration can inhibit respiration process and lower the levels of ethylene (Schirra and D'hallewin, 1997; Porat *et al*., 2000; llic *et al*., 2001).

Use of $KMnO_4$ as ethylene absorbent material proved to be effective in preventing a drastic decrease in the percentage of weight loss of lime. The loss of weight of a commodity due to increased respiration rate which causes a reshuffle compounds in fruits such as carbohydrates and produce energy CO2 and water that evaporates from the skin surface of the fruit that causes weight loss in juice content. Use of $KMnO_4$ oxidizes ethylene that can reduce fruit respiration rate, so that the weight loss can be reduced decline.

Wax coating methods known to have an influence in preventing a drastic decrease in weight loss when compared with control, but when compared with other treatments that delay maturity, wax coating treatment had the lowest value. This is presumably due to less optimal concentration of the emulsion layer of wax is used. Wax coating with the proper concentration of water will prevent the loss of 30-50% of the general condition (Pantastico, 1996). The use of layers to cover the surface of the fruit, then the loss of water due to transpiration

and respiration can be prevented so that a small percentage of weight loss. The use of wax coating can not prevent fouling known that bias occurs in the fruit.

Table 2. Weight loss (%) at various delay ripening treatment on two different time harvest for 5, 10, 15, 20, and 25 days of storage.

		Storage duration (days)				
Delay ripening treatments	0 *)	5	10	15	20	25
P1 (5 MAF ; HWT 40^o C ; 2 mnt)	40 gr	1,99 ab	2,11 b	2,16 ab	2,19 a	2,44 b
P2 (5 MAF ; HWT 40^o C ; 7.5 mnt)	40 gr	2,15 b	2,18 c	2,22 b	2,33 ab	2,37 a
P3 (5 MAF; HWT 50^o C ; 2 mnt)	40 gr	2,17 b	2,23 d	2,30 c	2,38 ab	2,42 a
P4 (5 MAF; HWT 50^o C ; 7.5 mnt)	40 gr	2,22 b	2,30 e	2,34 c	2,40 ab	2,52 bc
P5 (5 MAF ; $KMnO_4$)	40 gr	2,29 b	2,32 e	2,38 c	2,75 b	2,48 bc
P6 (5 MAF ; waxing)	40 gr	2,30 b	2,38 f	2,40 c	2,49 b	2,58 bc
P7 (6 MAF ; HWT 40^o C ; 2 mnt)	48 gr	1,92 ab	2,04 a	2,15 ab	2,22 ab	2,30 a
P8 (6 MAF ; HWT 40^o C ; 7.5 mnt)	48 gr	1,88 a	2,05 a	2,12 a	2,47 b	2,52 bc
P9 (6 MAF; HWT 50^o C ; 2 mnt)	48 gr	1,85 a	2,05 ab	2,13 a	2,35 ab	2,47 bc
P10 (6 MAF;HWT 50^o C ; 7.5 mnt)	48 gr	1,84 a	2,10 b	2,18 b	2,36 ab	2,60 c
P11 (6 MAF ; $KMnO_4$)	48 gr	1,89 a	2,08 ab	2,13 a	2,3 ab	2,41 a
P12 (6 MAF ; Waxing)	48 gr	1,82 a	2,10 b	2,18 b	2,39 ab	2,53 bc
Control	48 gr	2,21 b	2,42 f	2,48 d	2,64 b	2,66 c
LSD 5%		0,235	0,054	0,043	2,48	0,134

Values followed by the same letter showed that not significant different by Least Significant Difference Test (LSD) at 5% level, MAF : month after flowering, HWT : hot water treatmet, mnt : minutes, *) Data obtained from observation day 0 after treatment.

3.3 Vitamin C and Total Acidity

Hot water immersion treatment with visible enough can affect prevent re drastic reduction in the levels of vitamin C in orange juice (Table 3). Based on the observations, the higher the temperature and the length of duration of dyeing the lower content of vitamin C and total acid in orange juice. According to Rab *et al*., 2011 immersion in hot water is known to increase the reduction of ascorbic acid (vitamin C) is contained in citrus fruits that may be caused by the degeneration of ascorbic acid. The effect of treatment of $KMnO_4$ on levels of vitamin C had a significant effect. This is caused due to $KMnO_4$ is a strong oxidant that can oxidize ethylene, so the process of respiration can be reduced, resulting in fruit maturation process can be inhibited. With the delays fruit maturity levels of vitamin C can be hampered (Siagian, 2009).

