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Studies on shelf life extension of guava (Cv. Sardar) using different packaging materials

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Abstract

Aim : The study aimed to evaluate different packaging materials at different storage conditions for improving the shelf life of guava fruits.

Methodology : The guava fruits (Cv. Sardar) were stored at ambient and cold storage conditions (10°C, 90% RH) in four packaging materials viz., Cellulose acetate film bags (CAFB), Breathing bags (BB), Polypropylene bags (PPB) and Brown paper bags (BPB). The quality attributes like physiological loss in weight, colour, fruit firmness, sensory score and biochemical parameters such as non-reducing sugars, reducing sugars, total sugar, acidity, ascorbic acid, Total Soluble Solids (TSS) and pectin were evaluated.

Results : There was significant effect of packaging materials and storage conditions on quality of guava fruits during storage. The average weight loss at ambient condition irrespective of packaging material was twice (0.86 % per day) than that of cold storage condition (0.41 % per day). The average weight loss irrespective of storage conditions was highest for control fruits at ambient condition (1.88 % per day) and lowest for the fruits packed in Polypropylene bags (0.018 % per day). The fruit firmness decreased with storage period. Non-reducing sugars, reducing sugars and total sugars increased initially and subsequently decreased. Titrable acidity, ascorbic acid and pectin reduced and total soluble solids increased with advancement of storage period. Sensory evaluation revealed that fruits stored in cellulose acetate film bags and breathing bags at cold storage conditions could achieve shelf life of 18 days with high overall acceptability.

Interpretation : Studies revealed that the guava fruits can be stored upto 18 days in cellulose acetate film bags and breathing bags at 10°C with 90% RH storage conditions with acceptable sensory score.

Key words: Cellulose acetate bags, Cold storage, Guava fruit, Packaging materials, Shelf life

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Introduction

Guava (*Psidium guajava* L.) is one of the popular fruit of India. It belongs to family *Myrtaceae* and one of the most gregarious fruit. Fruit is native to tropical America, but it is cultivated in tropical and subtropical countries of the world. Guava is the fourth most widely grown fruits crop in India. The area under guava fruits in India is about 2.62 lakh ha, with production of 36.48 lakh tonnes in 2016-17 (Anonymous, 2017). The popular varieties of guava grown in India are Sardar, Allahabad Safeda, Lalit, Pant Prabhat, etc. (Anonymous, 2014). In Maharashtra, Sardar (L-49) is the leading cultivar. Guava is rich source of vitamin C, riboflavin, folic acid and minerals like calcium, iron and phosphorus (Adsule and Kadam, 1993). It exhibits a climacteric pattern of respiration and ethylene production. Usually, the fruits are harvested at different stage of maturity depending on the market demand. After reaching the physiological maturity, it ripens rapidly within 1 or 2 days resulting in early senescence of the fruit (Hind and Abu-Bakar, 2002). The fruits are packed in baskets made from locally available plant material. For distant markets, wooden or corrugated fibre board boxes are used along with cushioning materials viz., paddy straw, dry grass, guava leaves or paper shreds. Good ventilation is necessary to check build up of heat. Guava is a delicate fruit and requires careful handling during harvesting and transportation. The present practices are not sufficient to reduce the post harvest losses.

The shelf-life of guava fruit under ambient storage condition is limited. It undergoes post-harvest ripening and becomes over ripe and mealy (Gill, 2018). It has to be sold in local market immediately after harvest. This leads to glut situation resulting in low price and heavy losses to the farmers. Moreover, considerable proportion of the produce is lost during post-harvest value chain. Therefore, it is essential to increase post-harvest shelf life through packaging and storage intervention (Kusumaningrum *et al.*, 2015). Recently, several post-harvest technologies have been reported to extend shelf-life, maintain optimum fruit quality, freshness and minimize the losses (Kaur *et al.*, 2016). The most commonly used technologies are polyethylene packaging, use of fungicides and growth regulators, wax coatings (Perez *et al.*, 2002; Thakur *et al.*, 2002). Some of the improved technologies are modified and controlled atmospheric storage. Few of the packaging materials such as cellulose acetate film and breathing bags have not been reported yet for the shelf life extension of guava fruits. Cellulose acetate bags have characteristics such as incorporates a designed selectivity ratio, which means that the permeability of CO₂ across the membrane occurs at a rate 7 times faster than the rate of oxygen (Hughes and Jiang, 1995).

