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Response of passive modified atmospheric packaging on quality attributes and sensory analysis of pomegranate (*Punica Granatum*) Fruits cv. Mridula

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Abstract
Pomegranate is a non-climacteric fruit, with reference to its respiratory behaviour, but it is subjected to continuous physiological and biochemical changes after harvest with severe problems during post-harvest handling, storage and marketing. In the concerned study, freshly harvested pomegranate fruits packed in low density polyethylene (LDPE) 25 micron, polypropylene (PP) 25 micron, cling film and cellophane paper film were evaluated at Post-harvest Laboratory of the Department of Horticulture, CCS Haryana Agricultural University, Hisar, Haryana to find the best packaging film for maintaining the quality attributes during the storage period. Among all these packaging material LDPE 25 micron had the highest juice content. The different packaging material had no significant effect on total soluble solids to acid ratio, total sugars, reducing sugars and non-reducing sugar, however, storage period had significant effect on them and the significantly maximum total soluble solids to acid ratio and all sugars was observed on 12th day of storage, as these increased with the passage of time, on the contrary, the juice content was found maximum on the very first day but they decreased with the prolongation of storage period. As far as sensory analysis was concerned the pomegranate fruits wrapped in LDPE 25 micron packaging film had higher organoleptic rating and overall acceptability under storage conditions.

Keywords: Pomegranate, packaging material, MAP, quality attributes, organoleptic rating

Introduction
Pomegranate (*Punica granatum*, Punicaceae) is a choicest fruit mainly due to its exceptional and unique acid, agollic acid and minerals like calcium, iron, phosphorus, and magnesium. Along with sensory and nutritional properties. It has been associated with a high nutritional value and a large number of health benefits as the fruits are an excellent dietary source of organic acids, soluble solids, protein, fat, carbohydrates, tannin, vitamin C, thiamine, riboflavin, niacin, nicotinic nutritive value, it also has anti-mutagenic, anti-inflammatory and anti-hypertension activities (Bhowmik *et al.*, 2013 [4].
Although pomegranate is a non-climacteric fruit but it is subjected to continuous physiological and biochemical changes after harvest with severe problems during post-harvest handling, storage and marketing. Several post-harvest methods have been evaluated out of which, the modified atmosphere packaging (MAP) is a simple, economical and effective method for delaying post-harvest deterioration, and maintaining quality of pomegranate (Selcuk and Erkan, 2016) [12]. With increasing demand for fresh and natural products without addition of harmful chemicals, packaging film seems to be an ideal tool for preservation of minimally processed fruits, being cheap and easy to apply (Bhatia *et al.*, 2013) [3]. Packaging material also plays a significant role in attracting the consumers and prolonging the storage period of many fruits. It is often desirable to generate an atmosphere around the fruit low in oxygen (O_2) and/or high in carbon dioxide (CO_2) to influence the metabolism of the packed produce, which can result in reduction of respiratory activity, delaying softening, ripening, senescencing and reducing incidence of physiological disorders and pathogenic infestations.

Material methods
The fresh fruits of pomegranate cv. Mridula were procured from the Centre of Excellence for Fruits, Mangiana (Haryana). The experiment was carried out in Post-harvest Technology Laboratory of the Department of Horticulture, CCS Haryana Agricultural University, Hisar

during 2016-17. The individual fruits were wrapped with different packaging films viz., low density polyethylene (LDPE) 25 micron, polypropylene (PP) 25 micron, cling film, cellophane Paper and thereafter, wrapped fruits were kept in CFB boxes. The boxes were stored at room temperature with maximum 29±2°C, minimum 12±2°C and relative humidity 90±5%. Various observations of the stored fruits were recorded at three days interval with three replications.

The pomegranate juice content was calculated by juice volume divided by fruit weight. The total soluble solids to acid ratio can be calculated by dividing the total soluble solids and titratable acidity, where the total soluble solids of fruits were determined at room temperature by using hand refractometer having a range of zero to 32 (ERMA) by putting a drop of pomegranate juice and taking the readings and titratable acidity was determined as per the method suggested by AOAC (1990) [1]. Sugars were estimated by using the method of Hulme and Narain (1931) [6] and were expressed in per cent. The data were analyzed using completely randomized design (CRD) and critical differences (C.D.) at 5% level of significance with the help of a windows based computer package OPSTAT (Sheoran 2004) [13].