Treatment delay maturity is not known to affect the total content of acid lime fruit, it can be seen from the absence of the very real differences among all treatments in a few days of observation (Table 4). This statement is in accordance with the results of the study Obeed (2006) which states that there is no significant difference between treatment delay maturity of the "Mexican" Lime.

Table 3. Vitamin C (mg.100 ml^{-1}) at various delay ripening treatment on two different time harvest for 5, 10, 15, 20, and 25 days of storage.

Delay ripening treatments	Storage duration (days)					
	0 *)	5	10	15	20	25
P1 (5 MAF ; HWT 40° C ; 2 mnt)	108,33	102,66 ab	82,66 bc	76,66 c	58,00 c	50,00 d
P2 (5 MAF ; HWT 40° C ; 7.5 mnt)	108,00	91,00 ab	65,33 ab	63,33 b	50,66 bc	38,00 b
P3 (5 MAF; HWT 50° C ; 2 mnt)	107,67	88,66 ab	64,33 ab	63,33 b	40,66 ab	32,66 ab
P4 (5 MAF; HWT 50° C ; 7.5 mnt)	108.33	86,33 ab	59,33 a	55,66 ab	38,00 a	30,66 ab
P5 (5 MAF ; $KMnO_4$)	108,00	98,00 ab	71,33 b	66,66 bc	51,00 bc	39,00 b
P6 (5 MAF ; waxing)	107,67	85,00 a	55,00 a	51,66 a	35,33 a	28,66 a
P7 (6 MAF ; HWT 40° C ; 2 mnt)	116,67	112,33 ab	96,33 c	80,33 c	66,33 d	59,00 e
P8 (6 MAF ; HWT 40° C ; 7.5 mnt)	111,33	101,33 ab	75,66 b	71,33 bc	63,00 cd	54,00 d
P9 (6 MAF; HWT 50° C ; 2 mnt)	109,67	103,00 ab	76,33 b	66,00 bc	56,33 c	44,66 bc
P10 (6 MAF;HWT 50° C ; 7.5 mnt)	110,67	103,00 ab	67,66 ab	65,00 b	49,00 b	37,33 b
P11 (6 MAF ; $KMnO_4$)	120.,33	118,66 b	80,66 b	71,33 bc	64,33 d	49,33 cd
P12 (6 MAF ; Waxing)	102,33	87,00 ab	66,66 ab	58,66 ab	45,33 b	29,66 ab
Control	100,33	88,00 ab	82,66 ab	49,00 a	41,33 ab	29,00 a
LSD 5%		32,64	15,15	10,72	7,22	7,95

Values followed by the same letter showed that not significant different by Least Significant Difference Test (LSD) at 5% level, MAF : month after flowering, HWT : hot water treatmet, mnt : minutes, *) Data obtained from observation day 0 after treatment.

Table 4. Total acidity (%) at various delay ripening treatment on two different time harvest for 5, 10, 15, 20, and 25 days of storage.

Delay ripening treatments	Storage duration (days)					
	0 *)	5	10	15	20	25
P1 (5 MAF ; HWT 40° C ; 2 mnt)	1,33	1,02 ab	0,91 a	0,91 a	0,84 c	0,71 c
P2 (5 MAF ; HWT 40° C ; 7.5 mnt)	1,35	0,88 ab	0,74 a	0,63 a	0,47 b	0,61 c
P3 (5 MAF; HWT 50° C ; 2 mnt)	1,29	087 ab	0,79 a	0,63 a	0,56 b	0,39 b
P4 (5 MAF; HWT 50° C ; 7.5 mnt)	1,29	0,86 ab	0,71 a	0,57 a	0,49 b	0,26 ab
P5 (5 MAF ; $KMnO_4$)	1,32	0,96 ab	0,90 a	0,72 a	0,82 c	0,51 bc
P6 (5 MAF ; waxing)	1.29	0,83 ab	0,87 a	0,51 a	0,62 bc	0,52 bc
P7 (6 MAF ; HWT 40° C ; 2 mnt)	1,56	1,04 b	1,01 a	0,91 a	0,86 c	0,76 c
P8 (6 MAF ; HWT 40° C ; 7.5 mnt)	1,49	0,87 ab	0,76 a	0,68 a	0,60 b	0,44 bc
P9 (6 MAF; HWT 50° C ; 2 mnt)	1,62	0,85 ab	0,71 a	0,64 a	0,49 b	0,38 b
P10 (6 MAF;HWT 50° C ; 7.5 mnt)	1,53	0,72 a	0,61 a	0,55 a	0,38 ab	0,28 ab
P11 (6 MAF ; $KMnO_4$)	1,53	0,98 ab	0,86 a	0,72 a	0,55 b	0,45 bc
P12 (6 MAF ; Waxing)	1,62	0,93 ab	0,46 a	0,35 a	0,24 a	0,17 ab
Control	1,53	0,86 ab	0,58 a	0,30 a	0,23 a	0,15 a
LSD 5%		0,315	0,806	0,765	0,216	0,216

Values followed by the same letter showed that not significant different by Least Significant Difference Test (LSD) at 5% level, MAF : month after flowering, HWT : hot water treatmet, mnt : minutes, *) Data obtained from observation day 0 after treatment.

