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Effect of modified atmosphere packaging (MAP) on chilling injury and storage life of guava cv. Allahabada safeda stored at 6 ± 1ºC

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Abstract

An experiment was done to increase the storage life of guava by modified atmosphere packaging. In this study fruits were packed in polypropylene bags with 2 pores, 4 pores, 6 pores, 8 pores and10 pores and observed the chilling injury and storage life of guava cv. Allahabad safeda stored at 6 ± 1^0 C. This experiment was conducted at Fruit Research Station, Sangareddy, Medak District, Telangana. The experiment was done by using completely randomized design with factorial concept with three replications per treatment. Guava fruits cv. Allahabad safeda were packed in polypropylene bags with different ventilation (2, 4, 6, 8 and 10 pores) and stored at6 ± 1º C. Fruits packed in polypropylene bags with 4 pores significantly recorded lowest PLW. Significantly highest fruit firmness and organoleptic evaluation were recorded in fruits packed in polypropylene bags with 4 pores. Significantly lowest chilling injury and electrolyte leakage was recorded in fruits packed in polypropylene bags with 4 poresand corresponding increase the shelf life of upto 25.63 days. The fruits kept under control recorded a shelf life of 20.05 days only. Titratable acidity was significantly lowest in fruits packed in polypropylene bags with 4 pores. Fruits packed in polypropylene bags with 4 pores recorded significantly highest TSS, brix-acid ratio and ascorbic acid.

Keywords: guava, modified atmosphere packing, polypropylene, chilling injury, storage life

Introduction

Guava (*Psidium guajava* L.) the "poor man's fruit" and "apple of tropics" is a popular tree fruit of tropical and sub-tropical climate and is native to the Tropical America stretching from Mexico to Peru. It belongs to the family *Myrtaceae.* Guava is the fifth most widely grown fruit crop in India. It occupies 3.5 per cent of total fruit crop area in the country with 3.3 per cent production share. It is estimated that in India, it is grown in about 2.2 lakh ha with a total production of 25.10 lakh tonnes (NHB, 2013). It is grown in almost all states; however Maharashtra, Madhya Pradesh, Uttar Pradesh, Bihar, West Bengal, Punjab, Gujarat, Karnataka and Andhra Pradesh are the leading guava growing states in India (Kumar *et al*., 2011) [13]. In Andhra Pradesh it occupies an area of 0.089 lakh hectares, with an annual production of 1.34 lakh tones (NHB, 2013).

Guava fruit is extolled for delicious taste and high nutritional value. Besides its high nutritive value, it bears heavy crop every year and gives good economic returns involving very little input. But its delicate nature, short postharvest life, and susceptibility to chilling injury and diseases, limits the potential for commercialization of guava fruit. Guava being a climacteric fruit exhibits a rise in respiration and ethylene production during ripening, and is highly perishable in nature (Singh and Pal, 2008) [24], Being a highly perishable fruit, undergoes rapid postharvest ripening in a few days under ambient conditions. However, deterioration can be reduced by treating fresh guava with suitable substance which not only reduces the enzymatic activity but also depress the respiration rate.

In India post-harvest losses of fruits and vegetables are estimated to be 30-35 per cent which amount to losses to the extent of Rs 3000 crores (Mitbander, 1990). Postharvest losses can be minimized by adopting proper postharvest handling practices and better understanding of biochemical control of fruit ripening. Postharvest life of fruits and vegetables can be extended by modified atmosphere packaging and by cold storage. The postharvest physiology of fruits and vegetables includes two developmentally regulated phases namely ripening and senescence.

Ripening is accompanied by various biochemical changes which bring about characteristic taste, aroma and palatability of fruits. Biochemically and physiologically post-harvest technology is mainly concerned with slowing down the rate of respiration of the produce. By adopting proper post-harvest handling practices and proper understanding of biochemical changes in fruit ripening and senescence, the post-harvest losses can be minimized to a greater extent.

