Extending the shelf life of lychee using different CO_2:O_2 ratios and an ethylene absorbent in polyethylene bags

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The extension of the shelf life and quality of lychee was examined by using CO_2:O_2 ratios plus an ethylene absorbent in polyethylene bags. The weight loss of lychee increased according to storage time. Lychee stored in 3% ethylene absorbent with CO_2:O_2 flow rates of 0:0 PSI lost the most weight with a mean of 1.44%. The total soluble solid content (17.10-17.9 brix) and titratable acidity (0.25-0.31%) of lychee slightly decreased in all treatments according to storage time. Lychee stored in 4% ethylene absorbent with CO_2:O_2 flow rates of 5:5 PSI resulted in the best acceptable quality and longest storage life of 18 days. Lychee stored in LDPE bags with CO O_2 flow rates of 0:0 PSI lost the most weight with a mean of 1.70%. Total soluble solid content (15.73-17.2 brix) and titratable acidity (0.18-0.22%) in all lychee treatments decreased slightly according to storage time. Lychee stored in PE bags with CO_2:O_2 flow rates of 5:5 PSI had the best performance and longest storage life of 18 days with acceptable quality.

Key words: CO_2:O_2, ethylene absorbent, fruit quality, lychee, shelf-life

Introduction

Lychee is a worldwide economic fruit and roughly 18,412 tons are exported from Thailand each year with an estimated value of more than 600 million Baht. Future demand of lychee is likely to increase in the future. Lychee is a perishable fruit with a short shelf-life and fungal spoilage may cause serious losses over long distance transportation and during marketing. The optimum storage time for lychee is only 2-3 days. Over longer periods weight loss and browning of peal occurs resulting in a very short shelf-life (Lin and Chiang, 1981; Chang, 1983) Modified control packaging is an of alternative to extension storage life of lychee. Lee (1996) stated that increasing CO_2 content and lowering O_2 content would reduce chilling injury and decrease ethylene synthesis. Glahan (2000) found that a combination of plastic

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bags and ethylene absorbent could lengthen the storage life of Gros Michel, mangosteen and asparagus spear. In this study we assess the affect of storage bags and CO_2:O_2 content to increase the shelf-like of lychee.

Materials and methods

Influence of ethylene absorbent (EA), and CO_2:O_2 flow rates on quality and storage life of lychee

The statistical model was a 5 × 5 factorial completely randomised design comprising 5 levels of ethylene absorbent at 0, 1, 2, 3 and 4% by fresh weight of lychee (gm), and 5 levels of CO_2:O_2 at: 0:0, 5:5, 10:5, 15:10 and 20:10 PSI. Lychees were selected, placed in polyethylene bags (PE) and filled with CO_2:O_2 and ethylene absorbent (EA) according to treatment combinations + moisture absorbent (MA) 0.5 percent (by fresh weight of lychee), and stored at 14°C in a refrigerator.

Influence of packaging materials and CO_2:O_2 flow rates on quality and storage of lychee

The statistical model was a 3 × 5 factorial completely randomized design coomprising three types of plastic bags: polyethylene (PE) bags; low density polyethylene (LDPE) bags and; polypropylene (PP) bags; and ratios of CO_2:O_2 of 0:0, 5:5, 10:5, 15:10 and 20:10 PSI. Lychees were placed in the plastic bags and ethylene absorbent 1% (by fresh weight of lychee) + moisture absorbent (MA) 0.5% (by fresh weight of lychee) and filled with various CO_2:O_2 ratios and stored at 14°C in a refrigerator

Results

Influence of ethylene absorbent (EA), and CO_2:O_2 flow rates on quality and storage life of lychee

Percentage fresh weight loss

The weight loss of lychee in storage increased with time (Table 1.1, Fig 1.1). After 3 days storage the weight loss was 0.31-0.88%. Lychee stored with 2% ethylene absorbent + 0:0 PSI CO_2:O_2 for 18 days had the lowest weight loss of 1.25%, while lychee stored with 3% ethylene absorbent + 0:0 PSI

CO_2:O_2 had the greatest weight loss of 1.44%. Weight loss however, had no impact on shriveling of the peel (Fig. 7).

Total soluble solids

During lychee storage the total soluble solids slightly decreased with time (Fig. 2). At the start of the experiment total soluble solids was 17-08.2 brix while after 18 days of storage lychee with 3% ethylene absorbent + 0:0 PSI CO_2:O_2 the lowest soluble solids content of 17.00 brix was recorded. Lychee fruit stored with 2% ethylene absorbent + 5:5 PSI CO_2:O_2 had the highest total soluble solids content of 17.90 brix (Table 1).

