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Physico-chemical Attributes and Shelf-life of Guava as Influenced by Post-harvest Treatments and Packaging Materials

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Abstract: The present investigation aimed to study the efficacy of different post-harvest treatments and packaging materials on improving the quality and shelf-life of winter season guava fruits. The fruits were subject to various treatments such as dipping in distilled water for 5 minutes, hot distilled water @ 48°C for 2 minutes, 2 % hydrogen peroxide (H_2O_2) for 4 minutes, crude lemon grass oil @ 6 ml per carton, neem seed oil @ 90 %, 45 % and 22.5 %, packing untreated fruits in unperforated brown paper bag, perforated white polythene bag @ 100 gauge and 200 gauge. The untreated fruits were taken as control. The fruits were stored at ambient storage conditions for 12 days. Fruits were analysed for various physico-chemical characteristics, *viz.*, PLW, decay percentage, shelf life, TSS, acidity, ascorbic acid, reducing, non-reducing and total sugars at an interval of 0, 3, 6, 9 and 12 days. The results revealed that perforated white polythene bag of 200 gauge was the most effective in reducing weight loss and decay as compared to other treatments. Total soluble solids, reducing sugars, total sugars and ascorbic acid content were higher in fruits stored in perforated white polythene bag of 200 gauge and it was also effective in extending the shelf -life of guava fruits to 9.33 days. Thus, it can be concluded that perforated white polythene bag of 200 gauge can be recommended for extending storage period of guava fruits.

Keywords: neem seed oil, physiological loss in weight (PLW), shelf-life, storage, white perforated polythene bag

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1. Introduction

Guava commonly known as "apple of tropics" belongs to family Myrtaceae. It is the fourth most important fruit crop grown in India in area and production.

It has wider adaptability with low cost of cultivation and high nutritive value which makes it a highly remunerative crop. Winter season crop is superior in quality in terms of nutrition and taste as compared to rainy season crop (Rathore, 1976). Guava is a climacteric fruit, showing a typical increase in respiration and ethylene production during ripening (Brown and Wills, 1983). It is a highly perishable fruit due to its susceptibility to mechanical damage and chilling injury which limits its post-harvest life. The shelf-life and quality of guava fruits are influenced by the cultivar, cropping season, maturity stage, materials used for packing during storage, temperature and humidity of storage environment, physico-chemical changes and loss due to microbial attack (Islam, 2008).

Reduction in postharvest losses can help to extend the shelf life of guava. Pre-storage treatments such as precooling, coating of fruits with chemicals and plant extracts (essential oils), packaging or their combination can play an important role controlling insect pests and prevent bacterial and fungal rots in fruits (Nandaniya *et al.* 2017). Post-harvest dipping treatments enhance the shelf life of fruits by increasing their firmness and controlling the decay (Ahmed *et al.* 2009). The polyethylene packaging further has a concomitant effect in delaying senescence and physiological processes by creating modified atmospheric conditions around the produce by controlling the gaseous (CO_2 and O_2) concentration in the package (Neeraj *et al.* 2003). Thus, the present study was conducted to evaluate the efficacy of different dipping treatments and packaging bags for extending the storage life and quality of guava cv. Pant Prabhat under ambient storage conditions.

2. Materials and Methods

The present investigation was carried out at Post Harvest Laboratory of the Department of Horticulture, G.B.P.U.A. & T., Pantnagar on winter season guava crop. Physiologically mature fruits of guava cv. Pant Prabhat were harvested from Horticultural Research Centre, Patharchatta, Pantnagar. Healthy fruits of uniform size and colour were selected for the treatments and damaged and deformed fruits were discarded. The fruits were subject to various treatments such as dipping in distilled water for 5 minutes (T_2), hot distilled water @ 48°C for 2 minutes (T_3), 2% hydrogen peroxide (H_2O_2) for 4 minutes (T_4), crude lemon grass oil @ 6 ml per carton (T_5), neem seed oil @ 90 % (T_6), 45% (T_7) and 22.5 % (T_8), packing untreated fruits in unperforated brown paper bag (T_9), perforated white polythene bag @ 100 gauge (T_{10}) and 200 gauge (T_{11}) and were stored at ambient storage conditions for 12 days. The crude lemon grass oil in T_5 was applied on walls of the carton and not on the fruits. The size of carton was 32.5×22.5×15 cm. There was 2% perforation in the polythene bags used in treatments T_{10} and T_{11}. For control (T_1), fruits without any treatment were simply placed on brown paper sheet. In each treatment, three replications with fifteen fruits per replication were taken. The data on physiological loss in weight (PLW), decay percentage, shelf life, TSS, acidity, ascorbic acid, reducing, non-reducing and total sugars were recorded at an interval of 0, 3, 6, 9 and 12 days.

