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Effect of HDPE and LDPE packaging materials on chemical parameters of guava cv khaja

Soudamalla Nagaraju and AK Banik

Abstract
Guava (*Psidium guajava* L.), having 2n=22, belongs to the family Myrtaceae and is native of Mexico. Guava has limited storage potential at ambient conditions, which leads to glut in market and poor return to the growers. Moreover, over ripe fruit at ambient conditions lead to lot of wastage and economic losses. Post-harvest losses can be minimized by adopting proper post-harvest handling practices and better understanding of biochemical control of fruit ripening. Postharvest life of fruits and vegetables can be extended by using LDPE and HDPE films these films are commonly used to minimize weight loss, reduce abrasion, damage and delay. fruit ripening in view of above information an experiment is proposed to be conducted with following objectives,1) To increase the post-harvest life of guava fruits under ambient condition.2) To study the effect of packaging materials on and quality and shelf life of guava fruits. The experiment on "Some aspects post-harvest handling of guava cv. Khaja as influenced by packaging materials" was conducted during the period of December 2015-January 2016 in the department of Post-Harvest Technology of Horticultural Crops, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Nadia, to study the effect of treatments on quality of guava fruits. The cultivar of guava Khaja was harvested at mature but unripe stage. The guava fruit was packed in different microns of LDPE packages (1% LDPE+$KMNO_4$, 2% LDPE+$Kmno_4$ non purporated LDPE and control HDPE packages (1% HDPE+$KMNO_4$, 2% HDPE+$Kmno_4$ non purporated HDPE and control packaging. All treatments were kept in ambient condition. The fruits were examined for Tss Sugars, Acidity and Vitamin-C. 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 are found obviously easy for practical application for extending the shelf life of guava.

Keywords: HDPE, LDPE, guava cv khaja

Introduction
Guava (*Psidium guajava* L.), having 2n=22, belongs to the family Myrtaceae and is native of Mexico (Decandolle, 1904), while Persglove (1968) opined that it is originated in Brazil. It is a perennial tree of tropics and subtropics offering great economic potential (Pathak and Ojha, 1993) [48]. It is commercially cultivated in Pakistan, Bangladesh, India, Thailand, Mexico, Brazil, USA and several other tropical and subtropical countries of the world (Watson and Dallwitz, 2007). In India guava grown in an area of 268 thousand hectors with the production of 3668 thousand MT production (Anonymous, 2014) [8]. It is the fifth most widely grown fruit crops in India and the major producing states are Bihar, Andhra Pradesh, Utter Pradesh, Maharashtra, West Bengal, Karnataka, Gujarat and Madhya Pradesh. Guava is the third most important fruit crop of West Bengal state besides mango and Guava. In West Bengal about 25 cultivars are reported to grow in different districts, important among these are Lucknow-49, Allahabad Safeda, Dudhe Khaja, Gole Khaja, Kabli, Baruipur, Chittidar, Harijha. In West Bengal guava cultivated in an area of 14.4 thousand ha with 186thousand MT production (Anonymous, 2014) [8]. Guava fruits are rich in high-profile nutrients. With its unique flavor, taste, and health-promoting qualities, the fruit easily fits in the new functional foods category, often called "Super-fruits". Guava fruit contain Carbohydrates 14.3 gm. Protein 2.55 gm. Calcium 8 mg, Vitamin-C 228 mg, Vitamin-A 624 IU, Lycopene 5204µg, Energy 68 Kcal, and anti-oxidant property 496 mg/100 gram fruit.

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). 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.

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 using HDPE & HDPE with different perforation films are commonly used to minimize weight loss, reduce abrasion, damage and delay fruit ripening.

Materials and Methods

Experimental details

Location

The experiment was conducted in laboratory of Post-Harvest Technology of Horticultural C ropes, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur du ring 2015 -16. Two different varieties of Guava viz khaja. were collected from Guava research plot of All India Coordinated Research Project (AICRP) on tropical fruits at Mondouri.

Site of experiment

The Experiment on packaging with ethylene absorbent and post-harvest treatment on Guava cv khaja was carried out under the laboratory conditions in the department of Post-Harvest Technology of Horticultural Crops, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, W est Bengal during 2016, which is located approximately at 22.58 ^{0} N latitude, 88.32 ^{0} E longitude having an average altitude of 9.75m from the sea level.

Harvesting

Harvesting of fruits was done in the early morning hours. After harvest, the matured Guava fruits of uniform size and shape, free from mechanical damage, bruises and fungal or insect attack were selected and immediately transported to laboratory.

