Plant Archives Vol. 24, No. 2, 2024 pp. 1730-1734 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2024.v24.no.2.247

IMPACT OF DIFFERENT PACKAGING MATERIALS AND STORAGE TEMPERATURE ON PHYSICO-CHEMICAL CHARACTERISTICS AND QUALITY OF POMEGRANATE (*PUNICA GRANATUM* L.)

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(Date of Receiving-03-04-2024; Date of Acceptance-21-06-2024)

ABSTRACT

Pomegranate (*Punica granatum* L.) is referred to as "super fruit" because of its high nutritive value, high antioxidant capacity, potentially bioactive compounds, chemo- preventive properties having medicinal value and high consumers appeal (Ganesan & Mahadevan 2015). 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. Pomegranate, being a non-climacteric fruit has a tremendous possibility for different storage conditions by either using various polymeric films, CFB box or paper wraps which will not only retain fruit quality during storage but also help in alleviation of chilling injury during refrigerated transport and storage. Therefore, an experiment on Impact of different packaging material and storage temperature on shelf life , physico-chemical characteristics and quality of pomegranate was assessed at Department of Horticulture C. B. G. Ag. P.G. College, B.K.T., Lucknow with two factors of treatments and three replications in factorial completely randomized design. The first factor of treatment was different packaging materials and the second factor is storage temperature. The treatments were A_1-LDPE 25 micron with .5% perforation, A_2-Polypropylene bag with .5% perforation, A_3-Shrink wrapping, A_4-paper wrapping, A_5-control (without wrapping) C_1-storage at 5 ^{0}C and C_2-storage at ambient temperature with the effect of different packaging materials for extending shelf life, physico– chemical properties and quality of pomegranate fruit. Results revealed that Physiological loss in weight was found minimum with treatment T_5 (A_3C_1) i.e. 2.26 and 2.66 %,maximum fruit firmness 28.70 N and 26.46 N, maximum juice content in percentage 39.42 and 38.54% and the highest TSS content 12.40 and 12.35 ^{o}B were recorded with T_5 (A_3C_1) i.e. shrink wrapping with storage at 5 ^{0}C at refrigerator condition at 18th and 24th days after storage as compared to rest of the treatments significantly .However, the minimum values of all the characters were studied at refrigerator condition at 5 ^{0}C with T_9 (control) at the end of the storage days respectively.

***Key words*:** Shrink film, Polypropylene film, LDPE film, Refrigerator condition, Ambient, Temperature

Introduction

The pomegranate (*Punica granatum* L.) is a fruit bearing shrub, belongs to the family Lythraceae, Edible part of the pomegranate comprise of 78 % juice and 22 % seed (Kader *et al.*, 2009). The aril of pomegranate is an excellent dietary source as it contains a significant proportion of organic acids, soluble acids, polysaccharide, vitamins, fatty acids and mineral elements of nutritional significance. After harvest, it is persistent physiological and biochemical changes, resulting in severe quality loss and deterioration. Pomegranate even being a non-climacteric many seeded balausta, it is subjected to continuous physiological and biochemical changes after harvest with several problems of quality and decay loss during post-harvest handling and storage. The major cause limiting the storage potential of pomegranate is the development of decay, which is often caused due to the presence of fungal infection especially in blossom end of the fruit at harvest. Several post-harvest methods have been evaluated out of which, the temperature control (5^{o}C) is a simple, economical and effective method for delaying post-harvest deterioration, and maintaining quality of pomegranate (Selcuk and Erkan, 2016). The selection of most suitable packaging method plays a significant role in increasing the shelf life and maintaining its nutritional quality. Storage of pomegranate is influenced by the kind of packaging material used besides storage temperature. Packaging protects the pomegranate and serves as an alternative measure for controlling diseases and provides structural support for convenient storage and transport. Different packaging material *i.e*. LDPE (low density polyethylene film), PP (Polypropylene fim), shrink film, paper wrapping are being used for packaging and storage for improving the post-harvest loss in pomegranate. An experiment on Impact of different packaging material and different storage temperature on Physico-chemical characteristics and quality of pomegranate cv. Bhagwa is planned by using different polypropylene films as a packaging materials and different storage temperature to evaluate the potentiality in increasing shelf life, physico-chemical properties quality of pomegranate fruit.