PLW was calculated by subtracting the weight of the fruit on the day of observation from the initial fresh weight and expressed as percentage loss in reference to initial fruit weight. Fruit decay was worked out by counting the number of spoiled fruits against total number of fruits on the day of observation and was expressed in percentage. TSS was measured at room temperature with Abbe's hand refractometer having 0-32 % range. Sugars, titratable acidity and ascorbic acid were estimated by the methods described by Ranganna (1986). Shelf life of fruits was determined by counting the number of days till the fruits retained the optimum marketing and eating qualities. The experimental data was analysed with two factorial Completely Randomised Design (CRD) given by Snedecor and Cochran (1987) at 5 % level of significance. The per cent data was angularly transformed and given below the original data in tables. Microsoft excel 2016 was used for generating graphs.

3. Results and Discussion

The post-harvest life of fruits is significantly affected by the rate of water loss from the fruits. The number of storage days affected the physiological loss in weight (PLW) significantly, which increased gradually as the storage period progressed, irrespective of the treatment applied (Table 1). Fruits packed in perforated white polythene bag of 200 gauge thickness (T_{11}), recorded the lowest PLW (10.63%), followed by 10.88 per cent in fruits stored in perforated white polythene bag of 100 gauge thickness (T_{10}). The highest PLW (14.32 %) was registered in control fruits. Interactions between treatments and storage period was also found to be significant with maximum PLW (22.56%) in fruits under control on 12^{th} day of storage while minimum PLW (8.23%) was recorded in fruits under treatment T_{11} on 3^{rd} day of storage. These observations were similar to the findings of Ismail *et al.* (2010). The main reason behind loss in weight of fruits may be due to the loss of water caused by transpiration and respiration processes (Zhu *et al.* 2008). Packaging in polythene bag might have increased the CO_2 concentration and decreased the O_2 which eventually lowered the respiration rate of the fruits (Thompson, 2010).

Decay percentage of fruits directly contributes to the post-harvest losses. As evident from Table 1, maximum decay percentage (18.20 %) was observed in control (T_1) while it was minimum (9.65 %) in fruits packed in 100 gauge thickness perforated white polythene bag (T_{11}). There was no fruit decay on the initial day of storage. All the treatments exerted significant positive influence in reducing the decay percentage. The symptoms of decay started from 3rd day onward in the various treatments, however, fruits stored in perforated white polythene bag of 200 gauge (T_{11}) and 100 gauge (T_{10}) started decaying from 6th day onward. Highest decay percentage was recorded on 12th day of storage (26.99 %), while it was lowest on 3rd day of storage (6.80 %). Similar observation that the decay per cent of guava was maximum in control and increased during storage period was also reported by Ismail *et al.* (2010). As storage period advanced, there was gradual softening of fruits in all the treatments. In the fruits where no treatment was applied (control), maximum softening of fruits was observed facilitating entrance for decay causing microbes. In the treatment where fruits were kept in 200 gauge polybags, the rate of softening was slow and also the product was not in direct contact with the external environment which might have resulted in lower decay percentage.

The shelf life of guava fruits under ambient storage conditions was significantly affected by various treatments. The longest shelf life (9.33 days) and the shortest (5.00 days) were observed in fruits packed in perforated white polythene bags of 200 gauge and untreated control fruits, respectively (Fig. 1). The increase in shelf life of guava fruits in 200 gauge polybags may be due to lesser permeability of moisture along with reduced level of O_2 and increased level of CO_2 gas as compared to other treatments which might have modified the microclimate and preserved the fruit quality. Better isolation of fruits in 200 gauge polybags might have extended shelf life of fruits due to lesser exposure to pathogens and contaminants (Beaudry, 2000).

