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Effect of perforated and non-perforated films on quality and storage life of guava fruits

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ABSTRACT

An investigation was conducted to study the effect of different packaging materials to maintain quality and for extensions of storage life of guava cv. Sardar under cold storage conditions. Fruits of guava were harvested at firm mature stage, packed in different packaging materials, *viz*. LDPE, HDPE, PP films with and without perforation (5% venting area) and kept in CFB boxes followed by storage at 6-8°C and 90-95% RH. The conventional packaging such as newspaper lining and unpacked (control) in CFB boxes were also included for comparison. The fruits packed in different packaging films had lower PLW, more firmness, negligible spoilage, better colour development, acceptable quality and organoleptic rating as compared to control fruits. After two weeks of storage, fruits packed in perforated LDPE maintained higher organoleptic rating (8.63), lower PLW (0.91%), desirable firmness (8.30 lbf), excellent colour (a = -0.60; b = 26.15), minimum spoilage (0%) and better quality as compared to other treatments. The study revealed that guava fruits packed in 5% perforated LDPE polythene films can be stored for 14 days, as compared to unpacked control fruits which had storage life of 7 days.

Key words: Guava, LDPE film, HDPE film, PP film, storage.

INTRODUCTION

Guava (*Psidium guajava* L.) is a delicious and popular fruits. It is widely grown in tropical and subtropical regions of the country. At present, it ranks fifth among the fruits in India occupying 236 thousand ha area with annual production of 31.98 lakh MT (Anon, 2). Guava is also grown abundantly in northern India states owing to its higher productivity and consumer acceptance. Allahabad Safeda and Sardar (Lucknow-49) are the important commercial guava varieties and are grown at a large scale in northern India. Guava has limited storage potential at ambient conditions, which leads to glut in market and poor return to the growers. Moreover, overripe fruit at ambient conditions lead to lot of wastage and economic losses. The low temperature in winter months interferes with growth and developmental process of fruits leading to irregular supply or availability of guava fruits in the market (Mahajan *et al*., 10). Therefore, guava fruits are required to be managed appropriately from November to March in order to get a regulated market supply. This can be attained with judicious use of post-harvest treatment, followed by storage at appropriate temperature and relative humidity. Various attempts have been made to extend the storage life of guava with use of various chemicals and packaging materials (Hiwale and Singh, 7; Mahajan and Singh, 9).

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Among these, the use of packaging materials for storage is always preferred because it is free from any harmful residual effects on human health. Polyethylene film creates a modified atmosphere within the packaging, thereby reducing the transpirational losses and respiration rate. The packaging of guava fruits in polyethylene film minimizes the post-harvest losses and chilling injury and therefore ensures better quality of fruits during cold storage. Hence, the present studies were planned to standardize the technology for storage of surplus fruit in cold storage with the use of different packaging materials.

MATERIALS AND METHODS

The study was conducted at Post-harvest Laboratory, Department of Fruit Science, Punjab Agricultural University, Ludhiana during the year 2011-12. The uniform and disease-free plants of guava cv. Sardar, maintained under uniform cultural practices, were selected at RFRS, Bahadurgarh, Patiala, for getting of fruits. The physiologically mature and disease-free fruits of uniform size were packed in Low Density Polyethylene (LDPE), High Density Polyethylene (HDPE) and Polypropylene (PP) of 30 μm each. These packaging films were compared with paper lining, whereas in case of control, fruits were kept unpacked in CFB boxes. The details of the treatments like T_1 = LDPE 30 μm without perforation, T_2 = LDPE 30 μm with perforation (5%), T_3 = HDPE 30 μm without perforation, T_4 = HDPE 30 μm with perforation (5%), T_5 = PP 30 μm without perforation,

T_6 = PP 30 µm with perforation (5%), T_7 = Paper lining, and T_8 = Control (unpacked).

The experiment was laid out in completely randomized design with factorial arrangements. Each treatment was replicated thrice and each replicate consists of 2 kg fruits per replication per storage interval. Packed fruits were kept in walk-in cold rooms (6-8°C and 90-95% RH). The fruits were subjected to physico-chemical analysis at weekly intervals, *viz*., 7, 14, 21, 28 days. However, after 28 days of storage due to excessive decay incidence of fruits, the samples were assessed only for recording physiological loss in weight (PLW) and spoilage incidence.