Modified atmosphere packaging is a preservation technique used to prolong the shelf life of processed or fresh food by changing the composition of the air surrounding the food in the package. Modified Atmosphere Packaging (MAP) refers to the development of a modified atmosphere around the produce through the permeable polymeric films (Kader *et al.* 1989) [9] and MAP had been reported to maintain the quality of several tropical fruits (Kader *et al*. 1989; Gonzalez *et al*. 1990; Nanda *et al*. 2000; Gonzalez *et al*., 2003) [9, 5, 18, 6]. It is an inexpensive method compared to CA storage and transport and therefore, it had been suggested as an alternative to shipping in MA/CA (McGlasson, 1989) [16]. Kader (2003) [8] recommended 2-5 per cent O_2 and 0-1 per cent CO_2 for CA storage of guava at 5-15^{0}C, modified atmosphere storage can extend the storage life of many tropical and sub-tropical fruit (Kader 2003) [8]. Much research has been done to reduce the chilling injury of many fruits like sapota (Zora Singh Jones, 2001) [28], guava (Mathur, 1963) [15], avocado and cherimoya using Modified Atmosphere Packaging (MAP) which extended the storage life of fruits but with little effect on reducing or avoiding chilling injury.

Material and Methods

The experiment was carried out during 2013-14. Guava fruits of cultivar Allahabad Safeda, procured from the Fruit Research Station, located at Sangareddy, Medak district, Telangana were used in experiment. The guava fruits were harvested at the mature green stage. The skin colour is considered to be the best indicator of harvest maturity in guava fruit (Mercado-Silva *et al*, 1998) [17]. Polypropylene bags of100 gauge polypropylene bags of size 35 x 25 cm with 2,4,6,8 and 10 pores ventilation were used for packing of guava fruits. Circular holes with 0.5mm diameter were made on both sides of polypropylene bags and studied the effect of modified atmosphere packaging (MAP) on chilling injury and storage life of guava.

Results and Discussion

The effect of modified atmosphere packaging on physiological loss in weight (PLW) of guava cv. Allahabad safeda stored at 6 ± 1º C was presented in the Table 1. All the treatments reduced physiological loss in weight of fruits over the control. The lowest PLW (1.94) was recorded in fruits packed and stored in polypropylene bag with 4 pores.

Table 1: Effect of modified atmosphere packaging on physiological loss in weight (%) during storage of guava cv. Allahabad Safeda at 6±1˚C.

Treatment	Days after harvest					Mean
	5	10	15	20	25	
T_1 – 2 pores	0.70	1.43	2.25	2.73	3.10	2.04^e
T_2- 4 pores	0.52	1.31	2.16	2.65	3.06	1.94^f
T_3- 6 pores	0.58	1.56	2.28	3.02	3.36	2.16^d
T_4 – 8 pores	0.63	1.73	2.46	3.26	3.66	2.34^c
T_5- 10 pores	0.68	1.84	2.70	3.61	4.05	2.57^b
T_6 –control	1.56	2.65	3.42	4.20	5.44	3.45^a
Mean	0.77^e	1.75^d	2.54^c	3.24^b	3.77^a	
	F –test			S. Em ±		CD at 5%
Treatments	**			0.016		0.046
Days	**			0.014		0.042
Treatments × Days	**			0.036		0.103

Among all treatments, control recorded in highest PLW on 25th day while, fruits packed in polypropylene bag with 4 pores recorded lowest PLW up to 25th day during all intervals of storage. This minimum PLW in polypropylene bags could be due to low rate of respiration and transpiration. Khumbhar and Desai (1986) [12] also reported similar reduction in PLW of sapota packed in polyethylene bags.

The effect of modified atmosphere packaging on fruit firmness of guava cv. Allahabad Safeda stored at 6 ± 1º C is presented in Table 2. The treated fruits differed significantly with highest fruit firmness (6.35) in fruits packed in polypropylene bag with 4 pores. The lowest fruit firmness (4.60) was recorded in control.