Materials and Methods

The experiment was conducted at the post-harvest lab, Department of Horticulture, C. B. G. Ag PG College during *kharif* 2023. The fully matured pomegranate fruits were procured from orchard Bhanpur, Malihabad Lucknow. The fruits of pomegranate cv. Bhagwa which were apparently of uniform size, shape and colour were graded. After picking, the fruits were immediately brought to the Post Harvest Laboratory. The fruits which received injury of any type during transportation were rejected. The packing material *viz.*, 25-micron Low density polyethylene bag (LDPE) with .5% perforation, 25-micron Polypropylene bags (PP) with .5% perforation, shrink wrapping, Paper wrapping were used in the experiment to pack the fruit of pomegranate under room temperature and refrigerator condition.

The observations on physical and chemical parameters were recorded at six days interval for fruit stored in room temperature and refrigerated condition.

Table 1: Impact of different packaging material and storage temperature On P.L.W. and fruit firmness of pomegranate.

Treatments	Physiological Loss in weight (PLW)				Fruit Firmness			
Packaging material	Days after storage				Days after storage			
	6DAS	12DAS	18DAS	24DAS	6DAS	12DAS	18DAS	24DAS
A1 (LDPE 25 micron with 0.5 % perforation)	2.43	2.81	3.34	3.41	25.73	29.95	23.97	22.92
A2 (polypropylene bag with 0.5% perforation)	2.71	3.11	3.23	3.39	26.23	25.20	24.07	23.14
A3(shrink wrapping)	2.02	2.25	2.50	2.91	32.17	31.17	29.96	28.43
A4(paper wrapping)	2.82	3.10	3.25	3.96	24.95	23.09	22.20	20.22
A5Control(Without wrapping)	3.02	3.45	3.87	4.21	22.23	21.12	20.02	19.86
SEm±	.012	.022	.022	.011	.124	.164	.181	.166
CD at .05%level	.037	.066	.001	.001	.370	.486	.537	.492
Storage temperature(°C)								
C1(refrigerator storage condition 5°C)	2.01	2.15	2.63	2.96	29.77	28.98	28.13	26.51
C2(ambient storage condition)	2.59	2.89	3.13	3.95	24.77	23.03	22.65	21.43
SEm±	.008	.022	.054	.007	.079	.104	.114	.105
CD at 0.05%	.023	.066	.012	.020	.111	.146	.162	.148

Interaction between packaging material and storage temperature in pomegranate cv. Bhagwa

	Physiological Loss in weight				Fruit Firmness			
Treatments	6DAS	12DAS	18DAS	24DAS	6DAS	12DAS	18DAS	24DAS
T1(A_1XC_1)	2.01	2.14	2.96	3.96	27.07	25.38	25.10	23.35
T2(A_1XC_2)	2.08	2.31	3.31	4.10	26.68	24.31	22.85	23.10
T3(A_2XC_1)	1.91	2.06	2.24	3.16	31.57	30.60	27.61	26.42
T4(A_2XC_2)	2.03	2.40	3.21	4.08	29.19	28.00	26.88	23.17
T5(A_3XC_1)	1.53	1.65	2.26	2.66	32.76	31.74	29.26	28.70
T6(A_3XC_2)	1.97	2.28	2.48	3.25	29.81	28.54	27.61	26.08
T7(A_4XC_1)	2.58	2.72	3.10	4.13	24.08	22.27	21.66	19.80
T8(A_4XC_2)	2.69	2.90	3.56	3.95	22.84	21.53	20.66	19.10
T9(A_5XC_1)	3.35	3.91	3.37	4.70	22.21	21.22	20.71	19.83
T10(A_5XC_2)	4.28	4.75	4.98	5.53	19.00	18.25	16.79	15.18
Sem	.018	.031	.058	.013	.176	.232	.256	.234
CD at0.05% level	.052	.004	.173	.014	.523	.688	.760	.696

Physiological loss in weight (PLW) (%)

The weight of fruit was recorded at six days interval and Physiological Loss in Weight was calculated by noting the difference between initial and subsequent weights and it was expressed in per cent.

$$PLW\ (\%) = \frac{\text{Initial Weight-Final Weight}}{\text{Initial Weight}} \times 100$$

Fruit firmness (N)

The firmness of fruit was measured by using Texture analyzer. Hardness is the force required to compared a substance between the molar teeth or between tongue and plate to a given deformation or penetration and was recorded in Newton's.

