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Effect of Oxalic Acid on Control of Post-harvest Browning of Litchi (*Litchi chinensis* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Post-harvest browning of litchi is a common phenomenon that occurs due to enzymatic and non-enzymatic reactions. Enzymatic browning is primarily caused by polyphenol oxidase (PPO) activity, leading to the formation of brown pigments. Non-enzymatic browning is caused by the Maillard reaction between reducing sugars and amino acids. Factors such as temperature, humidity, and mechanical damage can accelerate browning. Proper handling, storage, and the use of antioxidants can help minimize post-harvest browning, extending the shelf life and maintaining the visual appeal of litchi fruits. The present investigation was laid out in the post-harvest laboratory of horticulture department, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during the year 2022-2023. The experiment was laid out in the CRBD with 8 treatments and 3 replications. Litchi fruit, Cv. Purvi (about 80%- matured stage), were harvest from a Local market Prayagraj, fruit was selected for uniformity of size and colour, and blemished and diseased fruit were discarded. The selected fruit were dipped in different oxalic acid concentration solution (0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5 and 4.0mM) and Bavistin (0.05mg) as the control) for 10 mint 4 h of

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harvest, and then air dried. Each 10 fruit of the treated fruit was packed into a plastic punnet and wrapped with a 0.2-mm polyethylene bag, and then stored in an ambient condition. Post-harvest storage studies revealed that under ambient and refrigerated storage conditions T_8 Oxalic acid (4.0mM) + Bavistin (0.05%) treatment showed slower rate of reduction on fruit length (cm) and fruit weight (g), browning (%) were significantly affected by treatments. There was significant effect of treatments on chemical parameters like pH, TSS (0Brix), acidity (%), ascorbic acid (mg100g), reducing sugar under ambient and refrigerated storage at different day's intervals.

Keywords: Browning; litchi, bavistin; oxalic acid; physical; chemical parameters.

1. INTRODUCTION

Litchi (*Litchi chinensis* L.) is one of the important subtropical fruits of India. It is a member of the family Sapindaceae (or soapberry family) and sub-family Nepheleae, which has about 150 genera and more than 2000 species Mishra *et al*. (2017). It is indigenous to south-eastern China from where it is considered to have reached eastern India through Myanmar by the end of 17th century or shortly thereafter Hayes (1957). In India, 585.30 thousand metric tonnes of litchi are produced annually from 84.20 thousand hectares area Anonymous [1]. India is the second largest producer of litchi in the world after China with an area and production of 86,000 ha and 552,000 tonnes, respectively during 2019-20. In India, Bihar, West Bengal, Jharkhand, and Assam accounts for 64.2% of the total litchi production in the country. It is an important evergreen, subtropical fruit tree. It possesses pinkish or bright red coloured skin and has juicy and sweet edible aril. It is a non-climacteric fruit and does not ripe off the trees after harvest. So, its fruit should be harvested at proper maturity stage to ensure its characteristic quality [2]. The litchi is a very significant subtropics fruit crop belongs to family Sapindaceae. It's extremely specific in climatically requirements and possibly because of this cause its farming is limited to few countries within the globe. Worldwide, commercial litchi production is cantered largely in the Northern hemisphere, with growing areas including China, Thailand, Taiwan, India, USA and Israel (Menzel, 2001). Oxalic acid (OA) is a natural organic acid and playing an important function in systemic resistance and response to environment (Zheng *et al*. 2012). Oxalic acid application is a secure and hopeful postharvest handling technology for keeping quality and prolonging storage life of fruit [3]. Oxalic acid has shown some antioxidant activities and plays a serious function in systemic strength, programmed cell death; redo homeostasis in plants and an anti-senescence effectiveness in harvested fruits (Wu et al. 2011). In addition, postharvest treatment of Oxalic acid reduced the activity of PPO enzyme [4]. Oxalic acid is a metabolic product that possesses several functional benefits including anti-browning effect. Furthermore, studies have shown that oxalic acid is the most effective anti-browning compound for litchi pericarp Zheng and Tian (2006). It has been reported that oxalic acid improves the shelf life of litchi fruit by reducing anthocyanin degradation, phenolic compound oxidation, and restriction of peroxidative activity Zheng and Tian (2006). The shelf life of litchi is improved by inhibition of high respiration and ethylene production at the post-harvest stage. 1–methylchyclopropane (1-MCP) is an anti-ethylene substance that monitors and blocks the ethylene receptors [5]. Litchi is one of the perishable fruits which has very short life, outer skin of litchi is susceptible to browning, which reduces market value [6,7]. To keep the original colour of litchi for long time is challenging during storage. Oxalic acid is a metabolic product that possesses several functional benefits shows anti-browning effect. Studied have shown that oxalic acid is the most effective anti-browning compound for litchi pericarp. It has been reported that oxalic acid improves the shelf life of litchi fruit by reducing anthocyanin degradation, phenolic compound oxidation, and restriction of per oxidative activity.

