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EFFICACY OF ORGANIC ACID AND CHITOSAN ON POST HARVEST SHELF LIFE OF LITCHI (*Litchi chinensis* Sonn.) FRUITS CV. ROSE SCENTED

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ABSTRACT : Pericarp browning and aril decay of litchi fruits shorten post-harvest storage and thus reduce market value. Efficacy of organic acid and chitosan on litchi fruits during storage was investigated during 2011. The experiment consisted of 8 treatments of organic acid and chitosan (control, chitosan 1%, Citric acid 5%, Citric acid 10%, Ascorbic acid 5%, Ascorbic acid 10%, Oxalic acid 5% and Oxalic acid 10%) and stored for 12 days at 2°C with RH 85-90%. Results showed that organic acid and chitosan increased anti-oxidation capacity and inhibited dehydration and microbial attack. Among all treatments, chitosan 1% exhibited a potential for shelf life extension of litchi fruits while oxalic acid 10% effectively controlled the pericarp browning of litchi fruits during postharvest storage.

Keywords : *Litchi, post harvest treatments, organic acid, chitosan coating, shelf life.*

Litchi (*Litchi chinensis* Sonn.) is a subtropical fruit with a high market value for its white, translucent aril and attractive red colour. Litchi is very delicate in nature and highly perishable, which accounts for its short shelf life. The attractive bright red colour may be lost within 48 hours (Underhill and Critchley, 11). Pericarp browning of harvested litchi fruits was believed to be a rapid degradation of anthocyanidin by polyphenol oxidase and peroxidase. Dehydration was another key factor leading to pericarp browning. Chitosan, a cationic polysaccharide was used to inhibit pericarp browning of litchi fruits (Zhang and Quantick, 13). Organic acids have been reported for effective control of enzymatic browning of fruits (Santerre *et al.,* 9). The optimal temperature for storage and transportation of litchi is 3-5°C. Post harvest handling and subsequent cold chain adopted will result in extended shelf life of litchi fruit up to 30-40 days (Chen *et al.*, 1). Therefore, the present study was aimed to investigate the efficacy of organic acid and polysachride on pericarp browning and reduce aril decay of litchi fruits.

MATERIALS AND METHODS

The experiment was carried out at Department of Horticulture, College of Agriculture, G.B. Pant University of Agriculture and Technology, Pantnagar, during 2011. Fruits were selected according to uniform size and colour and were randomly distributed into group of 30 fruits. The treatment applied were T_1 (Control), T_2 (Chitosan 1%), T_3 (Ascorbic acid 5%), T_4 (Ascorbic acid 10%), T_5 (Citric acid 5%), T_6 (Citric acid 10%), T_7 (Oxalic acid 5%), T_8 (Oxalic acid 10%). Stock solutions were prepared by taking the distilled water in a volumetric flask and calculation of each of chemical needed for 1 litre solvent. The stock solutions were prepared of citric acid, oxalic acid and ascorbic acid of 5% and 10%, respectively for each treatment. To prepare 1 litre of chitosan 1% concentration, 10.0 g of chitosan was dispersed in 1000 ml of distilled water to which 2 g of citric acid was added, and the mixture was heated to dissolve the chitosan and then kept for cooling. Fruits were dipped for 10 minutes and allowed to dry for 1hour after dipping. Fruits were placed in perforated polythene bags, maintained at 2% level of ventilation and placed in cold store at 2°C. Obsevations were recorded on fruit weight (g) with digital weighing machine, fruit volume (cc) with water displacement method, physiological loss in weight (%), TSS: Acidity ratio and anthocyanin content (mg/100g) according to method of Mazumdar and Majumdar (7). The data was analysed by Two Factorial Complete Randomised Block Design.

RESULTS AND DISCUSSION

Fruit volume and fruit weight under cold storage condition

Data (Table 1) showed that the highest fruit volume (22.93 cc) was observed in T_2 (Chitosan 1%) and lowest (20.33 cc) was recorded in T_8 (Oxalic Acid 10%) treatment. Storage period was found to influence the fruit volume of litchi fruit which was maximum (22.17 cc) on zero day and was *at par* with 2nd and 4th day of storage while minimum fruit volume (20.32 cc) was observed on the 14th day of storage. Interaction effect reflected that most of the treatments significantly affected the fruit volume during the period of storage (Fig. 1). The maximum fruit volume (23.80 cc) was recorded in T_2 (Chitosan 1%) and minimum fruit

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Table 1 : Efficacy of organic acids and chitosan on fruit volume (cc) under cold storage conditions.

