Effects of Ethylene Absorbents On The Storage Of Fresh Chilli Fruits

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Abstract

The study was evaluated the effective ethylene absorbent ($KMnO_4$) storage on fresh green chilli fruits under room temperature. The results showed that the application with ethylene absorbents on chilli fruits gave many benefits to control the fruit quality and prolong the storage life. Among the treatment with or without ethylene absorbents mainly on $KMnO_4$ in both chilli cultivars the best results to reduce the percentage of weight loss, higher retention in development of peel color (PCI), fruit firmness, heighter retention in TSS and TA values respectively were obtained in all shwe-art-nga-yoke fruit treated with 8% ethylene absorbent plus LDPE treatment for 11 days and in all Nga-yoke-ashy fruits treated with 8% ethylens absorbent plus LDPE treatment for 12 days during storage. However, ethylene absorbent plus LDPE can not influence pH level during storage under ambient temperature.

Keywords: ethylene, absorbent, weight loss, peel color

Introduction

The pepper belongs to the genus, *Capsicum.* The pepper used as a vegetable is native to tropical America where it was a highly developed and important food plant in early times. Peppers are attacked by various types of fungi and bacteria leading to rots and fruit decay (Salunkhe and Desai, 1984). Decaying fruits produce significant amounts of ethylene which may enhance ripening and decay of other fruits and so, periodic inspection and culling out of decayed fruits should be done (Acedo and Thanth, 2006). Increase in the rate of loss because normal physiological changes is caused by conditions that increase the rate of natural deterioration, such as high temperature, low atmospheric humidity and physical injury (Food and Agriculture Organization, 1989).

Ethylene absorbent as potassium permanganate reduced the concentration of ethylene and calcium hydroxide reduced the concentration of carbondioxide in sealed polyethylene bags (Scott et al., 1970). Removal of ethylene from the storage and shipping environment retards the spoilage, reduces loss and increases profits. In facts, the effects of ethylene absorbents applied on fresh green chilli fruits were explored in this study.

Materials and Methods

Time and place of the study

The study was conducted at the Vegetable and Fruit Research Development Centre (VFRDC) Fruit Laboratory in Yemon, Hlegu Township, Yangon. The experiment was done in April, 2018.

Materials

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Preparation for the experiments

In this study, two different shaped and sized of freshly harvested matured green chilli fruits: Nga-yoke-ashay (V1) and Shwe-art-nga-yoke (V2) cultivars were transported from the chilli farms of Thanlyin township. The harvested fruits were directly placed into a basket and covered with the fresh banana leaves during transporting from the farm to VFRDC laboratory. Maturity index of fresh chilli fruits were uniform shape, size, firm, shiny and glossiness in peel color and freshness. All selected chilli fruits for the study were washed thoroughly with chlorinated water, and then, air-dried for a few hours to complete drying and to prevent the occurrences of some decays and rots. Finally, all selected chilli fruits were set up immediately for the experiment and stored at room temperature.

Preparation of ethylene absorbents

Standard concentration of ethylene absorbent was prepared as follows: one molecular weight (158 g) of $KMnO_4$, half molecular weight (49 cc) of H_2SO_4 and 2 kg of rice-husk ash were thoroughly mixed, and they were then put into the cloth bags as ethylene scrubbers for the treatment. The amount of ethylene absorbents in a bag was measured based on the fruits weight in each replicate. The 2%, 4%, 6% and 8% ethylene absorbents were used in this study.

Data Collection

Data were collected as the following: cumulative weight loss percent, peel colour development, total soluble solids (TSS) and total acidity (TA), firmness, pH level respectively.

Methods

$$\textbf{Cumulative weight loss (\%)} = \frac{W0 - Wt}{W0} \times 100$$

Whereas, W0 = initial weight

Wt = weight at time (t).

Peel colour development

Measurement of peel colour development by using Munsell colour chart.

Total Soluble Solids (TSS) (°Brix)

Total soluble solids (TSS) was determined by using the refractometer reading.

Total Acidity Content (TA %)

TA (%) was determined by using the ATAGO fruit juice acid tester.

Firmness (Kg/cm^2)

$$\text{Firmness} = \frac{\text{Force in kg}}{\text{Area in } cm^2}$$

Area = $\pi r^2 = \pi \times d^2/4$ ($\pi = 3.14$)

pH level – pH value was measured using a digital pH meter .