2. MATERIALS AND METHODS

The present investigation was done to understand the effect of oxalic acid and Bavistin doses on post-harvest browning of Litchi variety Purvi. The experiment was carried out at Post harvest Laboratory, Department of Horticulture, Naini Agricultural Institute SHUATS, Prayagraj, U.P., during 2022-23. The experiment was laid out in complete randomized block design (CRBD). The different combination doses of oxalic acid and Bavistin used are as follows T_0 (Control); T_1 (Oxalic acid (0.5 mM) + Bavistin (0.05%); T_2 (Oxalic acid (1.0 mM) + Bavistin

(0.05%); T_3 (Oxalic acid (1.5 mM) + Bavistin (0.05%); T_4 (Oxalic acid (2.0 mM) + Bavistin (0.05%); T_5 (Oxalic acid (2.5 mM) + Bavistin (0.05%); T_6 (Oxalic acid (3.0 mM) + Bavistin (0.05%); T_7 (Oxalic acid (3.5 mM) + Bavistin (0.05%) and T_8 (Oxalic acid (4.0 mM) + Bavistin (0.05%). Observations were recorded at ambient storage and refrigerator storage for different days after harvest. Various characters studied comprised of fruit length, fruit weight, Browning assessment, pH, TSS, acidity, ascorbic acid content etc. The data were statistically analysed by the method suggested by Fisher and Yates [8]**.**

3. RESULTS AND DISCUSSION

3.1 Fruit Length (cm) and Fruit Weight (g)

The maximum fruit length at 9th days (3.67) and at 20 days (3.88) was found in treatment T_8 Oxalic acid (4.0mM) + Bavistin (0.05%). A further review of table also revealed that treatment Oxalic acid (0.5mM) and Oxalic acid (1.0mM) as found to be statistically at par to treatment T_8 Oxalic acid (4.0mM) + Bavistin (0.05%). Whereas the minimum fruit length at 9th days (2.87) at 20 Days (3.05) was found treatment control under ambient refrigerate storage condition. The maximum fruit weight (g) at 9th days (9.67) and at 20 days (10.75) was found in treatment T_8 Oxalic acid (4.0mM) + Bavistin (0.05%). A further review of table also revealed that treatment Oxalic acid (3.5mM) and Oxalic acid (2.5mM) as found to be statistically at par to treatment T_8 Oxalic acid (4.0mM) + Bavistin (0.05%). Whereas the minimum fruit weight (g) at 9th days (6.73) at 20 Days (7.81) was found treatment control under ambient refrigerate storage condition. The browning index increased as the storage duration advanced. However, the indices of the litchi fruit treated with 2- and 4-mM oxalic acid were observed significantly lower than that of the control five days after the fruit harvest [3]. Our present findings are in accordance with the result explained by Zheng and Tian [3]. The effect of oxalic acid on pericarp colour during storage was studied by Yadav (2015) and found 10%oxalic acid promising for colour retention of peel than KMS used alone or in combination with precooling on second day of storage.

