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Effect of packaging materials and storage conditions for intensify the shelf life of pomegranate fruits

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Abstract
The pomegranate (*Punica granatum* L.) is a non-climacteric fruit of punicaceae family. The possibility of storage in ambient conditions is limited, leading to overproduction in the market and reduced profits for producers. In addition, under ambient conditions, overripe fruits result in a lot of waste and economic loss. Pomegranate fruit rots as a result of improper treatment, lowering growers' profits. Physiological and biochemical changes occur after harvest, leading in significant quality loss and deterioration throughout post-harvest handling and storage. Packaging and storage are intimately connected, shelf life of fruit is directly depending on storage and packaging materials. The cultivar of pomegranate Bhagawa was packed in different packaging materials (LDPE, HDPE, LDPE + $KMnO_4$, HDPE + $KMnO_4$) and kept in ambient and cold storage conditions. The fruits were examined for Physiological loss in weight (%), total soluble solid (%) and titratable acidity (%) at 5 days interval up to 20 days of storage. The treatments which extended the shelf life and reduced the post-harvest losses without adversely affecting the fruit quality of pomegranate. These treatments are found obviously easy for practical application for extending the shelf life of pomegranate.

Keywords: Pomegranate, LDPE, HDPE, acidity, TSS, $KMnO_4$, shelf life, weight loss

Introduction

The pomegranate (*Punica granatum* L.) is a popular subtropical fruit crop. Pomegranate is a Latin word that means "apple with many seeds", "Danimma" in Sanskrit and also known as Anar (Abd-elghany *et al*., 2012) [1]. It is a fruit of the Punicaceae family, containing one genus and two species, *Punica granatum* L. and *Punica protopunica* (Graham *et al*., 1998) [8]. Pomegranates are native to Central Asia, but due to their adaptability to a wide range of climates and soil conditions, they are now produced in several places across the world. India is the world largest producer and Maharashtra has top producing state of pomegranate in the country. Pomegranate fruits are high source of proteins, carbohydrates, minerals, sugars and crude fibres (Mir *et al*., 2007 and Marathe *et al*., 2010) [14, 13].

Pomegranates have a limited capacity for storage under ambient circumstances, which causes a market oversupply and low returns for the growers. Additionally, ripe fruit left under ambient conditions lead to more wastage and causes huge losses. Fruit production and availability in the market are uneven due to the monsoon season's interfering with fruit growth and development. Consequently, compared to LDPE and HDPE films, the prolonged storage life is up to three weeks (Mahajan *et al.*, 2013) [15]. To ensure a consistent market supply, pomegranate fruits must be managed properly from June to October. In India, improper handling causes a 25-30% rotting in pomegranate fruit, which reduces farmers' profit margins. After harvest, it is persistent physiological and biochemical changes, resulting in severe quality loss and deterioration throughout post-harvest handling and storage. Post-harvest losses in pomegranate crops range from 15-50% (NHB, 2020) [18]. Using packaging materials for storage is mostly preferable because it leaves no hazardous residues on human health. The combination of horticulture produces and film permeability results in the passive evolution of an adequate environment within sealed packages, hence packaging material selection is very important (Mattos *et al*., 2012) [16]. Previous research on guava fruit has shown that the packaging material has an impact on the nutritional and sensory qualities of minimally processed produce (Mahajan *et al*., 2013) [15]. To observed these gaps, the current study examined the impact of packaging materials (LDPE and HDPE) containing the chemical KMnO4 and the transmission rate on the quality of minimally processed pomegranate fruits during cold storage and open condition (Idumah *et al*., 2019) [10].