Statistical Analysis

Statistical analysis of the results were carried out using IRRI STAT program. Each treatment consisted of 3 replications in this experiment using the Complete Randomized Design (CRD). Treatment means were compared using the Least Significant Differences (LSD) at 5% level of significance.

Results

Cumulative Weight Loss

Cumulative weight loss had significantly different over time among all treatments on both Nga-yoke-ashay (V1) and Shwe-art-nga-yoke (V2) cultivars throughout of the storage period at ambient temperature (30-36˚C) for 12 day in V1 and 11 days in V2 (Table 1 and 2). All controlled 0% ethylene absorbents (control) fruits had a drastic decreased trends in cumulative weight loss on both chilli cultivars compared to the other chilli fruits treated with different levels of ethylene absorbents.

The higher percentages of fruit weight in both chilli cultivars were observed obviously in all controlled 0% ethylene absorbents (Control) fruits compared with all ethylene absorbents treated fruits (Table 3). The lowest percentage in cumulative weight loss was observed in all fruits treated with 8% ethylene absorbents + LDPE treatments on both chilli cultivars, such as 12.94% in V1, 10.33% in V2 for 11 days storage periods and 13.59% in one more additional day of V1 (Table 3).

Table 1. Means of cumulative weight loss on Nga-yoke-ashay (V1) cultivar after stored at ambient temperature for 12 days.

Treat-ment	Cumulative Weight Loss (g) (V1)												
	Storage Period (day)												
	0	1	2	3	4	5	6	7	8	9	10	11	12
0% ethylene absorbent	103.00	85.67	78.33	70.00	63.67	60.33	56.67	49.33	38.67	31.67	26.33	24.33	20.33
2% ethylene absorbent	103.00	100.67	100.00	99.33	99.33	97.67	97.00	93.33	90.00	87.67	84.67	83.67	82.33
4% ethylene absorbent	103.00	100.33	100.00	99.00	98.67	96.00	95.67	92.67	90.33	88.33	86.33	85.00	83.33
6% ethylene absorbent	103.00	101.00	100.00	99.00	99.00	97.00	96.67	92.00	90.00	89.33	88.33	87.33	85.33
8% ethylene absorbent	103.00	101.00	100.33	99.33	98.33	96.67	95.33	93.00	92.00	91.00	90.00	89.67	89.00
LSD at 5% differences	0.0 ns	1.56**	0.73**	1.57**	3.59**	2.33**	2.54**	1.38**	3.56**	1.67**	1.29**	1.24**	1.06**
CV (%)	0.0	0.8	0.4	0.9	2.1	1.4	1.5	0.9	2.4	1.1	0.9	0.9	0.8

Each value represents the mean from 10 fruits. Mean differences within each column determined by LSD.
ns = not significant, ** = significant at 1%.

Table 2. Means of cumulative weight loss on Shwe-art-nga-yoke (V2) cultivar after stored at ambient temperature for 11 days.

Treat-ment	Cumulative Weight Loss (g) (V2)											
	Storage Period (day)											
	0	1	2	3	4	5	6	7	8	9	10	11
0% ethylene absorbent	100.00	85.33	72.33	62.00	55.00	50.67	46.67	37.33	31.00	28.33	27.00	23.67
2% ethylene absorbent	100.00	97.67	96.67	96.00	95.33	95.00	92.33	89.33	87.67	86.00	84.00	82.33
4% ethylene absorbent	100.00	99.00	97.33	96.33	95.00	93.67	93.33	91.33	89.33	88.33	86.67	85.67
6% ethylene absorbent	100.00	99.00	97.67	96.33	95.33	93.67	93.33	92.67	91.67	90.33	89.00	88.00
8% ethylene absorbent	100.00	99.00	97.67	96.67	96.00	95.00	94.33	94.33	93.33	92.00	90.67	89.67
LSD at 5% differences	0.0 ns	5.1*	0.6**	0.8**	1.0**	0.8**	1.4**	3.0**	2.3**	2.3**	2.1**	2.4**
CV (%)	0.0	5.1	0.6	0.8	1.0	0.8	1.4	3.0	2.3	2.3	2.1	2.4

Table 3. Percentage of cumulative weight loss .