3.2 Browning (%)

The minimum browning (%) at 9th days (71.00) and at 20 days (45.56) was found in treatment T_8 Oxalic acid (4.0mM) + Bavistin (0.05%). Whereas the maximum browning (%) at 9th days (398.30) at 20 days (360.08) was found treatment control under ambient refrigerate storage condition. Hydro-cooling litchi delayed pericarp browning and upgraded the overall quality of fruits after storage, reported by Ketsa and Leelawatana [9]. Litchi fruits are at a greater level of hydration after hydro-cooling and are speculated to be involved with pericarp browning (Olesen et al. 2003). Moreover, packaging system enhanced the accumulation of higher relative humidity and maintained a high humidity environment for fruit. Thus, the LDPE bag contributed to cause lower moisture loss. Pericarp browning of litchi fruit directly correlates with moisture loss [10]. The lower moisture loss influenced the lower browning score of litchi fruit [11]. Moreover, anthocyanin decolourization involved structural changes and anthocyanin structure and colour were directly dependent on pH (Nakayama & Powers, 1982). Date here indicates that the effect of oxalic acid on pericarp browning of litchi during the storage was associated with inhibition of the anthocyanin degradation rather than direct maintenance of the reddish colour of anthocyanin by pH change. The increase of anthocyanin content at the beginning of the storage time might result from anthocyanin synthesis after harvest.

3.3 pH, TSS (°Brix), Acidity, Ascorbic Acid Content (mg/100g) and Reducing and Non-reducing Sugar

The minimum pH at 9th days (4.94) and at 20 days (4.78) was found in treatment T_8 Oxalic acid (4.0mM) + Bavistin (0.05%). Whereas the maximum pH at 9th days (5.29) at 20 days (5.02) was found treatment control under ambient refrigerate storage condition. Moreover, anthocyanin decolourization involved structural changes and anthocyanin structure and colour were directly dependent on pH (Nakayama & Powers, 1982). Date here indicates that the effect of oxalic acid on pericarp browning of litchi during the storage was associated with inhibition of the anthocyanin degradation rather than direct maintenance of the reddish colour of anthocyanin by pH change. The increase of anthocyanin content at the beginning of the storage time might result from anthocyanin synthesis after harvest. The maximum TSS (°Brix) at 9th days (20.72) and at 20 days (22.81) was found in treatment T_8 Oxalic acid (4.0mM) + Bavistin (0.05%). A further review of table also revealed that treatment Oxalic acid (3.5mM), Oxalic acid (3.0mM) and Oxalic acid (2.5mM) as found to be

Table 1. Effect of oxalic acid and bavistin on fruit length (cm) and fruit weight (g) of litchi

Treatments No.	Treatments combinations	Fruit length (cm)				Fruit weight (g)			
		Ambient storage		Refrigerated condition		Ambient Storage		Refrigerated condition	
		0 day	9 days	0 day	20 days	0 day	9 days	0 day	20 days
T0	Control	3.16	2.87	3.32	3.05	18.43	6.73	19.48	7.81
T1	Oxalic acid (0.5mM)	3.48	3.14	3.69	3.47	19.75	8.76	20.93	9.82
T2	Oxalic acid (1.0mM)	3.42	3.10	3.66	3.43	19.28	8.70	20.50	9.78
T3	Oxalic acid (1.5mM)	3.33	3.07	3.59	3.37	19.36	8.48	20.59	9.57
T4	Oxalic acid (2.0mM)	3.38	3.05	3.59	3.36	19.40	8.84	20.64	9.92
T5	Oxalic acid (2.5mM)	3.77	3.46	4.01	3.78	20.08	9.06	21.33	10.15
T6	Oxalic acid (3.0mM)	3.24	3.02	3.50	3.27	19.25	8.64	20.51	9.72
T7	Oxalic acid (3.5mM)	3.81	3.56	4.02	3.79	20.15	9.58	21.39	10.67
T8	Oxalic acid (4.0mM)	3.87	3.67	4.11	3.88	20.37	9.67	21.62	10.75
F-Test		**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
SEd (+)		**0.125**	**0.02**	**0.12**	**0.20**	**0.114**	**0.081**	**0.220**	**0.097**
C.D. at 0.5%		**0.264**	**0.05**	**0.26**	**0.43**	**0.242**	**0.171**	**0.446**	**0.205**