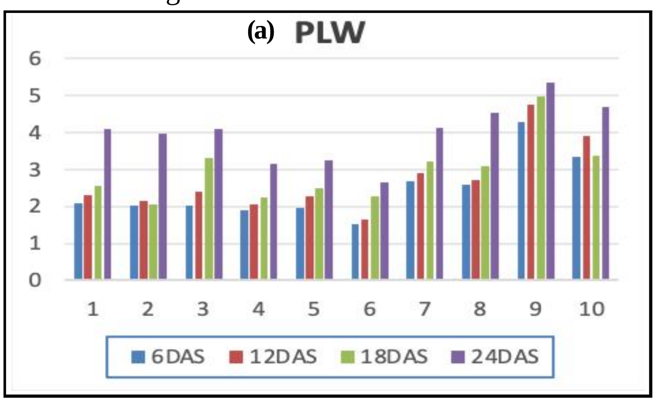
Juice content (%)

The juice of pomegranate arils was extracted by using double muslin cloth. The juice percentage was expressed on weight basis per unit weight of the fruit.

$$Juice\ (\%) = \frac{\text{Weight of Juice}}{\text{Weight of fruit}} \times 100$$

Total soluble solids (Brix index)

The content of total soluble solids in the juice was measured with the help of Erma Hand digital Refractometer (0-32°B). The prism of refractometer was washed with distilled water and wiped by muslin cloth after recording each observation. The entire data was analyzed statistically by using ANOVA. Chemical analysis (Sheoran, 2023) for plant and soil was done by using standard methods in the Department of Horticulture, C B G Ag PG College (U.P.), India



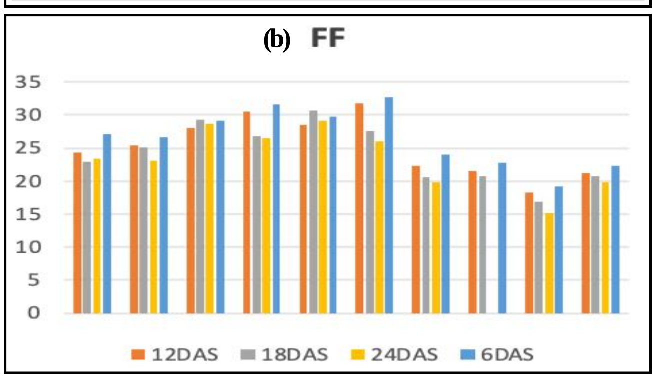


Fig. 1: (a and b) Impact of different packaging and storage temperature on PLW and fruit firmness.

Results and Discussion

Impact of different packaging material and storage temperature on Physiological loss in weight (%) and fruit firmness of pomegranate

The physiological loss in weight of pomegranate fruit *cv*. Bhagwa was influenced by different packaging material and storage temperature significantly with the advancement of storage days. The data presented in Table 1 , Fig. 1 (a and b) depicted that minimum physiological loss in weight 2.50% and 2.91% and maximum fruit firmness 37.18 N and 36.09 N were found with treatment A_3 (shrink wrapping) after 18[th] and 24[th] days of storage significantly. However, the physiological

Table 2: Impact of different packaging material and storage on juice content (%) of pomegranate.

Treatment	6DAS	12DAS	18DAS	24DAS
A1 (LDPE bag with 0.5% perforation)	33.59	32.22	31.46	30.26
A2 (polypropylene bag with 0.5% perforation)	34.58	33.11	32.19	30.52
A3(shrink wrapping)	39.31	37.62	37.18	36.09
A4(Paper wrapping)	32.40	31.19	29.29	28.78
A5(Absolute control)	30.92	29.56	28.29	27.09
SEm	.004	.052	.031	.011
CD at .05% level	.013	.154	.094	.034
Storage temperature				
C1(Refrigerator storage at 5°C)	33.40	32.13	31.04	30.12
C2 (Ambient temp storage at 27°C)	34.99	33.35	32.32	30.97
SEm	.003	.033	.200	.007
CD at .05% level	.008	.097	.890	.320