Treatments	Cumulative Weight Loss (%)		
	V1 (at day-12)	V1 (at day-11)	V2 (at day-11)
Control	80.26	76.38	76.33
2% ethylene absorbent	20.07	18.77	17.67
4% ethylene absorbent	19.10	17.48	14.33
6% ethylene absorbent	17.16	15.21	12.00
8% ethylene absorbent	13.59	12.94	10.33

Development of Peel Color (PCI)

The initial development of peel color (PCI) in both chilli cultivars showed dark yellowish green (2.5 GY, 6/10 in chromameter scale) in Munsell color chart. Nga-yoke-ashay (V1) can retain their initial PCI only about 2 days and only about 4 days in Shwe-art-nga-yoke (V2), respectively after stored at room temperature. Among all ethylene absorbent treatments, V2 can retain their initial PCI (2.5 GY, 6/10 in chromameter scale) only about 1-9 days stored at room temperature depending on their concentration of ethylene absorbents used on the chilli fruits. Generally, in V1, changes into yellowish red (7.5 YR in Munsell color chart) color of fruits peel were observed in all fruits treated with ethylene absorbent treatments plus LDPE within 6-10 days of storage period under room temperature. Changes into red color of chilli fruits peel (10 R stage in Munsell color chart) were attained in all fruits treated without ethylene absorbent treatments 0% ethylene absorbent plus (control) in both chilli cultivars during 4-12 days in V1 and 8-11 days in V2 stored at room temperature.

Table 4. Peel color development of chilli fruits (V1 and V2) after 12 days storage at ambient T°.

Trt	Peel Color Index (PCI) (V1)												
	Storage Period (day)												
	0	1	2	3	4	5	6	7	8	9	10	11	12
1	2.5GY 6/10	2.5GY 6/10	2.5GY 8/12	2.5GY 8/12	10R 4/10	10R 4/10	10R 4/10	10R 4/10	10R 4/10	10R 4/10	10R 4/10	10R 4/10	10R 4/10
2	2.5GY 6/10	2.5GY 7/10	2.5GY 7/10	2.5GY 7/10	2.5GY 7/10	2.5GY 7/10	7.5YR 6/10	7.5YR 6/10	10R 4/10	10R 4/10	10R 4/10	10R 4/10	10R 4/10
3	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 7/10	7.5YR 6/10	7.5YR 6/10	7.5YR 6/10	10R 4/10	10R 4/10	10R 4/10
4	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	7.5YR 6/10	7.5YR 6/10	10R 4/10	10R 4/10
5	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	7.5YR 6/10	10R 4/10	10R 4/10

Trt	Peel Color Index (PCI) (V2)											
	Storage Period (day)											
	0	1	2	3	4	5	6	7	8	9	10	11
1	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 8/12	2.5GY 8/12	2.5GY 8/12	10R 4/10	10R 4/10	10R 4/10	10R 4/10
2	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 8/12	2.5GY 8/12	10R 4/10	10R 4/10	10R 4/10
3	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 8/12	2.5GY 8/12	2.5GY 8/12
4	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 8/12	2.5GY 8/12	2.5GY 8/12
5	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 6/10	2.5GY 8/12	2.5GY 8/12	2.5GY 8/12

Firmness

All fruits in V1 cultivar can retain their firmness for 4 days which showed no changes in fruits firmness as in initial. However, changes in fruit firmness and data from statistical analysis were observed in all treatments started from 9 days to 12 storage periods at ambient temperature. In facts, changes in fruit firmness had significantly different in all within treatments and among treatments in V2 variety over time the whole periods of storage at ambient temperature. Higher retention in fruit firmness at 12th day, was obtained in all 2% and 6% ethylene absorbents + LDPE treated fruits, such as 7.37 kg cm^2 and 7.40 kg cm^2 in V1 cultivar and in all 8% and 6% ethylene absorbents + LDPE treated fruits, such as 8.50 kg cm^2 and 8.40 kg cm^2 in V2 cultivar while all 0% ethylene absorbents (control) treated fruits on both cultivar showed the lower values in fruits firmness.

Table 5. Means of fruit firmness on Nga-yoke-ashay (V1) and Shwe-art-nga-yoke (V2) cultivars after stored at ambient temperature.