Table 2. Effect of oxalic acid and bavistin on browning (%) of litchi

Treatments No.	Treatments combinations	Browning			
		Ambient storage		Refrigerated condition	
		0 days	9th days	0 days	20th days
T0	Control	57.87	398.30	41.10	360.08
T1	Oxalic acid (0.5mM)	49.84	211.29	44.29	185.74
T2	Oxalic acid (1.0mM)	50.52	197.81	45.11	172.40
T3	Oxalic acid (1.5mM)	46.08	256.44	40.50	230.56
T4	Oxalic acid (2.0mM)	40.30	192.49	34.89	166.86
T5	Oxalic acid (2.5mM)	18.58	177.54	12.92	152.13
T6	Oxalic acid (3.0mM)	41.85	307.90	36.33	282.46
T7	Oxalic acid (3.5mM)	13.45	93.83	8.01	68.50
T8	Oxalic acid (4.0mM)	0.00	71.00	0.00	45.56
F-Test		**S**	**S**	**S**	**S**
SEd (+)		**1.446**	**4.012**	**1.446**	**0.165**
C.D. at 0.5%		**3.065**	**8.506**	**3.065**	**0.350**

Table 3. Effect of oxalic acid and bavistin on ph and TSS of litchi

Treatments No.	Treatments combinations	pH				TSS [°Brix]			
		Ambient storage		Refrigerated condition		Ambient storage		Refrigerated condition	
		0 day	9 days	0 day	20 days	0 day	9 days	0 day	20 days
T0	Control	4.65	5.29	4.60	5.02	17.84	18.76	18.89	20.21
T1	Oxalic acid (0.5mM)	4.48	5.11	4.52	5.10	19.11	19.79	20.33	21.40
T2	Oxalic acid (1.0mM)	4.38	5.19	4.35	5.08	19.22	20.06	20.50	21.52
T3	Oxalic acid (1.5mM)	4.41	5.22	4.44	5.17	19.15	19.74	20.44	21.58
T4	Oxalic acid (2.0mM)	4.35	5.19	4.38	4.88	19.04	19.75	20.34	21.44
T5	Oxalic acid (2.5mM)	4.22	5.08	4.20	4.91	20.02	20.51	21.34	22.51
T6	Oxalic acid (3.0mM)	4.32	5.12	4.28	4.90	19.71	19.77	21.06	22.23
T7	Oxalic acid (3.5mM)	4.16	5.04	4.12	4.68	20.08	20.65	21.49	22.64
T8	Oxalic acid (4.0mM)	4.10	4.94	4.08	4.78	20.14	20.72	21.59	22.81
F-Test		**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
SEd (+)		**0.009**	**0.027**	**0.050**	**0.165**	**0.04**	**0.10**	**0.049**	**0.080**
C.D. at 0.5%		**0.018**	**0.056**	**0.105**	**0.350**	**0.10**	**0.21**	**0.104**	**0.148**

Table 4. Effect of oxalic acid and bavistin on acidity (%) and ascorbic acid (mg/100g)