Material and Method

The experiment was carried out in Laboratory of Post-Harvest Technology, Department of Horticulture, Lovely Professional University, Phagwara (Punjab) during the year 2022. Bhagawa variety of pomegranate was collected from regional farmer. In a laboratory, an experiment was conducted on pomegranate post-harvest treatment and packaging with ethylene absorbent. Fruits were harvested in the morning hours. After harvest, uniform ripe pomegranates fruits were picked and quickly delivered to the laboratory free of mechanical damage, bruising, and fungal or insect infestation. Fruits were washed in tap water and then distilled water adding 50 ppm chlorine ($CaCl_2$) to minimize microbial activity, then dried on the surface with a fan at room temperature (Rico D. *et. al.*, 2007) [21]. After adequate surface drying, pomegranate fruits are ready to eat. The assumption that the amount of oxygen taken by the produce is related to the extent of metabolic activity (senescence level) coupled with its respiration underlies the significance of respiration rate measurement in evaluating the efficacy of packing systems. (Del Nobile *et al*., 2007) [7]. Pomegranate fruits were packed using different packaging materials, such as Low Density Polyethylene 50 µ (LDPE) and High Density Polyethylene 50 µ (HDPE), after proper surface drying, and one ethylene absorbent sachet was placed in each bag @ 4 gm $KMnO_4$ /kg of fruit. Packaged sample stored at 5±2 ºC for refrigerator condition and 27 to 34 °C for open condition up to 20 days and data were recorded on 0, 5, 10, 15, and 20 days of storage. Factorial Completely Randomized Design (FCRD) was followed for experiment with 3 repetitions of treatments.

Physiological loss in weight (%)

Fruit weights were recorded every five days interval. PLW was calculated by taking the difference between the original and succeeding weights of fruit and expressing it as a percentage.

$$\text{PLW (\%)} = \frac{\text{Initial weight} - \text{Final weight X 100}}{\text{Initial weight}}$$

Total soluble solid (%)

The total soluble solids content of the juice was determined using an Erma Hand Refractometer (0-32 ^{0}B). A drop of fruit juice was placed on the refractometer's prism, and the value of TSS was recorded in percent. The prism of the refractometer was washed with distilled water and wiped with a muslin cloth after recording each observation (Bhat, 2011) [6].

Titratable acidity (%)

The method provided by Ranganna was used to calculate acidity (1986). 10 gm of sample were finely crushed and transferred to a volumetric flask, which was then filled with distilled water to a level of 100 ml. Whatman No. 1 filter paper was used to filter the contents. 2-3 drops of phenolphthalein indicator were added to a 10 ml sample in a conical flask, and the titration was performed against 0.1N NaOH. The final point is indicated by the appearance of light pink colour. It was calculated and reported as a percentage using the formula below. (Citric acid eq. wt. = 0.064)

$$\text{Acidity (\%)} = \frac{\text{Titre} \times \text{Normality of NaoH} \times 0.064 \times \text{volume made up}}{\text{Weight of sample} \times \text{Aliquot taken}} \times 100$$

Result and discussion

Physiological loss in weight (%)

Different packaging materials with ethylene absorbent and storage conditions had a substantial impact on the physiological weight loss of pomegranate fruit. The physiological weight loss was shown to be increasing as the storage period progressed in all treatment combinations. However, when compared to cold storage conditions, the loss rate was faster at room temperature. Fresh fruit does not lose weight physiologically at first. The physiological weight loss in pomegranate fruit in room temperature and cold storage was 8.75% and 2.69%, respectively up to 20 days of storage.

Among the both of storage conditions, the influence of packaging material on physiological weight loss was increased. At the end of the shelf life, the physiological weight loss increased from 0.00 to 2.31% in HDPE + $KMnO_4$, 2.54% in LDPE + $KMnO_4$, 7.64% in HDPE, 7.95% in LDPE and 9.69% in Control. Table 1 show that when the storage duration was prolonged, the physiological weight loss increased. T4C1 had the lowest physiological weight loss (4.21%) at the end of its shelf life at room temperature, while T0C1 had the highest (16.45%). T4C2 had the lowest physiological weight loss (0.60%) at the end of its shelf life in cold storage, while T0C2 had the highest physiological weight loss (4.36%).

Results are in accordance with the findings reported by Waskar (2011) [22], Barman *et al.* (2011) [4] and Kumar *et al.* (2013) [11] for pomegranate fruit. The possible reason for reduction in physiological loss in fruit weight may be due to slow respiration, evapotranspiration and metabolic activity of fruit (Miano and Jokhio 2010; Wijewardane and Guleria 2009) [17, 23]. Potassium permanganate absorb the ethylene whereas, HDPE has good tensile strength, mechanical property and barrier for gas and water properties which reduce the physiological loss in weight.

Table 1: Effect of packaging materials and storage conditions on physiological loss in weight (%) of Bhagawa cv. of Pomegranate.