Treatment combination	6DAS	12 DAS	18DAS	24DAS
T1 (A_1XC_1)	34.53	33.03	32.17	31.04
T2 (A_1XC_2)	33.76	32.16	30.17	28.66
T3 (A_2XC_1)	39.99	38.46	37.51	36.07
T4 (A_2XC_2)	34.86	33.60	32.40	30.66
T5 (A_3XC_1)	41.85	40.21	39.42	38.54
T6 (A_3XC_2)	36.98	35.02	34.95	32.64
T7 (A_4XC_1)	32.65	31.42	30.15	29.49
T8 (A_4XC_2)	31.23	30.23	29.17	28.66
T9 (A_5XC_1)	29.97	27.76	26.87	24.66
T10(A_5XC_2)	26.98	25.53	24.18	23.52
SEm	.006	.730	.044	.016
CD at.05%level	.018	.218	.132	.048

loss in weight was faster at room temperature than the refrigerated condition significantly. Whereas, maximum physiological loss in weight (4.21%) and minimum fruit firmness 20.92 N was found with absolute control A_5 significantly after 24th days of storage of pomegranate fruit. The data of interaction between different packaging material and storage temperature revealed that A_3C_1 (Shrink wrapping at 5°C refrigerated condition) results in minimum physiological loss in weight 2.66% and maximum fruit firmness 28.70N at the end of the storage days (24th DAS) respectively which was followed by 3.16% PLW and 26.42N (fruit firmness) with treatment A_2C_1 (Poly Propylene with .5% perforation at 5°C refrigerated condition) significantly after 24th days of storage. The physiological loss in weight increases with advancement of storage days whereas, fruit firmness decreases with the advancement of storage days. Maximum loss in physiological weight 4.70% and minimum firmness of fruits 19.83 N was recorded at 5°C refrigerated temperature at the end of shelf life (after 24th days of storage) with A_5C_1 (control) respectively. Fruits packed in different packaging film recorded lower weight loss, which was due to their role in altering CO_2 concentration inside the packages and thereby, reducing humidity inside the wrappers (Bhatiya *et al.*, 2015). The reduction in weight loss in shrink wrapping of pomegranate may be due to alleviation of water stress creation around each fruit which reduces respiration rate as the film is differently permeable to O_2 and CO_2 transmission and similar in weight loss of pomegranate were supported by Sharma and Kumar (2021) same findings were reported by Pongener *et al.*, (2011) in peaches.

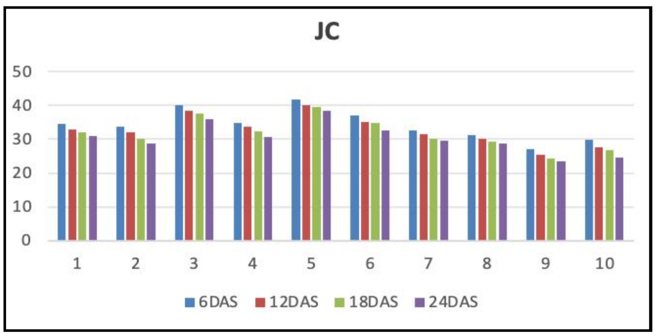


Fig. 2(a): Impact of different packaging and storage temperature on Juice Content (%) Effect of different packaging material and storage temperature on juice content % and TSS% of Pomegranate.

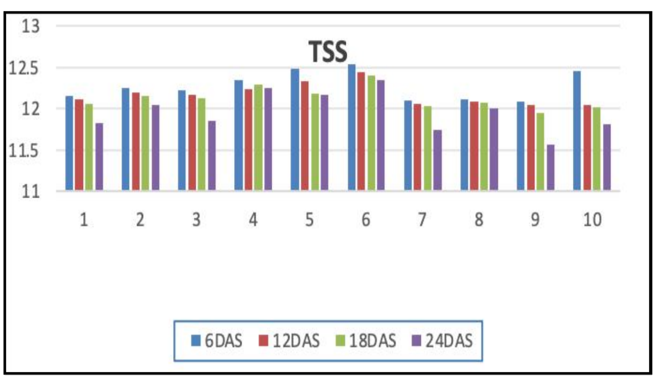


Fig. 2(b): Impact of different packaging material and storage temperature on TSS.

Table 3: Impact of different packaging material and storage on TSS on pomegranate.