Treatments No.	Treatments combinations	Acidity (%)				Ascorbic acid (mg/g)			
		Ambient storage		Refrigerated condition		Ambient storage		Refrigerated condition	
		0 day	9 days	0 day	20 days	0 day	9 days	0 day	20 days
T0	Control	0.92	0.77	0.90	0.78	24.59	23.23	26.17	25.07
T1	Oxalic acid (0.5mM)	0.87	0.72	0.86	0.74	27.52	26.40	29.07	27.90
T2	Oxalic acid (1.0mM)	0.82	0.67	0.81	0.68	29.10	27.72	30.66	29.44
T3	Oxalic acid (1.5mM)	0.74	0.65	0.72	0.67	29.37	27.19	30.95	29.76
T4	Oxalic acid (2.0mM)	0.70	0.61	0.68	0.62	28.60	27.07	30.11	28.98
T5	Oxalic acid (2.5mM)	0.68	0.62	0.65	0.64	30.03	28.86	31.65	30.41
T6	Oxalic acid (3.0mM)	0.72	0.64	0.70	0.65	30.23	29.18	32.01	30.85
T7	Oxalic acid (3.5mM)	0.66	0.45	0.64	0.47	31.18	29.72	32.89	31.72
T8	Oxalic acid (4.0mM)	0.58	0.37	0.55	0.39	32.34	29.57	34.22	32.99
F-Test		**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
SEd (+)		**0.029**	**0.022**	**0.021**	**0.023**	**0.131**	**0.068**	**0.202**	**0.268**
C.D. at 0.5%		**0.061**	**0.047**	**0.045**	**0.048**	**0.278**	**0.145**	**0.427**	**0.568**

Table 5. Effect of oxalic acid and bavistin on reducing sugar and non-reducing sugar of litchi

Treatments No.	Treatments combinations	Reducing sugar (%)				Non reducing sugar (%)			
		Ambient storage		Refrigerated condition		Ambient storage		Refrigerated condition	
		0 day	9 days	0 day	20 days	0 day	9 days	0 day	20 days
T0	Control	24.59	23.23	26.17	25.07	1.94	2.11	2.99	3.57
T1	Oxalic acid (0.5mM)	27.52	26.40	29.07	27.90	2.19	2.19	3.34	4.02
T2	Oxalic acid (1.0mM)	29.10	27.72	30.66	29.44	2.15	2.20	3.40	4.14
T3	Oxalic acid (1.5mM)	29.37	27.19	30.95	29.76	2.19	2.19	3.43	4.16
T4	Oxalic acid (2.0mM)	28.60	27.07	30.11	28.98	2.34	2.17	3.57	4.29
T5	Oxalic acid (2.5mM)	30.03	28.86	31.65	30.41	2.35	2.21	3.79	4.50
T6	Oxalic acid (3.0mM)	30.23	29.18	32.01	30.85	2.19	2.16	3.71	4.45
T7	Oxalic acid (3.5mM)	31.18	29.72	32.89	31.72	2.36	2.30	3.51	4.23
T8	Oxalic acid (4.0mM)	32.34	29.57	34.22	32.99	2.48	2.32	3.93	4.59
F-Test		**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
SEd (+)		**0.131**	**0.068**	**0.202**	**0.268**	**0.043**	**0.054**	**0.043**	**0.074**
C.D. at 0.5%		**0.278**	**0.145**	**0.427**	**0.568**	**0.092**	**0.115**	**0.091**	**0.157**

