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Effect of pre-harvest treatment, packaging and storage conditions on shelf life and quality of lasora (*Cordia myxa*) fruits

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Lasora (*Cordia myxa* L.) is a drought hardy multipurpose fruit plant of arid and semi-arid parts of India. The species is mainly grown for fresh fruits used for vegetable and pickle but other plant parts are also known for ethnomedicinal uses. The fruiting season of lasora is only for two months during March–April when the temperature remains quite high. The shelf life of fruits under ambient condition is only 2–3 days. Several previous studies on fruit crops have reported use of pre-harvest spray of calcium chloride and packaging materials to prolong shelf life of fruits (Kudachikar *et a*l. 2000, Gill *et al.* 2005 and Mahajan *et al*. 2015). However, there is no scientific study on pre-harvest spray and packaging films on shelf life of lasora fruits, hence, the study was conducted at ICAR-Central Arid Zone Research Institute, Jodhpur during April, 2019 to derive the information on the effect of pre-harvest spray of calcium chloride, pre-cooling, packaging materials and storage conditions on shelf life and quality of lasora fruits.

The experiment was conducted in last week of April to first fortnight of May 2019. The treatments comprised of three levels of pre-harvest spray of calcium chloride, two levels of pre-cooling and three types of packaging materials i.e. brown paper bags, low density polyethylene (LDPE) bags and plastic trays covered with cling film. Pre-harvest spray of calcium chloride in water (control, 1 and 2%) was done two weeks before harvesting while water spray served as control. Fresh matured but unripe fruits of variety Maru Samridhi were collected from the orchard of ICAR-Central Arid Zone Research Institute, Jodhpur. There were total 18 treatment combinations and two storage conditions i.e. ambient and refrigerated conditions. Pre-cooling of the fruits was done by dipping the fruits in cold water (4ºC) for half an hour. The fruits were divided into 500 g according to treatment (Table 1). The data were recorded on physiological loss in weight (PLW), per cent spoilage, temperature and humidity in ambient condition and total phenol and antioxidant activities of the fruits at the terminal stages of the storages or till the fruits appeared marketable. The data on spoilage of the fruits during storage in terms of shriveling and fungal infection were recorded after 7 days and 14 days of storage. The total phenol content from the dried fruit extract in acetone was determined using a modified Folin-Ciocalteu colorimetric method (Singleton *et al*. 1999) and the results were expressed as milligrams of gallic acid equivalents per gram dry weight (mg GAE/g DW). Different concentrations of gallic acid i.e. 25, 50, 75, and 100 ppm were prepared in methanol for preparation of standard curve. For the determination of total phenol, 1ml (1000 ppm) of dried fruit extract was mixed with 5 ml of Folin-Ciocalteu reagent. After 5 min, 2 ml of sodium carbonate (75 g/l) was added and the mixture was kept in dark for 2 h at room temperature and the absorbance was measured at 760 nm. The total phenols in the extracts were measured in terms of gallic acid equivalents (GAE) by the following given equation.

$$T = CV/M$$

where T, total phenolic contents (GAE) in milligram per gram extract; C, the concentration of gallic acid established from the calibration curve (mg/ml); V, the volume of extract in millilitre and M, the weight of sample extract (g).

The antioxidant activity of methanolic extract of fruits was determined on the basis of their free radical scavenging activity of the stable 2,2-Dipheny-1-pycril-hydrazyl (DPPH) free radical. In this assay, a volume of 2 ml of methanolic solution of fruit extract was mixed with 2 ml DPPH (0.1 mM). An equal amount of methanol and DPPH was taken as control. The samples were then kept in dark at room temperature for 30 min and the absorbance was measured at 517 nm using a UV-VIS spectrophotometer (Model TS2080PLUS, Analytical Technologies Limited). The antioxidant activity was expressed as per cent inhibition calculated using the following formula:

$$\text{DPPH radical scavenging activity in } \% = [(A_0 - A_1)/A_0] \times 100$$

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where, A_0, absorbance of the DPPH solution; A_1 absorbance of the sample.