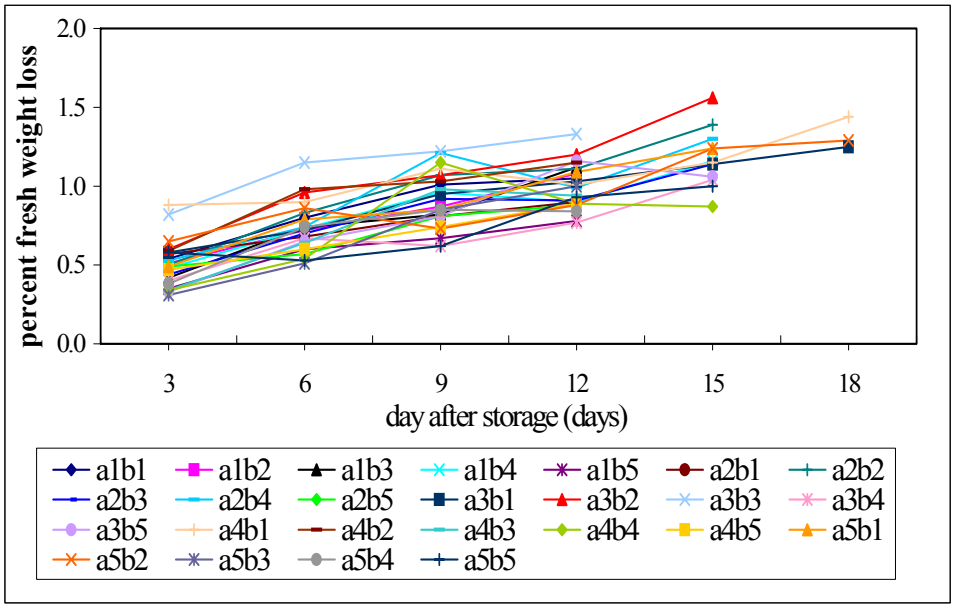

Fig. 1. Percentage weight loss of lychee after storage in ethylene absorbent with various CO_2:O_2 flow rates.

Titratable acidity

Titratable acidity in lychee decreased with storage time (Fig. 3) from 0.27-0.47% at the start of the experiment, whereas after 18 days storage in 4% ethylene absorbent + 5:5 PSI CO_2:O_2 titratable acidity was the lowest (0.25%). When stored in 2% ethylene absorbent + 0:0 PSI CO_2:O_2 titratable acidity content was highest at 0.31% (Table 2).

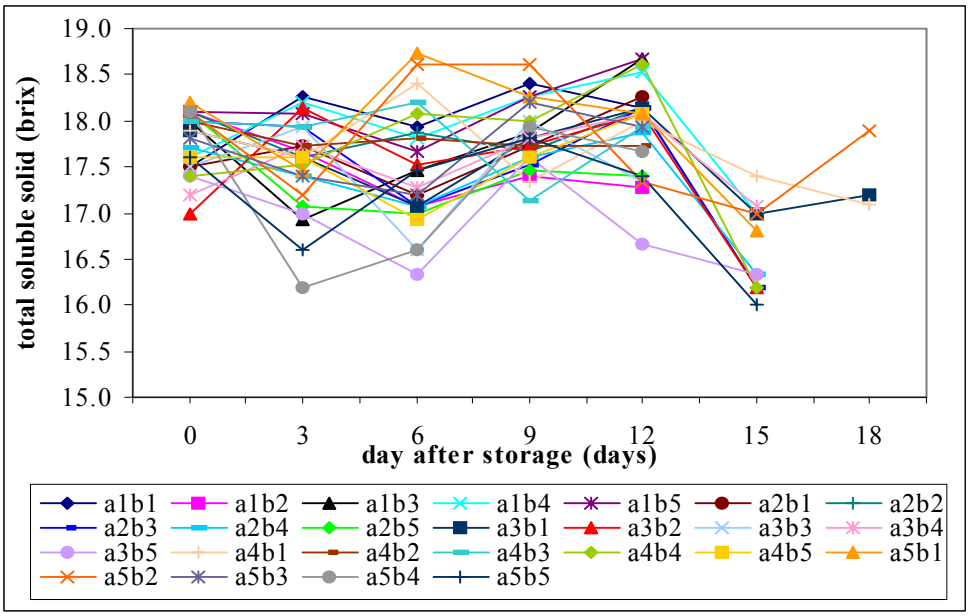

Fig. 2. Total soluble solids in lychee after storage in ethylene absorbent with various CO_2:O_2 flow rates.

Peel and pulp colour

The outer peel of lychee before storage was red (Red Group 47A-C). After 3-9 days of storage the outer and inner peel colour had not changed, whereas after 12-18 days the inner and outer peel had more intensity (Red Group 46C-47C). Pulp was greyish-white (Group 156C) before storage and retained the original colour throughout the experiment (Figs 4-7).

Palatability

The palatability of lychee decreased with storage time (Table 2). Before storage palatability ranged from 4.64-4.94, while after 18 days of storage lychee stored in 4% ethylene absorbent + 5:5 PSI CO_2:O_2 showed the highest palatability score of 2.08 and was barely acceptable for consumption.

Storage life

Lychee stored without ethylene absorbent + 0:0, 5:5, 10:5 and 20:10 PSI CO_2:O_2, 1% ethylene absorbent + 0:0 and 20:10 PSI CO_2:O_2, 2% ethylene absorbent + 10:5 PSI CO_2:O_2, 3% ethylene absorbent + 5:5, 10:5 and 20:10

PSI CO_2:O_2, 4% ethylene absorbent + 15:10 and 10:5 PSI CO_2:O_2 resulted in the shortest storage times of up to of 12 days. Lychee stored with 2% ethylene absorbent + 0:0 PSI CO_2:O_2, 3% ethylene absorbent + 0:0 PSI CO_2:O_2 and 4% ethylene absorbent + 5:5 PSI CO_2:O_2 resulted in the longest storage life of 18 days (Table 2).