The permeability characteristics of cellulose acetate film bags are much higher than other packaging films. Lowering the oxygen level reduces the metabolic activity of the produce and therefore, slows down the ethylene generation rate of the produce as well. The CO₂ level inside the cellulose acetate films is maintained between 5-10 %, its antifungal characteristics slows the growth of fungus and mould, store seasonal and off-season

fruits and vegetable in cold storage for longer duration. Polyfilm bag with patch of non woven polymer material with high permeability for CO₂ and O₂ led improvement in shelf life of banana, mango and whole corn increased to 14, 20 and 24 days, respectively (Chandra, 2010). Breathing bags have characteristics like controlling respiration and the rate of dehydration, maintaining humidity, thus leading to reduced weight loss and maintaining the freshness of the produce for longer duration (Scetar *et al.*, 2010). Considering the delicate nature and short shelf life of fresh guava fruits, a study with selected packaging materials was undertaken on Cv. sardar, an important Indian cultivar of guava in order to reduce the storage losses in fresh guava fruits.

Materials and Methods

Guava fruits (Cv. Sardar) of uniform size, maturity and light green colour were procured from Horticulture Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India. The harvested fruits were immediately brought to the laboratory of Dr. Annasaheb Shinde College of Agricultural Engineering and Technology, Mahatma Phule Krishi Vidyapeeth, Rahuri for further study. The cleaned fruits were separated into different lots for treatment. Fruits were stored in cellulose acetate film bags (Freshlife, India formerly known as Techno Fresh (India) Agri. Solution Pvt. Ltd.) of 65 micron thickness where in polyfilm bag was punched and cellulose acetate membrane patched over punched portion to allow exchange of gases, Breathing bags (Luk Plastcon Ltd., India) of 25 micron thickness, Polypropylene bags (Suryodaya Polymers, India) of 50 micron thickness, Brown paper bags of 70 micron. Storage conditions studied were ambient storage (29-32°C and 32-63 % RH) and cold storage conditions (10±1°C and 85-90 % RH). A completely randomised design (CRD) with three replications was used for execution of experiments.

The physiological loss in weight (PLW) of fruit was estimated by weighing the stored fruit in different packs with an electronic balance having least count of 0.01 g (Yenge *et al.*, 2015). The TSS in the guava fruit was measured with the help of hand held refractometer (Erma make). The reducing, non-reducing, total sugars titratable acidity, ascorbic acid and pectin content was determined by using standard analytical methods (Ranganna, 1986). The surface colour of the guava fruits was assessed with a Premier Colour Scan Instrument (Make: BYK Gardner Instruments, Germany). The firmness of guava fruit was determined using the Universal Testing Machine (UTM) Model-AG-X (Make: Shimadzu Corporation, Japan). Universal testing machine measures force, distance and time in a most basic test, thus provides three dimensional product analysis. Forces could be measured against set distances and distances may be measured to achieve set forces. Test module measured force of penetration (N), at test speed of 10 mm min⁻¹ for distance 25 mm, with test option 'start to return, using 5 mm cylindrical probe. The shelf life of guava was calculated based on the number of days fruits could be stored with marketable or acceptable quality. The organoleptic evaluation with respect to colour, flavour, taste of guava fruits was carried out on nine point hedonic scale.

Results and Discussion

In all the treatment combinations percent physiological loss in weight of guava fruits increased with advancement of storage period. The maximum physiological weight loss value for different treatments were 1.36, 1.59, 0.19, 9.41, 9.80, 0.19, 0.59, 0.19, 8.07 and 13.06 % after 12, 12, 8, 6, 4, 18, 18, 14, 12 and 10 days of storage treatment cellulose acetate film bag, breathing bag, polypropylene bag, brown paper bag, control at ambient storage and cellulose acetate film bag, breathing bag, polypropylene bag, brown paper bag, control at cold storage, respectively. The average weight loss at room condition irrespective of packaging was twice as faster (0.86% per day) than at cold storage condition (0.41% per day) which might be due to reduction in respiration and transpiration rate under cold storage condition (Patel *et al.*, 2016). The average weight loss at ambient condition irrespective of packaging material was twice (0.86 % per day) than that of cold storage condition (0.41% per

day) which might be due to reduction in respiration and transpiration rate under cold storage condition (Aindongo *et al.*, 2014). The average weight loss irrespective of storage condition was highest for control fruits at ambient condition (1.88 % per day) and lowest for the fruits packed in polypropylene bag (0.018% per day) which may be due to lesser availability of oxygen that had resulted in suppressed rate of respiration. Secondly, polypropylene bag might have worked as a barrier for vapor transmission to the surrounding atmosphere.