Treatment	Firmness (kg/cm2)							
	V1				V2			
	Storage Period (day)				Storage Period (day)			
	0	4	9	12	0	4	9	11
0% ethylene absorbent	9.67	10.00	8.47	4.33	9.43	5.07	8.37	5.03
2% ethylene absorbent	9.47	10.00	10.00	7.37	9.30	8.23	6.97	5.60
4% ethylene absorbent	8.63	10.00	10.00	6.07	9.57	7.93	6.83	6.80
6% ethylene absorbent	9.13	10.00	10.00	7.40	10.00	9.47	10.00	8.50
8% ethylene absorbent	9.03	10.00	10.00	7.13	10.00	9.83	10.00	8.40
LSD at 5% differences	0.9ns	0.0ns	0.53*	0.59*	0.24**	0.39**	0.41*	0.24**
CV (%)	5.2	0.0	2.9	5.4	0.4	8.4	8.84	6.0

Each value represents the mean from 10 fruits. Mean differences within each column determined by LSD.
ns = not significant, ** = significant at 1%, * = significant at 5%.

Total Soluble Solids (TSS)

The TSS values had significantly different in all treatments and among treatments in both chilli cultivars throughout of the storage periods for 12 days at ambient temperature.

Changes in TSS contents were gradually increased over time in all treatments after 12 days stored at room temperature. Among all treatments in both chilli cultivar, higher maintenance in TSS contents was observed in 4%, 6%, and 8% ethylene absorbent + LDPE treatments, such as 10˚Brix in V1 cultivar and 9˚Brix in V2 cultivar respectively compared to all fruits which were no treated with ethylene absorbents 0% ethylene absorbent (control) treatments.

Table 6 . Means of total soluble solids (TSS) values on Nga-yoke-ashay (V1) and Shwe-art-nga-yoke (V2) cultivars after storage.

Treatment	Total Soluble Solids (TSS) (˚Brix)							
	V1				V2			
	Storage Period (day)				Storage Period (day)			
	0	4	9	12	0	4	9	11
0% ethylene absorbent	8.00	8.13	8.53	7.00	7.40	5.67	6.17	8.07
2% ethylene absorbent	8.00	8.33	8.53	9.47	8.00	9.00	9.27	8.27
4% ethylene absorbent	8.00	9.00	9.00	10.00	8.00	8.00	8.00	9.00
6% ethylene absorbent	8.00	9.00	9.00	10.00	8.00	7.80	7.47	9.00
8% ethylene absorbent	8.00	9.00	9.00	10.00	8.00	7.87	7.67	9.00
LSD at 5% differences	0.21ns	0.36**	0.35*	0.28**	0.34*	0.55**	0.51**	0.28**
CV (%)	0.1	1.3	2.2	2.0	2.3	3.8	3.5	1.7

Each value represents the mean from 10 fruits. Mean differences within each column determined by LSD.
ns = not significant, ** = significant at 1%, * = significant at 5%.

Total Acidity (TA)

Although values of percentage in total acidity (TA) had significantly different among treatments at day-o and at day-4 in V1 variety, there was not significantly different among treatments from 9-12 days of storage period. However, in V2 cultivar, there was significantly different in percentage of TA values among treatments at day-0 and day-11 during storage at ambient temperature. According to Table 7 a gradual decreased trend in percentage of TA values was occurred in 2% ethylene absorbents + LDPE treatments on both chilli cultivars. The rest of the other treatments had no trends of changes in percentage of TA values in both cultivars. On the other hands, the highest percentage in TA values was obtained in all fruits treated with 4% and 6% ethylene absorbent treatments in V1 that was 1.11% and 1.08%, respectively and 1.22% in all V2 fruits treated with 8% ethylene absorbent treatment.

Table 7. Means of total acidity (TA) contents on Nga-yoke-ashay (V1) and Shwe-art-nga-yoke (V2) cultivars after storage.

