EFFECT OF CHITOSAN CONCENTRATION AND DIPPING TIME IN ACID-CHITOSAN COATING SOLUTION ON QUALITY OF "*TIEU DA BO*" LONGAN FRUITSDURING COLD STORAGE

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ABSTRACT

In order to find out the concentration and dipping time of acid-chitosan coating solution for treating "Tieu Da Bo" longan fruits to reduce browning and maintain good quality during storage, an investigationwas carried out in a completely randomized factorial design with two factors by dipping longan fruits in 0; 0.2; 0.3; 0.4% chitosan coating solution containing 0.3 N citric acid (pH 3.3) for 1, 3 and 5 minutes. The treated fruits in each treatment were then packaged in PE bag with 0.035mm thickness and stored at 5°C,80-95% RH for 26 days, and observations of fruit quality during storage were taken place. Results indicated that 0.2% chitosan solution containing 0.3 N citric acid (pH 3.3) for 3 minutes could retard skin color changes with the lowest browning grade and disease percentage, and high L value compared to the others. Based on browning grade, the fruits treated with 0.2% chitosan (pH 3.3) were still acceptable after 26 days of storage, while other treatments on fruits were not acceptable. In addition, weight loss and internal quality did not change much during storage.*

Keywords: *chitosan, pericap browning, longan fruit.*

TÓM TẮT

Ảnh hưởng của nồng độ và thời gian xử lý chitosan đến chất lượng của nhãn tiêu da bò trong quá trình tồn trữ lạnh

Nhằm giảm sự hóa nâu vỏ, kéo dài thời gian bảo quản cũng như duy trì chất lượng cho nhãn tiêu da bò, nghiên cứu được thực hiện và bố trí theo kiểu hoàn toàn ngẫu nhiên với 2 yếu tố gồm các nghiệm thức nhúng nhãn tiêu da bò trong dung dịch chitosan ở các nồng độ 0; 0,2; 0,3; 0,4% được chỉnh về pH 3,3 bằng dung dịch acid citric 0,3 N trong thời gian 1, 3 và 5 phút. Sau đó nhãn được đóng gói trong bao PE có độ dày 0,035 mm và tồn trữ lạnh ở 5°C, độ ẩm 80-95%. Các chỉ tiêu chất lượng được đánh giá trong các khoảng thời gian đến 26 ngày ở điều kiện tồn trữ lạnh. Kết quả nghiên cứu cho thấy nhúng nhãn tiêu da bò bằng dung dịch chitosan 0,2% trong 3 phút (chỉnh về pH 3,3 bằng acid citric) giúp hạn chế chuyển màu vỏ và có chỉ số hóa nâu, tỷ lệ bệnh thấp nhất, chỉ số L cao so với các nghiệm thức còn lại. Xét về chỉ số hóa nâu, nhãn được xử lý bằng dung dịch chitosan 0,2 % (pH 3,3) vẫn được chấp nhận sau 26 ngày bảo quản, trong khi đó*

nhãn được xử lý ở các nghiệm thức khác không còn được chấp nhận. Kết quả cũng cho thấy hao hụt khối lượng và chất lượng bên trong của nhãn không thay đổi nhiều trong quá trình tồn trữ lạnh.

Từ khóa: *bảo quản, chất lượng, chitosan, hóa nâu, nhãn.*

1. Introduction

Longan (*Dimocarpuslongan*Lour.) is a subtropical and tropical fruit belonging in Sapindaceae family and commercially planted in China, Thailand, Vietnam and Malaysia (Jiang *et al.*, 2002). In Vietnam, longan *cv.* "Tieu Da Bo" is the primary variety grown for export. Postharvest problems on "Tieu Da Bo" longan are similar to those reported by various researchers on longan, such as rapidly browning and decay of fruits after harvest; short postharvest life - approximately 3-5 days at 20°C and 2-3 weeks at 4-7°C, 90-95% RH depending upon the variety (Jiang *et al.*, 2002; Tian *et al.*, 2002; Duan *et al.*, 2007; Apai, 2010; Khunpon *et al.*, 2011). Pericarp browning on longan fruit is due to the oxidation of phenolic compounds and this may be associated with dehydration, heat stress, senescence, chilling injury and diseases (Pan, 1994). Although postharvest browning problem on longan fruits are being successfully solved by fumigating sulfur dioxide, using SO_2 results in negative impacts on human health as well as life environment and thus is banned or limited use by many countries. Therefore, alternative treatments to SO_2 fumigation are required.

