DOI : 10.5958/0974-0112.2018.00088.9

Indian J. Hort. 75(3), September 2018: 523-527

Effect of Generally Regarded as Safe (GRAS) chemical treatments on the quality of litchi during storage

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ABSTRACT

Pericarp browning of litchi is the most important problem which takes place rapidly after harvest and reduces the commercial acceptability and shelf-life of fruit. To study the combine effect of Generally Regarded as Safe (GRAS) chemicals on the litchi fruits,the combinational treatments with sodium hypochlorite (0.2%) + KMS (0.5%), sodium hypochlorite (0.2%) + KMS (0.6%), sodium hypochlorite (0.2%) + sodium chlorite (0.05%), and sodium hypochlorite (0.2%) + sodium chlorite (0.06%) by the immersion method were given to Shahi litchi fruits. The treated fruits were packed in punnets and stored at 2ºC and 90-95% relative humidity. In general, all treatments significantly reduced pericarp browning. The most remarkable effect was obtained with sodium hypochlorite (0.2%) in combination with KMS (0.5%) followed by sodium chlorite (0.05%), which was effective in delaying anthocyanin degradation, polyphenol oxidase activity and weight loss as well as retaining higher amounts of total soluble solids, titratable acidity and phenolic content in fruits. The combinational treatment of sodium hypochlorite and KMS (0.5%) was able to extend shelf life up to 25 days and could be used as cost-effective alternative method to reduce pericarp browning and fruit quality deterioration of litchi during low temperature storage.

Key words: *Litchi chinensis*, Pericarp browning, fruit quality.

INTRODUCTION

Litchi (*Litchi chinensis* Sonn.) is the most renowned edible fruit of soapberry family, Sapindaceae and native to subtropical areas of southern China. India is the second largest producer of litchi in the world after China. In India, Bihar contributes major production (70% of total production) followed by West Bengal, Jharkhand, Assam, Punjab etc., contributing total production of 585 MT of litchi annually from 84,000 ha (NHB, 11). The red colour of the pericarp turns brown within 2-3 days after harvest of the fruits which drastically reduces the commercial value of the fruits. Pericarp browning, generally related to water loss or desiccation from the pericarp, often limits the marketability of litchi. Underhill and Critchley (14) concluded that desiccation or moisture loss from pericarp tends to increase its pH, which plays great role in pericarp browning, as reduced pH results in improved red colouration. At pH (>4) anthocyanin is converted to a colourless form and stimulates PPO activity which leads to independent browning in the epicarp to become more visible. Furthermore, Bhushan *et al*. (1) reported that water loss or dehydration causes rapid loss of membrane integrity which leads to interactions of the substrate with various enzymes such as peroxidase (POD), lipoxygenase (LOX), polyphenol oxidase (PPO), anthocyanins and phenylalanine ammonia lyase (PAL). To overcome this problem, pre-treatments and low-temperature storage are the two vital wings of postharvest management of this perishable commodity to maintain the quality for extended periods.

Numerous approaches have been tried since the time of commercialization of this fruit but each approach has it's certain limitations either relating to the tedious and costly method of applications or short duration effect or human health concern. According to the literature, the combinational application of GRAS chemicals by dip or spray method may maintain the quality of fruit which will thus help in extending the marketability of litchi for a prolonged period. In our study, sodium hypochlorite was used as a treatment due to its acidic nature as well as disinfectant and fungicidal property (Cerioni *et al*., 2). The potassium metabisulphite (KMS) as a source of SO_2, which acts as antimicrobial and antioxidant, have been used since it is reported to inhibit browning in several fruits (Milne *et al*., 10). Sodium chlorite (SC) is an oxidising and sanitising agent which is able to generate chlorine dioxide (ClO_2) in an acidic environment which was reported to reduce enzymatic browning of fruits and vegetables (Liu *et al*., 5). With the above advantages of these GRAS chemicals, the present study was formulated, for treatment as the combinational application for

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inhibiting the pericarp browning of litchi fruits during low-temperature storage.