Washing

Washing of fruits was done in tap water & then in distilled water containing 50 ppm of chlorine (CaCl 2) to reduce the microbial load, after that kept under fan for surface drying at room temperature.

Environmental parameter

The place from where fruits were taken comes under subtropical humid region. The average temperature ranges from 20. 5 ^{O} C –30.98 ^{O} C during the month of October to December.

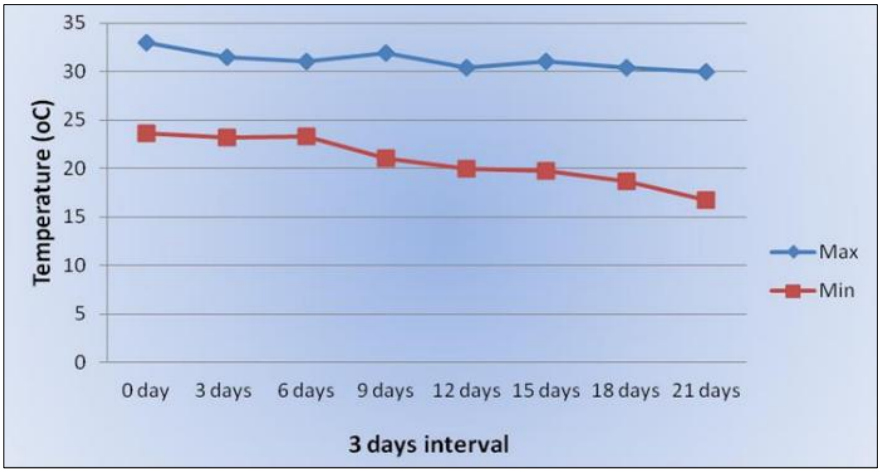
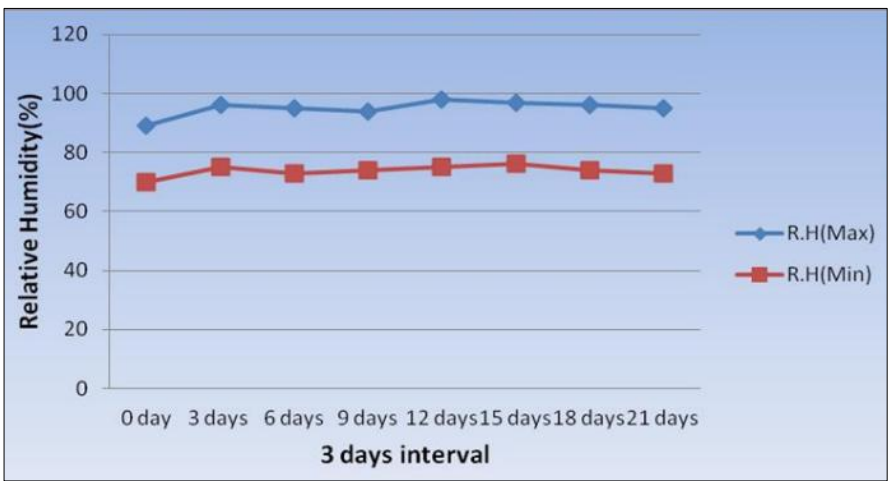


Fig 1: Graphical representation of temperature during storage of Guava



Source: Department of Agro - meteorology and physics, BCKV

Fig 2: Graphical representation of Relative humidity (%) during storage of Guava

Effect of packaging and ethylene absorbent on quality and shelf life of Guava cv Khaja

Guava fruits cv. Khaja was harvested at properly matured but unripe stage and brought to the laboratory for post-harvest study. The hands were separated from the bunch, washed and kept under fan for surface drying. Guava fruits after proper surface drying. Guava fruits after proper surface drying were packed with different packaging materials viz. Low Density Polyethylene(LDPE) and High density polythene (HDPE) with varying amount of perforation i.e. 1%,2% and no perforation and one ethylene absorbent sachets was place d in each bag @4gm KMnO 4 /Kg of fruit). Fruits without packaging and ethylene absorbent were kept as control for comparison. 10 fruits were placed in each polyethylene bag and constituted one replication.