Treatments	Physiological loss in weight (%)				
	0 Day's	5 Day's	10 Day's	15 Day's	20 Day's
Packaging Material					
Control (T0)	0.00	2.25	4.58	6.17	9.69
LDPE (T1)	0.00	1.90	3.85	5.85	7.95
HDPE (T2)	0.00	1.40	2.95	5.50	7.64
LDPE + KMno4 (T3)	0.00	0.65	0.12	1.76	2.54
HDPE + KMno4 (T4)	0.00	0.41	0.99	1.55	2.31
SE (m)	0.00	0.02	0.04	0.08	0.05
CD at 5%	0.00	0.06	0.12	0.22	0.14
Storage Condition					
Room temperature (C1)	0.00	2.26	5.08	6.99	8.75
Refrigerator (C2)	0.00	0.55	1.22	2.00	2.69

SE (m)	0.00	0.01	0.03	0.05	0.03
CD at 5%	0.00	0.04	0.08	0.16	0.10
Packaging and Storage interaction					
T0C1	0.00	3.43	5.20	12.34	16.45
T1C1	0.00	2.26	4.60	8.90	13.30
T2C1	0.00	4.20	14.80	6.71	10.22
T3C1	0.00	1.90	3.86	6.15	8.48
T4C1	0.00	0.82	1.78	2.69	4.21
T0C2	0.00	0.91	1.99	3.12	4.36
T1C2	0.00	0.91	1.62	2.41	3.28
T2C2	0.00	0.70	1.40	2.30	3.11
T3C2	0.00	0.61	1.31	2.20	2.90
T4C2	0.00	0.00	0.20	0.42	0.60
SE (m)	0.00	0.03	0.06	0.11	0.07
CD at 5%	0.00	0.08	0.16	0.32	0.20

Total soluble solid (%)

Table 2 shows the influence of different packaging materials on TSS of pomegranate cv. Bhagwa under various storage conditions. Different packaging materials and storage conditions had a substantial impact on the TSS of pomegranate fruit. The TSS was discovered to rise as the storage duration progressed.

However, when compared to cold storage condition, the rate was faster at room temperature. Fresh fruit had a TSS of 16.12 °B. The TSS of pomegranate fruit was determined to be 16.62 °B and 16.82 °B, respectively, at the conclusion of a 20-day storage life at room temperature and at cold storage. During both storage conditions, the influence of packaging material on TSS was increased. At the end of the shelf life, the TSS was increased from 16.12 to 16.71 °B in HDPE + $KMnO_4$, 16.62 °B in LDPE + $KMnO_4$, 16.49 0B in HDPE, 16.41 °B in LDPE, and 16.72 °B in Control.

Table 2: Effect of packaging materials and storage conditions on Total soluble solid (%) of Bhagawa cv. of Pomegranate.

Treatments	Total soluble solid (%)				
	0 Day's	5 Day's	10 Day's	15 Day's	20 Day's
Packaging Material					
Control (T0)	16.12	16.23	16.37	16.56	16.72
LDPE (T1)	16.12	16.16	16.24	16.31	16.41
HDPE (T2)	16.12	16.19	16.27	16.37	16.49
LDPE + KMno4 (T3)	16.12	16.22	16.34	16.49	16.62
HDPE + KMno4 (T4)	16.12	16.24	16.37	16.55	16.71
SE (m)	0.01	0.01	0.01	0.02	0.01
CD at 5%	NS	0.03	0.04	0.04	0.04
Storage Condition					
Room temperature (C1)	16.11	16.24	16.42	16.61	16.82
Refrigerator (C2)	16.12	16.20	16.33	16.48	16.62
SE (m)	0.01	0.01	0.01	0.02	0.01
CD at 5%	NS	0.02	0.03	0.03	0.03
Packaging and Storage interaction					
T0C1	16.12	16.25	16.42	16.63	16.81
T1C1	16.12	16.20	16.33	16.50	16.66
T2C1	16.12	16.23	16.37	16.52	16.67
T3C1	16.12	16.20	16.33	16.50	16.70
T4C1	16.12	16.30	16.55	16.60	16.76
T0C2	16.12	16.27	16.42	16.58	16.77
T1C2	16.12	16.18	16.26	16.34	16.40
T2C2	16.12	16.22	16.32	16.42	16.51
T3C2	16.12	16.19	16.29	16.39	16.59
T4C2	16.12	16.22	16.34	16.47	16.64
SE (m)	0.01	0.01	0.02	0.02	0.03
CD at 5%	NS	NS	0.06	0.06	0.06

Table 2 shows that as the storage duration was extended, the TSS increased. T1C1 had the lowest TSS (16.66 °B) at the end of its shelf life at room temperature, whereas T0C1 had the highest (16.81 °B). T1C2 had the lowest TSS (16.40 °B) at the end of its shelf life in cold storage, while T0C1 had the highest (16.77 °B). The results were also in accordance with Hailu *et al.* (2012) [9] who reported high TSS content in HDPE with ethylene absorbent packaged fruits than LDPE with absorbent, LDPE and HDPE packaging material. Accordingly, HDPE with $KMnO_4$ packaging material is high TSS than other packaging materials.

