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Effect of wrapping material on quality parameters of guava (*Psidium guajava* L.) fruits during storage

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Abstract
An experiment was conducted in Post-harvest Laboratory of the Department of Horticulture, G.B. Pant University of Agriculture and Technology, Pantnagar, to examine the effect of different wrapping materials on physiological parameters of guava cv. Safeda stored at room temperature during rainy season. The guava fruits harvested at mature green stage were individually wrapped in different wrappers such as tissue paper, blotting paper and newspaper, whereas control was kept unwrapped. The fruits were examined for shelf-life, physiological loss in weight and other physical parameters at different days of storage. The results revealed that guava fruits wrapped in tissue paper followed by butter paper proved to be the best treatments among all the treatments, which not only extended the shelf life and increased marketable fruits but also reduced the post-harvest losses without adversely affecting the fruit quality of guava. These treatments were found easy for practical application for extending the shelf life of guava.

Keywords: Guava, wrappers, postharvest loss, storage, self-life

Introduction
The Guava (*Psidium guajava*) is the one of the most important, highly prolific, delicious and nutritious fruit of tropical and sub-tropical regions. It is the fourth most important fruit in area and production after mango, banana and citrus in India. Guava fruits are cultivated in India since early 17th century and due to its wider adaptability in diverse soils and agro-climatic conditions, low cost of the cultivation, prolific bearing and being highly remunerative with fruit nutritive values, it has gained more popularity among the fruit growers. It has high nutritive value and also known as apple of sub-tropics. The fruit is an excellent source of vitamin C containing 2-5 times more than oranges and 10 times more than tomatoes. It is a good source of calcium, phosphorus and iron. Fruits may be utilized to make products like jelly, jam, cheese, juice, canned segments and nectar. However, the most commercial use of guava is for jelly preparation. In ambient condition, the guava fruit becomes fully ripe in three and five days. Generally, guava is highly perishable, susceptible to mechanical damage, chilling injury and has a limited postharvest shelf life (Ismail *et al.*, 2010) [6]. It is most difficult to store or transport it over long distance; therefore, it needs immediate marketing and utilization. Investigations have shown that the maximum physiological loss in weight (13.37%), the maximum increase in TSS% fruits resulted when wrapped in newspaper at room temperature. However minimum PLW (2.91%) was observed in fruits wrapped in HDPE (Kumar *et al*., 2003) [7]. Highest moisture content (83.90%), fruit weight (310g), diameter (23.22 cm) were observed in Guava variety Kazi (Biswas, 1999) [3]. Guava fruits at green stage packed in cryovac PD-900 and stored at 8 ℃ (85- 90% RH) for 49 days had lower weight loss (Yamashita and Benassi, 2000) [13]. However, best physico-chemical characteristics and marketability quality for up to 16 days was observed when fruit was harvested at mature green stage and wrapped in transparent polyethylene bags stored at refrigerated at 10 ℃ (Gonzaga *et al*., 1999) [5]. Pereira *et al*. (2003) [10] found that fruits packed in polyethylene terephthalate (PET) trays and stored at 5 ℃ had the lowest weight loss microbial spoilage and best physico-chemical characteristics. Packing fruits in rigid or flexible packaging retained freshness. The highest retention of green colour (20%) was observed in the polythene laminated with aluminium foil packaging (Mandhyan, 1999) [8]. Keeping in views the importance and perish ability nature of guava, an attempt has been made in the present study to evaluate the effect of different wrapping materials on storage life and physico-chemical characteristics of guava.