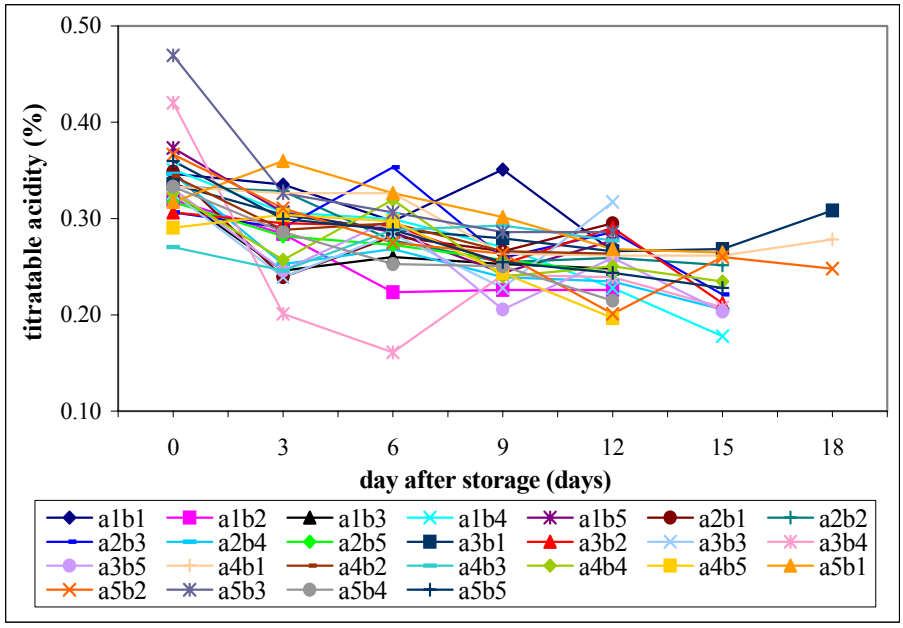

Fig. 3. Titratable acidity of lychee after storage in ethylene absorbent with various CO_2:O_2 flow rates.

Influence of packaging materials and CO_2:O_2 flow rates on quality and storage life of lychee

Percent fresh weight loss

According to the behavior of fresh Weight loss in lychee during storage increased with time (Table 3 and Fig. 8). After 3 days of storage weight loss was 0.23-0.46%. After 18 days of storage in PP bags + 0:0 PSI CO_2:O_2 weight loss was lowest at 1.14% and in LDPE bags + 0:0 PSI CO_2:O_2 was 1.7%. Weight had no impact on shriveling of the peel (Fig 2.1).

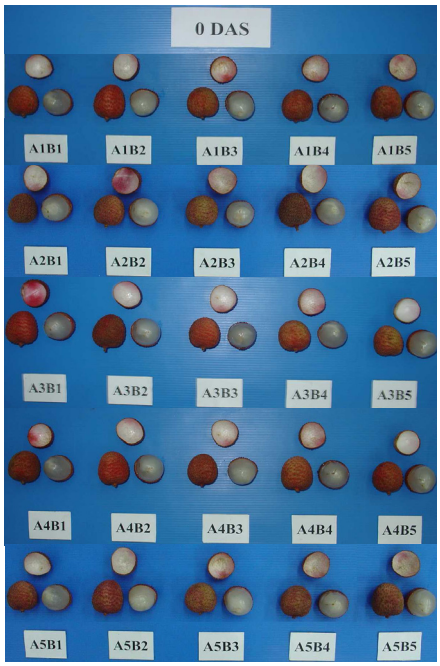

Fig. 4. Lychee before storage.

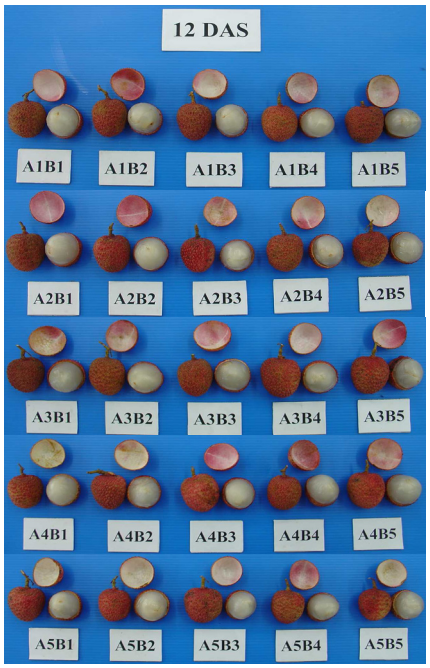

Fig. 5. Lychee after 12 days storage in ethylene absorbent with various CO_2:O_2 flow rates.