Among various safely alternative approaches as compared to SO_2 fumigation, such as dipping in solution of organic acids (as reported by Sarsud *et al.*,1992); edible coatingusing chitosan/nano-silica hybrid film (Shi *et al.*, 2013); controlled atmosphere storage as given by Tian *et al.* (2001), acid-coating such as dipping longan fruit in 1.2% chitosan coating solution containing 1% citric acid (pH 3.3) as reported by Apai *et al.*(2009) showed a potential ability to solve postharvest problems on longan fruits. A combination of acid and chitosan coating could prevent skin browning, because activity of PPO's were inhibited under acid conditions. In addition, the forming of semipermeable film as well as antifungal activity of chitosan retarded water loss and rot diseases of fruits, so the quality of longan fruits was maintained better.

With the aim to evaluate treatment effectiveness of acid-chitosan coating approach to postharvest problems on Vietnamese longan fruits cv. 'Tieu Da Bo', a study titled "Effect of chitosan concentration and dipping time in acid-chitosan coating solution on quality of '*Tieu Da Bo*'longan fruits during cool storage" was carried out.

2. Materials and methods

2.1. Fruit and preparations

Longan fruits *cv.* "Tieu Da Bo" were harvested in commercial mature from longanorchards belonging to Cai Lay district, Tien Giang province. After harvest, fruits were packed in styrofoam boxes (20kg) and immediately transported to the Division of Postharvest Technology, Southern Horticultural Research Institute (SOFRI), where the experiment was

conducted. At the lab, the longan fruits were sorted out for quality uniformity and cut off the stems of fruit. After sorting, fruits were washed in chlorinated water (200 ppm) and followed by rinsing with clean water and finally dried under electrical fans for 30 minutes at room temperature.

2.2. Preparation of acid-chitosan coating solutions

Stock solution of chitosan 0.5% were prepared by dispersing chitosan in 1.5% acetic acid, stirring continously by heating magnetic stirrer (Theidolph, German) overnight. Then the solution was filtered 2 times through filter cloths. From the stock solution of chitosan 0.5%, 0.2%, 0.3% and 0.4% chitosan solutions were prepared and adjusted to pH 3.3 by 0.3N citric acid (Inolab level 1 WTW, German).

2.3. Experiment design and treatments

The experiment was designed as complete randomized design (CRD) with two factors*i.e.* concentration of chitosan coating solution containing 0.3 N citric acid (pH 3.3) with four levels of 0; 0,2; 0,3; 0,4% chitosan solution and dipping time at 1,3 and 5 minutes of dip. Each treatmentwas triplicated and 30 fruits were used for one replicate.

Longan fruits prepared as described above, were dipped in 0, 0.2, 0.3, 0.4% chitosan solutions for 1, 3 and 5 minutes as indicated in the experiment design and the control was carried out as dipped in distilled water. Afer that, fruits in all treatments and the control were dried by using electrical fans and then were packed in perforated polyethylene bags (30 fruits/bag). The bags of longan fruits were placed in perforated carton boxes and stored at 5°C (80-85% RH) in a coolstore.

2.4. Fruit quality assessments

Fruit quality was assessed at the beginning of storage (0 day) and at 14, 18, 22 and 26 days after storage at 5°C, RH=80-85%.