Materials and Methods

The experiment was conducted during the winter season of 2017 in Post-harvest Laboratory of the Department of Horticulture, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. The fruits were taken from Horticultural Research Centre, Patharchatta, located at the North-West Plains of *Tarai* region of Uttarakhand. The fruits of guava cv. Sardar were harvested at green mature stage from the experimental orchard. Diseased, undesirable and damaged fruits were sorted out from the samples. Healthy fruits of uniform size were taken for conducting the experiment and individual fruits are wrapped in different wrapping materials *viz*, W_1-Tissue paper, W_2 - Blotting paper, W_3-Newspaper and W_4-Without wrapping (control). The treatments were laid out in completely randomized design with three replications and various physiological parameters were studied during experimentation. The fruit length and diameter was measured at the widest point of the fruit with the help of Vernier calipers. The average was expressed in centimeters. Shrinkage percentage was determined by calculating difference between initials fruit diameter and fruit diameter after storage and this value is expressed in percentage. The water displacement method was used to measured volume of the guava fruits. On initial day fruits was weighed on an electronic weighing balance and also reweighed at the end of each shelf life. The weight loss was determined and expressed as percent loss from initial weight. Decay loss was assessed as total rotted decayed fruits in terms of percentage on number basis. The number of decayed fruits due to fungus or any micro-organisms infection was recorded every 3 days and calculated as a percentage of the total number of fruits. Specific gravity was calculated by dividing the average fruits weight by average fruits volume. Ten grams of fruit pulp were taken and placed in electric oven at 60 ℃ for 72 hours until the weight become constant. Moisture content percentage was determined by calculating difference between initial weight of fruit pulp and oven dried weight of fruit pulp and expressed into percentage. The data were analyzed with the procedures described by Gomez and Gomez (1984) [4].

Result and Discussion

Data in the table 1 indicates that the fruit length was decreased significantly with the advancement of storage duration. The minimum (9.83%) fruit shrinkage was recorded in fruits wrapped under the tissue paper, followed by blotting paper (10.56%), whereas, the maximum shrinkage (12.98%) was noted in control after 12 days of storage. Fruit length was decreased during the storage period, which was similar to the finding of Tiwari (2011) [12] who observed decrease in fruit length of mango in containers and wrappers with the advancement of the storage duration. Fruit breadth decreased significantly with the advancement of storage duration (Table 2). The minimum shrinkage (10.09%) in fruit breadth was recorded in fruits wrapped under the tissue paper followed (10.25%) by blotting paper, whereas, the maximum shrinkage (11.11%) was recorded in without wrapper. The decrease in fruit length and breadth with increase in storage period might be due to increased moisture loss, resulting in shrinkage of fruits (Avesh *et al*., 2019) [1]. The fruit weight was significantly affected by wrappers (Table 3). The maximum fruit weight (127.32g) was recorded in blotting paper followed by tissue paper. Whereas the minimum fruit weight (98.77g) was reported under control at 12 days of storage duration. The minimum fruit weight loss at room temperature under blotting paper might be due to fact that its moisture absorbing capacity created suitable micro-climate surrounding the fruits (Miano *et al.*, 2010) [9].

The effect of wrappers on fruit volume was found to be significant (Table 4). The maximum fruit volume (120.70 ml) was recorded in fruits wrapped in the tissue paper followed by (117.96 ml) blotting paper, while the minimum fruit volume (101.47 ml) was recorded in without wrapping at 12 days of storage duration. The findings reflect that fruit shrinkage might have caused due to moisture loss from the fruits leading to reduction in volume of fruits. The treatments might have reduced moisture loss from the fruits, thus preventing shrinkage and maintaining volume better then control. Data presented in the table 5 indicates that physiological loss in weight increased significantly with the advancement of storage duration. No physiological loss in weight was observed on the initial day of storage. The maximum physiological loss in weight (26.75%) was recorded in non wrapped fruits by fruits wrapped under newspaper. The minimum physiological loss in weight of guava fruits wrapped in newspaper might be due to the development of high humidity inside the bags, which reduced the rate of water loss from the fruit surface through a process of transpiration (Rana *et al.*, 2018) [11]. The data regarding to dry matter shows highly significant difference among all the treatments. The fruits dry matter increased significantly with the advancement of storage duration (Table 6). The maximum fruit dry matter (27.38%) was recorded in fruits without wrapping, followed by fruits wrapped under newspaper (26.29%). While the minimum fruit dry matter (23.76%) was recorded in fruits wrapped under tissue paper at 12 days of storage duration. The increase in dry matter per cent with the advancement of storage duration might be due to the withdrawal of water from the pulp to peel.