The experiment was laid out in factorial CRD and the data were analyzed statistically using standard methods. The data on the main effects of pre-harvest spray of calcium chloride, pre-cooling and packaging materials on PLW at ambient and refrigerated conditions (Table 1, 2). Pre-harvest spray of calcium chloride could not influence the PLW significantly till 4th day but it was significantly less on 7th day and mean PLW under ambient conditions. The PLW was significantly less under refrigerated conditions at all intervals except after two days as compared to control. Optimum levels of calcium in the fruits as a result of pre-harvest spray might have delayed ripening, resisted moisture loss and reduced the respiration rate as also reported by Bender (1998). The shelf life of other fruits in cold storage was also reported to be improved by $CaCl_2$ (Wahdan *et al*. 2011). Optimum level of calcium in the fruits maintain the fruit freshness as it is component of middle lamellar tissue of cell wall. The pre-cooled fruits also exhibited significantly lower PLW compared to non pre-cooled fruits under ambient condition while it was ineffective under refrigerated conditions. This is quite obvious as pre-cooling of the fruits just after harvest removes field heat and reduces respiration rate and PLW at least for some time. Among the packaging materials, LDPE bag was found most efficient in arresting the PLW followed by cling wrap, while brown paper lost significantly higher PLW at all intervals under both ambient and refrigerated conditions (Table 1 and 2). The maximum shelf life of fruits under ambient conditions was recorded in LDPE (7 days) followed by cling wrap (4 days) and least in brown paper bag (2 days). The shelf life of fruits can be considered as a stage when the fruits remain marketable or PLW is about 10%. Pal *et al*. (1997) stated that about 10% PLW is considered as an index for termination of shelf life (threshold level) of commodities. According to this assumption, the shelf life of lasora fruits, under ambient conditions was maximum in LDPE package (7 days) followed by 4 days in cling film and least (2 days) in brown paper packed fruits. The shelf life of fruits under refrigerated conditions followed the same trend but it could be extended up to 14 days in LDPE and cling film packed fruits and 7 days in brown paper. Generally, PLW occurs as loss of moisture through transpiration and utilization of some reserve food material during respiration. The lower loss of physiological weight in fruits in LDPE and cling film is obvious as they allowed lower moisture loss as compared to brown paper bags where the physiological loss in weight of the fruits occurred freely due to porous nature. The lower PLW in the fruits packed in LDPE bags was due to lower rate of transpiration and respiration as a result of accumulation of carbon dioxide and water vapour in the bags, whereas their accumulation was almost absent in brown paper bags and comparatively less in cling film. Similar results were obtained by Singh *et al*. (2013) in ber.

Table 1 Effect of $CaCl_2$, packaging and pre-cooling on PLW (%) under ambient conditions at different days of storage

Treatment	2 Days	4 Days	7 Days	Mean
Pre-harvest spray of Cacl₂ (A)				
Control (water spray)	5.19	9.74	16.29	10.40
1%	5.41	9.89	18.64	11.31
2%	4.95	9.51	16.62	10.36
SEm±	0.35	0.53	0.21	0.18
LSD (P=0.05)	NS	NS	0.60	0.54
Packaging materials (B)				
LDPE Bag	0.86	2.50	4.85	2.73
Brown paper	8.62	14.70	25.67	16.33
Cling film	6.08	11.93	21.06	13.02
SEm±	0.60	0.58	0.21	0.18
LSD (P=0.05)	0.96	1.48	0.60	0.54
Pre-cooling with water (C)				
Control	5.77	10.56	16.61	10.98
Pre-cooled	4.60	8.87	17.70	10.39
SEm±	0.28	0.42	0.17	0.15
LSD (P=0.05)	0.78	1.21	0.49	0.44
Significance (Interactions)				
A × B	NS	NS	*	*
A × C	*	*	*	*
B × C	*	*	*	*
A × B × C	NS	NS	*	*

NS-non-significant, *Significant difference at P=0.05.

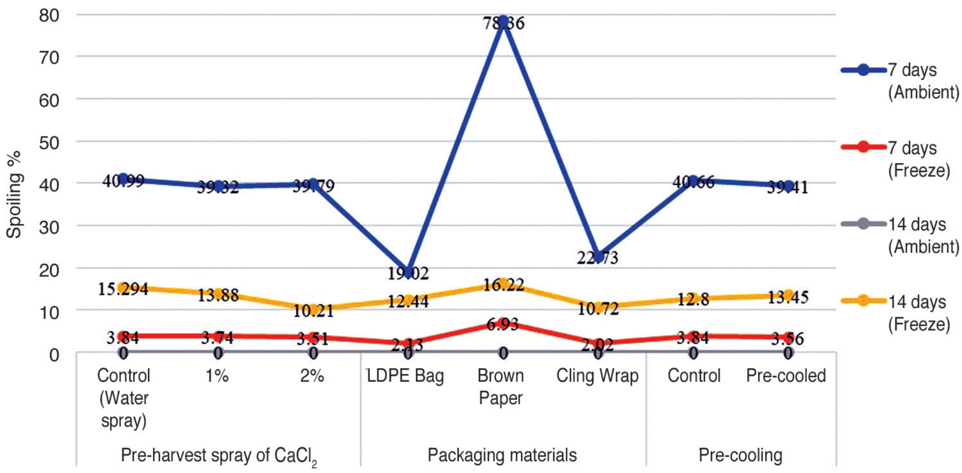

Fig 1 Effect of $CaCl_2$, packaging and pre-cooling on spoilage of lasora fruits during storage under ambient and refrigerated conditions.