Amongst all the treatment combinations, the average physiological loss in weight was maximum for control fruits followed by brown paper bag at atmospheric storage while the minimum average weight loss was observed for treated cellulose acetate film bag followed by treated polypropylene bag at cold storage. Yenge *et al.* (2015) reported the increased physiological loss in weight of fresh fig fruits stored in corrugated fiber board box at ambient condition. Silip and Hajar

Table 1: Effect of packaging material and storage period on non-reducing sugars of guava fruits at ambient and cold storage

Storage regime	Packaging materials	Reducing sugars (%)									
		Storage period (days)									
		0	2	4	6	8	10	12	14	16	18
Ambient storage	CAFB		4.07	4.21	4.69	5.24	4.93	4.82	-	-	-
	BB		4.15	4.25	4.67	5.22	4.8	4.74	-	-	-
	PPB		4.23	4.67	5.20	3.99	-	-	-	-	-
	BPB		4.30	5.28	4.04	-	-	-	-	-	-
	Control	3.94	5.26	4.09	-	-	-	-	-	-	-
Cold storage	CAFB		4.17	4.25	4.42	4.48	5.01	5.22	5.08	4.84	4.77
	BB		4.05	4.27	4.40	4.47	4.83	5.11	5.05	4.87	4.75
	PPB		4.41	4.57	4.99	5.23	5.25	4.69	4.18	-	-
	BPB		4.42	4.51	4.79	5.05	4.34	4.13	-	-	-
	Control		4.49	4.62	4.76	4.25	4.06	-	-	-	-
	S.E(±)		0.09	0.09	0.10	0.09	0.10	0.10	0.12	0.09	0.10
	C.D. at 5%		0.28	0.28	0.31	0.28	0.31	0.31	0.41	NS	NS

Table 2: Effect of packaging material and storage period on reducing sugars of guava fruits at ambient and cold storage

Storage regime	Packaging materials	Non-reducing sugars (%)									
		Storage period (days)									
		0	2	4	6	8	10	12	14	16	18
Ambient storage	CAFB		4.46	4.48	4.50	4.54	4.04	3.87	-	-	-
	BB		4.41	4.52	4.56	4.59	4.09	3.98	-	-	-
	PPB		4.49	4.67	4.71	4.13	-	-	-	-	-
	BPB		4.59	4.74	4.05	-	-	-	-	-	-
	Control	4.32	4.86	3.92	-	-	-	-	-	-	-
Cold storage	CAFB		4.38	4.42	4.47	4.51	4.56	4.60	4.30	4.01	3.95
	BB		4.41	4.44	4.52	4.58	4.63	4.68	4.27	4.11	3.92
	PPB		4.47	4.51	4.57	4.66	4.73	4.18	4.00	-	-
	BPB		4.52	4.61	4.67	4.77	4.13	3.98	-	-	-
	Control		4.56	4.69	4.81	4.14	4.01	-	-	-	-
	S.E(±)		0.10	0.09	0.10	0.10	0.10	0.08	0.09	0.09	0.07
	C.D. at 5%		NS	0.28	0.29	0.30	0.31	0.27	NS	NS	NS

Table 3: Effect of packaging material and storage period on total sugars of guava fruits at ambient and cold storage

Storage regime	Packaging materials	Total sugars (%)									
		Storage period (days)									
		0	2	4	6	8	10	12	14	16	18
Ambient storage	CAFB		8.53	8.69	9.19	9.78	8.97	8.69	-	-	-
	BB		8.56	8.77	9.23	9.81	8.89	8.72	-	-	-
	PPB		8.72	9.34	9.91	8.12	-	-	-	-	-
	BPB		8.89	10.02	8.09	-	-	-	-	-	-
	Control	8.26	10.12	8.01	-	-	-	-	-	-	-
Cold storage	CAFB		8.55	8.67	8.89	8.99	9.57	9.82	9.38	8.85	8.70
	BB		8.46	8.71	8.92	9.05	9.46	9.79	9.32	8.98	8.69
	PPB		8.88	9.08	9.56	9.89	9.98	8.87	8.18	-	-
	BPB		8.94	9.12	9.46	9.82	8.47	8.11	-	-	-
	Control		9.05	9.31	9.57	8.39	8.07	-	-	-	-
	S.E(±)		0.19	0.20	0.19	0.19	0.19	0.20	0.29	0.20	0.16
	C.D. at 5%		0.57	0.59	0.58	0.58	0.60	0.60	0.68	NS	NS