A composite sample of fruits from each replication was blended and homogenized pulp was used for the estimation of different quality and storage parameters. The physiological loss in weight (PLW) after each storage interval was calculated by subtracting final weight from the initial weight of the fruits and expressed in per cent. The colour of the fruits was measured with colour difference meter (Mini Scan XE Plus, Hunter Lab, USA) and expressed as L, a, b Hunter colour values (Hunter, 8). The fruit firmness was measured with the help of a penetrometer (Model FT-327, USA) using 8 mm stainless steel probe and expressed in terms of pound force pressure (lb force). The overall organoleptic rating of the fruits was assessed by a panel of five judges on the basis of external appearance, texture; taste and flavour, on a 9-point Hedonic scale (Amerine *et al*., 4). The spoilage was calculated by counting the total number of fruits that registered fungal rot or displayed fungal mycelial growth out of 100 fruits kept separate in each treatment to assess the decay incidence (%). Total soluble solids (TSS) content was determined with the help of an hand refractometer (Model Erma, Japan) and expressed in per cent after making the temperature correction at 20°C. Acidity and vitamin C was estimated as per standard procedures (AOAC, 1). The data thus obtained were statistically analyzed by as described by Singh *et al*. (13).

RESULTS AND DISCUSSION

A steady increase in the physiological loss in weight (PLW) in film packaged guava fruits was noticed with passage of time as compared to control, where a faster and abrupt rise in PLW was observed with advancement of storage periods (Table 1). The perforation in packaging film maintained the higher PLW as compared to the without perforation. The maximum mean PLW (6.66%) was recorded in unpacked fruits (control) followed by treatments in which fruits was packed in newspaper lining (6.31%). The fruits packed in HDPE, LDPE and PP films with perforation recorded 1.27, 1.20, 1.05% mean PLW, respectively. The minimum mean PLW (0.67%) was observed in fruits packed in non-perforated PP film which was statistically at par with treatment in which fruits were packed in LDPE film without perforation. Lower PLW in polythene films might be due to reduction in respiration rate and transpiration which maintained high humidity inside polythene packaging. Minimum weight loss in non-perforated PP and LDPE films packed fruits could be due to less availability of oxygen for respiration, which ultimately retarded the rate of respiration and thereby lowering the moisture loss due to transpiration. These findings are in agreement with previous findings of Venkatesha and Reddy (14) and Yameshita and Benassi (15) in guava. The guava fruits packed in newspaper lining and unpacked (control) fruits exhibited the highest PLW as compared to fruits packed in polythene film might be due to exposure of fruit surface to the open atmospheric conditions resulting in higher rate of transpiration and respiration leading to higher physiological loss in weight.

The minimum average cumulative spoilage incidence (35.46%) was recorded in fruits packed in perforated LDPE film, which was closely followed by fruits packed in PP (with perforation) with an incidence of 35.85% (Table 1). The maximum decay incidence was recorded in control (51.42%) followed by fruits packed in newspaper lining (47.99%). The spoilage of fruits increased as the storage period advances. Among packaging films, the spoilage was observed to be higher in fruits packed in non-perforated film as compared to fruits packed in perforated films. This might be due to condensation of moisture in the surface of fruits, anaerobic conditions and break down of enzymes etc. during storage, which encouraged the multiplication of micro-flora. Fruits soften due to ripening and senescent changes results in fruit softening which further predisposes it to the fungal pathogenic rots. Likewise, Yameshita and Benassi (15) observed higher spoilage in guava fruits packed in polythene films without ventilation.

The film packed fruits showed a gradual and steady increase in organoleptic rating up to 14 days of storage, after which decline in organoleptic rating was observed (Table 2). Whereas, in control fruits, organoleptic rating increased up to 7 days of storage and thereafter declined at a faster pace. The significantly higher mean organoleptic rating (8.02) was recorded in perforated LDPE film packed fruits, followed by perforated PP (7.96) and HDPE (7.87) packed films. The fruits packed in newspaper lining and control registered 6.95 and 6.59 mean values of organoleptic rating, respectively, at the end of storage. Among the different packaging treatments,

Table 1. Effect of different packaging materials on physiological loss in weight (%) and spoilage (%) of guava cv. Sardar under cold storage conditions.