Treatment (T)	Storage Days (S)								Mean
	0 day	2 day	4 day	6 day	8 day	10 day	12 day	14 day	
Control (H_2O) (T_1)	22.65	22.40	22.05	21.40	20.85	20.65	20.17	19.99	21.27
Chitosan 1% (T_2)	23.80	23.60	23.33	23.15	22.85	22.42	22.21	22.06	22.93
Ascorbic acid 5% (T_3)	23.00	22.75	22.50	22.35	22.00	21.78	21.60	21.42	22.18
Ascorbic acid 10% (T_4)	21.20	21.00	20.70	20.55	20.20	19.92	19.69	19.49	20.34
Citric acid 5% (T_5)	21.75	21.56	21.30	21.10	20.85	20.59	20.42	20.25	20.98
Citric acid 10% (T_6)	21.50	21.25	20.70	20.48	20.13	19.88	19.82	19.47	20.41
Oxalic acid 5% (T_7)	22.30	22.05	21.65	21.45	21.25	20.82	20.50	20.31	21.29
Oxalic acid 10% (T_8)	21.20	20.90	20.65	20.45	20.15	19.92	19.78	19.56	20.33
Mean	22.17	21.94	21.61	21.37	21.04	20.75	20.53	20.32	21.22
	Treatment (T)			Storage Days (S)			$T \times S$		
CD (P = 0.05)	0.60			0.60			1.70		

Table 2 : Efficacy of organic acids and chitosan on fruit weight (g) under cold storage conditions.

Treatment (T)	Storage Days (S)								Mean
	0 day	2 day	4 day	6 day	8 day	10 day	12 day	14 day	
Control (H_2O) (T_1)	22.53	22.21	21.96	21.67	21.45	21.22	21.00	20.79	21.61
Chitosan 1% (T_2)	21.55	21.20	20.97	20.81	20.37	20.12	19.92	19.78	20.59
Ascorbic acid 5% (T_3)	21.90	21.49	21.14	20.91	20.61	20.42	20.22	19.99	20.84
Ascorbic acid 10% (T_4)	21.73	21.42	21.20	20.91	20.58	20.32	20.10	19.88	20.77
Citric acid 5% (T_5)	23.09	22.73	22.50	22.11	21.71	21.47	21.22	21.05	21.99
Citric acid 10% (T_6)	23.63	23.34	23.17	22.75	22.47	22.35	22.19	21.98	22.74
Oxalic acid 5% (T_7)	21.83	21.45	21.29	20.98	20.60	20.39	19.97	19.75	20.79
Oxalic acid 10% (T_8)	21.86	21.45	21.23	20.78	20.39	20.12	19.99	19.78	20.70
Mean	22.27	21.91	21.68	21.37	21.03	20.80	20.58	20.38	21.25
	Treatment (T)			Storage Days (S)			$T \times S$		
CD (P = 0.05)	0.29			0.29			0.82		

volume (19.47 cc) was recorded in T_6 (Citric Acid 10%) on 14th day of storage period.

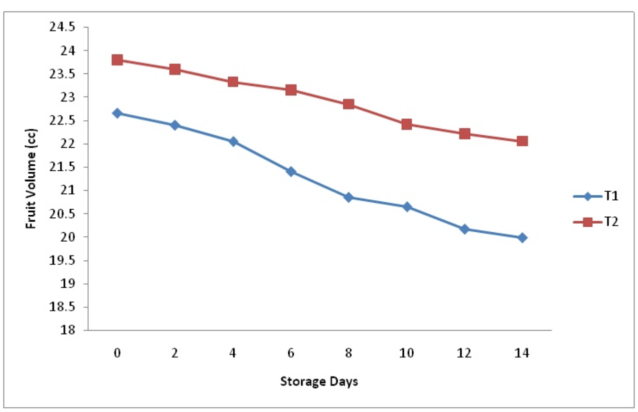

Figure 1 : Efficacy of organic acids and chitosan on fruit volume (cc) under cold storage conditions.

It is evident from data that organic acid and polysaccharide had significant effect on change in fruit weight during storage (Fig. 2). Data presented in Table 2 revealed that the maximum fruit weight (22.74g) was observed in T_6 (Citric Acid 10%) and minimum (20.59 g) was observed in T_2 (Chitosan 1%) treatment. Storage period was found to influence the fruit weight of litchi fruit which was maximum (22.27 g) on zero day. Minimum fruit weight (20.38 g) was observed on 14th day of storage. The maximum fruit weight (23.63 g) under interaction effect was observed in T_6 (Citric Acid 10%) at zero day and minimum (19.75 g) was observed in T_7 (Oxalic acid 5%) on the 14th day of storage.