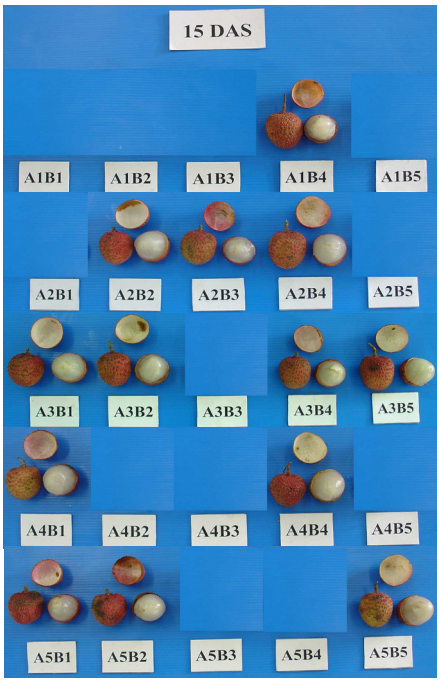

Fig. 6. Lychee after 15 days storage.

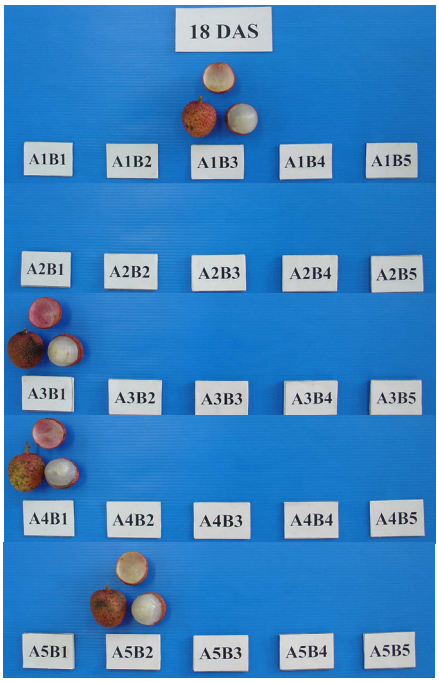

Fig. 7. Lychee after 18 days storage in ethylene absorbent with various CO_2:O_2 flow rates.

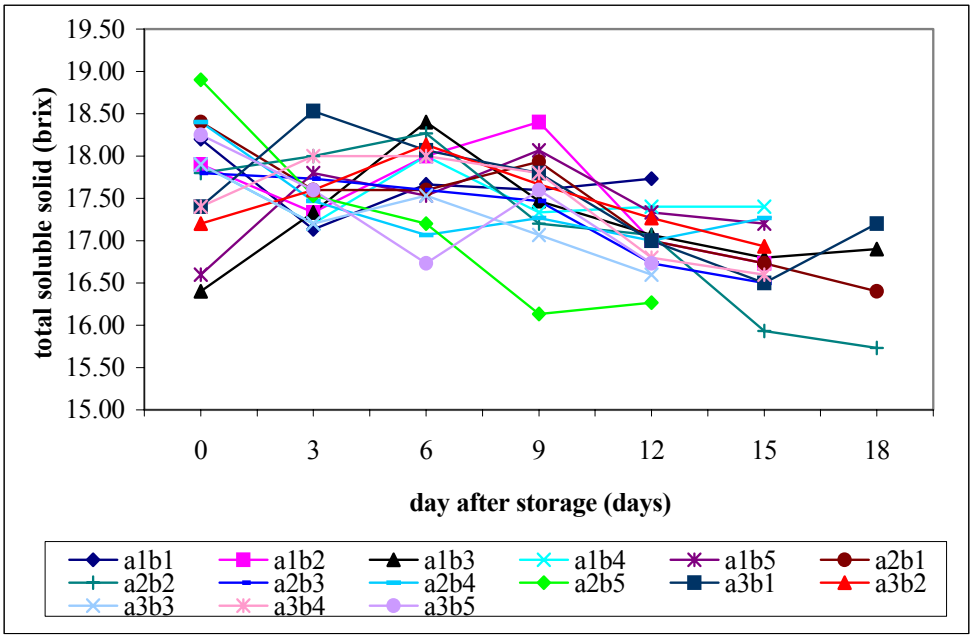

Fig. 8. Weight loss in lychee after storage in plastic bags with various CO_2:O_2 flow rates.

Total soluble solid

During storage period for 3-9 days in PE and PP bags the total soluble solids of lychee fruit slightly increased after which this decreased slightly (Fig. 2). Before storage total soluble solids in lychee was 16.40-18.90 brix. After 18 days of storage in LDPE bags + 5:5 PSI CO_2:O_2 the lowest total soluble solids content of 15.73 brix was recorded and those stored in PP bags + 0:0 PSI CO_2:O_2 had the highest total soluble solids content of 17.20 brix (Table 3).

Titratable acidity (TA)

Titratable acidity decreased with storage time (Fig. 10). Before storage titratable acidity was 0.23-0.46%, whereas after 18 days storage in LDPE bags + 0:0 PSI CO_2:O_2 it was lowest at 0.18%, while those stored in LDPE bags + 5:5 PSI CO_2:O_2 and PP bags + 0:0 PSI CO_2:O_2 had the highest titratable acidity 0.31% (Table 3).