MATERIALS AND METHODS

Litchi fruits (cv. Shahi) were harvested at commercial maturity (90-95% of peel colour having red colour) from the orchard of National Research Centre on Litchi, Muzaffarpur, Bihar. Fruits having the uniform size, shape and colour, as well as free from diseases, were selected. De-stalking of fruits was done, leaving 2 mm pedicel with the help of the sharp scissor. The fruits were transported to Division of Food Science and Postharvest Technology laboratory, ICAR-IARI, New Delhi, in CFB boxes within 48 hours of harvest and spoiled fruits if any were sorted out. Then the fruits were treated with sodium hypochlorite (0.2%) + KMS (0.5%) (T1), sodium hypochlorite (0.2%) + KMS (0.6%) (T2), sodium hypochlorite (0.2%) + sodium chlorite (0.05%) (T3), sodium hypochlorite (0.2%) + sodium chlorite (0.06%) (T4) and control (T5). The application was done by dipping the fruits in respective solution of chemical for 5 minutes and drying for 10 minutes, followed by next chemical treatment. Finally, the fruits were packed in CFB boxes and stored at 2ºC and 90-95% relative humidity. The fruit samples were withdrawn from cold storage at regular intervals for the analysis of physio-chemical attributes.

Browning of litchi pericarp was accessed visually by measuring the total browned area on the pericarp taking 50 fruits of each treatments by using following scale: 0 = no browning (excellent quality); 1 = slight browning; 2 = <1/4 browning; 3 = 1/4–1/2 browning; 4 = 1/2–1/3 browning and 5 = >1/3 browning (poor quality). Fruits having browning index above 2.0 were considered as un-acceptable for marketing quality. The browning index was calculated as BI= $\sum$ (browning scale × % of corresponding fruits within each class). Physiological loss in weight was determined by weighing the fruits at different intervals which were calculated as the difference between the initial weight and the final weight at the time of measurement and expressed as the percentage of initial fruit weight.

Fruit quality attributes such as total soluble solids (TSS), titratable acidity and total phenolics content were determined in according to standard methods (Ranganna, 13). The total anthocyanin content was determined by using the pH-differential method (Wrolstad *et al*., 15) using two buffer systems-potassium chloride buffer, pH 1 (0.025 M) and sodium acetate buffer, pH 4.5 (0.4 M). Polyphenol oxidase activity was assayed with catechol as a substrate according to the method of Zauberman *et al*. (17). The experiment was conducted in a factorial completely randomised design with three replications, each replication having 50 fruits. The data obtained from the experiments were analysed as per design and the results were compared from ANOVA by calculating the critical difference (CD) at 5%level of significance. The data were analysed using the WASP 2.0 (Web Agri Stat Package).

RESULTS AND DISCUSSION

Pericarp browning is the main factor influencing postharvest quality and storage life of litchi fruits. Browning of litchi fruits is due to oxidation of phenolic compounds by the activities of polyphenol oxidase which causes degradation of anthocyanin pigments. In our study, higher concentrations of KMS (0.6%) and sodium chlorite (0.06%) were used but found less effective in reducing pericarp browning (Fig. 1) which may be due to tissue damage (Lu *et al.*, 6) leading to oxidation of phenolic compounds by PPO resulting to pericarp browning of litchi fruits. Browning of fruits increased as the storage period extended, however, fruits treated with KMS (0.5%) had lowest browning index (1.87) followed by sodium chlorite treated fruits (0.05%) (1.88) or those which were not treated with any chemical i.e. control (2.88) at 25 days of storage. In a similar study, Wu *et al*. (16) also reported that sulphur dioxide inhibited enzymatic browning in longan fruits during storage by inhibiting PPO activity.

Irrespective of the treatments, there was a continuous increase in weight loss of stored litchi (Table 1). It was found that water loss from KMS (0.5%) treated fruits were less (9.98 %) than sodium chlorite (0.05%) treated fruits (10.02 %) whereas weight loss from control fruits was found to be 11.74%, which was 1.8% higher than the KMS (0.5 %) coated fruits. Lower water loss from KMS (0.5%) treated fruits may be due to liberation of SO_2 by KMS which possibly maintained cell integrity and permeability of tissues, thereby hindered the loss of moisture from the fruit surface.

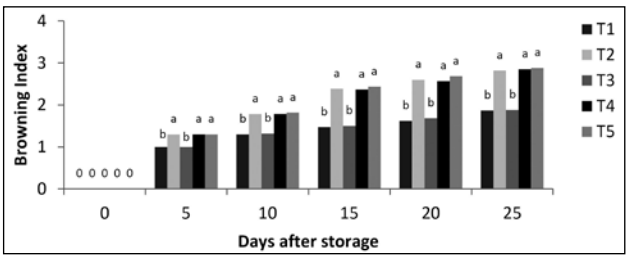

Fig. 1. Effect of different treatments on quality of litchi stored at 2ºC and 90-95% RH. Columns with different letters of each storage period indicate significantly different (p ≤ 0.05).