Treatment	Total Acidity (%)							
	V1				V2			
	Storage Period (day)				Storage Period (day)			
	0	4	9	12	0	4	9	11
0% ethylene absorbent	1.82	0.92	1.33	1.27	1.35	0.97	1.08	0.40
2% ethylene absorbent	1.60	1.01	0.89	0.92	1.45	1.20	1.10	0.86
4% ethylene absorbent	1.46	0.99	0.95	1.11	1.32	1.44	1.00	1.10
6% ethylene absorbent	1.35	0.59	0.83	1.08	1.42	1.39	1.07	1.11
8% ethylene absorbent	1.37	0.93	0.97	0.91	1.31	1.42	1.06	1.22
LSD at 5% differences	**0.12***	**0.20***	0.43ns	0.28ns	**0.89***	0.55ns	0.16ns	**0.14****
CV (%)	4.3	12.0	22.8	13.9	3.5	22.6	8.2	8.0

Each value represents the mean from 10 fruits. Mean differences within each column determined by LSD. ns = not significant, ** = significant at 1%, * = significant at 5%.

pH Level

The initial pH value was 6.00 in both chilli cultivars. However, the pH values were gradually decreased overtime in all 0% ethylene absorbent plus (control) treatments in both cultivar. However, the pH values were not changed in all fruits treated with 4%, 6% and 8% ethylene absorbent treatments in V2 throughout of the storage periods for 11 days at room temperature and up to 9 days of storage periods. After 12 days of storage period under room temperature, the lowest values of pH levels, 4.00 was obtained in all fruits treated with control, 6%, and 8% ethylene absorbent treatments plus LDPE in V1 and 5.00 in pH values at 0% ethylene absorbent treatment plus LDPE in V2. The highest level of pH values, 5.00 was obtained in all V1 fruits treated with 2%, and 4% ethylene absorbent treatments plus LDPE and 7.00 in pH values in all V2 fruits treated with 2% ethylene absorbent treatment.

Table 8. Means of pH levels on Nga-yoke-ashay (V1) and Shwe-art-nga-yoke (V2) cultivars after storage.

Treatment	pH Level							
	V1				V2			
	Storage Period (day)				Storage Period (day)			
	0	4	9	12	0	4	9	11
0% ethylene absorbent	6.00	4.00	3.00	4.00	6.00	7.00	5.00	5.00
2% ethylene absorbent	6.00	5.00	6.00	5.00	6.00	6.00	5.00	7.00
4% ethylene absorbent	6.00	5.67	6.00	5.00	6.00	6.00	6.00	6.00
6% ethylene absorbent	6.00	6.00	4.00	4.00	6.00	6.00	6.00	6.00
8% ethylene absorbent	6.00	6.00	6.00	4.00	6.00	6.00	6.00	6.00
LSD differences	0.00ns	0.49**	0.13**	0.24**	0.00ns	0.28**	0.47**	0.57**
CV (%)	0.0	4.8	0.0	0.0	0.0	0.0	0.0	0.0

Each value represents the mean from 10 fruits. Mean differences within each column determined by LSD.
ns = not significant, ** = significant at 1%.

Discussions and Conclusion

The results of the study showed that the treatments combined with different levels of ethylene absorbents which mainly included $KMnO_4$ and LDPE gave the significant effects on the storage life of fresh green chilli fruits for nearly 2 weeks