Total soluble solids (TSS) content of the fruits increased initially upto 6 days and thereafter declined as the storage period progressed (Table 2). Highest TSS (10.35 °B) was reported in fruits stored in perforated white polythene bag of 200 gauge (T_{11}) whereas minimum TSS (9.72 °B) was recorded in control fruits. In case of T_{11}, TSS increased gradually till 9th day of storage (11.63 °B) while in case of control fruits, TSS was highest on 6th day, after which there was a sharp decline and lowest TSS was observed on 12th day of storage (8.47 °B). Initial increase in TSS content and then gradual decrease later during storage was similar to the findings of Singh *et al.* (2018). Gradual increase in the TSS content with increasing storage period for all the treatments might be due to hydrolysis

Table 1: Effect of different post-harvest treatments on physiological loss in weight (%) and decay (%) in guava

Treatments	*Storage period (days)*											
	Physiological loss in weight (%)						*Decay (%)*					
	0	*3*	*6*	*9*	*12*	*Mean*	*0*	*3*	*6*	*9*	*12*	*Mean*
T_1: Control	0.00 (0.00)	5.52 (13.58)	7.24 (15.60)	11.56 (19.87)	14.73 (22.56)	7.81 (14.32)	0.00 (0.00)	4.52 (12.27)	11.13 (19.48)	21.53 (27.63)	27.50 (31.62)	12.94 (18.20)
T_2: Distilled water (5 minutes)	0.00 (0.00)	5.31 (13.32)	6.34 (14.58)	11.28 (19.62)	14.29 (22.20)	7.45 (13.94)	0.00 (0.00)	3.38 (10.60)	10.00 (18.43)	20.11 (26.64)	25.75 (30.48)	11.85 (17.23)
T_3: Hot distilled water (48°C for 2 minutes)	0.00 (0.00)	5.25 (13.25)	6.33 (14.56)	11.22 (19.57)	12.71 (20.82)	7.10 (13.64)	0.00 (0.00)	3.33 (10.51)	5.40 (13.43)	18.37 (25.37)	25.70 (30.45)	10.56 (15.95)
T_4: Hydrogen Peroxide (H_2O_2) 2% for 4 minutes	0.00 (0.00)	5.15 (13.11)	6.34 (14.58)	10.09 (18.51)	12.31 (20.53)	6.78 (13.35)	0.00 (0.00)	2.33 (8.77)	4.87 (12.74)	15.47 (23.15)	23.16 (28.76)	9.17 (14.68)
T_5: Crude lemon grass oil 6 ml per carton	0.00 (0.00)	5.05 (12.99)	6.23 (14.44)	9.77 (18.21)	11.73 (20.02)	6.56 (13.13)	0.00 (0.00)	1.57 (7.19)	4.50 (12.24)	15.13 (22.88)	23.05 (28.68)	8.85 (14.20)
T_6: Neem seed oil (90%)	0.00 (0.00)	3.15 (10.22)	5.27 (13.27)	8.17 (16.60)	10.10 (18.52)	5.34 (11.72)	0.00 (0.00)	1.40 (6.78)	4.60 (12.38)	10.60 (19.00)	19.20 (25.98)	7.16 (12.83)
T_7: Neem seed oil (45%)	0.00 (0.00)	3.27 (10.41)	5.38 (13.41)	8.25 (16.69)	10.17 (18.59)	5.41 (11.82)	0.00 (0.00)	1.20 (6.29)	4.13 (11.73)	10.27 (18.68)	18.31 (25.32)	6.78 (12.40)
T_8: Neem seed oil (22.5%)	0.00 (0.00)	3.36 (10.56)	5.45 (13.49)	8.42 (16.86)	10.43 (18.84)	5.53 (11.95)	0.00 (0.00)	1.05 (5.88)	4.00 (11.53)	10.23 (18.65)	18.15 (25.21)	6.69 (12.25)
T_9: Brown wrapping paper bag	0.00 (0.00)	2.86 (9.73)	4.54 (12.30)	7.89 (16.30)	9.92 (18.35)	5.04 (11.34)	0.00 (0.00)	1.27 (6.47)	3.13 (10.19)	9.13 (17.58)	16.24 (23.76)	5.96 (11.60)
T_{10}: Perforated white polythene bag (100 gauge)	0.00 (0.00)	2.34 (8.80)	4.24 (11.88)	7.41 (15.79)	9.46 (17.91)	4.69 (10.88)	0.00 (0.00)	0.00 (0.00)	2.63 (9.33)	8.75 (17.20)	15.88 (23.48)	5.45 (10.00)
T_{11}: Perforated white polythene bag (200 gauge)	0.00 (0.00)	2.05 (8.23)	4.15 (11.75)	7.16 (15.52)	9.21 (17.66)	4.52 (10.63)	0.00 (0.00)	0.00 (0.00)	2.00 (8.13)	8.51 (16.96)	15.48 (23.16)	5.20 (9.65)
Mean	0.00 (0.00)	3.94 (11.29)	5.59 (13.63)	9.20 (17.60)	11.37 (19.64)		0.00 (0.00)	1.82 (6.80)	5.13 (12.69)	13.46 (21.25)	20.77 (26.99)	
Factors	S.Em.±			C.D. at 5%			S.Em.±			C.D. at 5%		
Storage intervals (S)	(0.048)			(0.134)			(0.022)			(0.061)		
Treatments (T)	(0.071)			(0.199)			(0.032)			(0.091)		
Interaction (S × T)	(0.159)			(0.455)			(0.072)			(0.203)		