Treatments Details

T1: HDPE (1%perforation) + KMnO4
T2: HDPE (2%perforation) **+** KMnO4
T3: HDPE (Non-perforation) + KMnO4
T4: LDPE (1%perforation) + KMnO4
T5: LDPE (2%perforation) + KMnO4
T6: LDPE (Non-perforation) + KMnO4
T7: Control (without packaging and ethylene absorbent)
Design of experiment: CRD (Completely Randomized Design)
No. of treatments: 7
Repetition of treatments: 3
Varieties of Fruits: Guava cv.-Khaja

Total soluble solids (0Brix)

Total soluble solids (^{0}Brix) in order to estimate the total soluble solid contents, a hand refractometer (Erma, Japan) were used. It was properly washed with distilled water and dried. The observed shadow level was adjusted to '0' reading with a drop of distilled water. Subsequently the water was blotted out, the refractometer was dried and a drop of freshly squeezed juice was placed on the plate (specimen chamber) to record the refractometer reading. The reading after necessary was expressed as ^{0}Brix.

Titratable acidity

Titratable acidity was determined as percentage citric acid according to method described in A.O.A.C. (1990). Fruit sample was taken from 3 places (shoulder, middle and apex portion) by cutting with stainless steel knife and juice was extracted from the samples. The 10 ml. extract was taken in a beaker and diluted with distilled water and made volume 100 ml. out of 100 ml extract again 10 ml of extract was taken in 3 small beakers for further analysis. Aliquot of diluted juice was titrated against standard alkali solution 0.1 NaOH using phenolphthalein as indicator. the reading was expressed as percentage (%).

Reducing sugar

Reducing sugar was determined by taking different parts of a fruit using the copper reduction method as described by Ranganna (1991). The reducing sugar contents of the fruit extract, which was prepared similarly as in case of titratable acidity, were estimated by titrating against a mixture of equal quantities of Fehling's A and B. the titration was then carried out under boiling condition using methylene blue as an indicator. The reading was expressed as a percentage (%).

Calculation

$$\text{Reducing sugar (\%)} = \frac{\text{Mg of invert sugar} \times \text{dilution}}{\text{Titre} \times \text{Weight of the sample taken}} \times 100$$

Total sugars

In order to estimate the total sugar levels of fruit known quantity of pulp or juice, containing non-reducing sugars were taken and converted to reducing sugar by acid hydrolysis. For acid hydrolysis the extracts were treated with a known quantity of concentrated HCl. The acidified juice extract was heated up to boil (10 minutes) and cooled, thereby assuring the conversion of non-reducing sugars to reducing forms without interfering with the reducing sugars that is already present in them. After cooling, a small quantity of sodium hydroxide solution was added till the reaction is neutralized or slightly alkaline and this was tested using litmus paper. The solutions were then made up to known volume by adding distill water and titrated against Fehling's solutions as described in case of reducing sugar. The reading was expressed in percentage (Ranganna, 1991).

Calculation

$$\text{Total sugar (\%)} = \frac{\text{Mg of invert sugar} \times \text{dilution}}{\text{Titre} \times \text{Weight of the sample taken}} \times 100$$

Ascorbic acid (mg/100 g)

Ascorbic acid content of guava pulp samples were determined by 2, 6-dichlorophenol indophenol titration method as described by (Ranganna, 1986).

Calculation

Mg of ascorbic acid per 100 g =

$$\frac{\text{Titre x Dye factor x Volume made up x 100}}{\text{Aliquot of extract taken for estimation x Weight of sample taken}}$$

Statistical Analysis

The analysis of the data obtained in experiment was analyzed by completely randomized design with 4 replications by adopting the statistical procedure of (Gomez and Gomez, 1984) [26].

Results and Discussion

Total soluble solids (%)

Data pertaining to changes in TSS content due to various types of packaging combined with with ethylene absorbent are given in table-1. The TSS content of Guava in this study varied from 10.5 to 25.33 °Brix during the storage period. It is apparent from the table that the difference in TSS content was significant under the influence of the treatments on all days of storage. The data showed a constant increase in TSS value during the course of storage with untreated control maintaining higher values for TSS.

Control fruits showed maximum TSS (25.33 °Brix) on 12th day followed by HDPE with 2% perforation (25.17 °Brix). Un-perforated LDPE and un-perforated HDPE showed a minimum TSS content of 23.33 and 23.83^{0}Brix, respectively on same day of storage.

During storage there was an increasing trend in TSS of Guava fruits under various treatments. A significant variation of TSS among various treatments was noticed. The increase in TSS content during storage could be due to losses in water through

respiration and evaporation during storage resulting in accumulation of different solutes in cell vacuoles. Increasing in TSS content reflects hydrolysis of starch into sugars as Guava fruit ripen. This result was in line with the finding of Stover and Simmonds (1987) [50] who reported that the conversion of starch in to sugars was reported to be the most important change in ripening Guavas.