There was a significant decline in acidity content during storage in all the treatments (Table 2). However, fruits treated with sodium chlorite (0.05%) retained higher acidity (0.24%) among all the treatments. Decreasing trend in acidity content may be due to the utilisation of acids in the respiratory process and other reactions (Mahajan *et al*., 7), which may be lowered further by penetration of acid into the fruit aril.

During storage, TSS gradually increased upto 10 days in all the treatments but decreased in later storage days (Table 3). However, TSS remained higher than the initial day on last day of storage in all treatments except control. The highest TSS was found in KMS (0.5%) treated fruits followed by sodium chlorite (0.05%) at 25 days of storage. This initial increase in TSS may be due to dehydration and conversion of starch and polysaccharides into simple sugars. But, later decreased in TSS may be due to biochemical activities like utilisation of reducing sugars and other organic metabolites (Marboh *et al*., 8).

In this study, total anthocyanin content in the peel decreased gradually due to degradation of anthocyanin pigments with the advancement of storage period in all the fruits. However, KMS (0.5%) treated fruits retained higher anthocyanin pigments (6.0 mg/100g) than control fruits, followed by those treated with sodium chlorite (0.05%) at 25 days of storage (Fig. 2). Higher concentration of anthocyanin in KMS (0.5%) treated fruits may be due to bleaching action of the chemical caused by nucleophilic ion reactions which might have resulted in the removal of its original colour and subsequent release of positive ions by anthocyanin, generating the red colour under acidic medium as reported Neog & Saikia (12).

All the treated fruits showed a significant delay in increase in PPO activities but KMS (0.5%) dipped fruits showed the lowest PPO activity (132.43 units/ min/mg) whereas control fruits showed the highest

Table 1. Effect of different treatments on physiological loss in weight (%) of cold stored litchi fruits.

	Days of storage													
Treatment	2	4	6	8	10	12	14	16	18	20	22	24	26	Mean
T1	1.56	3.19	4.63	5.41	5.97	6.50	7.16	7.66	8.16	8.75	9.21	9.60	9.98	6.75
T2	2.15	3.99	5.30	5.75	6.52	7.39	8.00	8.54	9.10	9.64	10.25	10.84	11.32	7.60
T3	1.59	3.28	4.57	5.25	5.88	6.36	7.07	7.50	8.01	8.61	9.15	9.54	10.02	6.68
T4	2.05	3.81	5.23	5.80	6.60	7.68	7.98	8.55	9.06	9.69	10.22	10.91	11.44	7.62
T5	2.01	3.84	4.95	5.94	6.70	7.84	7.93	8.71	9.25	9.85	10.39	11.01	11.74	7.70
Mean	1.87	3.62	4.94	5.63	6.33	7.15	7.63	8.20	8.72	9.31	9.84	10.38	10.90	
CD at 5%														
Treatment (A)							0.582							
Storage (B)							0.939							
A × B							2.099							

Table 2. Effect of different treatments on titratable acidity (%) of cold stored litchi fruits.

Treatment	0 days	5 days	10 days	15 days	20 days	25 days	Mean
T1	0.50	0.39	0.34	0.29	0.24	0.22	0.33
T2	0.50	0.38	0.33	0.28	0.24	0.21	0.32
T3	0.51	0.38	0.35	0.29	0.26	0.24	0.34
T4	0.49	0.38	0.32	0.28	0.22	0.20	0.31
T5	0.49	0.40	0.32	0.30	0.25	0.20	0.33
Mean	0.44	0.39	0.33	0.29	0.24	0.21	
CD at 5%							
Treatments (A)				0.014			
Storage (B)				0.016			
A × B				0.035			

Table 3. Effect of different treatments on total soluble solids (ºB) of cold stored litchi fruits.

Treatment	0 day	5 day	10 day	15 day	20 day	25 day	Mean
T1	17.73	18.10	18.53	18.40	18.10	18.13	18.17
T2	18.00	18.33	18.73	18.50	18.17	18.01	18.29
T3	17.90	18.27	18.70	18.53	18.20	18.26	18.31
T4	17.80	18.17	18.60	18.37	18.13	17.90	18.17
T5	17.87	18.23	18.63	18.40	18.17	17.77	18.18
Mean	17.86	18.22	18.64	18.44	18.15	18.01	
CD at 5%							
Treatment (A)				0.117			
Storage (B)				0.129			
A × B				0.288			

activity (169.47 units/min/mg) at 25 days of storage (Fig. 3). According to McEviley *et al*. (9), PPO contains copper (Cu) which is essential for enzyme activity in its active site. The chemicals like KMS and sodium chlorite might have affected the oxidation level of copper causing alternation in the catalysis of PPO activity. Neog and Saikia (12) reported that when sulphite causes reduction of oxygen, the oxidase cannot oxidise polyphenol or can't combine with quinines which cause inactivity of quinines to take part in the reaction. Thus, this hinders the oxidation of pericarp, thereby reducing the pericarp browning.