Treatment	Storage period (days)				
	7	14	21	28	Mean
			PLW (%)		
LDPE without perforation	0.20	0.31	0.96	1.21	0.69
LDPE with perforation (5%)	0.39	0.91	1.53	1.95	1.20
HDPE without perforation	0.20	0.61	1.30	1.63	0.94
HDPE with perforation (5%)	0.38	0.96	1.69	2.04	1.27
PP without perforation	0.13	0.61	0.77	1.16	0.67
PP with perforation (5%)	0.30	0.72	1.39	1.79	1.05
Newspaper lining	2.80	4.77	8.00	9.66	6.31
Control	3.29	4.93	8.56	9.87	6.66
Mean	0.96	1.73	2.90	3.66	
$CD_{0.05}$ Storage interval (A) = 0.18, Treatment (B) = 0.26, Interaction A × B = 0.52					
			Spoilage (%)		
LDPE without perforation	0	0	47.20	100	36.80
LDPE with perforation (5%)	0	0	41.86	100	35.46
HDPE without perforation	0	0	55.10	100	38.77
HDPE with perforation (5%)	0	0	44.27	100	36.07
PP without perforation	0	0	49.96	100	37.49
PP with perforation (5%)	0	0	43.43	100	35.85
Newspaper lining	0	28.93	63.03	100	47.99
Control	0	34.70	71.00	100	51.42
Mean	0	7.95	51.76	100	
$CD_{0.05}$ Storage interval (A) = 2.75, Treatment (B) = 3.89, Interaction A × B = 7.77					

perforated film showed high organoleptic rating than non-perforated film. This may be due to high concentration of CO_2 and low O_2 inside non-perforated films, which leads to anaerobic respiration, thus undesirable flavour and taste of fruits. These results are in agreement with results of Gasper *et al.* (5).

There was a continuous decline in the fruit firmness with the advancement of storage periods irrespective of different films (Table 2). The fruit packed in non-perforated PP recorded highest fruit firmness (9.99 lbf) followed by treatments in which the fruits were packed in LDPE (9.94 lbf) and HDPE (9.67 lbf) films without perforation. The control fruits recorded the minimum average fruit firmness (7.87 lbf). Among the different treatments, guava fruits packed in non-perforated films retained higher firmness of fruits rather than fruits packed in films with perforation. Polythene film packed guava fruit can be successfully kept under cold storage conditions for 14 days, whereas in control treatment fruits maintained acceptable firmness upto 7 days of storage. Guava fruits on 28 days of storage completely loose firmness and are unmarketable due to microbial spoilage. These results are in agreement with findings of Gasper *et al.* (5) earlier observed in guava fruit storage study. Maximum firmness of fruits packed in non-perforated film might be due to high CO_2 and low O_2 levels inside the polythene which lead to slow ripening and respiration. Therefore, due to slow ripening process, fruit retained its firmness.

The packaging films delayed the loss of green colour in guava fruits. Maximum loss of green colour was found in fruits packed in newspaper lining and in unpacked fruits (Table 3). There was continuous decrease in 'a' value in all the treatments, but it was decreased sharply in unpacked (control) fruits. The highest 'a' value (-5.90) was recorded in non-perforated PP film, followed by LDPE (without perforation) packed fruits (-5.03). The lowest 'a' value (-1.33) was found in control fruits. Fruits packed in perforated films retained less green colour as compared to those without perforation in which

Table 2. Effect of different packaging materials on organoleptic rating (1-9 scale) and firmness (lbf) of guava cv. Sardar under cold storage conditions.

Treatment	Storage period (days)				
	0	7	14	21	Mean
	Organoleptic Rating (1-9 scale)				
LDPE without perforation	8.00	8.43	8.60	6.46	7.86
LDPE with perforation (5%)	8.00	8.63	8.77	6.67	8.02
HDPE without perforation	8.00	8.20	8.41	5.76	7.59
HDPE with perforation (5%)	8.00	8.37	8.62	6.50	7.87
PP without perforation	8.00	8.40	8.50	6.23	7.78
PP with perforation (5%)	8.00	8.57	8.70	6.56	7.96
Newspaper lining	8.00	8.32	6.90	4.60	6.95
Control	8.00	8.15	6.40	3.83	6.59
Mean	8.00	8.38	8.11	5.83	
$CD_{0.05}$ Storage interval (A) = 0.09, Treatment (B) = 0.13, Interaction A × B = 0.26					
	Firmness (lbf)				
LDPE without perforation	12.00	10.86	9.52	7.40	9.94
LDPE with perforation (5%)	12.00	10.67	8.30	6.36	9.33
HDPE without perforation	12.00	10.72	9.30	6.67	9.67
HDPE with perforation (5%)	12.00	10.56	8.26	6.23	9.26
PP without perforation	12.00	10.90	9.58	7.50	9.99
PP with perforation (5%)	12.00	10.62	8.46	6.43	9.38
Newspaper lining	12.00	8.90	6.83	5.30	8.26
Control	12.00	8.46	6.20	4.82	7.87
Mean	12.00	10.21	8.30	6.34	
$CD_{0.05}$ Storage interval (A) = 0.04, Treatment (B) = 0.06, Interaction A × B = 0.13					

Table 3. Effect of different packaging materials on colour of guava cv. Sardar under cold storage conditions.