Result and Discussion

1. Juice content (%)

The data presented in Table 1 indicate that different packaging films and the storage period had statistically significant effect on juice content of pomegranate fruits under ambient room conditions, however, non-significant variation in juice content was found for the interaction between packaging materials and storage period. The fruits wrapped in LDPE 25 micron retained maximum juice content (46.94%) as compared to other packaging materials and the minimum juice content (45.56%) was found in unwrapped control fruits, while the treatment cellophane paper (45.97%) and cling film (45.99%) were statistically at par with each other in respect of juice content of fruits. The juice retention in fruits showed a decreasing trend with the advancement of the storage period, while in the early days of storage, the decrease in juice content was slower but with increase in time, it became more rapid. The maximum juice content in pomegranate fruits (47.51%) was noticed on zero day and the minimum on 12th day (44.30%) of storage. LDPE 25 micron found to be very effective packing material in controlling reduction in juice content of fruits. Earlier, similar results in Kinnow mandarin were reported by Mahajan *et al.* (2006) [8].

Table 1: Effect of different packaging materials on juice content (%) of pomegranate cv. Mridula

Treatments	Storage period (days)					Mean
	0	3	6	9	12	
LDPE 25 micron	47.51	47.26	46.91	46.73	46.28	46.94
Polypropylene 25 micron	47.51	47.12	46.63	45.98	44.85	46.42
Cling film	47.51	47.01	46.45	45.22	43.76	45.99
Cellophane paper	47.51	46.96	46.37	45.26	43.73	45.97
Control	47.51	46.79	45.72	44.89	42.87	45.56
Mean	47.51	47.03	46.42	45.62	44.30	
C.D. at 5% level of significance	Treatments (T)= 0.35, Storage period (S)= 0.35 Treatments × storage period= NS					

2. TSS to acid ratio (%)

The TSS to acid ratio of pomegranate fruits packed in different packaging films presented in Table 2 followed an increasing trend with the advancement of storage period. Under ambient room conditions, the maximum TSS to acid ratio (33.88%) was observed in unwrapped fruits and the minimum TSS to acid ratio (32.36%) in fruits packed with LDPE 25 micron, whereas, the ratio was noticed minimum on zero day (31.09%) and maximum on 12th (35.60%) day of storage, as this ratio increased gradually with the advancement of storage period. This might be due to the increase in total soluble solids and decrease in titratable acid content in the fruits with the increase in storage duration.

Table 2: Effect of different packaging materials on TSS to acid ratio (%) of pomegranate cv. Mridula

Treatments	Storage period (days)					Mean
	0	3	6	9	12	
LDPE 25 micron	31.09	31.19	32.19	33.34	34.05	32.36
Polypropylene 25 micron	31.09	31.93	32.21	33.76	35.28	32.50
Cling film	31.09	32.00	33.17	33.83	36.54	33.44
Cellophane paper	31.09	32.10	33.34	34.78	36.92	33.59
Control	31.09	33.02	33.73	35.55	37.10	33.88
Mean	31.09	32.05	33.24	33.90	35.60	

3. Total sugars (%)

The data pertaining to total sugars in stored pomegranate fruits packed in different packaging materials in Table 3 revealed a significant variation with respect to period of storage. Under ambient room conditions, the total sugars increased with increasing storage period and were found minimum on zero day (9.34%) of storage, which was statistically at par with total sugars on 3rd day of storage (9.42%) and the maximum total sugars was recorded on 12th day (9.90%) of storage. However, no significant variation was recorded with respect to different packaging materials and the interaction between the packaging materials and the storage period. The minor rise in sugar concentration in juice of packed fruit was probably due to water loss at slower rate. The delayed increase in the sugar content under film packaging might be attributed to the inherent property of films in delaying the metabolic activities of fruits during storage due to delay in ethylene production and respiration rate (Abeles *et al.*, 1992) [2]. The results of present study are in accord with the findings of Nielsen and Leufven (2008) [10] in strawberry and Mohla *et al.* (2005) [9] in pear. Bhullar (1983) [5] in kagzi lime observed that conversion of cell wall materials like hemicellulose and pectin from insoluble to soluble fraction might have also added towards rise in sugars during later period of storage.