Quality attributes selected for assessing included weight loss, pericarp colour, browning index, rot incidence, total soluble solids (TSS) and titratable acidity (TA). Weight loss was evaluated by using electrical balance (UX420S, 420 g ± 0.01, Japan) with weight loss (%) = (initial sample weight – current sample weight)/initial sample weight x 100. Pericarp colour was evaluated by using Chroma colour meter (Minolta-CR400, Japan) (L*, a*, b*) system. Three readings were taken from equator of fruit, as described by Piriyavinita *et al.* (2011). Browning index (BI) was estimated by measuring the extent of total brown area on each fruit surface using the following scale (Jiang and Li, 2001): 0= no browning; 1= 1-5% browning; 2= 6-11% browning; 3 = 12-25% browning; 4= 25-50% browning and và 5= ≥ 50% browning. BI = Σ (browning scale x percentage of corresponding fruits within each class). Fruit having (BI≥3) was unacceptable by consumers. Rot disease development on the fruit surface was recorded from 1-4 with 0= no visual development of disease; 1= less than 10%; 2=10-30%; 3= 31-70%; 4= more than 70% of the affected surface area of disease (Thavong *et al.*, 2010). Disease severity = Σ (number of fruits with each score x score)/total observed fruits. Diseaseincidence = (number of fruits having fungal/total observed fruits) x 100.

Pulps of fruits were homogenized in a grinder and filtered through filter cloth to get the juice. The juice was collected to analyze for total soluble solids (TSS)by using hand refractometer (ATAGO, Japan); titratable acid (TA), % citric acid, determined by titration of 5 ml juice with 0.1 N NaOH using 3 drops of 1% phenolphthalein as indicator, TA (%) = 0.0064 x Volume of titrated 0.1 N NaOH x 100 / volume of sample.

2.5. Statiscal analysis

The data obtained were analyzed of variance (ANOVA) according to two factorial completely randomized design, using 8.0 SAS sofware. Treatments were compared by Duncan test at a significance level ($p<0.05$).

3. Results and discussion

3.1. Results

3.1.1. Effect of acid-chitosan coating solution on quality of "Tieu Da Bo" longan fruits after dipping

Dipping in acid-chitosan coating solution helped to improve pericarpcolour of "Tieu Da Bo" longan fruits in term of the lightness of fruit skin. Other quality atributes were not significantly different ($P<0.05$) as compared to control which was only dipped in distilled water (data not shown).

3.1.2. Effect of acid-chitosan coating solutions on quality of "Tieu Da Bo" longan fruits during storage

+ Weight loss (%)

Weight loss is due to water loss and this is also one of the major causes resulting in pericarp browning of "Tieu Da Bo" longan fruits after harvest. As shown in Table 1, longan fruits dipped in acid-coating solutions had less weight loss than control. Both of the chitosan concentration and dipping time had significantly impacted at $P<0.05$ to weight loss and in general, the higher concentrate of chitosan in the acid-chitosan coatings, the lower level in weight loss of longan during storage. However, there was no interaction between the concentrates and dipping times to weight loss of longan in all obervations during the storage (table 1).

Table 1: Effect of chitosan concentration and dipping time in acid-chitosan coating solutionon weight loss of "Tieu Da Bo" longan during storage at 5°C

Concentration (%) (A)	Dipping time (minute) (B)	Weight loss (%)			
		14 days	18 days	22 days	26 days
0	1	0.36	0.45	0.49	0.57
	3	0.35	0.46	0.49	0.58
	5	0.35	0.45	0.48	0.58
0.2	1	0.35	0.45	0.47	0.52
	3	0.34	0.44	0.47	0.51
	5	0.34	0.45	0.47	0.53

Concentration (%) (A)	Dipping time (minute) (B)	Weight loss (%)			
		14 days	18 days	22 days	26 days
0.3	1	0.36	0.45	0.47	0.52
	3	0.35	0.45	0.47	0.53
	5	0.36	0.44	0.47	0.52
0.4	1	0.36	0.45	0.47	0.51
	3	0.34	0.44	0.48	0.52
	5	0.33	0.45	0.47	0.51
CV%		4.58	3.03	1.23	1.56
A		*	*	*	*
B		*	*	*	NS
A*B		NS	NS	NS	NS

Means within a column followed by the same letter are not significantly difference at p<0.05, "": significant difference, "NS": non-significant difference*

+ Pericarp colour

Table 2: Effect of chitosan concentration and dipping time in acid-chitosan coating solution on pericarp colourof "Tieu Da Bo" longan during storage at 5°C