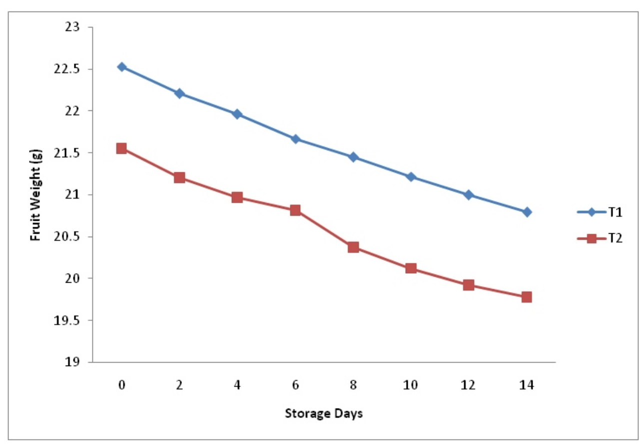

Figure 2 : Efficacy of organic acids and chitosan on fruit weight (g) under cold storage conditions.

Volume and weight of fruits decreased consistently with the increase in storage periods under cold storage.

Table 3 : Efficacy of organic acids and chitosan on physiological loss in weight (%) under cold storage conditions.

Treatment (T)	Storage Days (S)								Mean
	0 day	2 day	4 day	6 day	8 day	10 day	12 day	14 day	
Control (H_2O) (T_1)	0.00	1.41	2.50	3.79	4.76	5.77	6.76	7.69	4.08
Chitosan 1% (T_2)	0.00	1.59	2.68	3.39	5.44	6.60	7.54	8.20	4.43
Ascorbic acid 5% (T_3)	0.00	1.86	3.47	4.51	5.88	6.71	7.68	8.71	4.86
Ascorbic acid 10% (T_4)	0.00	1.39	2.43	3.74	5.29	6.46	7.49	8.50	4.41
Citric acid 5% (T_5)	0.00	1.53	2.53	4.24	5.94	6.99	8.07	8.80	4.76
Citric acid 10% (T_6)	0.00	1.22	1.92	3.69	4.88	5.39	6.09	6.98	3.77
Oxalic acid 5% (T_7)	0.00	1.76	2.47	3.89	5.62	6.59	8.51	9.51	4.79
Oxalic acid 10% (T_8)	0.00	1.83	2.85	4.89	6.69	7.95	8.53	9.50	5.28
Mean	0.00	1.57	2.60	4.02	5.56	6.57	7.59	8.49	4.55
		Treatment (T)			Storage Days (S)			T × S	
CD (P = 0.05)		0.41			0.41			1.71	

However, the rate of decrease was slower in T_2 (Chitosan 1%) treated fruits. The chitosan treated fruits, resulted in minimum volume and weight loss during storage. Lesser rate of reduction in volume and weight loss of the fruits in treatment of chitosan may be due to retarded process of respiration and transpiration or rate of the moisture loss from the fruits (Jiang *et al.,* 3).

Physiological loss in weight under cold storage condition

The effect of various treatments on physiological loss in weight of litchi fruits at different days of storage (Table 3 and Fig. 3) revealed that minimum loss in weight (3.77 g) in T_6 treatment (Citric Acid 10%) and maximum loss in weight (5.28 g) in T_8 (Oxalic Acid 10%) treatment. With the advancement of storage period, it was observed that there was a significant change in weight loss of fruits under all treatments. Minimum weight loss (1.57 g) was noticed on the 2nd day, while maximum loss in weight (8.49 g) took place on the 14th day of storage at cold temperature. Effects of interaction among treatments and storage, period on physiological loss in weight were found statistically significant. T_6 treatment (Citric Acid 10%) reduced the fruit weight loss significantly to 1.22 g and 1.92 g on the 2nd and 4th day of storage respectively, while maximum weight loss was recorded with T_8 treatment (Oxalic Acid 10%) which was observed 9.50 g on 14th day of cold storage period.