Table 3: Effect of different packaging materials on total sugars (%) of pomegranate cv. Mridula

Treatments	Storage period (days)					Mean
	0	3	6	9	12	
LDPE 25 micron	9.34	9.39	9.43	9.46	9.6	9.44
Polypropylene 25 micron	9.34	9.41	9.59	9.63	9.79	9.55
Cling film	9.34	9.43	9.53	9.66	9.98	9.59
Cellophane paper	9.34	9.42	9.56	9.71	10.05	9.62
Control	9.34	9.45	9.6	9.73	10.09	9.64
Mean	9.34	9.42	9.54	9.64	9.90	
C.D. at 5% level of significance	Treatments (T)= NS, Storage period (S)= 0.10 Treatments × storage period= NS					

4. Reducing sugars (%)

The analysis of variance of reducing sugars of stored pomegranate fruits packed in different packaging materials presented in Table 4 followed significant variation over the storage period, however, statistically non-significant effect on reducing sugars was found with respect to packaging materials and the interaction between packaging materials and period of storage. Under ambient room conditions, the least amount of reducing sugars was recorded on zero day of storage (7.36%), which was statistically at par with reducing sugars in pomegranate fruit on 3rd day of storage (7.41%) and the highest on 12th day (7.77%) of storage. The results are in accordance with the reports of Kahlon and Bajwa (1991) [7] in litchi and Waskar *et al.* (1999) [14] in sapota who have reported an increase in reducing sugars content during storage.

Table 4: Effect of different packaging materials on reducing sugars (%) of pomegranate cv. Mridula

Treatments	Storage period (days)					Mean
	0	3	6	9	12	
LDPE 25 micron	7.36	7.39	7.43	7.45	7.58	7.44
Polypropylene 25 micron	7.36	7.41	7.5	7.55	7.68	7.50
Cling film	7.36	7.42	7.51	7.59	7.8	7.54
Cellophane paper	7.36	7.43	7.52	7.6	7.86	7.55
Control	7.36	7.42	7.53	7.6	7.94	7.57
Mean	7.36	7.41	7.50	7.56	7.77	
C.D. at 5% level of significance	Treatments (T)= NS, Storage period (S)= 0.09 Treatments × storage period= NS					

5. Non-reducing sugar (%)

The experimental results in Table 5 pertaining to non-reducing sugar in stored pomegranate fruits packed in different packaging materials showed an increasing trend with the advancement of storage period. The least amount of non-reducing sugar was recorded on zero day of storage (1.98%) and the utmost amount of non-reducing sugar on 12th day of storage (2.13%) under ambient room conditions. The non-reducing sugar content of pomegranate fruit found minimum in LDPE 25 micron coated fruits and the maximum in unwrapped fruits.

Table 5: Effect of different packaging materials on non reducing sugar (%) of pomegranate cv. Mridula

Treatments	Storage period (days)					Mean
	0	3	6	9	12	
LDPE 25 micron	1.98	2.00	2.00	2.01	2.02	2.00
Polypropylene 25 micron	1.98	2.00	2.09	2.08	2.11	2.05
Cling film	1.98	2.01	2.02	2.07	2.18	2.05
Cellophane paper	1.98	1.99	2.04	2.11	2.19	2.06
Control	1.98	2.03	2.07	2.13	2.15	2.07
Mean	1.98	2.01	2.04	2.08	2.13	