Conc. (%) (A)	Dipping time (min) (B)	L*				a*			
		14 days	18 days	22 days	26 days	14 days	18 days	22 days	26 days
0	1	54.59	53.61	52.59	49.64	3.39	3.40	4.07	6.75
	3	53.98	52.55	51.55	49.06	4.13	4.51	4.84	6.06
	5	55.70	53.31	51.70	48.04	3.80	4.16	4.82	5.61
0.2	1	54.26	53.51	52.61	51.36	3.46	3.76	5.76	6.31
	3	**54.39**	**53.25**	**52.72**	**51.75**	4.59	5.26	5.89	7.30
	5	53.75	52.96	51.78	51.01	3.43	4.44	4.77	6.72
0.3	1	53.15	52.39	51.67	49.73	3.61	4.97	5.22	7.39
	3	53.25	52.24	51.89	49.79	4.46	4.91	5.35	6.22

Conc. (%) (A)	Dipping time (min) (B)	L*				a*			
		14 days	18 days	22 days	26 days	14 days	18 days	22 days	26 days
0.4	5	54.73	52.92	51.40	48.33	5.08	5.3	6.17	6.24
	1	54.19	53.18	51.83	49.57	3.25	4.85	4.96	6.42
	3	54.84	53.62	51.59	49.16	3.80	4.37	4.56	6.43
	5	53.39	52.34	51.15	49.14	3.63	5.00	5.14	7.34
CV%		2.80	3.17	4.04	2.08	22.04	19.60	17.69	14.08
A		NS	NS	NS	*	*	NS	NS	NS
B		NS	NS	NS	*	NS	NS	NS	NS
A*B		NS	NS	NS	NS	NS	NS	NS	NS

Means within a column followed by the same letter are not significantly difference at p<0.05, "": significant difference, "NS": non-significant difference*

Longan is a non-climateric fruit and pericarp colour is almost unchanged except browning. As a result, the yellow colour of "tieu da bo" longan fruits measured via b* valuein the (L, a, b) system was mostly changed (data not shown). However, the increase of redness as given in a* valueand decrease of the lightness in L* value indicated that browning of thepericarp has increased with the increase of the storage time. Moreover, at the storage time of 26 days,the lightness (L*) oflongan in the treatment of (0.2 % and 3 min) gave significantly higher value as compared to the control and others (table 2). This result revealed that treating longan fruit with 0.2% chitosan (pH 3.3) slowed down pericarp change of Tieu Da Bo longan during storage.

+ **Browning index (BI) and browning percentage**

BI and browning percentage of longan fruits in the treatments and control assessed and given in table 3. In general, BI and browning percentage increased with the increase of storage duration from 14 days at 5°C. The least BI recorded in 0.2% chitosan treatments for 1, 3 minutes, had the value 2.53; 2.43 (browning scale <25%), respectively after 26 days storage and under this evaluation, longan quality in these treatments were acceptable. While the others and control had BI values higher than 3 and the quality of longan was unacceptable in longer periods of 26 day storage (table 3).

Along with BI, browning percentage of longan fruit also increased with the storage times; however, there were non-significant differences among the treatments.

Table 3: Effect of chitosan concentration and dipping time in acid-chitosan coating solutionon BI and browning percentage of "Tieu Da Bo" longan during storage at 5°C