Table 2: Effect of modified atmosphere packaging on fruit firmness (kg.cm^2) during storage of guava cv. Allahabad safeda at 6 ± 1ºC.

Treatments	Days after harvest					Mean
	5	10	15	20	25	
T_1 – 2 pores	8.48	7.53	6.26	4.81	2.86	5.99^b
T_2- 4 pores	8.55	7.76	6.45	4.92	4.10	6.35^a
T_3- 6 pores	8.45	7.15	6.13	4.65	2.61	5.79^c
T_4 – 8 pores	8.45	6.91	5.85	4.10	2.10	5.48^d
T_5- 10 pores	8.43	6.86	5.72	3.52	1.75	5.25^e
T_6 –control	7.42	6.15	5.24	3.10	1.10	4.60^f
Mean	8.29^a	7.05^b	5.94^c	4.18^d	2.42^e	
	F –test			S. Em ±		CD at 5%
Treatments	**			0.013		0.038
Days	**			0.012		0.035
Treatments × Days	**			0.030		0.086

Khumbhar and Desai (1986) [12] reported similar increase in firmness of sapota packed in polyethylene bags. In control, lower firmness was recorded resulting from the exposure of fruit to atmosphere and concomitant increase in ripening process (Littiman, 1972) [14]. Fruit softening during ripening and concomitant decrease in firmness is attributed to increased solubilization of cell wall pectin by the action of pectin methyl esterase and polygalactouranase hydrolysis of starch to glucose in sapota (Selvaraj and Pal, 1984) [23].

The effect of modified atmosphere packaging on chilling injury of guava cv. Allahabad Safeda stored at 6 ± 1º C are presented in the Table 3. The treated fruits differed significantly with highest chilling injury (3.22)) recorded in control. The lowest chilling injury (1.86) was recorded in fruits packed in polypropylene bag with 4 pores.MAP reduced the chilling injury by maintaining high humidity inside the packs. Water loss had been shown to cause excessive production of active oxygen species (AOS), thus provision of high humidity through MAP prevented chilling-induced oxidative stress (Hodges *et al.* 2004) [7].

Table 3: Effect of modified atmosphere packaging on chilling injury(skin Scald)during storage of guava cv. Allahabad safeda at 6 ± 1º C.

Treatments	Days after harvest					Mean
	5	10	15	20	25	
T_1 – 2 pores	1.05	1.48	1.95	2.31	3.46	2.05^e
T_2- 4 pores	1.00	1.36	1.64	2.20	3.10	1.86^f
T_3- 6 pores	1.08	1.57	2.15	2.55	3.61	2.19^d
T_4 – 8 pores	1.10	1.62	2.25	2.61	3.86	2.29^c
T_5- 10 pores	1.10	1.73	2.28	2.85	3.95	2.39^b
T_6 –control	1.41	2.46	3.50	4.10	4.62	3.22^a
Mean	1.13^e	1.70^d	2.29^c	2.78^b	3.76^a	
	F –test			S. Em ±		CD at 5%
Treatments	**			0.024		0.069
Days	**			0.022		0.063
Treatments × Days	**			0.055		0.155

Modified atmosphere packaging on electrolyte leakage of guava cv. Allahabad Safeda stored at 6 ± 1º C was presented in the Table 4. The treated fruits differed significantly with highest electrolyte leakage (13.86) recorded in the control. The treatment with lowest chilling injury has shown the lowest electrolyte leakage. The lowest electrolyte leakage (9.97) was recorded in the fruits packed in polypropylene bag with 4 pores. Chauhan *et al.* (2006) [2] reported that the lowest electrolyte conductivity values were obtained with a specific gas mixture of 3% O_2 + 6 % CO_2 +91% N_2 in papaya. Rachit Suwapanich and Methinee Haesungcharoen (2006) [21] reported that electrolyte leakage (EL) increased as the mango fruits were stored longer at 8 or 13° C, although this increase was greater at 13° C beyond 14 days and fruits were fully ripe showing internal browning.