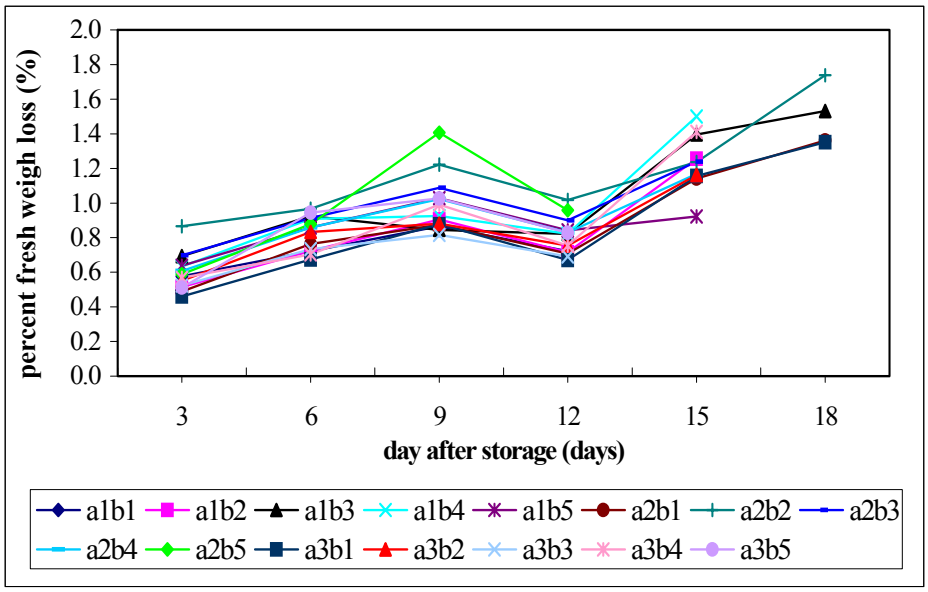

Fig. 9. Total soluble solids in lychee after storage in plastic bags with various CO_2:O_2 flow rates.

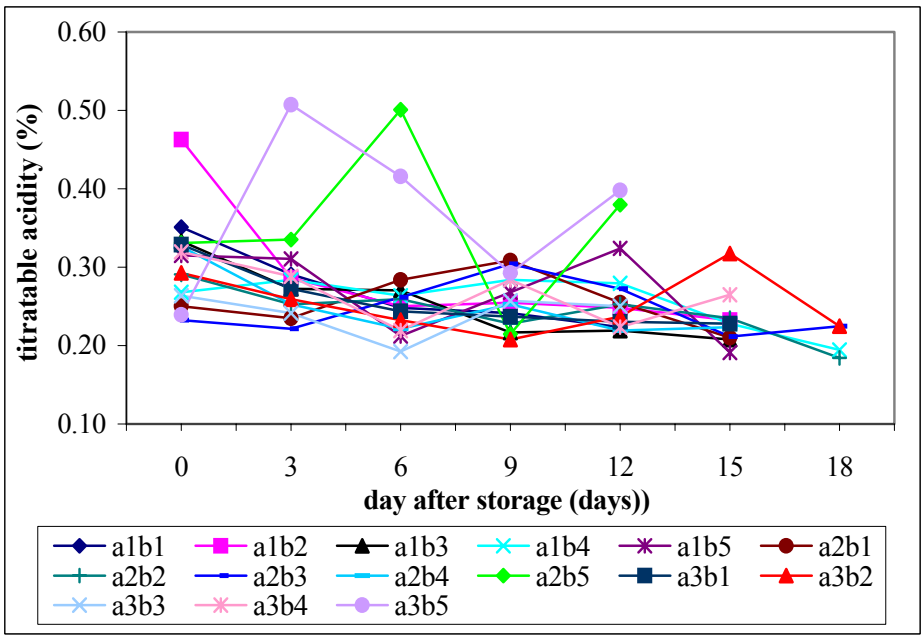

Fig. 10. Titratable acidity of lychee after storage in plastic bags with various CO_2:O_2 flow rates.

Peel and pulp colour

The outer peel of lychee fruits before storage was red (Red Group 47A-C). After 3-6 days of storage the outer and inner peel retained its colour. After 9-18 days of storage, both the inner and outer peel had more intensity (Red Group 46C-47C). The pulp was greyish-white (GYG 156C) before storage and retained this colour throughout the experiment (Figs 11-14).

Palatability score

According to table 2.2 palatability score of lychee fruit decreased corresponding to storage time increase whereas before storage palatability score range of 3.89-4.67 while an 18 days storage lychee those stored with PE bag + CO_2:O_2 10:15 PSI showed the highest palatability score of 2.83 and could rarely accepted.

Storage life

Lychee fruit stored with PE bags + 0:0 PSI CO_2:O_2, LDPE bags + 20:10 PSI CO_2:O_2, PP bags + 10:15 and 20:10 PSI CO_2:O_2 resulted in the shortest storage times of 12 days. Lychee stored with PE bags + 10:5 PSI CO_2:O_2, LDPE bags + 0:0 5:5 PSI CO_2:O_2 and PP bags + 0:0 PSI CO_2:O_2 gave the longest storage life of 18 days (Table 4).

Discussion

Weight loss of lychee fruit during storage increases with storage time. Glahan (2000) stated that respiration occurs continuously after harvest fresh and reaches a peak depending on the species and variety. Respiration results in the release of water from lychee fruit causing weight loss. In the present experiment, weight loss had no impact on shriveling of the lychee fruit which is similar to that reported for other fruits (Glahan, 2004a,b).