Conc. (%) (A)	Dipping time (min) (B)	BI				Browning percentage (%)			
		14 days	18 days	22 days	26 days	14 days	18 days	22 days	26 days
0	1	0.4^{a}	1.8^{a}	2.55^{a}	3.13^{ab}	13.33	60.00	63.33	85.00
	3	0.38^{ab}	1.9^{a}	2.52^{a}	3.33^{a}	15.00	65.00	65.00	83.33
	5	0.45^{a}	1.88^{a}	2.37^{a}	3.12^{ab}	16.67	66.67	66.67	86.67
0.2	1	0.3^{bc}	1.05^{e}	1.35^{e}	2.53^{d}	11.67	36.67	40.00	73.33
	3	0.25^{c}	1.02^{e}	1.33^{e}	2.43^{d}	10.00	26.67	40.00	73.33
	5	0.32^{bc}	1.35^{d}	1.45^{d}	2.83^{c}	15.00	38.33	40.00	75.00
0.3	1	0.28^{c}	1.48^{d}	1.88^{dc}	3.12^{ab}	13.33	43.33	56.67	85.33
	3	0.3^{bc}	1.87^{a}	2.18^{a}	2.95^{ab}	11.67	48.33	51.67	81.67
	5	0.38^{ab}	1.88^{a}	2.32^{a}	3.15^{b}	15.00	55.00	58.33	75.00
0.4	1	0.43^{a}	1.63^{bc}	2.08^{bc}	3.22^{ab}	16.67	50.00	60.00	78.33
	3	0.37^{ab}	1.85^{a}	2.27^{a}	3.3^{a}	16.67	63.33	58.33	78.33
	5	0.42^{a}	1.78^{ab}	2.35^{ab}	3.3^{a}	18.33	55.00	63.33	86.67
CV%		12.35	5.57	6.58	5.14	16.32	11.03	11.48	7.92
A		*	*	*	*	*	*	*	*
B		NS	*	*	NS	NS	NS	NS	*
A*B		*	*	*	*	NS	NS	NS	NS

Means within a column followed by the same letter are not significantly difference at $p<0.05$, "": significant difference, "NS": non-significant difference*

+ Disease severity and disease incendence

Rot disease is one the postharvest problems on longan and it results in decays for longan fruits and the disease is also associated with browning of the pericarp. Disease severity and disease incidence of longan fruits in the treatments and control

were recorded in table 4. Disease severity and disease incidence of longanincreased after 22 days storage at 5°C. There were non-significant differences in disease incidence among the treatments, however, disease incendencein longan fruit treated with 0.2% chitosan for 1, 3, 5 minutes were ≤10%. Disease incendencewas recordedat the least percentage (6.67%) in 0.2% chitosan treatment for 3 minutes and it was significant difference ($P<0.05$) as compared to others. The highest value of disease incendence of fruits was recorded in 0 and 0.4% chitosan treatments.

Table 4: Effect of chitosan concentration and dipping time in acid-chitosan coating solutionon disease severityand disease incidence of "Tieu Da Bo" longan during storage at 5°C

Conc. (%) (A)	Dipping time (B)	Disease severity				Diseaseincidence (%)			
		14 days	18 days	22 days	26 days	14 days	18 days	22 days	26 days
0	1	0	0	1.07	1.68	0	0	16.67	33.33^{a}
	3	0	0	1.15	1.82	0	0	16.67	38.33^{a}
	5	0	0	1.10	1.77	0	0	18.33	36.67^{a}
0.2	1	0	0	0.22	0.82	0	0	6.88	11.67^{cd}
	3	0	0	0.07	0.58	0	0	2.09	6.67^{d}
	5	0	0	0.30	0.90	0	0	10.00	18.33^{bc}
0.3	1	0	0	0.90	1.30	0	0	10.00	20.00^{b}
	3	0	0	0.90	1.33	0	0	13.33	23.33^{b}
	5	0	0	1.00	1.53	0	0	15.00	31.67^{a}
0.4	1	0	0	0.97	1.73	0	0	18.33	36.67^{a}
	3	0	0	1.00	1.77	0	0	16.67	38.33^{a}
	5	0	0	1.10	1.83	0	0	18.33	36.67^{a}
CV%		0	0	13.27	8.75	0	0	18.11	15.37
A		NS	NS	*	*	NS	NS	*	*
B		NS	NS	*	*	NS	NS	*	*
A*B		NS	NS	NS	NS	NS	NS	NS	*

Means within a column followed by the same letter are not significantly difference at p<0.05, "": significant difference, "NS": non-significant difference*

+ Total soluble solids and titratable acidity

Table 5: Effect of chitosan concentration and dipping time in acid-chitosan coating solutionon total soluble solids (TSS) and titratable acidity (TA) of "Tieu Da Bo" longan during storage at 5°C