Treatment	TSS °B			
	6 DAS	12DAS	18DAS	24DAS
A1 (LDPE 25 micron with 0.5 % perforation)	12.20	12.16	12.09	11.84
A2 (polypropylene bag with 0.5% perforation)	12.28	12.20	12.17	12.10
A3(shrink wrapping)	12.52	12.38	12.34	12.30
A4(Paper wrapping)	12.49	12.10	12.38	11.70
A5(Absolute control)	12.27	12.04	11.99	11.78
SEm	.047	.011	.072	.011
CD at .05% level	.139	.034	.214	.032
C1(Refrigerator storage at 5°C)	12.35	12.14	12.10	11.90
C2 (Ambient temp 27°C)	12.37	12.21	12.19	11.97
SEm	.003	.007	.045	.007
CD at .05% level	.088	.021	.135	.010

Treatment combination	TSS%			
	6DAS	12DAS	18DAS	24DAS
T1 (A_1XC_1)	12.25	12.20	12.15	12.04
T2 (A_1XC_2)	12.16	12.12	12.06	11.83
T3 (A_2XC_1)	12.35	12.24	12.29	12.25
T4 (A_2XC_2)	12.22	12.17	12.13	11.86
T5 (A_3XC_1)	12.54	12.44	12.40	12.35
T6 (A_3XC_2)	12.49	12.33	12.19	12.17
T7 (A_4XC_1)	12.12	12.09	12.07	12.00
T8 (A_4XC_2)	12.10	12.06	12.03	11.74
T9 (A_5XC_1)	12.06	12.00	11.95	11.57
T10 (A_5XC_2)	11,96	11.55	11.48	11.42
Sem	.007	.019	.006	.008
CD at .05% level	.019	.057	.017	.023

Maximum percentage of juice content 37.18%, 36.09% and maximum TSS 12.34% ,12.30% presented in Table 2, Fig. 2 and Table 3, Fig. 3 were found with A_3 (shrink wrapping) after 18th and 24th days of storage which was followed by A_2 (polypropylene film with .5% perforation) *i.e.* 32.19% and 30.52% juice content % and TSS % were found 12.17 and 12.10% after 18th and 24th days of storage respectively. The data represented in Table 2 revealed that the juice content % of treatment A_1(30.26%) and A_2(30.52%) were significantly at par after 24th days of storage. More juice content and TSS was recorded at refrigerated condition of storage rather than the ambient room temperature. Interaction study revealed that maximum juice content 38.54% and TSS 12.35% was recorded with A_3C_1 (shrink film wrapped fruits stored at 5°C refrigerated condition) after 24th days of storage significantly. All the treatments were significantly different to each other and influence the juice content and TSS respectively with advancement of storage days. However, at refrigerator temperature condition (5°C) the minimum juice content 24.66% and TSS 11.57% was found with A_5C_1 (Absolute control) after the end of storage days significantly. This result indicates that as in pomegranate the moisture loss of rind was higher in the aril of fruits stored at ambient condition without any covering of packaging material significantly. At the same time when the rind goes water deficit, the water is then replaced by the arils (Sood, 2012) film covering greatly reduced rind moisture loss resulting in the retention of freshness of the fruit in the terms of fruit juice percentage and TSS (Bhowmik *et al*., 2013). 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. (Siddiqui *et al.*,1997). Shrink wrapping found to be very effective packing material in controlling reduction in juice content of fruits. Earlier, similar results in Kinnow mandarin were reported by Navale *et al*., (2011)

The result of present study was corroborated that the increase in TSS during storage period could be attributed to the water loss and hydrolysis of starch and conversion of other polysaccharides to soluble form of sugar (Idumah *et al*., 2019).

Conclusion

The shrink film helped in reducing the loss in weight, firmness, juice content and maintained the various qualities attributes like total soluble solids, of the fruits better than unwrapped control fruits during the storage period respectively. The pectin methyl esterase enzyme activity was also found to be lower in shrink film packed fruits over the unwrapped control fruits. The in-package gaseous composition (O_2 and CO_2) in shrink film packed fruits was found to be at desired level which resulted in maintenance of pleasant flavour of the fruits. On the other hand, LDPE film accumulated very high level of CO_2, which led to formation of fermenting odour and decay of fruits in the package.

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