Total soluble solids and titratable acidity content of lychee fruit changed throughout the storage period. The may be a result of storage coniditions which may reduce metabolic processes in the lychee fruit. The storage methods used in this study could be implemented in the post harvest handling of lychee and extens the shelf-life of products as found in Gros Michale (Glahan and Kerdsiri, 2001) banana ‘Kluai Khai’ (Glahan and Chockpachuen, 2003) and longkong (Glahan and Adireklap, 2005).

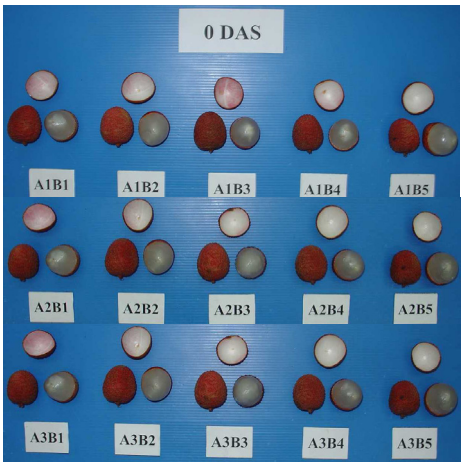

Fig. 11. Lychee before storage.

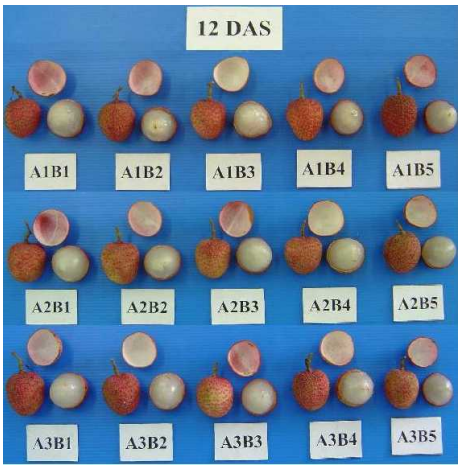

Fig. 12. Lychee after storage for 12 days in plastic bags with various CO_2:O_2 flow rates.

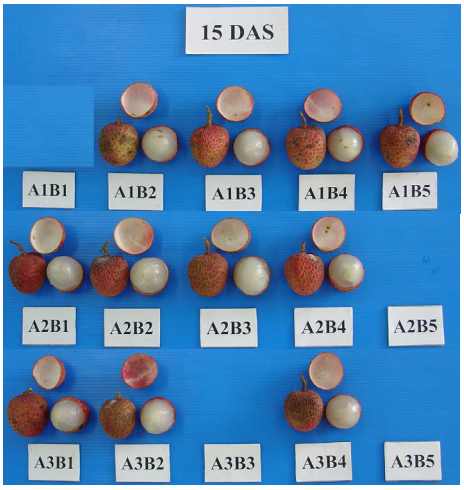

Fig. 13. Lychee after 15 days storage.

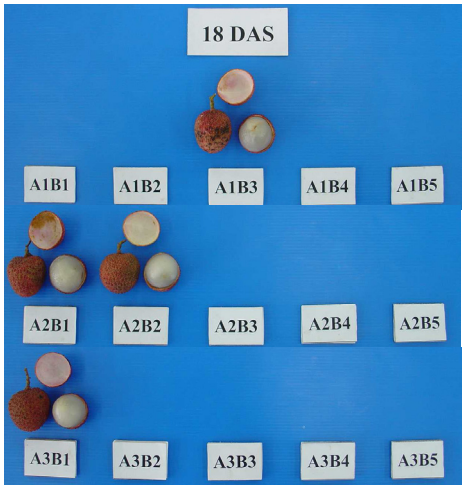

Fig. 14. Lychee after 15 days storage in plastic bags with various CO_2: O_2 flow rates.

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Table 1. Weight loss and amount of total soluble solids of lychee after storage in ethylene absorbent at various CO_2:O_2 flow rates.