Un-perforated polyethylene bags are known to reduce loss of moisture and hydrolysis of polysaccharides resulting in less increase in TSS. While decrease in TSS in PE treatments may be due to the fact that these treatments retarded the respiration and conversion of polysaccharides into disaccharides and monosaccharides.

The maximum TSS was observed in T2 (2% perforated HDPE) after control. The results were also in conformity with Hailu *et al*. (2012) [30] who reported a high TSS content in HDPE packaged fruits than LDPE. Visalakshi *et al*. (2012) reported that Guava Fruits stored in the polythene bags of 500 gauge thickness with 2.5 percent ventilation recorded the highest total soluble solids. Observations of Emerald and Sreenarayanan (1999) [22] in Guava and Akhtar *et al*. (2012) [5] in loquat are also in agreement with these findings.

Table 1: Effect of packaging and ethylene absorbent on 0 Tss (%) of Guava fruits cv. Khaja

Treatments		Days				
		0	3	6	9	12
T_1	1% perforated HDPE+$KMnO_4$	10.5	14.63	19.26	22.17	24.51
T_2	2% perforated HDPE+ $KMnO_4$	10.5	15.96	20.16	22.77	25.17
T_3	Un-perforated HDPE+ $KMnO_4$	10.5	14.06	18	21.33	23.83
T_4	1% perforated LDPE+$KMnO_4$	10.5	14.46	18.93	21.97	24.17
T5	2% perforated LDPE+$KMnO_4$	10.5	14.94	19.66	22.50	25.04
T_6	Un-perforated LDPE+ $KMnO_4$	10.5	13.83	17.43	21.03	23.33
T7	Control(no packaging)	10.5	16.33	21.16	23.87	25.33
	SE.m(+)	-	0.229	0.229	0.214	0.138
	CD (0.05%)	-	0.693	0.675	0.65	0.419

Reducing sugar (%)

Data given in table 2 indicates that among the treatments there were significantly differences with respect to reducing sugars.

From the result it can be observed that reducing sugar content in all the treatments exhibited a continuous increase throughout the storage period. Maximum reducing sugars was observed in case of control (T7) in ambient temperature on the 12th day of storage.

Reducing sugars was minimum in T6 (un-perforated LDPE) 5.90% on the 12th day of storage that was significantly at par with T3 (6.04%) (Un-perforated HDPE) as shown in table. Similar results were observed at 3rd, 6th and 9th day of storage..

Among the various treatment maximum reducing sugars was observed in T2 (2% perforated HDPE) after control. An increasing trend in the reducing sugar was found in all the treatment with the increase in storage period. The increase in the reducing sugar content of Guava fruits could be due to hydrolysis of starch into soluble sugars as Guava fruit ripen (Simmonds, 1987) [50]. This conversion was found to be faster in control fruits than the other packaging treatments.

The results are in agreement with Hailu *et al*. (2012) [30] who also reported a high value of reducing sugar in perforated HDPE than LDPE. The results are also in close proximity of those obtained by Visalakshi *et al*. (2012), Narayana (2002) [46] in Guava fruits and Shantha Krishnamurthy and Kushalappa (1985) [35].

Table 2: Effect of packaging and ethylene absorbent on reducing sugar (%) of Guava fruits cv. Khaja

Treatment		Days				
		0	3	6	9	12
T_1	1% perforated HDPE+$KMnO_4$	1.085	2.07	2.90	4.90	6.57
T_2	2% perforated HDPE+ $KMnO_4$	1.085	2.60	3.54	5.63	7.06
T_3	Un-perforated HDPE+ $KMnO_4$	1.085	1.77	2.43	4.08	6.04
T_4	1% perforated LDPE+$KMnO_4$	1.085	2.00	2.79	4.67	6.30
T_5	2% perforated LDPE+$KMnO_4$	1.085	2.42	3.11	5.22	6.97
T_6	Un-perforated LDPE+ $KMnO_4$	1.085	1.93	2.20	3.90	5.90
T7	Control(no packaging)	1.085	2.90	4.42	6.73	7.67
	SE.m(+)	-	0.059	0.123	0.078	0.094
		-	0.18	0.373	0.237	0.286
	CD(0.05)%					

Total sugar (%)

The change in total sugar content as influence by various treatments was studied and detail given in Table-3. There were statistically significant differences among the treatments with respect to total sugar. It is observed that total sugar percentage increased with advancement of storage period up to 12th day for all treatment.