Conc. (A)	Dipping time (B)	TSS (%)				TA (%)			
		14 days	18 days	22 days	26 days	14 days	18 days	22 days	26 days
0	1	20.07	19.77	19.70	18.90	0.030	0.026	0.026	0.024
	3	21.13	20.00	19.67	18.78	0.028	0.028	0.026	0.024
	5	20.40	19.97	19.77	18.98	0.032	0.030	0.026	0.024
0.2	1	19.77	19.77	19.50	19.20	0.027	0.026	0.026	0.026
	3	20.47	20.33	19.90	19.45	0.028	0.026	0.026	0.026
	5	20.53	20.30	19.77	19.67	0.028	0.026	0.024	0.024
0.3	1	20.17	20.13	19.90	19.47	0.026	0.026	0.021	0.021
	3	20.37	20.23	19.80	19.43	0.026	0.026	0.024	0.021
	5	20.37	20.17	19.73	19.56	0.026	0.026	0.024	0.021
0.4	1	20.47	20.20	19.83	19.23	0.026	0.026	0.024	0.021
	3	21.07	20.17	19.90	19.67	0.030	0.028	0.026	0.024
	5	20.33	20.27	19.90	19.78	0.026	0.026	0.026	0.024
CV%		2.90	1.94	2.11	5.34	10.505	8.231	6.376	8.11
A		NS	*	*	NS	NS	NS	*	*
B		NS	NS	NS	NS	NS	NS	*	*
A*B		NS	NS	NS	NS	NS	NS	NS	NS

Means within a column followed by the same letter are not significantly difference at p<0.05, "": significant difference, "NS": non-significant difference*

Beside pericarp colour, browning and disease, internal quality was also evaluated through total soluble solids (TSS) and titratable acidity (TA). These two attributes also changed during storage duration and the results were recorded in table 5. TSS and TA reduced with the increase of storage duration at 5°C, started from 14 days storage, however, there were non-significant differences among the treatments. 0.2% chitosan for 3 minutes treatment got higher TSS and TA values than others (table 5).

3.2. Discussion

With the results obtained as described above, we can say that 0.2% chitosan solution (pH 3.3) for 3 minutes wasthesuitabletreatment for "Tieu Da Bo"longan fruits to maitainthe quality in

terms of delay pericarp browning and rot disease development. Under the storage condition at 5°C, quality of "Tieu Da Bo" longan fruit was acceptable for 26 days storage. Storage temperature condition is important for extending storage time. Paull and Chen (1987) reported that longan fruit stored at 4-7°C, 90-96% RH could retain to 2-3 weeks even though pericarp colour turned brown, however, storage temperature at 10°Ccould maitain 7-14 days or 3-5 days at 20°C (Zhang and Quantick, 1997) and unacceptable after 10 days (Wall *et al.*, 2011). Furthermore, combining with modified atmosphere pack helped to reduce water loss, decrease weight loss. Results of Zhang and Quantick (1997) showed that using PE bag with 0.03 mm thickness could maintain storage life up to 6 days at room temperature, 35 days at 4°C. Moreover, PE film could reduce moisture loss at temperature from 3-30°C (Su and Yang, 1996; Xu*et al.*, 1998). Zhou *et al.* (1997) reckoned that longan cv. 'Shixia' stored at 3°C in sealed PE bag could be sold after 48 days and 30 days for longan in perforated bag, while unpacked fruits were only acceptable up to 20 days at the same storage temperature. Similar results also recorded in another varieties (Lu *et al.*, 1992; Chen *et al.*, 1998).

Longan was non-climateric fruit so it couldn't ripen after harvest (Paull and Chen, 1987), however, fruit continued metabolism and water loss. Chitosan was used to lengthen postharvest life and maitain quality of fruits and vegetables by forming as a semipermeable coating film outside the fruit and acting as a gas barrier, reduced respiration rate, water loss, enzyme activity and slowed down ripening process as well as reduction of ethylene production, so increase storage life of fruits (Maftoonazad and Ramaswamy, 2005). This effect was reported on many kinds of agricultural products such as tomato, strawberry, longan, apple, mango, banana, bell pepper,... (El-Ghaouth *et al.*, 1991a, 1992; Du *et al.*, 1997, 1998; Jiang and Li, 2001; Kittur *et al.*, 2001; Li and Yu, 2000; El-Ghaouth *et al.*, 1992). Pericarp colour of fruit were also sustained by application of chitosan. Reduction of anthocyanin colour in fruit treated with chitosan was slow, this was proved in litchi, strawberry and raspberry (Li and Chung, 1986; Zhang and Quantick, 1997, 1998). Change in pericarp colour as well as biochemical properties of longan fruit treated with 0.2% chitosan for 3 minutes were slower than others which reached senescene leading higher browning and disease. On the contrary, results of El-Ghaouth *et al.* (1991b) showed that there were synthesis of anthocyanin in strawberry treated with chitosan, the reason might be the effect of kinds of crops, source of chitosan.