Spoilage percentage gradually increased significantly with the advancement of storage duration (Table 7). The maximum spoilage percentage (50.75%) was recorded in fruits without wrapping followed (46.91%) by fruits wrapped under newspaper, whereas the minimum spoilage percentage (37.21%) was recorded in fruits wrapped in tissue paper followed by fruits in blotting paper (41.14%) at 12 days of storage duration. The minimum spoilage percentage at room temperature was recorded under tissue paper wrappers as result of its moisture absorbing capacity which created suitable micro-climate surrounds the fruits due to which its shelf life increased and all the fruits remained in an edible condition (Miano *et al*. 2010) [9]. The maximum specific gravity (1.13) was found in tissue paper followed by blotting paper (1.12). The minimum specific gravity (1.05) was recorded in without wrapping at 12 days of storage duration (Table 8). The specific gravity increased significantly with the advancement of storage duration due to the depletion of fruit weight is more than the corresponding decreases in its volume. In addition, accelerated respiration and biochemical activities may contribute the vanished fruit voids and also due to migration of biochemical compound from peel to pulp may be the cause to increase specific gravity of fruits. The moisture content gradually decreased with the advancement of storage duration (Azzolini *et al*., 2004) **[2]**. The maximum moisture content (68.29%) was found in the fruits wrapped in tissue paper, closely followed by fruits wrapped in blotting paper (67.50%), however tissue paper and blotting paper were statistically at *par* on each other (Table 9). The maximum moisture content in the fruits wrapped in tissue paper it might be due to the fact that the more moisture retention in the fruits wrapped in tissue paper which increased moisture percentage of the fruit as compared to control.

Table 1: Effect of wrappers on fruit length (cm) in winter season crop

Treatments	Storage Intervals (days)					Shrinkage (%)
	0	3	6	9	12	
Tissue paper	6.10	5.97	5.82	5.66	5.50	9.83
Blotting paper	6.06	5.91	5.75	5.58	5.42	10.56
Newspaper	5.76	5.55	5.39	5.22	5.05	12.33
Without wrapping	5.70	5.46	5.30	5.13	4.96	12.98
S.Em.±	0.055	0.046	0.029	0.044	0.032	
C.D. at 5%	0.161	0.136	0.086	0.131	0.094	

Table 2: Effect of wrappers on fruit breadth (cm) in winter season crop

Treatments	Storage Intervals (days)					Shrinkage (%)
	0	3	6	9	12	
Tissue paper	6.44	6.22	6.03	5.95	5.79	10.09
Blotting paper	6.24	6.02	5.83	5.75	5.60	10.25
Newspaper	6.03	5.81	5.62	5.54	5.39	10.61
Without wrapping	5.94	5.72	5.53	5.45	5.28	11.11
S.Em.±	0.056	0.064	0.053	0.105	0.043	
C.D. at 5%	0.165	0.189	0.155	0.122	0.127	

Table 3: Effect of wrappers on fruit weight (g) in winter season crop

Treatments	Storage Intervals (days)				
	0	3	6	9	12
Tissue paper	147.34	143.71	138.11	132.19	125.09
Blotting paper	148.03	143.62	137.80	131.90	127.32
Newspaper	132.53	126.71	120.50	114.52	109.14
Without wrapping	123.83	116.87	110.49	104.44	98.77
S.Em.±	1.302	1.157	0.976	1.187	1.135
C.D. at 5%	3.822	3.398	2.866	3.485	3.331

Table 4: Effect of wrappers on fruit volume (ml) in winter season crop

Treatments	Storage Intervals (days)				
	0	3	6	9	12
Tissue paper	148.01	142.17	135.39	127.32	120.70
Blotting paper	145.40	139.47	132.08	124.05	117.96
Newspaper	139.47	132.75	124.64	115.72	109.63
Without wrapping	132.84	126.18	117.08	107.90	101.47
S.Em.±	1.263	1.262	1.063	0.785	1.013
C.D. at 5%	3.708	3.707	3.120	2.304	2.974

Table 5: Effect of wrappers on physiological loss in weight (%) in winter season crop