Table 2: Effect of different post-harvest treatments on fruit TSS (°Brix) and titratable acidity (%) in guava.

Treatments	*Storage period (days)*											
	TSS (°Brix)						*Titratable acidity (%)*					
	0	*3*	*6*	*9*	*12*	*Mean*	*0*	*3*	*6*	*9*	*12*	*Mean*
T_1: Control	9.10	10.50	11.00	9.54	8.47	9.72	0.29 (3.09)	0.21 (2.63)	0.16 (2.27)	0.14 (2.12)	0.12 (2.01)	0.18 (2.42)
T_2: Distilled water (5 minutes)	9.10	10.43	10.93	9.63	8.60	9.74	0.29 (3.09)	0.22 (2.71)	0.17 (2.36)	0.15 (2.24)	0.13 (2.06)	0.19 (2.49)
T_3: Hot distilled water (48°C for 2 minutes)	9.10	10.32	10.85	10.00	8.73	9.80	0.29 (3.09)	0.22 (2.71)	0.17 (2.39)	0.14 (2.17)	0.13 (2.07)	0.19 (2.48)
T_4: Hydrogen Peroxide (H_2O_2) 2% for 4 minutes	9.10	10.22	10.94	10.33	8.83	9.88	0.29 (3.09)	0.23 (2.75)	0.18 (2.41)	0.15 (2.24)	0.14 (2.17)	0.20 (2.53)
T_5: Crude lemon grass oil 6 ml per carton	9.10	10.25	10.87	10.34	8.97	9.90	0.29 (3.09)	0.24 (2.83)	0.19 (2.50)	0.15 (2.24)	0.14 (2.12)	0.20 (2.55)
T_6: Neem seed oil (90%)	9.10	10.03	10.63	10.28	9.67	9.94	0.29 (3.09)	0.25 (2.87)	0.20 (2.56)	0.16 (2.32)	0.15 (2.22)	0.21 (2.61)
T_7: Neem seed oil (45%)	9.10	9.94	10.63	10.43	9.77	9.97	0.29 (3.09)	0.24 (2.79)	0.19 (2.48)	0.15 (2.22)	0.14 (2.17)	0.20 (2.55)
T_8: Neem seed oil (22.5%)	9.10	9.87	10.59	10.40	9.83	9.96	0.29 (3.09)	0.24 (2.81)	0.18 (2.41)	0.15 (2.19)	0.14 (2.12)	0.20 (2.52)
T_9: Brown wrapping paper bag	9.10	9.82	10.52	10.97	10.53	10.19	0.29 (3.09)	0.24 (2.81)	0.22 (2.67)	0.16 (2.32)	0.15 (2.24)	0.21 (2.62)
T_{10}: Perforated white polythene bag (100 gauge)	9.10	9.77	10.38	11.23	10.83	10.26	0.29 (3.09)	0.26 (2.90)	0.24 (2.79)	0.19 (2.48)	0.17 (2.36)	0.23 (2.72)
T_{11}: Perforated white polythene bag (200 gauge)	9.10	9.62	10.30	11.63	11.10	10.35	0.29 (3.09)	0.26 (2.94)	0.25 (2.85)	0.21 (2.62)	0.19 (2.48)	0.24 (2.79)
Mean	9.10	10.07	10.69	10.44	9.58	9.97	0.29 (3.09)	0.24 (2.79)	0.19 (2.52)	0.16 (2.29)	0.15 (2.18)	
Factors	S.Em.±			C.D. at 5%			S.Em.±			C.D. at 5%		
Storage intervals (S)	0.013			0.036			(0.007)			(0.020)		
Treatments (T)	0.019			0.054			(0.011)			(0.030)		
Interaction (S × T)	0.043			0.120			(0.24)			(0.067)		