4. Conclusion

0.2% chitosan solution containing 0.3 N citric acid (pH 3.3) for 3 minutes could retard skin color changes of longan fruit showing through the lowest browning grade and disease percentage, and high L* value compared to the others. Based on browning grade, the fruits treated with 0.2% chitosan (pH 3.3) were still acceptable after 26 days of storage, while other treatments on fruits were not acceptable. In addition, weight loss and internal quality did not change much during storage.

REFERENCES

[1] Apai W., 2010. Effects of fruit dipping in hydrochloric acid then rinsing in water on fruit decay and browning of longanfruit. *Crop Prot.* 29: pp.1184-1189.

[2] Apai W., Sardsud V., Boonprasom P. and Sardsud U., 2009.Effects of chitosan and citric acid on pericarp browning and polyphenol oxidase activity of longan fruit. *Songklanakarin J. Sci. Technol.* 31(6): pp.621-628.

[3] Chen Y.Z., Chen M.H., Cui J., Chen K.G., Su S.Y., Chen M.D., Cui T., Zhong D.S. and Chen Z.X., 1998. Major measurements of storage and transportation of longan fruit. *Guangdong Agric. Sci.* 24: pp.20-21.

[4] Du J., Gemma H. and Iwahori S., 1997. Effects of chitosan coating on the storage of peach, Japanese pear and kiwifruit. *J. Jan. Hort. Sci.* 66: pp.15-22.

[5] Du J., Gemma H. and Iwahori S., 1998. Effects of chitosan coating on the storability and on the ultrastructural changes of "Jonagold" apple fruit in storage. *Food Preserv. Sci.* 24: pp.23-29.

[6] Duan X.W., Su X.G., You Y.L., Qu H.X., Li Y.B. and Jiang Y.M., 2007. Effect of nitric oxide on pericarp browning of harvested longan fruit in relation to phenolic metabolism. *Food Chem.* 104: pp.571-576.

[7] El-Ghaouth A., Anil J., Ponnampalam R. and Boulet M., 1991b. Use of chitosan coating to reduce water loss and maintain quality of cucumber and bell pepper fruits. *J. Food Process. Preserv.* 15: pp.359-368.

[8] El-Ghaouth A., Arul J., Ponnampalam R. and Boulet M., 1991a. Chitosan coating effect on storability and quality of fresh strawberries. *J. Food Sci.* 56(6): pp.618-620.

[9] El-Ghaouth A., Ponnampalam R., Castaigne F. and Arul J., 1992. Chitosan coating to extend the storage life of tomatoes. *Hort. Sci.* 27(9): pp.1016-1018.

[10] Jiang Y.M. and Li Y.B., 2001. Effects of chitosan coating on postharvest life and quality of longanfruit. *Food Chem.* 73: pp.139-143.

[11] Jiang Y.M., Zhang D.C. and Ketsa S., 2002. Postharvest biology and handling of longan (*Dimocarpus Longan* Lour.) fruits. *Postharvest Biol. Technol.* 26: pp.241-252.

[12] Khunpon B., Uthaibutra J., Faiyue B. and Saengnil K., 2011. Reduction of enzymatic browning of harvested "Daw" longanexocarp by sodium chlorite. *ScienceAsia.* 37: pp.234-239.

[13] Kittur F.S., Kumar K.R. and Tharanathan R.N., 2001. Functional packaging properties of chitosan films. *European Food Research and Technology*, 206: pp.44-47.