Titratable acidity

Table 3 shows the influence of different packaging materials on the acidity of pomegranate cv. Bhagwa under various storage conditions. Different packaging materials and storage conditions had a substantial impact on the acidity of pomegranate fruit. The acidity percentage was shown to decrease as the storage duration progressed. However, when compared to cold storage conditions, the rate was faster at room temperature. Fruit had an initial acidity of 0.41%. The acidity percent of pomegranate fruit was determined to be 0.30% and 0.37% after 20 days of storage at room temperature and cold storage, respectively. During both storage conditions, the acidity of pomegranate fruit treated with packaging material was reduced. At the end of the shelf life, the acidity was reduced from 0.41% to 0.38% in HDPE + $KMnO_4$, 0.36% in LDPE + $KMnO_4$, 0.34% in HDPE, 0.33% in LDPE, and 0.32% in Control. The acidity reduced as the storage period increased, as seen in Table 3.

T4C1 had the highest acidity percent (0.33%) at the end of its shelf life at room temperature, while T0C1 had the lowest acidity percent (0.23%). T4C2 had the highest acidity percent (0.38%) at the end of its shelf life in cold storage, while T0C2 had the lowest acidity percent (0.35%). The rate of acidity decline was faster at room temperature, which could be attributable to a higher rate of respiration. Due to the high temperature and low humidity during room temperature storage, the drop in acidity may be caused by the quick conversion of organic acids into sugars and the utilisation of acids during respiration. The results obtained in the study are also similar with the observations of (Waskar., 2011) [22] in pomegranate.

Table 3: Effect of packaging materials and storage conditions on Titratable acidity (%) of Bhagawa cv. of Pomegranate

Treatments	Titratable acidity (%)				
	0 Day's	5 Day's	10 Day's	15 Day's	20 Day's
Packaging Material					
Control (T0)	0.41	0.39	0.37	0.35	0.33
LDPE (T1)	0.41	0.39	0.37	0.36	0.34
HDPE (T2)	0.41	0.39	0.37	0.35	0.33
LDPE + KMno4 (T3)	0.41	0.39	0.38	0.37	0.36
HDPE + KMno4 (T4)	0.41	0.40	0.39	0.38	0.38
SE (m)	0.02	0.01	0.02	0.01	0.01
CD at 5%	NS	0.01	0.01	0.02	0.01
Storage Condition					
Room temperature (C1)	0.41	0.39	0.36	0.32	0.30
Refrigerator (C2)	0.41	0.40	0.39	0.38	0.37
SE (m)	0.00	0.01	0.02	0.01	0.01
CD at 5%	NS	0.01	0.01	0.02	0.01
Packaging and Storage interaction					
T0C1	0.41	0.36	0.33	0.29	0.23
T1C1	0.41	0.37	0.34	0.30	0.24
T2C1	0.41	0.36	0.30	0.29	0.27
T3C1	0.41	0.38	0.36	0.32	0.29
T4C1	0.41	0.39	0.37	0.35	0.33
T0C2	0.42	0.39	0.37	0.36	0.35
T1C2	0.41	0.39	0.38	0.37	0.36
T2C2	0.41	0.39	0.37	0.35	0.33
T3C2	0.41	0.40	0.39	0.38	0.37
T4C2	0.41	0.40	0.40	0.39	0.38
SE (m)	0.02	0.01	0.02	0.01	0.01
CD at 5%	NS	NS	0.03	0.01	0.02

Conclusion

The present experiment has resulted that pomegranate fruit packaging with LDPE, HDPE, LDPE + $KMnO_4$, HDPE + $KMnO_4$ has maintained the quality in both the storage condition and extended the shelf life with minimum expenditure. This practice is easy for handling and practically possible.

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