Table 2 Effect of $CaCl_2$, packaging and pre-cooling on PLW (%) in refrigerator at different days of storage

Treatment	2 days	4 days	7days	10 days	12 days	14 days	Mean
Pre-harvest spray of $CaCl_2$							
Control (water spray)	1.70	2.73[a]	4.40[a]	6.42[a]	8.15[a]	10.08[a]	5.58
1 %	1.48	2.87[a]	4.75[a]	6.94[b]	9.15[b]	11.52[b]	6.12
2 %	1.58	2.58[b]	4.12[b]	6.16[c]	7.95[c]	9.86[c]	5.38
SEm±	0.07	0.07	0.10	0.15	0.19	0.25	0.12
LSD (P=0.05)	NS	0.21	0.30	0.43	0.57	0.74	0.33
Packaging materials (B)							
LDPE Bag	0.78[a]	1.18[a]	1.58[a]	2.04[a]	2.64[a]	3.59[a]	1.97
Brown Paper	2.94[b]	5.23[b]	8.95[b]	13.08[b]	17.21[b]	21.32[b]	11.45
Cling Wrap	1.03[c]	1.77[c]	2.75[c]	4.40[c]	5.39[c]	6.56[c]	3.65
SEm±	0.07	0.07	0.10	0.15	0.19	0.25	0.11
LSD (P=0.05)	0.196	0.21	0.30	0.43	0.57	0.74	0.33
Pre-cooling with water							
Control	1.44	2.52	4.03	5.93	7.72	9.64	5.21
Pre-cooled	1.06	2.93	4.81	7.08	9.11	11.33	6.16
SEm±	0.06	0.06	0.08	0.12	0.16	0.21	0.09
LSD (P=0.05)	0.16	0.17	0.24	0.35	0.45	0.60	0.27
Significance (Interactions)							
A × B	*	*	*	*	*	NS	*
A × C	NS	*	NS	NS	NS	NS	*
B × C	*	*	*	*	*	*	*
A × B × C	*	*	NS	NS	NS	NS	*

NS-non-significant, *Significant differences at P=0.05, different super scribed letters in a column indicate significant differences at P=0.05.

Deterioration of fruit quality could be judged by extent of shriveling, change in peel color, fungal infection and loss of turgidity. The fruits were observed for deterioration in quality for 7 days in ambient condition and 14 days in refrigerator. Significant differences in spoilage of the fruits were recorded due to pre-harvest spray of calcium chloride, packaging materials and pre-cooling after 7 days of storage in ambient condition (Fig 1). Among the packaging materials, maximum spoilage occurred in brown paper bags (78.36%) and mostly it was in the form of shriveling. The spoilage was significantly less in LDPE and cling film packed fruits. The spoilage of the fruits up to 7 days of storage in refrigerated condition was low and it was not affected significantly by pre-harvest spray of calcium chloride and pre-cooling. However, the effect of packaging material was evident with significantly highest spoilage in brown paper bag (6.93%) while it was at par in LDPE and in cling film. The spoilage of the fruits in refrigerator after 14 days of storage revealed significant differences due to calcium chloride and packaging materials. Pre-harvest spray of 2% calcium chloride resulted in minimum spoilage followed by 1% calcium chloride and maximum spoilage in control. Among the packaging materials, minimum spoilage occurred in cling film followed by LDPE and brown paper bag. In refrigerator, spoilage occurred due to shriveling and fungal infection in LDPE and cling film while in brown paper it was purely due to shrinkage. Higher level of shriveling in brown paper bag might be due to free exchange of air, while low shrinkage in LDPE bag was due to creation of humid environment. These results corroborate with earlier reports in peach (Mahajan *et al*. 2015) and ber (Singh *et al*. 2013). The spoilage due to fungal infection showed reverse trend in LDPE and brown paper bag since it was more in LDPE bags due to accumulation of higher humidity and vice versa in brown paper bags.