Treatment	a*					b**				
Storage interval (days)	0	7	14	21	Mean	0	7	14	21	Mean
LDPE without perforation	-5.58	-7.15	-4.58	-2.83	-5.03	19.82	21.75	19.97	20.00	20.39
LDPE with perforation (5%)	-5.58	-6.57	-0.60	5.00	-1.93	19.82	25.99	26.15	21.89	23.46
HDPE without perforation	-5.58	-6.15	-7.95	2.55	-4.28	19.82	23.19	21.61	17.79	20.60
HDPE with perforation (5%)	-5.58	-3.92	-2.33	2.91	-1.70	19.82	26.83	27.48	20.15	23.57
PP without perforation	-5.58	-7.32	-5.60	-5.12	-5.90	19.82	21.85	20.20	17.97	19.96
PP with perforation (5%)	-5.58	-5.22	-3.35	4.85	-2.32	19.82	26.29	25.46	21.36	23.23
Newspaper lining	-5.58	-1.26	-3.20	4.30	-1.43	19.82	26.39	27.41	22.62	24.06
Control	-5.58	-4.21	-1.14	5.61	-1.33	19.82	26.93	28.51	23.62	24.72
Mean	-5.58	-5.22	-3.33	2.16		19.82	24.90	24.60	20.68	
$CD_{0.05}$	Storage interval (A) = 0.95 Treatment (B) = 1.34 Interaction (A B) = 2.68					Storage interval (A) = 0.97 Treatment (B) = 1.38 Interaction (A × B) = 2.75				

*a (+ve value) = Red (-ve value) = Green, **b (+ve value) = yellow (-ve value) = blue fruits retained its green colour. In the perforated polythene packed fruits 'b' value showed a continuous increasing trend with the increase in storage periods and attained maximum value up to 14 days of storage, thereafter a reduction in the value was observed. In non- perforated films 'b' value continuously decreased with increase in storage periods. Maximum 'b' value (24.72) was observed in unpacked (control) fruits, followed by fruits wrapped in newspaper lining (24.06). Minimum (19.96) 'b' value was observed in non-perforated PP and LDPE (20.39) films packed fruits. There was better yellow colour development in the control fruits up to 14 days of storage, after which a declining trend in 'b' value was observed leading to unpleasant colour of the fruits. Similar, observations were found by Amarante *et al.* (3) in an experiment conducted on guava.

Total soluble solids (TSS) content increased slowly and steadily up to 14 days in all the polythene film wrapped fruits, after which decline in the TSS was recorded at 21 days of storage (Table 4). After 14 days of storage interval the highest TSS (10.76%) was recorded in guava fruits packed in perforated PP film, closely followed 10.70 per cent TSS in fruits packed in perforated LDPE film. The lowest TSS (8.50%) was observed in fruits kept as unpacked (control). All the treatments with non-perforated films had low TSS content as compared to perforated films. On the other hand, unpacked control fruits recorded increase in TSS up to 7 days and then declined sharply afterwards. Likewise, Goutam *et al.* (6) observed in guava that TSS of fruits was found increasing for few days in storage and later on decline in TSS was occurred. Guava fruits packed in polythene films retained high percentage of TSS as compared to unpacked control fruits. These results are in agreement with findings of Parihar and Kumar (11) on guava.

The titratable acidity of guava fruits packed in polythene films showed a linear declining trend with the advancement of storage periods (Table 4). The packaging films helped in better retention of acidity as compared to control. After 14-day of storage interval the highest titratable acidity (0.38%) was recorded in the fruits packed in non-perforated HDPE film, followed by 0.36% acidity in non-perforated LDPE and perforated PP films. The lowest mean titratable acidity (0.31%) was recorded in control fruits, followed by fruits wrapped in newspaper lining (0.36%). The progressive reduction in the acidity with advancement of storage periods may be attributed to utilization of organic acid in pyruvate decarboxylation reaction occurring during the ripening process of fruits. A declining trend in acidity in guava fruits was noticed during storage and it was observed in all the treatments. The present study results are in agreement with the results of Goutam *et al.* (6) in guava, who also reported decrease in acidity with advancement of storage periods. The maintenance of higher acidity in the film wrapped fruits may be due to the decreased hydrolysis of organic acids and subsequent accumulation of organic acids, which oxidized at a slow rate because of decreased respiration in these films. The higher acidity in film wrapped guava fruits as compared to control, as found in the present study confirms the previous findings of Siddiqui and Gupta (12) in guava.