The effect of modified atmosphere packaging on organoleptic evaluation of guava cv. Allahabad safeda stored at 6 ± 1º C is presented in the Table 5. The treated fruits differed significantly with highest organoleptic score (6.80) in fruits packed in polypropylene bag with 4 pores. The lowest organoleptic score (5.86) was recorded in fruits kept under control. Similar results were reported in sapota fruits stored in polythene bags of 150 guage with 1 percent ventilation (Kariyanna *et al.* 1995) [11]. Better taste and flavour had reported in Banganapalli mangoes packed in polythene bags of 250 guage with 1 percent ventilation (Gautam and Neeraja, 2005) [4].

Table 4: Effect of modified atmosphere packaging on electrolyte leakage (%) during storage of guava cv. Allahabad safeda at 6 ± 1º C.

Treatments	Days after harvest						Mean
	1	5	10	15	20	25	
T_1 – 2 pores	4.44	5.50	7.10	8.44	9.10	10.21	10.21^e
T_2- 4 pores	4.32	5.42	6.98	8.25	8.92	9.97	9.97^f
T_3- 6 pores	4.51	5.68	7.30	8.52	9.35	10.40	10.40^d
T_4 – 8 pores	4.60	5.75	7.46	8.68	9.48	10.71	10.71^c
T_5- 10 pores	4.65	5.81	7.58	8.73	9.57	10.86	10.86^b
T_6 –control	4.66	6.33	9.44	11.66	12.52	13.86	13.86^a
Mean	4.69^f	5.75^e	7.64^d	9.05^c	9.64^b	9.82^a	
	F –test		S.Em ±		CD at 5 %		
Treatments	**		0.012		0.033		
Days	**		0.012		0.033		
Treatments × Days	**		0.029		0.081		

Table 5: Effect of modified atmosphere packaging on organoleptic evaluation (score) during storage of guava cv. Allahabad safeda at 6 ± 1º C.

Treatments	Days after harvest						Mean
	1	5	10	15	20	25	
T_1 – 2 pores	4.20	6.40	7.50	8.10	8.38	5.53	6.68^b
T_2- 4 pores	4.21	6.60	7.60	8.21	8.53	5.65	6.80a
T_3- 6 pores	4.19	6.25	7.40	7.97	8.10	4.92	6.47^c
T_4 – 8 pores	4.17	6.28	7.49	7.99	8.15	5.05	6.52^c
T_5- 10 pores	4.18	6.30	7.40	8.05	8.20	4.80	6.48^c
T_6 –control	4.10	5.82	6.86	7.35	7.65	3.42	5.86^d

Mean	4.18^{f}	6.27^{d}	7.37^{c}	7.94^{b}	8.16^{a}	4.90^{e}	
	F –test		S.Em ±		CD at 5 %		
Treatments	**		0.012		0.033		
Days	**		0.012		0.033		
Treatments × Days	**		0.029		0.081		

The effect of modified atmosphere packaging on total soluble solids of guava cv. Allahabad safeda stored at 6 ± 1º C was presented in the Table 6. The treated fruits differed significantly with highest (11.44) total soluble solids in fruits packed in polypropylene bag with 4 pores. The lowest (10.96) total soluble solids was recorded in fruits kept under control This could be due to delay in ripening and decreased rate of starch hydrolysis (Thomas, 1986) [26]. Similar pattern of results was reported by Rokolhuu Keditsu Akali Sema Maiti (2003) [22] in mandarin fruits. Storage of Banganapalli mangoes in polythene bags resulted in decreased quality in terms of TSS (Gautam and Neeraja, 2005) [4].

Table 6: Effect of modified atmosphere packaging on total soluble solids (^{0}Brix) during storage of guava cv. Allahabad safeda at 6 ± 1º C.