Total phenol content and antioxidant activity of the fruits at the end of storage revealed that irrespective of treatments, total phenolic content was significantly higher in fruits stored in refrigerator as compared to ambient condition. Pre-harvest spray of calcium chloride both at 1 and 2% recorded significantly higher total phenol at ambient (after 7 days) and in freeze (after 14 days) as compared to their respective control. The fruits packed in either LDPE bags or in cling film showed significantly higher total phenol as compared to brown paper bag both under ambient and refrigerator conditions. The antioxidant activity could not be recorded in the fruits stored in ambient condition but it was recorded in the fruits stored in freeze even after 14 days of storage. Significant differences due to different treatments in antioxidant activity were also recorded in fruits stored

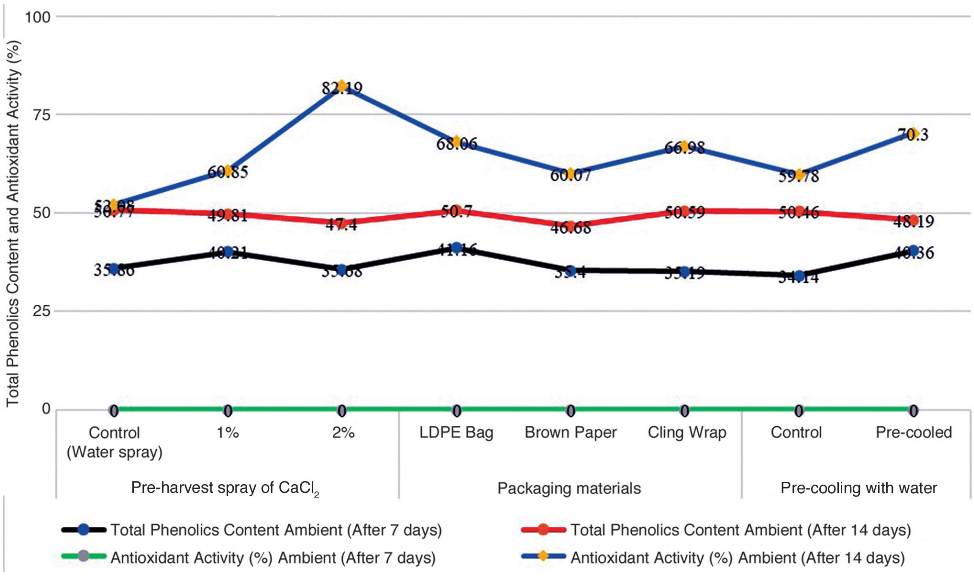

Fig 2 Effect of $CaCl_2$, packaging and pre-cooling on total phenol content antioxidant activity of lasora fruits during storage under ambient and refrigerated conditions.

in freeze. The pre-harvest spray of $CaCl_2$ (2%) recorded significantly higher antioxidant activity (82.19 GAE mg/g DW) as compared to control (52.07 GAE mg/g DW). Among the packaging materials, fruits packed in LDPE & cling film recorded significantly higher antioxidant activity while it was lowest in brown paper bag packed fruit (Fig 2). The quantity of phenolic compounds in fruits may vary according to maturity stage. In this study, the fruits of lasora were harvested at slight immature stage which contains maximum total phenol and consequent antioxidant activity. This activity starts declining during the storage period more rapidly under ambient conditions due to ripening and other physiological changes.

SUMMARY

An experiment was conducted on the effect of pre-harvest spray of calcium chloride (1–2%), pre-cooling, packaging materials and storage conditions on shelf life and quality of lasora fruits. The LDPE bags were found most efficient in reducing the PLW followed by cling film and brown paper bags both under ambient and refrigerated conditions. The pre-cooled fruits revealed significantly lower PLW compared to non pre-cooled fruits up to 4^{th} day in ambient condition and till 14^{th} day in refrigerated conditions. Under ambient conditions, the maximum shelf life of 7 days was recorded in LDPE followed by cling film wrap and brown paper bags while under refrigerated conditions it could be extended up to 14 days in LDPE and cling film packed fruits and 7 days in brown paper. The spoilage was significantly higher at ambient condition within 7 days in LDPE packed fruits (3.54%) and least in cling film. The spoilage increased to 10–12% in refrigerator when the fruits were stored for longer duration and it was not affected significantly by different treatments. The antioxidant activity was absent in the fruits stored in ambient condition while it was recorded in refrigerated fruits even after 14 days of storage.

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