of starch into sugar. The decrease in total soluble solids at advanced stage might be the result of increased rate of respiration in later stages of storage which led to its faster utilization in oxidation process through Kreb's cycle (Singh, 1980).

Fruits packed in 200 gauge white polythene bag (T_{11}) recorded maximum titratable acidity (2.79%) followed by 2.72 per cent in fruits stored in perforated white polythene bag of 100 gauge (T_{10}) while it was minimum (2.42%) in control (T_1) (Table 2). There was gradual decrease in the acidity of fruits with advancing storage period. It was highest on 3rd day of storage (3.09%) and decreased to 2.18% on 12th day of storage. The decline in titratable acidity in all the treatments and control during storage period might be due to oxidation of ascorbic acid. The decrease in titratable acidity may also be attributed to the increased rate of metabolic activities and conversion of different organic compounds into sugars during storage period (Echeverria and Valich, 1989).

Highest ascorbic acid (241.24 mg/100g pulp) was found in fruits stored in perforated white polythene bag of 200 gauge (T_{11}) closely followed by 239.18 mg/100g pulp in fruits packed in 100 gauge thickness perforated white polythene bag (T_{10}). The minimum ascorbic acid content (200.32 mg/100g pulp) was observed in control (T_1) (Fig. 2). This might be due to lower rate of oxidation of ascorbic acid inside perforated white polythene bag as compared to fruits kept in open (control). Storage days exerted significant influence on ascorbic acid of fruits, which decreased gradually with increase in storage period. The first day of storage registered the maximum ascorbic acid content (283.06 mg/100g pulp) while it was minimum (123.10 mg/100g pulp) on the 12th day of storage. Similar findings were observed by Ismail *et al.* (2010) that the ascorbic acid was decreased for all the treatments and control during storage period.

Sugar content in fruits was significantly influenced by the various treatments and storage period. Maximum reducing sugars (11.20%) were reported in fruits packed in perforated white polythene bag of 200 gauge (T_{11}) which was *at par* with 11.17 per cent observed in fruits stored in 100 gauge perforated white polythene bag (T_{10}) (Fig. 3). Minimum reducing sugars (10.69%) were recorded in control fruits (T_1) and were *at par* with 10.73 per cent found in fruits treated with distilled water (T_2). An increase in reducing sugars in all treatments was observed with the advancement of storage period, but this increase was registered only up to 6th day of storage (11.91%) and thereafter it declined as the storage period advanced and minimum was registered on 12th day of storage (10.08%). In T_{11}, reducing sugars increased till 9th day of storage (12.49%) and decreased thereafter. On the other hand, fruits kept in brown paper bags (T_9)