Treatments	Days after harvest						Mean
	1	5	10	15	20	25	
T_1 – 2 pores	9.77	10.60	11.60	11.90	12.30	11.25	11.28^{b}
T_2- 4 pores	9.80	10.72	11.9	12.10	12.35	11.45	11.44^{a}
T_3- 6 pores	9.73	10.70	11.48	11.78	12.05	11.21	11.16^{c}
T_4 – 8 pores	9.76	10.66	11.47	11.75	12.20	11.20	11.17^{c}
T_5- 10 pores	9.70	10.65	11.51	11.70	12.15	11.10	11.15^{c}
T_6 –control	9.70	10.82	11.34	11.86	12.05	10.00	10.96^{d}
Mean	9.74^{f}	10.79^{e}	11.56^{c}	11.85^{b}	12.18^{a}	11.03^{d}	
	F –test		S.Em ±		CD at 5 %		
Treatments	**		0.013		0.035		
Days	**		0.013		0.035		
Treatments × Days	**		0.030		0.085		

The effect of modified atmosphere packaging ontitratable acidity of guava cv. Allahabad safeda stored at 6 ± 1º C is presented in the Table 7. The treated fruits on par with highest titratable acidity (0.31) recorded in fruits kept under control and fruits packed with 10 pores. The lowest (0.25) titratable acidity was recorded in fruits packed in polypropylene bag with 4 pores stored at 6 ± 1º C. Similar decrease in acidity was reported by Barnell (1941) [1] and Pool *et al.* (1972) [20]. The decrease in acidity in later stages may be due to utilization of sugars and acids for respiration. Similar decreased in acidity was reported by Selvaraj and Pal (1984) [23] in sapota fruits.

Table 7: Effect of modified atmosphere packaging on titratableacidity (%) during storage of guava cv. Allahabad safeda at 6 ± 1º C.

Treatments	Days after harvest						Mean
	1	5	10	15	20	25	
T_1 – 2 pores	0.45	0.36	0.26	0.21	0.17	0.14	0.27^{c}
T_2- 4 pores	0.44	0.33	0.25	0.20	0.16	0.13	0.25^{d}
T_3- 6 pores	0.49	0.38	0.30	0.24	0.19	0.16	0.29^{b}
T_4 – 8 pores	0.50	0.40	0.30	0.22	0.18	0.15	0.29^{b}
T_5- 10 pores	0.50	0.41	0.31	0.23	0.19	0.17	0.30^{a}
T_6 –control	0.49	0.40	0.32	0.26	0.22	0.18	0.31^{a}
Mean	0.48^{a}	0.38^{b}	0.29^{c}	0.23^{d}	0.19^{e}	0.16^{f}	
	F –test		S.Em ±		CD at 5 %		
Treatments	**		0.002		0.006		
Days	**		0.002		0.006		
Treatments × Days	*		0.006		0.016		

The effect of modified atmosphere packaging on brix-acid ratio of guava cv. Allahabad safeda stored at 6 ± 1º C is presented in the Table 8. The treated fruits differed significantly with highest brix-acid ratio (54.90) in fruits packed in polypropylene bag with 4 pores. The lowest brix-acid ratio (39.72) was recorded in the fruits kept under control. This may be attributed to retardation in ripening process and associated biochemical changes in the fruits as reported by Karianna, (1990).

The effect of modified atmosphere packaging on ascorbic acid content of guava cv. Allahabad safeda stored at 6 ± 1º C is presented in the Table 9. The treated fruits differed significantly with highest levels of ascorbic acid (195.25 mg/100g) in the fruits packed in polypropylene bags with 4 pores. The lowest (171.57) levels were recorded in fruits kept under control. In all the treatments the ascorbic acid content was found to increase initially during storage up to few days and decrease later on as the storage progressed. This may be attributed due to high CO_2 during storage, which has hampered ascorbic acid biosynthesis during storage (Singh and Sudhakar Rao, 2005 b) [25].

Table 8: Effect of modified atmosphere packaging on brix-acid ratioduring storage of guava cv. Allahabad safeda at 6 ± 1º C.