3.4 Juice content

Treatment delay maturity with hot water immersion method of temperature 40°C for 2 minutes at the time harvest 6 months after flowering can keep lowering the content of juice content of lime, which contains juice content is one indicator of fruit exports (Table 5). Hot water immersion treatment with outrageously high temperatures or with prolonged immersion duration, is expected to result in damage to the texture of the fruit so that there will be a high respiration and loss of water content in the fruit. Observations content of lime juice

seemed to increase on days 5 and 10 after treatment. This is according to research conducted Khan (2007) that the increased content of orange juice, but at certain times of orange juice has decreased due to the loss of water content in the fruit. Content of lime juice looks much more contained by the citrus fruit harvest time 6 months after treatment, it is alleged at that age, lime has been the optimization of metabolic systems in the fruit of the womb which eventually will result in optimal fruit harvest compared with these 5 months after flowering.

Table 5. Juice content (ml) at various delay ripening treatment on two different time harvest for 5, 10, 15, 20, and 25 days of storage.

	Storage duration (days)					
Delay ripening treatments	0 *)	5	10	15	20	25
P1 (5 MAF ; HWT 40^o C ; 2 mnt)	12,33	18,00 b	18,00 b	16,67 b	16,00 b	12,00 b
P2 (5 MAF ; HWT 40^o C ; 7.5 mnt)	13,00	15,67 ab	16,66 ab	15,33 a	14,33 b	11,67 b
P3 (5 MAF; HWT 50^o C ; 2 mnt)	12,00	14,00 ab	14,66 ab	14,00 a	13,00 a	11,33 b
P4 (5 MAF; HWT 50^o C ; 7.5 mnt)	12,33	13,00 a	14,33, a	14,00 a	12,33 a	10,67 ab
P5 (5 MAF ; $KMnO_4$)	12,33	16,33 b	17,33 ab	16,33 a	15,67 b	12,33 b
P6 (5 MAF ; waxing)	12,33	15,33 ab	15,33 ab	14,00 a	11,33 a	9,00 a
P7 (6 MAF ; HWT 40^o C ; 2 mnt)	27,00	32,00 e	32,33 e	32,67 d	31,33 f	19,33 d
P8 (6 MAF ; HWT 40^o C ; 7.5 mnt)	26,00	30,00 d	30,67 de	28,67 c	27,33 e	17,00 cd
P9 (6 MAF; HWT 50^o C ; 2 mnt)	25,33	30,00 d	29,33 de	28,00 c	25,67 e	18,00 d
P10 (6 MAF;HWT 50^o C ; 7.5 mnt)	27,33	28,00 d	27,67 d	26,67 c	25,00 de	17,67 cd
P11 (6 MAF ; $KMnO_4$)	25,33	27,67 cd	27,67 d	27,33 c	27,00 e	16,67 cd
P12 (6 MAF ; Waxing)	25,33	25,33 c	24,33 c	24,00 bc	23,00 d	15,67 c
Control	26,00	27,00 cd	27,00 cd	25,00 c	20,33 c	17,00 cd
LSD 5%		2,95	3,20	2,39	2,28	2,10

Values followed by the same letter showed that not significant different by Least Significant Difference Test (LSD) at 5% level, MAF : month after flowering, HWT : hot water treatmet, mnt : minutes, *) Data obtained from observation day 0 after treatment.

II. CONCLUSION

Delay ripening treatment by means of hot water immersion, the use of $KmnO_4$ and wax coating can maintain the physical and chemical quality of orange juice during storage compared with control. Immersion treatment with hot water at a temperature 40^o C for 2 minutes on fruit harvest time 6 months after flowering (P7) is the best treatment in the lime delay fruit maturity compared with other treatments up to 20 days of shelf life at all observation parameters. Time harvest of lime 6 months after flowering has the ability to maintain the physical and chemical quality of the fruit harvest when compared with 5 months after flowering.

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