statistically at par to treatment T_8 Oxalic acid (4.0mM) + Bavistin (0.05%). Whereas the minimum TSS (°Brix) at 9^{th} days (13.89) at 20 days (2.57) was found treatment control under ambient refrigerate storage condition. Reduced breathing often delays softening and slows down various changes in structure such as TSS associated with maturation. Plastic film has been found to be helpful in reducing respiration levels and extending the shelf-life of litchi fruit (Boonsiri, 2010)**.** They also stated that sealing individual climatic fruits in polyethylene bags of low-density delayed ripening and softening, and thus improved marketability. The minimum acidity (%) at 9^{th} days (0.37) and at 20 days (0.39) was found in treatment T_8 Oxalic acid (4.0mM) + Bavistin (0.05%). A further review of table also revealed that treatment Oxalic acid (3.5mM) as found to be statistically at par to treatment T_8 Oxalic acid (4.0mM) + Bavistin (0.05%). Whereas the maximum acidity (%) at 9^{th} days (0.77) at 20 days (0.78) was found treatment control under ambient refrigerate storage condition. The maximum ascorbic acid (mg100g) at 9^{th} days (29.57) and at 20 days (32.99) was found in treatment T_8 Oxalic acid (4.0mM) + Bavistin (0.05%). A further review of table also revealed that treatment Oxalic acid (3.5mM) and Oxalic acid (3.0mM) as found to be statistically at par to treatment T_8 Oxalic acid (4.0mM) + Bavistin (0.05%). Whereas 9^{th} minimum ascorbic acid (mg100g) at 9^{th} days (23.23) at 20 days (25.07) was found treatment control under ambient refrigerate storage condition. The maximum reducing sugar at 9^{th} days (26.57) and at 20 days (32.99) was found in treatment T_8 Oxalic acid (4.0mM) + Bavistin (0.05%). Whereas the minimum reducing sugar at 9^{th} days (23.23) at 20 Days (25.07) was found treatment control under ambient refrigerate storage condition. The maximum non-reducing sugar at 9^{th} days (2.32) and at 20 days (4.59) was found in treatment T_8 Oxalic acid (4.0mM) + Bavistin (0.05%). Whereas the minimum non-reducing sugar at 9^{th} days (2.11) at 20 Days (3.57) was found treatment control under ambient refrigerate storage condition.

4. CONCLUSION

From this experiment, it is concluded that treatment with T_8 Oxalic acid (4.0mM) + Bavistin (0.05%) for 2 min and stored at ambient storage and refrigerator condition was the most effective treatment for maximum retention of physical, physio-chemical analysis parameters of litchi fruit.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Anonymous (2014). Litchi, The Maiden With Runners. Botgard.ucla.edu. Archived from the original on 6 July 2010.
2. Jiang YM, Wang Y, Song L, Liu H, Lichter A, Kerdchoechuen O et al. Postharvest characteristics and handling of litchi fruit-an overview. Aust. J. Exp. Agric. 2006;46:1541-1556.
3. Zheng XL and Tian SP. Effect of oxalic acidon control of postharvest browning of litchi fruit. Food Chemistry. 2006;96: 519–523.
4. Yoruk R, Balaban MO, Marshall MR, Yoruk S. The inhibitory effect of oxalic acid on browning of banana slices. In: Annual Meeting and Food Expo, Anaheim, California, 30 G-18. 2002;74.
5. Candan AP, Graell J, Crisosto C, Larrigaudiere C. Improvement of storability and shelf-life of „Blackamber" plums treated with 1-methylcyclopropene. Food Sci. Technol. Int. 2006;15:437–444.
6. Jiang YM, Fu JR. Postharvest browning of litchi by water loss and its prevention by controlled atmosphere storage at high relative humidity. Lebensmittel Wissenschaft Und Technology. 1999b; 32:278–283.
7. NHB (2021). National Horticultural Board, Ministry of Agriculture & Farmers Welfare (DAC & FW), Government of India; 2020-21.
8. Fisher RA, Yates F. Statistical Tables for Biological, Agricultural and Medical Research. Oliver and Boyd, London. 1963;143.
9. Ketsa S, Leelawatana K. „Effect of precooling and polyethylene film liners in corrugated boxes on quality of lychee fruits". Frontier in Tropical Fruit Research. 1991;321(1):742–746.
10. Arah IK, Amaglo H, Kumah EK, Ofori H. „Preharvest and postharvest factors affecting the quality and shelf life of harvested tomatoes: A mini review". International Journal of Agronomy; 2015. Article ID 478041.

11. Molla MM, Rahman E, Khatun A, Islam F, Uddin Z, Ullah A, Saha MG, Miaruddin M. Colour retention and extension of shelf-life of litchi fruit in response to storage and packaging technique. American Journal of Food Technology. 2017;12(5)322–331.

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