Treatment combination EA+CO_2:O_2 (PSI)	Weight loss (%)				Total soluble solid (brix)			
	3 days	12 days	15 days	18 days	0 days	12 days	15 days	18 days
a_1b_1 0%+0:0	0.54b-f[1/]	1.05a[1/]	-	-	17.50a[1/]	18.13a[1/]	-	-
a_1b_2 0%+5:5	0.51b-h	1.08a	-	-	18.10a	17.27a	-	-
$a_1b_3$0%+10:15	0.42c-i	1.12a	-	-	18.00a	18.67a	-	-
$a_1b_4$0%+15:10	0.48b-i	0.90a	1.16c-e[1/]	-	17.60a	18.53a	17.00ab[1/]	-
$a_1b_5$0%+20:10	0.35f-i	0.78a	-	-	18.10a	18.67a	-	-
a_2b_1 1%+0:0	0.57b-e	0.94a	-	-	17.50a	18.27a	-	-
a_2b_2 1%+5:5	0.50b-i	1.11a	1.39b	-	18.10a	18.13a	16.20c	-
a_2b_3 1%+10:15	0.44c-i	0.91a	1.14c-e	-	18.00a	18.13a	16.20c	-
a_2b_4 1%+15:10	0.53b-g	0.99a	1.30bc	-	17.70a	17.87a	16.33c	-
a_2b_5 1%+20:10	0.49b-i	0.88a	-	-	18.10a	17.40a	-	-
a_3b_1 2%+0:0	0.58b-d	1.03a	1.14c-e	1.25b[1/]	17.90a	18.13a	17.00ab	17.20b[1/]
a_3b_2 2%+5:5	0.60bc	1.20a	1.56a	-	17.00a	18.07a	16.20c	-
a_3b_3 2%+10:15	0.82a	1.33a	-	-	17.50a	17.33a	-	-
a_3b_4 2%+15:10	0.40d-i	0.77a	1.04e	-	17.20a	18.07a	17.07ab	-
a_3b_5 2%+20:10	0.33hi	1.16a	1.06de	-	17.40a	16.67a	16.33c	-
a_4b_1 3%+0:0	0.88a	1.01a	1.15c-e	1.44a	17.90a	18.00a	17.40a	17.10b
a_4b_2 3%+5:5	0.59b-d	1.15a	-	-	18.00a	17.73a	-	-
a_4b_3 3%+10:15	0.34g-i	0.94a	-	-	18.00a	17.93a	-	-
a_4b_4 3%+15:10	0.34g-i	0.89a	0.87f	-	17.40a	18.60a	16.20c	-
a_4b_5 3%+20:10	0.47b-i	0.89a	-	-	17.60a	18.07a	-	-
a_5b_1 4%+0:0	0.49b-i	1.09a	1.24b-d	-	18.20a	18.07a	16.80b	-
a_5b_2 4%+5:5	0.65b	0.88a	1.24b-d	1.29b	18.10a	17.33a	17.00ab	17.90a
a_5b_3 4%+10:15	0.31i	0.84a	-	-	17.80a	17.93a	-	-
a_5b_4 4%+15:10	0.38e-i	0.84a	-	-	18.10a	17.67a	-	-
a_5b_5 4%+20:10	0.58b-d	0.93a	1.00ef	-	17.60a	17.40a	16.00c	-

[1/] Means in column with common letter (s) are not significantly different at 5% by DNMRT.

Table 2. Titratable acidity, palatability score and storage life of lychee after storage in ethylene absorbent with various CO_2:O_2 flow rates.

Treatment Combination EA+CO_2:O_2 (PSI)	Titratable acidity (%)				Palatability score				Storage life (days)
	0 days	12 days	15 days	18 days	0 days	12 days	15 days	18 days	
a_1b_1 0%+0:0	0.35a[1/]	0.33a[1/]	-	-	4.81a[1/]	3.66a[1/]	-	-	12c
a_1b_2 0%+5:5	0.32a	0.24a	-	-	4.92a	2.58a	-	-	12c
$a_1b_3$0%+10:15	0.33a	0.25a	-	-	4.75a	3.77a	-	-	12c
$a_1b_4$0%+15:10	0.35a	0.29a	0.18e[1/]	-	4.83a	3.96a	2.08c-e[1/]	-	15b
$a_1b_5$0%+20:10	0.37a	0.28a	-	-	4.82a	2.94a	-	-	12c
a_2b_1 1%+0:0	0.35a	0.26a	-	-	4.86a	3.24a	-	-	12c
a_2b_2 1%+5:5	0.33a	0.29a	0.25a-c	-	4.83a	3.75a	2.25b-d	-	15b
a_2b_3 1%+10:15	0.31a	0.30a	0.22b-d	-	4.83a	2.76a	1.75ef	-	12c
a_2b_4 1%+15:10	0.35a	0.25a	0.21b-d	-	4.78a	2.94a	2.03de	-	15b
a_2b_5 1%+20:10	0.32a	0.27a	-	-	4.94a	3.23a	-	-	12c
a_3b_1 2%+0:0	0.34a	0.29a	0.27a	0.31a[1/]	4.92a	3.23a	2.53ab	1.08c[1/]	15b
a_3b_2 2%+5:5	0.31a	0.28a	0.21c-e	-	4.89a	3.39a	2.08c-e	-	15b
a_3b_3 2%+10:15	0.33a	0.25a	-	-	4.75a	3.22a	-	-	12c
a_3b_4 2%+15:10	0.42a	0.20a	0.21de	-	4.69a	2.67a	2.08c-e	-	15b
a_3b_5 2%+20:10	0.33a	0.25a	0.20de	-	4.92a	2.83a	1.56f	-	12c
a_4b_1 3%+0:0	0.33a	0.31a	0.26ab	0.28b	4.83a	2.61a	2.61a	1.88b	18a
a_4b_2 3%+5:5	0.34a	0.28a	-	-	4.75a	2.39a	-	-	12c
a_4b_3 3%+10:15	0.27a	0.28a	-	-	4.64a	2.64a	-	-	12c
a_4b_4 3%+15:10	0.33a	0.28a	0.23a-d	-	4.89a	2.39a	2.44a-c	-	15b
a_4b_5 3%+20:10	0.29a	0.28a	-	-	4.69a	2.58a	-	-	12c
a_5b_1 4%+0:0	0.32a	0.33a	0.26ab	-	4.86a	3.23a	2.17b-d	-	15b
a_5b_2 4%+5:5	0.37a	0.28a	0.26ab	0.25c	4.69a	2.98a	-	2.08a	18a
a_5b_3 4%+10:15	0.47a	0.31a	-	-	4.67a	2.92a	-	-	12c
a_5b_4 4%+15:10	0.33a	0.26a	-	-	4.69a	1.67a	-	-	12c
a_5b_5 4%+20:10	0.36a	0.28a	0.23a-d	-	4.86a	2.72a	2.25b-d	-	15b

[1/] Means in column with common letter (s) are not significantly different at 5% by DNMRT.