Treatment	Days after harvest						Mean
	1	5	10	15	20	25	
T_1 – 2 pores	21.71	30.14	44.62	56.67	72.35	80.36	50.98^b
T_2- 4 pores	22.72	33.27	47.92	60.5	76.88	88.08	54.90^a
T_3- 6 pores	19.86	28.24	38.27	49.08	63.42	70.06	44.82^d
T_4 – 8 pores	19.52	26.65	38.23	53.40	67.5	74.678	46.66^c
T_5- 10 pores	19.40	26.09	37.13	50.86	64.21	65.29	43.83^d
T_6 –control	19.89	27.05	35.44	45.62	54.77	55.56	39.72^e
Mean	20.51^f	28.57^e	40.27^d	52.69^c	66.52^b	72.34^a	
	F –test			S. Em ±			CD at 5%
Treatments	**			0.47			1.33
Days	**			0.47			1.33
Treatments × Days	**			1.16			3.26

Table 9: Effect of modified atmosphere packaging on ascorbic acid (mg 100 g^{-1}) during storage of guava cv. Allahabad safeda at 6 ± 1º C.

Treatments	Days after harvest						Mean
	1	5	10	15	20	25	
T_1 – 2 pores	160.30	176.25	186.40	204.10	225.36	178.58	188.50^b
T_2- 4 pores	164.80	178.65	194.10	210.20	238.15	185.60	195.25^a
T_3- 6 pores	156.20	168.52	179.10	197.80	220.80	176.32	183.12^c
T_4 – 8 pores	156.10	167.60	175.80	195.40	215.30	175.90	181.05^d
T_5- 10 pores	156.20	166.80	174.66	195.65	214.72	175.30	180.56^d
T_6 –control	155.80	161.52	172.20	187.15	194.32	165.45	171.57^e
Mean	158.23^g	169.33^f	180.38^c	198.38^b	218.11^a	176.19^d	
	F –test		S.Em ±		CD at 5 %		
Treatments	**		0.223		0.645		
Days	**		0.223		0.645		
Treatments × Days	**		0.560		1.58		

Table 10: Effect of modified atmosphere packaging on ripening (in days) and shelf life during storage of guava cv. Allahabad safeda at 6 ± 1º C.

T Treatments	Ripening (Days)	Shelf life(Days)
T_1 – 2 pores	17.36^b	24.40^b
T_2- 4 pores	19.47^a	25.63^a
T_3- 6 pores	15.20^c	23.33^c
T_4 – 8 pores	15.20^c	23.10^c
T_5- 10 pores	14.33^c	22.32^d
T_6 –control	9.42^d	20.05^e
Mean	15.2	23.13
F-test	*	**
S. Em±	0.577	0.28
CD at 5% Level	1.80	0.89

Modified atmosphere packaging on the days taken to ripening and shelf life of guava cv. Allahabad safeda stored at 6 ± 1º C is presented in the Table 10. The treated fruits differed significantly with significantly highest days taken for ripen (19.47) recorded in fruits packed in polypropylene bags with 4 pores followed by fruits packed in polypropylene bags with 2 pores (17.36). The lowest days taken to ripen (9.42) was recorded in fruits kept under control. Similar results were reported in mango cv. 'Kent' fruits individually sealed in LDPE and HDPE films having thickness 0.01 and 0.02 mm, respectively, hen stored at 20 0c for four weeks resulted delayed ripening (Gonzalez *et al*. 1990) [5]. The treated fruits differed significantly with significantly highest shelf life (25.63) recorded in fruits packed in polypropylene bags with 4 pores followed by fruits packed in polypropylene bags with 2 pores (24.40). The lowest shelf life (20.05) was recorded in the fruits kept under control. Use of MAP has also been reported to extend the storage period in peach and European plum (Fernandez-Trujillo *et al*. 1998; Truk and Ozkurt, 1994) [3, 27]. Similar increase in shelf life due to lowering chilling injury was reported (Hodges *et al.* 2004) [7] and lower electrolyte leakage (Chauhan *et al.* 2006) [2] in MAP packing. This might be due to lower chilling ijury (4.2.3) and electrolyte leakage (4.2.4) in the present investigation.

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