Less weight loss in was recorded in Citric acid 10% treatment. Factors responsible for less weight loss can be understand as an increase in the efficiency of the rind to absorb these antibrowning agents more effectively. This in turn could have an effect on lowering down the rate of respiration and transpiration and thereby reducing weight loss (Jiang and Fu, 4). In contrast oxalic acid was found to record the highest weight loss which might be due to reduction in fruit firmness. This finding corroborate with that of Olesen *et al.* (8) who observed higher water loss in oxalic acid dipped fruits due to fruit softening, indicating structural damage to the cross-linkages in the cell wall.

Table 4 : Efficacy of organic acids and chitosan on anthocyanin content (mg/100g) under cold storage conditions.

Treatment (T)	Storage Days (S)								Mean
	0 day	2 day	4 day	6 day	8 day	10 day	12 day	14 day	
Control (H_2O) (T_1)	4.30	4.15	4.05	3.85	3.60	3.65	3.35	3.20	3.74
Chitosan 1% (T_2)	6.15	6.05	5.85	5.67	5.45	5.25	5.05	4.90	5.55
Ascorbic acid 5% (T_3)	5.35	5.15	5.05	4.90	4.75	4.60	4.45	4.30	4.82
Ascorbic acid 10% (T_4)	5.60	5.45	5.30	5.10	4.75	4.65	4.50	4.35	4.96
Citric acid 5% (T_5)	4.95	4.85	4.65	4.45	4.15	3.95	3.85	3.75	4.32
Citric acid 10% (T_6)	5.10	4.95	4.75	4.60	4.25	4.05	3.90	3.75	4.42
Oxalic acid 5% (T_7)	6.30	6.10	5.95	5.80	5.60	5.45	5.30	5.20	5.71
Oxalic acid 10% (T_8)	6.75	6.65	6.50	6.30	6.05	5.90	5.80	5.65	6.20
Mean	5.56	5.42	5.26	5.08	4.82	4.66	4.39	4.39	4.97
		Treatment (T)			Storage Days (S)			T × S	
CD (P = 0.05)		0.10			0.10			0.28	

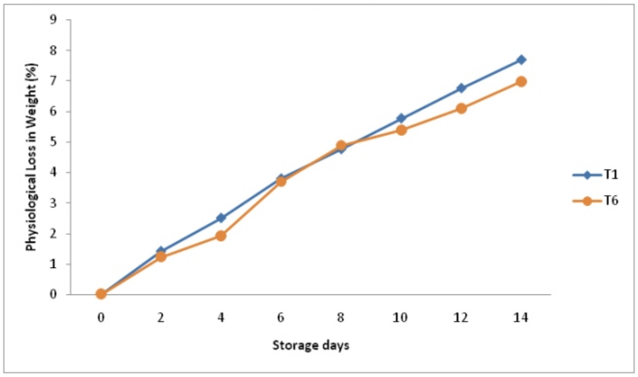

Figure 3 : Efficacy of organic acids and chitosan on physiological loss in weight (%) under cold storage conditions.

Anthocyanin content under cold storage condition

It is evident from the data (Table 4 and Fig. 4) that organic acid and chitosan significantly affected anthocyanin content of the fruits during storage period. The maximum value (6.20 mg/100g) of anthocyanin was recorded in T_8 (Oxalic Acid 10%) and minimum value (3.74 mg/100g) was recorded in T_1 (control) treatment. Storage period was found to influence the anthocyanin content of litchi fruit which was minimum (3.20 mg/100g) on 14th day and maximum (6.75 mg/100g) with T_8 (Oxalic acid 10%) was found on zero day. Interaction effect reflected that most of the treatments significantly affected the anthocyanin content during the period of storage. The maximum value (6.75 mg/100g) was recorded on zero day in T_8 (Oxalic Acid 10%) and minimum (3.20 mg/100g) on 14th day in T_1 (control) treatment.

Perusal of the data on anthocyanin concentration indicated that the treatments applied were significantly superior over control, though the anthocyanin pigment kept decreasing during the storage period. Total anthocyanin concentration decreased during storage which might be due to degradation of anthocyanin. The anthocyanins are found stable at pH below 3, but are converted to colourless chromenols, in an acid-reversible reaction, as the pH rises. Anthocyanins are also prone to enzymatic and non-enzymatic oxidation, often leading to melanin by-products (Kaiser, 5). After harvest of litchi fruit, due to physiological stress, membrane disintegration in the pericarp occurs due to moisture loss which leads to release of PPO in active form. When PPO comes in contact with anthocyanin in presence of oxygen, the anthocyanin gets irreversibly broken down into melanin by-products creating pericarp browning (Lin *et al*., 6). Anthocyanase, which catalyses the hydrolysis of sugar moieties from Anthocyanin to anthocyanidin, was identified in litchi pericarp and this might contribute to the browning of litchi pericarp involved in anthocyanase-anthocyanin-PPO reaction (Ducamp *et al*. 2).