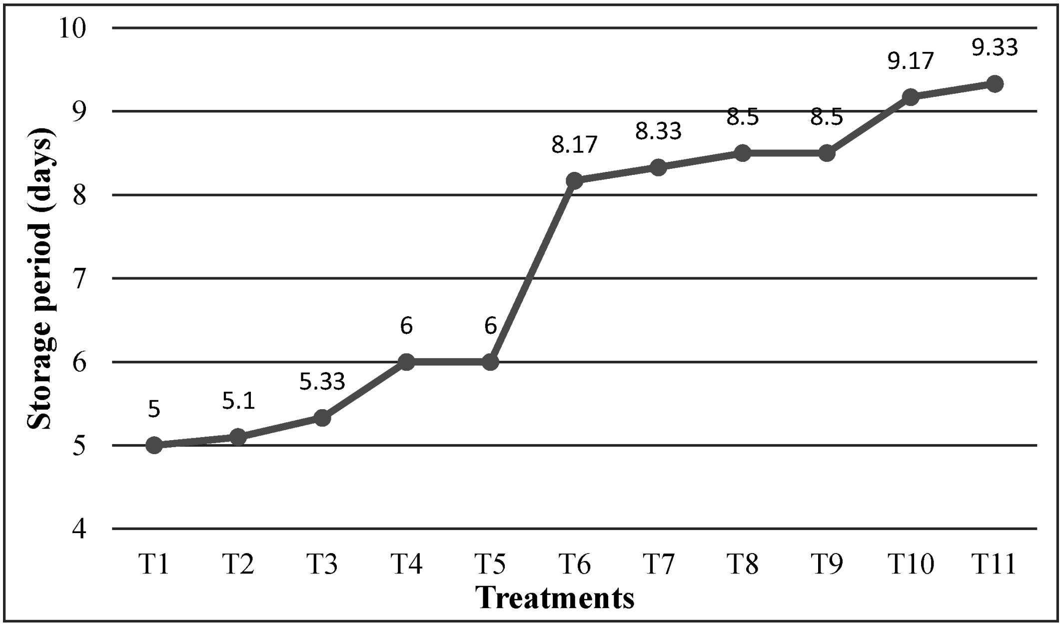

Figure 1: Effect of different post-harvest treatments on shelf life of fruits under ambient storage conditions in guava

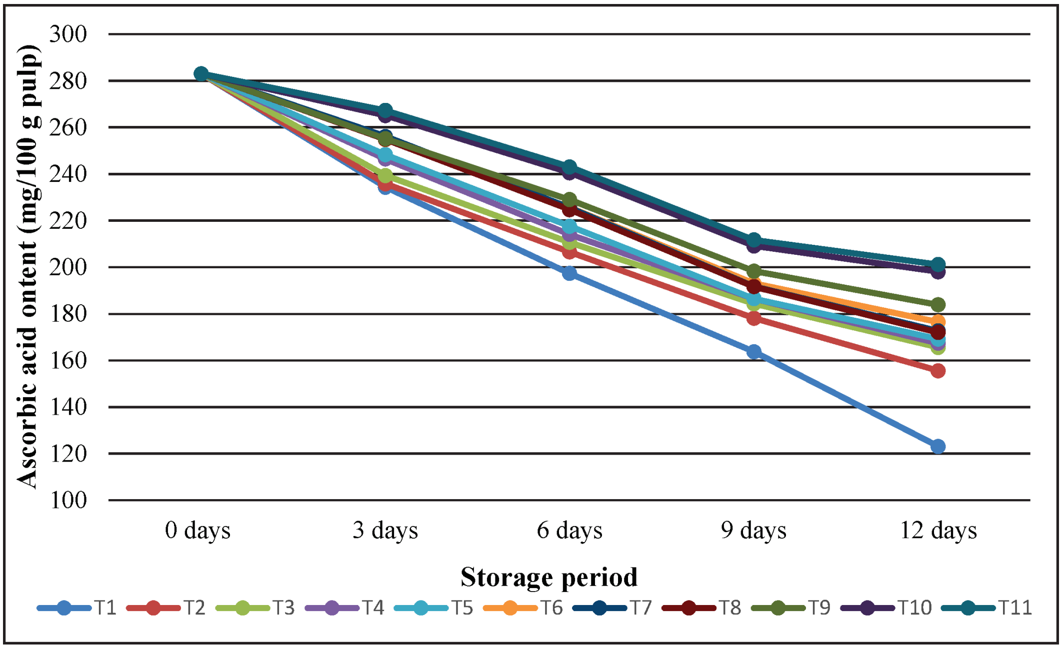

Figure 2: Effect of different post-harvest treatments on ascorbic acid content (mg/100g pulp) in guava