6. Organoleptic rating

The data on organoleptic rating are presented in Table 6. The pomegranate fruits packed in different packaging materials varied from each other in respect of organoleptic rating. Under ambient room conditions, the pomegranate fruits packed in LDPE 25 micron packaging film illustrated the highest organoleptic rating (8.0), while the minimum organoleptic rating (7.2) was given to the fruits kept unwrapped. On zero day of storage (8.5), the pomegranate fruits had the maximum organoleptic rating and minimum organoleptic rating (6.6) on 12th day of storage. The sensory quality or organoleptic rating of stored pomegranate fruits packed in different packaging materials, differed with respect to the type of packaging materials as well as under various storage period. The fruits got the maximum rating on the 0th day (8.25) and the minimum on the 12th day (5.47) of storage. Among the different packaging materials, LDPE 25 micron depicted the best organoleptic rating to stored fruits. This characteristic feature of LDPE film, having a proper balance for the permeability of carbon dioxide and oxygen and relative humidity, maintained better overall sensory quality in strawberry fruits (Panda and Goyal, 2016) [11]. It is expected that the altered atmosphere might disturb the aroma profile but there was no loss of aroma in strawberries cv. Honeoye (Nielsen and Leufven, 2008) [10].

Table 6: Effect of different packaging materials on organoleptic rating of pomegranate cv. Mridula

Treatments	Storage period (days)					Mean
	0	3	6	9	12	
LDPE 25 micron	8.5	8.4	8.2	7.9	7.2	8.0
Polypropylene 25 micron	8.5	8.3	8.2	7.8	6.8	7.9
Cling film	8.5	8.2	8.0	7.6	6.7	7.8
Cellophane paper	8.5	8.2	7.7	7.2	6.5	7.6
Control	8.5	8.0	7.2	6.6	5.7	7.2
Mean	8.5	8.2	7.9	7.4	6.6	

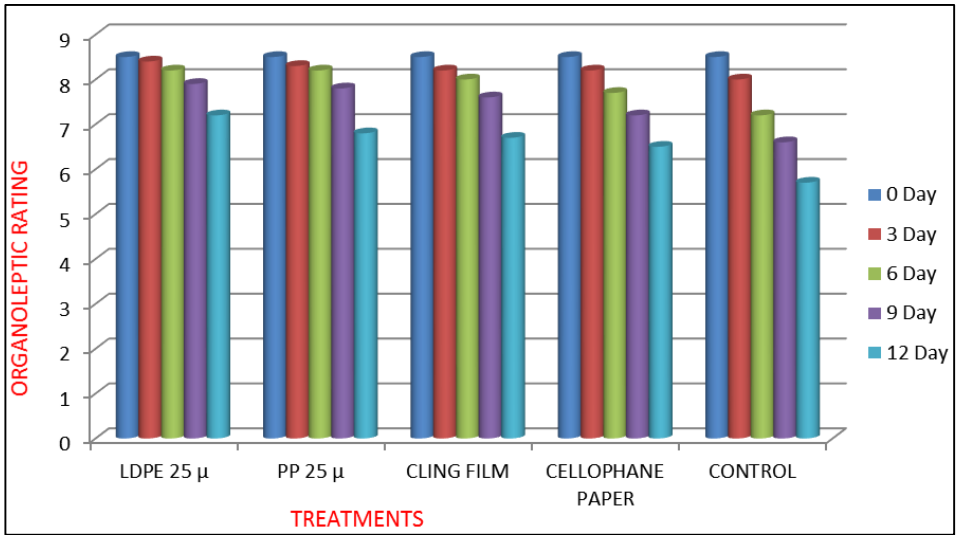

Fig 1: Effect of different packaging materials on organoleptic rating of pomegranate cv. Mridula

Conclusion

In this experiment, the juice content of pomegranate fruits was affected by the different packaging materials, where LDPE 25 micron packaging film proved the best in maintaining highest juice content of fruits and had higher organoleptic rating and overall acceptability under ambient room storage conditions. The different packaging material had no significant effect on total soluble solids to acid ratio, pH, total sugars, reducing sugars and non-reducing sugar, however, storage period had significant effect on them and the significantly maximum total soluble solids to acid ratio and all sugars was observed on 12th day of storage, as these increased with the passage of time, on the contrary, the juice content was found maximum on the very first day but they decreased with the prolongation of storage period.

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