Dipping of fruits in oxalic acid prevented pericarp browning and restored the red color, maintained the level of total anthocyanins, and inhibited an increase in PPO and POD activities, which are associated with pericarp browning. This implies that oxalic acid prevents litchi pericarp enzymatic browning by acting as an inhibitor of these enzymes. There are few reports on the inhibition of PPO and POD by oxalic acid (Son *et al.,* 10).

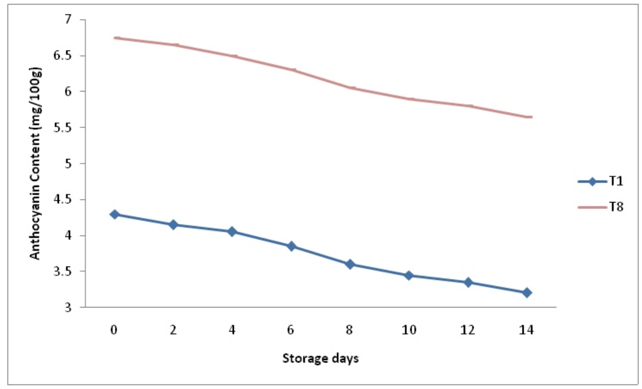

Figure 4 : Efficacy of organic acids and chitosan on anthocyanin content (mg/100g) under cold storage conditions.

TSS: Acid ratio under cold storage condition

The examination of data (Fig. 5) indicates that with the advancement of storage period, it was observed that there was an increase in TSS: Acidity ratio of fruits under all treatments with maximum value (95.95) on the 14th day in T_1 treatment (Control) and minimum (27.50) on zero day of storage in T_8 (Oxalic Acid 10%) treatment. The maximum TSS: Acidity ratio (95.95) under interaction effect was observed in T_1 (Control) at 14th day and minimum (27.50) was observed in T_8 (Oxalic acid 10%) on the zero day of storage.

The highest TSS: Acidity ratio was observed increasing in due course of time because the TSS tends to increase and acidity decrease with the advancement of storage period. The control showed the maximum TSS: Acidity ratio due to the fact that all the treatments were acidic in nature and somehow the acid got leached in the fruits through micropores present in pericarp of litchi fruit. Titratable acidity values include the contribution of the thin layer of solution adsorbed onto the pericarp. All layers of the pericarp are not impregnated to the same extent, and it is probably the epicarp, where the oxidase activity is the most intense which is the most directly affect the fruit acidity and p*H* (Underhill and Critchley, 12).

In conclusion, oxalic acid effectively suppressed colour deterioration in litchi fruits, the efficacy of acid dipping in preventing browning is dependent on time and concentration used. Dipping fruit in oxalic acid

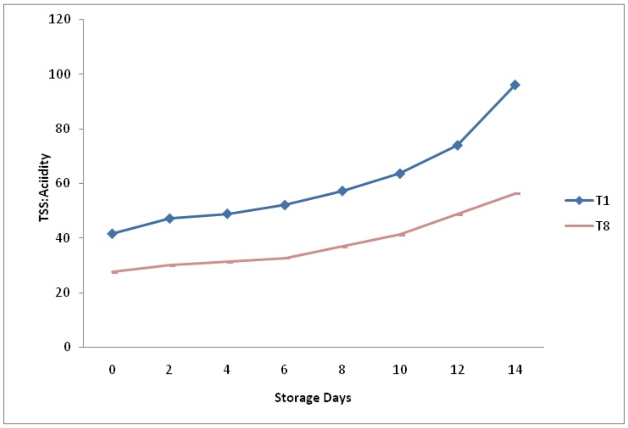

Figure 5 : Efficacy of organic acids and chitosan on TSS : Acidity ratio under cold storage conditions.

prevented pericarp browning and restored the red color, maintained the level of total anthocyanins, and inhibited increase in polyphenol oxidase and peroxxidase activities, which are associated with pericarp browning. The chitosan acted as anti-transparent coating for reducing respiration and transpiration rate. Chitosan contains anti-fungal properties, therefore, inhibits fungal growth to some extent. Hence, to maintain quality maintenance and shelf life extension of litchi fruit, chitosan may help in formation of novel strategies that could be feasible for storage of litchi fruit on commercial scale.

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