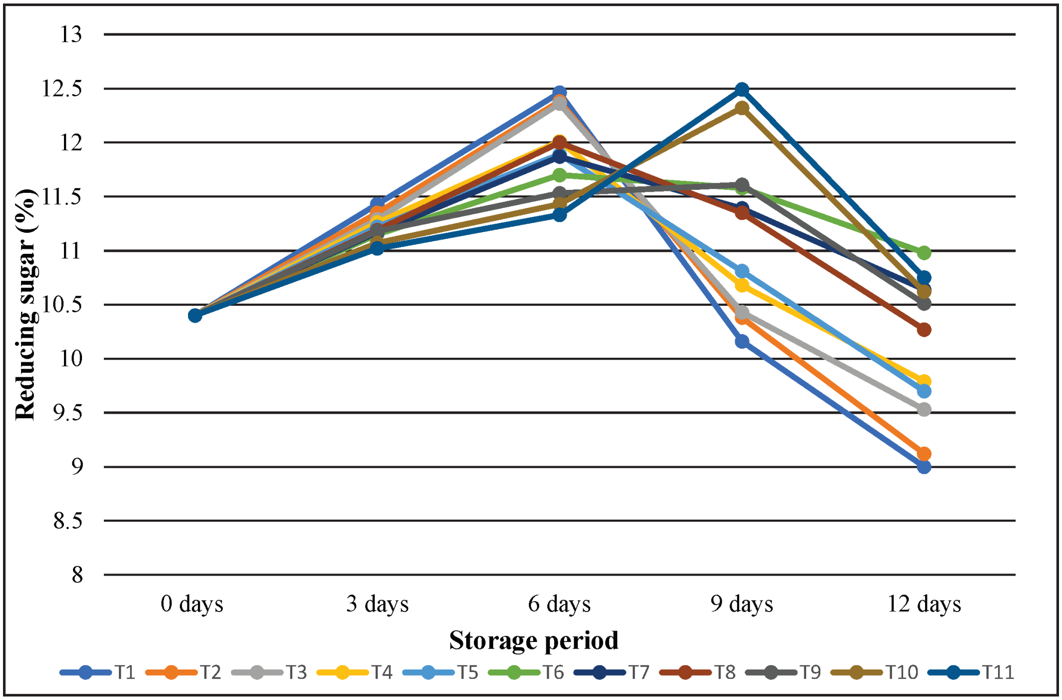

Figure 3: Effect of different post-harvest treatments on reducing sugars (%) in guava

registered highest non-reducing sugars (11.01%) closely followed by 10.96 per cent in fruits stored in 200 gauge perforated white polythene bag (T_{11}) while the lowest (10.43%) was recorded in fruits treated with 90 per cent neem seed oil (T_6) (Fig. 4). Non-reducing sugars increased initially up to 9th day and later decreased gradually as the storage period progressed. Interactions between treatments and storage period revealed that T_{11} recorded highest (12.05%) non-reducing sugars on 12th day of storage while T_6 recorded the lowest fruit non-reducing sugars (9.72 %) on 12th day of storage. Maximum total sugars (15.78%) were observed in fruits kept in perforated white polythene bag of 200 gauge (T_{11}) followed by 15.71 per cent in fruits packed in 100 gauge perforated white polythene bag (T_{10}) while it was minimum (15.30 %) in control fruits (T_1) which was *at par* with T_2 (distilled water) and T_4 (hydrogen peroxide @ 2 % for 4 minutes) (Fig. 5). Total sugars content also increased initially up to 6th day and then decreased gradually as the storage period advanced. A similar trend in total sugars content of peach fruits packed in polythene films was observed by Pongenar *et al.* (2011). T_{11} registered maximum total sugars (17.27%) on 9th day of storage while T_1 retained the minimum total sugars (13.75%) on 12th day of storage. These observations were similar to the findings of Augustin