[14] Li C.F. and Chung Y.C., 1986. The benefits of chitosan to postharvest storage and the quality of fresh strawberries. In: Muzarelli R., Jeuniaux C., Graham G.W. (Eds.), *Chitin in Nature and Technology*. Plenum Press, New York, USA, pp.908-913.

[15] Li H and Yu T., 2000. Effect of chitosan on incidence of brown rot, quality and physiological attributes of postharvest peach fruit. *Journal ScienceFood Agriculture* 81: pp.269-274.

[16] Lu R.X., Zhan X.J., Wu J.Z., Zhuang R.F., Huang W.N., Cai L.X. and Huang Z.M., 1992. Studies on storage of longan fruits. *Subtrop. Plant Res. Commun.* 21: pp.9-17.

[17] Maftoonazad N. and Ramaswamy H.S., 2005. Postharvest shelf-life extension of avocados using methyl-cellulose-based coating. *LWT* 38: pp.617-624.

[18] Pan X.C., 1994. Study on relationship between preservation and microstructure of Euphoria longan fruit. *J. Guangxi Agric. Univ.* 13: pp.185-188.

[19] Paull R.E. and Chen N.J., 1987. Changes in longan and rambutan during postharvest storage. *HortScience*. 22: pp.1303-1304.

[20] Piriyavinita P., Ketsa S. and Doorn W.G.V., 2011. 1-MCP extends the storage and shelf life of mangosteen (*Garcinia mangostana L.*) fruit. *Postharvest Biology and Technology*, 61: pp.15-20.

[21] Sardsud V., Sardsud U., Sittigul C. and Chaiwangsri T., 1992. *The effects of post-fumigation washing treatments and storage temperature on disease development in fresh Longan.*

[22] Shi S., Wang W., Liu L., Wu S., Wei Y. and Li W., 2013. Effect of chitosan/nano-silica coating on the physicochemical characteristics of Longan fruit under ambient temperature. *J. Food Engineer.* 118 (1): pp.125-131.

[23] Su Y.R. and Yang B.D., 1996. Experiments on storage of postharvest longan fruit at ambient temperature. *Fujian Fruits* 24: pp.14-17.

[24] Thavong P., Archbold D.D., Pankasemsuk T. and Koslanund R., 2010. Postharvest use of hexanal vapor and heat treatment on longan fruit decay and consumer acceptance. *Thammasat Int. J. Sci. Technol.* 15: pp.54-63.

[25] Tian S., Xu Y., Jiang A. and Gong Q., 2002. Physiological and quality responses of longan fruit to high O_2 or high CO_2 atmospheres in storage. *Postharvest Biol. Technol.* 24: pp.335-340.

[26] Tian S.P., Xu Y., Gong Q.Q., Jiang A.L., Wang Y. and Fan Q., 2001. Effects of controlled atmospheres on physiological properties and storability of longan fruit. *ISHS Acta Horticulturae* 575: pp.659-665.

[27] Wall M.M., Nishijima K.A., Keith L.M. and Nagao M.A., 2011. Influence of packaging on quality retention of longans (*Dimocarpuslongan*) under constant and fluctuating postharvest temperatures. *Hortscience* 46(6): pp.917-923.

[28] Xu X.D., Zheng S.Q., Xu J.H., Jiang J.M., Huang J.S. and Liu H.Y., 1998. Effect of smudging sulphur on physiological changes during the deteriorative process of peels of picked longans. *J. Fujian Acad. Agric. Sci.* 13: pp.35-38.

[29] Zhang D. and Quantick P.C., 1997. Effects of chitosan coating on enzymatic browning and decay during postharvest storage of litchi (*Litchi sinensis*Sonn.) fruit. *Postharvest Biol. Technol.* 12: pp.195-202.

[30] Zhang D. and Quantick P.C., 1998. Antifungal effects of chitosan coating on fresh strawberries and raspberries during storage. *J. Hort. Sci. Biotechnol.* 73: pp.763-767.

[31] Zhou Y., Ji Z.L. and Lin W.Z., 1997. Study on the optimum storage temperature and chilling injury mechanism of longan fruit. *Acta Hort. Sin.* 24: pp.13-18.