Total phenolic content in all the fruits decreased dramatically during storage which may be due to oxidation during the browning process (Fig. 4). Generally, oxidation of phenolic compounds into quinones catalyses and then polymerization of quinones into brown polymeric compound which results in the development of brown colour. It was found that treated litchi fruits significantly delayed the decrease in phenolic content during storage, however lowest phenolic content (147.87ug GAE/g) was found in sodium chlorite (0.06 %) treated fruits and highest phenolic content (178.33 ug GAE/g) was found in sodium chlorite (0.05 %) followed by KMS (0.5 %) in comparison to control fruits at 25 days of storage. Increasing trend in PPO activity in litchi fruit might be due to the fact that PPO might have oxidised the phenolic compounds which might have lowered the phenolic content in the fruit (Duan *et al*., 3). In contrast, higher content of phenolic compounds in KMS (0.5%) and sodium chlorite (0.05%) treated fruits may be due to lower PPO activity. A similar trend of phenolic content has also be reported in litchi (Liang *et al*., 4).

The results showed that combination treatments of sodium hypochlorite with GRAS chemicals can be effective in preventing the pericarp browning and maintaining other quality parameters of litchi

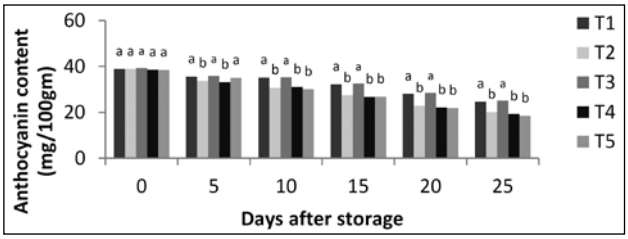

Fig. 2. Effect of different treatments on quality of litchi stored at 2ºC and 90-95% RH. Columns with different letters of each storage period indicate significantly different (p≤0.05).

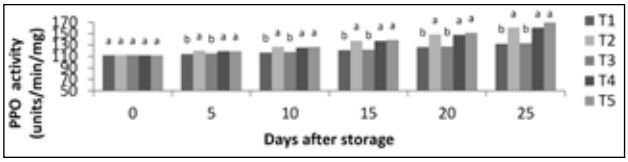

Fig. 3. Effect of different treatments on quality of litchi stored at 2ºC and 90-95% RH. Columns with different letters of each storage period indicate significantly different (p≤0.05).

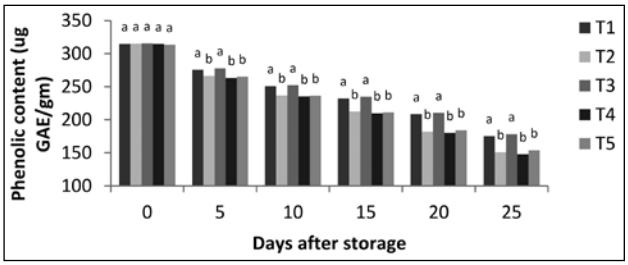

Fig. 4. Effect of different treatments on quality of litchi stored at 2ºC and 90-95% RH. Columns with different letters of each storage period indicate significantly different (p≤0.05).

fruits during storage at 2ºC for 25 days. The most remarkable effect was obtained with sodium hypochlorite (0.2%) in combination with KMS (0.5%), followed by sodium chlorite (0.05%) which was effective in delaying anthocyanin degradation, polyphenol oxidase activity and weight loss as well as retaining higher amounts of total soluble solids, titratable acidity and phenolic content in fruits. It is concluded that the combinational treatment of sodium hypochlorite (0.2%) and KMS (0.5%) was able to extend shelf life up to 25 days and could be used as cost-effective alternative method to reduce pericarp browning and fruit quality deterioration of litchi during low temperature storage.

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Received : May, 2017; Revised : July, 2018;
Accepted : August, 2018