Treatments	Storage Intervals (days)				
	0	3	6	9	12
Tissue paper	0.00	3.01 (9.71)	6.15 (14.18)	10.33 (18.56)	14.18 (21.91)
Blotting paper	0.00	2.55 (8.95)	7.04 (15.29)	11.29 (19.55)	14.50 (22.73)
Newspaper	0.00	4.39 (12.09)	9.23 (17.68)	13.37 (21.44)	18.31 (25.32)
Without wrapping	0.00	5.62 (13.70)	10.78 (19.15)	15.67 (23.30)	20.29 (26.75)
S.Em. ±	0.00	0.031	0.064	0.099	0.185
C.D. at 5%	0.00	0.092	0.187	0.289	0.543

Table 6: Effect of wrappers on dry matter (%) in winter season crop

Treatments	Storage Intervals (days)				
	0	3	6	9	12
Tissue paper	9.66 (18.08)	12.38 (20.52)	14.02 (21.96)	15.08 (22.82)	16.28 (23.76)
Blotting paper	10.09 (18.51)	12.99 (21.11)	14.31 (22.21)	15.39 (23.08)	16.62 (24.03)
Newspaper	11.56 (19.86)	14.68 (22.52)	16.69 (24.10)	18.05 (25.13)	19.63 (26.29)
Without wrapping	12.30 (20.52)	15.52 (23.19)	17.73 (24.89)	19.30 (26.05)	21.16 (27.38)
S.Em. ±	0.110	0.096	0.140	0.147	0.183
C.D. at 5%	0.322	0.283	0.410	0.432	0.538

Table 7: Effect of wrappers on spoilage (%) in winter season crop

Treatments	Storage Intervals (days)				
	0	3	6	9	12
Tissue paper	0.00	6.67 (12.29)	16.67 (23.85)	26.67 (30.98)	36.67 (37.21)
Blotting paper	0.00	6.67 (12.28)	16.67 (23.85)	30.00 (32.99)	43.33 (41.14)
Newspaper	0.00	10.00 (18.43)	23.33 (28.77)	46.67 (43.06)	53.33 (46.91)
Without wrapping	0.00	20.00 (26.55)	33.33 (35.20)	50.00 (44.98)	60.00 (50.75)
S.Em. ±	0.000	0.111	0.243	0.390	0.503
C.D. at 5%	0.000	0.325	0.712	1.145	1.478

Table 8: Effect of wrappers on specific gravity in winter season crop

Treatments	Storage Intervals (days)				
	0	3	6	9	12
Tissue paper	0.97	0.99	1.04	1.10	1.13
Blotting paper	0.96	0.98	1.03	1.09	1.12
Newspaper	0.94	0.96	1.00	1.05	1.09
Without wrapping	0.93	0.95	1.00	1.02	1.05
S.Em. ±	0.009	0.008	0.006	0.009	0.009
C.D. at 5%	0.026	0.024	0.017	0.027	0.026

Table 9: Effect of wrappers on moisture content (%) in winter season crop

Treatments	Storage Intervals (days)				
	0	3	6	9	12
Tissue paper	89.17 (70.94)	88.29 (70.11)	87.80 (69.66)	87.01 (68.96)	86.12 (68.29)
Blotting paper	88.43 (70.15)	87.52 (69.34)	87.03 (68.91)	86.24 (68.27)	85.35 (67.50)
Newspaper	85.36 (67.53)	84.26 (66.62)	83.77 (66.27)	82.98 (65.24)	82.09 (64.96)
Without wrapping	83.64 (66.14)	82.50 (65.25)	82.01 (64.89)	81.22 (64.31)	80.33 (63.66)
S.Em.±	0.59	0.69	0.71	0.63	0.72
C.D. at 5%	1.73	2.01	2.08	1.84	2.11

Conclusion

On the basis of above finding, it can be concluded that fruits individually wrapped in tissue paper proved best for maintaining shelf life and quality of guava fruits. It can be recommended for the extend storage period, marketability and to maintain quality during storage of guava cv. Sardar.

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