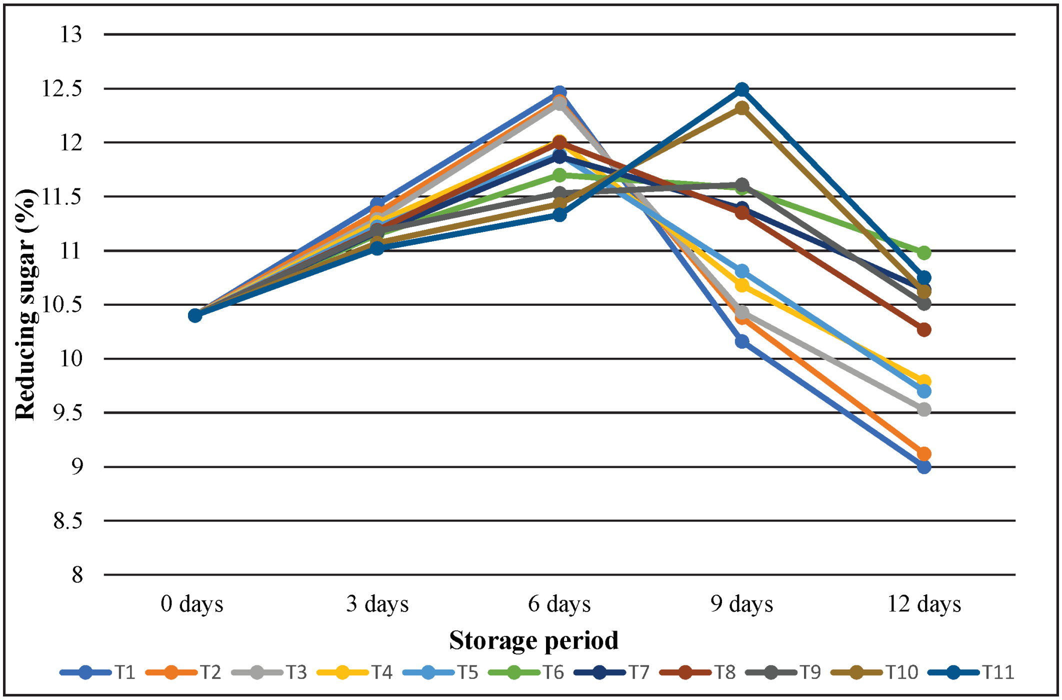

Figure 4: Effect of different post-harvest treatments on non-reducing sugars (%) in guava

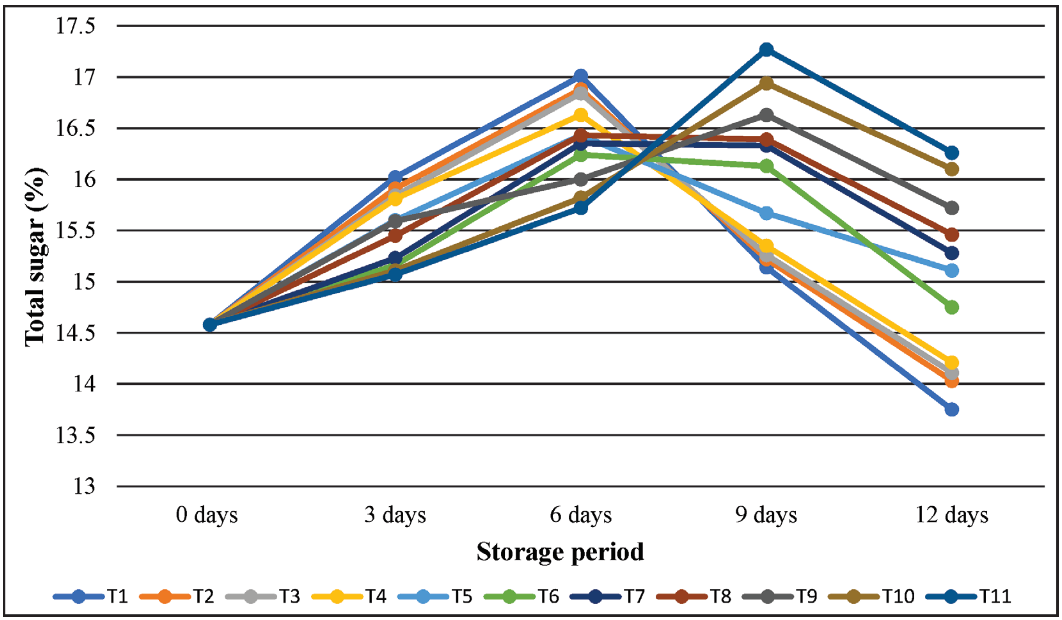

Figure 5: Effect of different post-harvest treatments on total sugars (%) in guava

et al. (1988) and Ismail *et al.* (2010) that total sugars content increased during storage period. The initial rise may be due to water loss from fruits through evapo-transpiration and inhibition of activities of enzymes responsible for degradation of sugars, while the subsequent decline may be due to utilization of sugars in respiration.

4. Conclusions

Results from this research showed that the physico-chemical changes during storage was slow in case of 200 gauge thickness perforated white polythene bag as compared to other treatments and it can be used to extend the storage period, marketability and maintain the quality of fruits during storage in guava cv. Pant Prabhat.

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