The vitamin-C of guava fruits packed under polythene films showed a linear declining trend with the advancement of storage periods (Table 4). The maximum average vitamin C (180 mg/ 100 g) was recorded in the fruits packed in non-perforated PP film, followed by non-perforated LDPE film which recorded 175.4 mg 100 g. Fruits packed in perforated films have low vitamin C as compared to fruit packed in non-perforated films which retained high levels C. The lowest mean vitamin C (160 mg/ 100 g) was recorded in control fruits followed by fruits wrapped in newspaper lining (163.2 mg/ 100 g), which was at par with each other. The unpacked control fruits have significantly less vitamin C as compared to fruits packed in polythene films. During the storage interval between 7-21 days, the highest vitamin C was recorded in non-perforated PP film, which was range between (186-168 mg/ 100 g), followed by non-perforated LDPE (174-165 mg) and HDPE (170-150 mg) films. Likewise, decrease in vitamin C during storage had been reported in guava by Goutam *et al.* (6), Parihar and Kumar (11), and Yamashita and Benassi (15).

Perforated films retained less vitamin C as compared to non-perforated films might be due to high O_2 concentration in perforated films which increase oxidation of vitamin C by oxidizing enzymes which ultimately decrease in vitamin C content of fruits. The maximum retention of vitamin C was recorded in non-perforated PP films, while the minimum retention of vitamin C was recorded in control, newspaper lining and perforated HDPE films during storage. PP non-perforated packed fruits could retain a higher level of vitamin C might be due to reduced activities of oxidizing enzymes and also due to low O_2 permeability of this film that result in higher retention of vitamin C up to last day of storage. Results of the present study revealed that guava fruits packed in five percent perforated LDPE film and kept in Corrugated Fibre Board (CFB) boxes can be stored for 14 days with acceptable fruit quality at 6-8°C temperature and 90-95% relative humidity.

Table 4. Effect of different packaging materials on TSS (%), titratable acidity (%) and vitamin C (mg/100 g pulp) of guava cv. Sardar under cold storage conditions.

Treatment	Storage period (days)				
	0	7	14	21	Mean
			TSS (%)		
LDPE without perforation	9.20	10.56	10.64	8.73	9.78
LDPE with perforation (5%)	9.20	10.74	10.85	8.90	9.92
HDPE without perforation	9.20	10.33	10.54	8.20	9.57
HDPE with perforation (5%)	9.20	10.62	10.70	8.57	9.76
PP without perforation	9.20	10.47	10.60	8.43	9.67
PP with perforation (5%)	9.20	10.67	10.76	8.63	9.81
Newspaper lining	9.20	10.80	8.67	7.33	9.50
Control	9.20	10.86	8.50	6.83	9.35
Mean	9.20	10.63	10.66	8.20	
CD (p = 0.05) Storage interval (A) = 0.07, Treatment (B) = 0.10, Interaction A × B = 0.21					
			Titratable acidity (%)		
LDPE without perforation	0.52	0.51	0.36	0.27	0.41
LDPE with perforation (5%)	0.52	0.44	0.32	0.25	0.38
HDPE without perforation	0.52	0.38	0.32	0.32	0.39
HDPE with perforation (5%)	0.52	0.34	0.30	0.28	0.37
PP without perforation	0.52	0.51	0.38	0.28	0.42
PP with perforation (5%)	0.52	0.47	0.36	0.25	0.40
Newspaper lining	0.52	0.34	0.31	0.26	0.36
Control	0.52	0.28	0.25	0.19	0.31
Mean	0.52	0.41	0.32	0.26	
CD (p = 0.05) Storage interval (A) = 0.02, Treatment (B) = 0.03, Interaction A × B = 0.06					
			Vitamin C (mg/ 100 g of pulp)		
LDPE without perforation	192.7	174	170	165	175.4
LDPE with perforation (5%)	192.7	168	162	155	169.4
HDPE without perforation	192.7	170	168	150	170.2
HDPE with perforation (5%)	192.7	162	156	148	164.7
PP without perforation	192.7	186	174	168	180.2
PP with perforation (5%)	192.7	180	172	160	176.2
Newspaper lining	192.7	160	155	145	163.2
Control	192.7	158	150	140	160.0
Mean	192.7	169.7	163.4	153.9	
CD (p = 0.05) Storage interval (A) = 5.92, Treatment (B) = 8.37, Interaction (A × B) = NS					

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