Table 3. Weight loss and total soluble solids in lychee after storage in plastic bags with various CO_2:O_2 flow rates.

Treatment Combination CO_2:O_2 (PSI)	Percent fresh weight loss (%)				Total soluble solid (brix)			
	3 days	12 days	15 days	18 days	0 days	12 days	15 days	18 days
a_1b_1 PE+0:0	0.58a[1/]	1.35ab[1/]	-	-	18.20a[1/]	17.73a[1/]	-	-
a_1b_2 PE+5:5	0.51a	1.37a	1.26a-c[1/]	-	17.90a	17.00a	16.73a-c[1/]	-
a_1b_3 PE+10:15	0.69a	0.92bc	1.40ab	1.46b[1/]	16.40a	17.07a	16.80ab	16.90[1/]
a_1b_4 PE+15:10	0.63a	1.02a-c	1.50a	-	17.90a	17.40a	17.40a	-
a_1b_5 PE+20:10	0.64a	1.07a-c	0.92bc	-	16.60a	17.33a	17.20ab	-
a_2b_1 LDPE+0:0	0.49a	1.05a-c	1.14a-c	1.70a	18.40a	17.00a	16.73a-c	16.40a
a_2b_2 LDPE+5:5	0.87a	1.00a-c	1.24a-c	1.65a	17.80a	17.07a	15.93c	15.73b
a_2b_3 LDPE+10:15	0.70a	1.15a-c	1.24a-c	-	17.80a	16.73a	16.50bc	-
a_2b_4 LDPE+15:10	0.61a	1.01a-c	1.17a-c	-	18.40a	17.00a	17.27ab	-
a_2b_5 LDPE+20:10	0.59a	1.05a-c	-	-	18.90a	16.27a	-	-
a_3b_1 PP+0:0	0.46a	0.92bc	1.16a-c	1.14c	17.40a	17.00a	16.50bc	17.20a
a_3b_2 PP+5:5	0.55a	0.86c	1.16a-c	-	17.20a	17.27a	16.93ab	-
a_3b_3 PP+10:15	0.52a	1.30ab	-	-	17.90a	16.60a	-	-
a_3b_4 PP+15:10	0.57a	1.12a-c	1.41ab	-	17.40a	16.80a	16.60a-c	-
a_3b_5 PP+20:10	0.51a	1.24a-c	-	-	18.25a	16.73a	-	-

[1/] Means in column with common letter (s) are not significantly different at 5% by DNMRT.

Table 4. Titratable acidity and palatability score for lychee after storage in plastic bags with various CO_2:O_2 flow rates.

Treatment Combination CO_2:O_2 (PSI)	Titratable acidity (%)				Palatability score				storage life (days)
	0 days	12 days	15 days	18 days	0 days	12 days	15 days	18 days	
a_1b_1 PE+0:0	0.35a[1/]	0.22a[1/]	-	-	4.44a[1/]	3.47a[1/]	-	-	12c[1/]
a_1b_2 PE+5:5	0.46a	0.25a	0.23bc[1/]	-	4.17a	3.47a	3.11ab[1/]	-	15b
a_1b_3 PE+10:15	0.33a	0.22a	0.23bc	0.19b[1/]	4.53a	3.58a	2.58b	2.83a[1/]	18a
a_1b_4 PE+15:10	0.27a	0.28a	0.23bc	-	4.31a	3.51a	2.71ab	-	15b
a_1b_5 PE+20:10	0.32a	0.32a	0.19c	-	3.89a	3.22a	3.38a	-	15b
a_2b_1 LDPE+0:0	0.25a	0.25a	0.21bc	0.18b	4.50a	3.89a	2.89ab	1.00d	15b
a_2b_2 LDPE+5:5	0.29a	0.25a	0.23bc	0.22a	4.53a	3.28a	1.78c	1.92c	18a
a_2b_3 LDPE+10:15	0.23a	0.27a	0.21bc	-	4.08a	2.72a	2.38bc	-	15b
a_2b_4 LDPE+15:10	0.33a	0.22a	0.22bc	-	4.67a	2.28a	2.56b	-	15b
a_2b_5 LDPE+20:10	0.33a	0.38a	-	-	4.22a	2.67a	-	-	12c
a_3b_1 PP+0:0	0.33a	0.23a	0.23bc	0.22a	4.44a	3.76a	2.67ab	2.17b	18a
a_3b_2 PP+5:5	0.29a	0.24a	0.32a	-	4.57a	3.72a	2.94ab	-	15b
a_3b_3 PP+10:15	0.26a	0.25a	-	-	4.23a	2.67a	-	-	12c
a_3b_4 PP+15:10	0.32a	0.22a	0.26ab	-	4.28a	3.33a	2.50b	-	15b
a_3b_5 PP+20:10	0.24a	0.40a	-	-	4.66a	2.89a	-	-	12c

[1/] Means in column with common letter (s) are not significantly different at 5% by DNMRT.