Table 4: Effect of packaging material and storage period on the shelf-life and organoleptic evaluation of guava fruits at ambient and cold storage

Storage regime	Packaging materials	Shelf-life(days)	Overall acceptability									
			Storage period (days)									
			0	2	4	6	8	10	12	14	16	18
Ambient storage	CAFB	12		8.50	8.25	8.00	8.00	7.50	7.00			
	BB	12		8.50	8.50	8.00	7.75	7.25	7.00			
	PPB	8		8.50	8.00	7.00	6.50					
	BPB	6		8.00	7.00	6.00						
	Control	4		7.00	6.00							
Cold storage	CAFB	18	9.00	9.00	9.00	8.50	8.50	8.00	8.00	8.00	7.50	7.50
	BB	18		9.00	9.00	8.50	8.25	8.00	7.75	7.50	7.50	7.50
	PPB	14		9.00	8.50	8.50	8.00	7.75	7.50	7.50		
	BPB	12		9.00	8.25	8.00	7.50	7.00	7.00			
	Control	10		8.50	8.00	7.50	7.00	7.00				

(2007) reported higher weight loss in guava fruit stored at 15°C due to high temperature which caused higher rate of fruit respiration. In all the treatments, including different packaging materials and storage conditions, colour value L* (lightness) of guava fruits increased with advancement of storage period. The rate of increase in lightness was lowest at cold storage conditions for treated cellulose acetate film bag followed by breathing bag, while at ambient conditions higher increase in lightness was observed. At ambient storage conditions, the control samples showed highest increase in L* value by 19.07 in four days followed by fruits packaged in brown paper bag by 18.87 in six days. Color values a* increased over the storage period indicating loss of greenness of guava fruits.

The green color was lost at faster rate at ambient conditions with highest increase in a* value observed in control fruits by 13.66 in 4 days followed by fruits stored in brown paper

bag from 12.02 in six days. Degradation of green color was restricted most in fruits packaged in cellulose acetate film bag followed by breathing bag stored at cold storage conditions. Siqueira *et al.* (2005) reported that the decrease in greenness is associated with degradation of chlorophyll due to the breakdown of chemical structure and due to changes in pH, brought out by accumulation of organic acids and activation of chlorophyllase enzyme. The results were on similar lines to those obtained by Gowda and Huddar (2001) for mango and Ribeiro *et al.* (2005) for guavas, Cv. Paluma. Yellowness (b* values) of guava fruits increased with advancement of storage period. The rate of yellowness development was fastest for fruits stored at ambient than cold storage. The control fruits at ambient storage conditions showed highest increase in b* values (12.54 in four days) followed by fruits packed in brown paper bag and stored at ambient (11.55 in six days). The development of yellowness was restricted most in fruits stored at cold storage condition packed in cellulose

Fig. 1: Effect of packaging material and storage period on acidity of guava fruits at ambient and cold storage.

Fig. 2: Effect of packaging material and storage period on ascorbic acid of guava fruits at ambient and cold storage.

acetate film bag (9.63 in 18 days) followed by breathing bag (10.53 in 18 days). Change in colour L^* , a^* and b^* values were due to degradation of chlorophyll and increased carotenoid pigments during storage. The maintenance of greenness and delayed onset of yellowness in cold stored fruits may be due to the reduced rate of respiration under cold storage condition which had resulted in reduced physico-chemical changes (Patel *et al.*, 2016). The better performance of cellulose acetate film bag and breathing bag packaging material was observed at both types of storage regimes which may be due to maintenance of modified atmospheric conditions inside the packaging material owing to lower permeability of oxygen over CO_2 leading to reduced rate of respiration and ethylene production (Hughes and Jiang, 1995). The maximum loss of firmness was recorded for control at ambient storage followed by brown paper bag at ambient storage,

while it was minimum for cellulose acetate film bag at cold storage followed by breathing bag at cold storage. The firmness value for different treatments were 6.35, 5.31, 4.73, 5.08, 4.90, 6.67, 5.94, 4.80, 5.50 and 5.04 N after 12, 12, 8, 6, 4, 18, 18, 14, 12 and 10 days of storage for cellulose acetate film bag, breathing bag, polypropylene bag, brown paper bag, control at ambient storage and cellulose acetate film bag, breathing bag, polypropylene bag, brown paper bag, control at cold storage, respectively. The reduction in firmness was due to reduction in pectin and conversion of protopectin into soluble pectin. Degradation of protopectin results in loosening of bonds between the cells and softening of fruit tissues (Billy *et al.*, 2008; Ghafir *et al.*, 2009; Pongener *et al.*, 2011). Softening of guava fruits during ripening due to reduced and disassembled pectin compounds has been earlier reported by Nara *et al.* (2001).