under ambient temperature (30-36˚C). Generally, fresh green chilli fruits without any postharvest treatments can be stored under room temperature only for 4 or 5 days. According to Debney et al. (1980), *Capsicum* can be stored in a plastic bag in the refrigerator for approximately one week. The study showed that the increased or decreased percentages in cumulative fruits weight loss were directly proportional to the more or less concentrations of ethylene absorbents mainly in $KMnO_4$ used on the chilli fruits. Higher concentration of $KMnO_4$ ethylene absorbents caused the lower percentage in cumulative weight loss in both chilli cultivars. Shwe-art-nga-yoke (V2) had the lowest percentage in cumulative weight loss, 10.33% after 11 days of storage period at ambient temperature than Nga-yoke-ashay (V1). Nga-yoke-ashy had larger in size, length and surface area to volume ratio than Shwe-art-nga-yoke. Therefore, it caused higher percentage in weight loss because of the water loss from the stem ends. The above statement was agreed with the article of Food and Agriculture Organization (1989) indicated that the significant factor in water loss is the ratio of the surface area in relation to the volume the more rapid will be the loss of water. Weight loss causes by water loss, high respiration rate, larger in surface area to volume ratio. According to Salunkhe and Desai, 1984, peppers with a large surface to volume ratio, such as the long or small types, are particularly susceptible to water loss and thus are adapted to packaging. Batchmann and Earles (2000) described that the relative humidity (RH) of the storage until directly influences water loss in produce. According to Food and Agriculture Organization (1989), fruits, vegetables and root crops are living plant parts containing 65 to 95% water, and they continue their living processes after harvest. Their postharvest life depends on the rate at which they use up their stored food reserves and their rate of water loss. Klieber (2000) indicated that chillies have a thick waxy skin that prevents rapid drying. The surfaces of all plant parts are covered by a waxy or corky layer of skin or bark limiting water loss (Food and Agriculture Organization, 1989). According to Lease and Lease (1956a) cited by Purseglove et al. (1981) the temperature of storage has a greater influence on colour retention than does light, air, kind of container or whether the spice is stored in the whole or ground state. In fact, all ethylene absorbent treated chilli fruits can retain their development of PCI as in initial or longer storage life than 0% ethylene absorbent treatments under room temperature. These were agreed with Bachmann and Earles (2000) who indicated that temperature is the single most important factor in maintaining quality after harvest. An increase in temperature causes an increase in the rate of natural breakdown of all produce as food reserves and water content become depleted. In the study, there was the higher values in total soluble solids (TSS) contents and lower percentage in total acidity (TA) in all ethylene absorbent plus LDPE treatments. All treated with different levels of ethylene absorbent treatments can retard the ripening of chilli fruits which changed into yellowish red or dark red in color on the fruits peel. Retention in PCI was directly proportional to the higher concentration of ethylene absorbent levels mainly based on $KMnO_4$.

Scott et al. (1970) showed that potassium permanganate ($KMnO_4$) reduced the concentration of ethylene in sealed polyethylene bags containing bananas and additional storage life. Gross et al. (1986) cited by Klieber (2000) indicated that some chillies produce increased ethylene levels during colour changes.

As in conclusion, the application with ethylene absorbents on chilli fruits gave many benefits to control the fruit quality and prolong the storage life. Among the treatments with or without ethylene absorbents mainly on $KMnO_4$ in both chilli cultivars, the best results to reduce the percentage of weight loss, higher retention in development of peel color (PCI) and fruit firmness, higher retention in TSS and TA

values, respectively were obtained in all Shwe-art-nga-yoke fruits treated with 8% ethylene absorbent plus LDPE treatment for 11 days and in all Nga-yoke-ashy fruits treated with 6% and 8% ethylene absorbent plus LDPE treatment for 12 days after stored at ambient temperature (30-36˚C). However, the treated with ethylene absorbent plus LDPE cannotinfluence pH level during storage under ambient temperature.

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References

Acedo, A.L. and C.D. Thanth. (2006). RETA 6208 *Postharvest technology training and development of training master plan.* 17-20th October. Lao PDR.

Bachmann, J. and R. Earles. (2000). *Postharvest handling of fruits and vegetables. NCAT Agriculture Specialists*. Published 2000. ATTRA Publication # ID 116.

Debney, H.G., K.J. Blacher, B.J. Redding, and J.B. Watkins. (1980). *Handling and storage practices for fresh fruits and vegetables*. Australian United Fresh Fruit and Vegetables Association.

Food and Agriculture Organization of the United Nations, (1989). *Prevention of post-harvest food losses: fruits, vegetables and root crops*. Rome. Printed in Italy.

Klieber, A. (2000). *Chilli spice production in Australia*. A report for the Rural Industries Research and Development Corporation. RIRDC Publication No. 00/33. RIRDC Project No. UA-3 & A. April.

Salunkhe, D.K. and B.B. Desai. (1984). *Postharvest biotechnology of vegetables*. Vol. II. CRC Press, Inc. boca Raton, Florida.

Scott, K.J., W.B. McGlasson and E.A. Roberts. (1970). *Potassium permanganate as an ethylene absorbent in polyethylene bags to delay ripening of bananas during storage*. CSIRO PUBLISHING – Australian Journal of Experimental Agriculture. 10(43) pp. 237-240.

Siemonsma, J.S. and K. Piluek. (1994). *Plant resources of South-East Asia*. No. 8. Vegetables. p. 136.

Purseglove, J.W., E.G. Brown, C.L. Green, and S.R.T. Robbins. (1981). *Spices. Vol. I. Presented by Britain Longman*, London and New York.