Fig. 3: Effect of packaging material and storage period on TSS of guava fruits at ambient and cold storage.

Fig. 4: Effect of packaging material and storage period on pectin of guava fruits at ambient and cold storage.

In all the treatments, including packaging materials and storage conditions, non-reducing sugars, reducing sugars and total sugars increased till the fruits ripened and thereafter decreased (Table 1, 2 and 3). The maximum rate of increase in non-reducing sugars, reducing sugars and total sugars were for control at ambient storage followed by brown paper bag at ambient storage, while it was minimum for breathing bag at cold storage followed by cellulose acetate film bag at cold storage. The increase in non-reducing sugars, reducing sugars and total sugars during ripening was due to hydrolysis of starch and conversion of insoluble pectin into fraction (Rajesh *et al.*, 2012). Acidity of guava fruits decreased with advancement of storage period (Fig. 1). However, the overall effect was non-significant. Amongst all the treatment combinations, the average acidity reduction rate was maximum for control at ambient storage

followed by brown paper bag at ambient storage while it was minimum for cellulose acetate film bag at cold storage followed by breathing bag at cold storage. The decrease in acidity due to conversion of acid into salt and sugar by enzymes during ripening of guava fruits has been reported by Nishad *et al.* (2012).

Ascorbic acid decreased with advancement of storage period (Fig. 2). The average ascorbic acid reduction rate at ambient condition irrespective of packaging was twice ($27.12 \text{ mg } 100\text{g}^{-1} \text{ per day}$) than that of cold storage ($13.78 \text{ mg } 100\text{g}^{-1} \text{ per day}$) which may be due to reduction in respiration rate that had slowed down the physico-chemical changes under cold storage condition. Amongst all the treatment combinations, the average ascorbic acid reduction rate was maximum for control at ambient storage followed by brown paper bag at ambient storage; while it

was minimum for cellulose acetate film bag at cold storage followed by breathing bag at cold storage. Hind and Abu-Bakr (2002) reported a steady reduction in ascorbic acid content of guava fruits from green mature stage to fully ripen stage.

TSS of guava fruits increased with advancement of storage period (Fig. 3). The average rate of increase in TSS at ambient condition irrespective of packaging was twice as faster (1.66 % per day) than at cold storage condition (0.93 % per day) due to faster rate of increase in sugars under ambient storage condition. Amongst all the treatment combinations, the average increase in the rate of TSS was maximum for control at atmospheric storage followed by brown paper bag at atmospheric storage; while it was minimum for cellulose acetate film bag at cold storage followed by breathing bag at cold storage. Similar results were reported by Nishad *et al.* (2012). A remarkable increase in total sugars observed after the climacteric peak may be attributed to increase in enzyme activity responsible for starch hydrolysis and for decline in the rate of sugar breakdown by respiration (Hind and Abu-Bakr, 2002).

Pectin content decreased with storage period (Fig. 4) which may be due to ripening of fruits that might have resulted in decrease in pectin content. Amongst all treatment combinations, the average rate of pectin reduction was maximum for control at atmospheric storage followed by brown paper bag at atmospheric storage while it was minimum for breathing bag at cold storage followed by treatment cellulose acetate film bag at cold storage. During fruit ripening, pectin compounds are reduced and disassembled followed by softening. A gradual decline in pectin content with the advancement of storage period might be the result of pectin enzymes activity on natural pectin in fruits (Nara *et al.*, 2001). Packaging material and storage conditions significantly affected the shelf life of guava fruits. The minimum shelf life of 4 days was observed for control at atmospheric storage, while the maximum shelf life of 18 days was observed for cellulose acetate film bag and breathing bag at cold storage (Table 4) on the basis of scores of organoleptic ratings. The study concludes that the guava fruits (Cv. Sardar) harvested at physiological maturity had a shelf life of only 4 days at ambient condition and shelf life could be enhanced upto 18 days by packaging in cellulose acetate bags and breathing bag in cold storage conditions. The results will be highly useful for stakeholders in guava fruit industry namely growers, fruit aggregators, sellers and processors for packaging, storage and marketing of quality guava fruits.

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