Total sugars was minimum in T6 (un-perforated LDPE) 15.97% on the 12th day of storage that was followed by T3 (16.42%) (Un-perforated HDPE) as shown in table. On 6th day of storage Total sugar in T6 (6.93%) was at par with T3 (7.07%) treatment.

However, the maximum total sugar was seen in T7 (control) on 12th day of storage under ambient condition.

The total sugars of Guava fruits that were treated with various treatments showed a trend similar to TSS content. Highest total sugars were seen in T2 (2% perforated HDPE) after control. The increase in total sugars of fruits under different packages might be due to loss of water from the fruits and conversion of polysaccharides and pectic substances into sugars.

The present study was in line with the report of Dadzie and Orchard (1997) that, the most striking postharvest chemical change which occurs during the postharvest ripening of Guava is the hydrolysis of starch and the accumulation of sugar (that is, sucrose, glucose and fructose) which are responsible for the sweetening of the fruit. In this study, the maximum total sugar for control fruits was attained on 12th day.

The results were also in conformity with Narayana (2002) [46] who reported that total sugars of Karpuravalli Guava fruits increased gradually throughout the storage period and was maximum in the control and ventilated bags than the unvented polybags.

Similar results were also seen by Hailu *et al*. (2012) [30] reported that HDPE packaged fruits have a higher value of total sugar than LDPE packaged fruits. Guava fruits kept in the polythene bags of 500 gauge thickness with 2.5 per cent ventilation recorded the highest total sugars was reported by Visalakshi *et al*. (2012).

Table 3: Effect of packaging and ethylene absorbent on total sugar (%) of Guava fruits cv. Khaja

	Treatment	Days				
		0	3	6	9	12
T_1	1% perforated HDPE+$KMnO_4$	2.089	4.1	7.80	11.18	17.37
T2	2% perforated HDPE+ $KMnO_4$	2.089	4.42	8.08	12.25	17.93
T3	Un-perforated HDPE+ $KMnO_4$	2.089	3.41	7.07	10.63	16.42
T_4	1% perforated LDPE+$KMnO_4$	2.089	3.93	7.33	10.74	16.77
T_5	2% perforated LDPE+$KMnO_4$	2.089	4.17	7.93	11.93	17.77
T_6	Un-perforated LDPE+ $KMnO_4$	2.089	3.08	6.93	10.08	15.97
T_7	Control(no packaging)	2.089	4.67	9.63	14.00	18.83
	SE.m(+)	-	0.073	0.091	0.15	0.118
	CD (0.05%)		0.223	0.277	0.455	0.358

Titratable acidity (%)

The data showing change in percentage of titratable acidity in Guava due to different packaging materials and ethylene absorbent are presented in Table-4

The acidity contents of the fruits increased initially from 0 to 3 days after that decreased gradually during the storage in all treatments, the values of treated fruits being more than that of control fruits during the entire period of observation from the 3rd to 12th day. From the perusal of data, it was seen that T3 (un-perforated HDPE) showed higher acidity percentage during the entire period of storage with the value of 0.53, 0.45, 0.43, 0.38 per cent from 3, 6, 9 and 12th day, respectively. Thus, treated fruits exhibited a tendency to retain more acidity during storage. The lowest value of acidity was observed in T7 (control) with 0.17% acidity in the 12th day of storage.

The highest acidity was observed in T3 (un-perforated HDPE). The titratable acidity of fruits showed an increasing trend from the beginning till day 3 which could be due to the synthesis of organic acids from carbohydrate. After that, it showed a decreasing trend which could be due to its utilization of organic acids as a substrate and by conversion of acids into sugars. This result was in agreement with Gowen (1995) [27] who reported that in the course of ripening free acidity increases until it reaches fully ripe stage and then free acidity decreased gradually thereafter.

The results were in conformity with Borkar *et al.* (2008) [14] who reported a high value of titratable acidity in Guava fruits packed in 250 gauge non-perforated HDPE bags. Similar results were seen by Singh *et al.* (2010) in Guava fruits stored in unvented polybags delayed conversion process of starch into sugar. Maximum TA (0.52%) was retained in HDPE and Minimum TA was recorded in control and perforated LDPE by Akhtar *et al*. (2012) [5] in loquat. These findings are in line with and supported by Shantha Krishnamurthy and Kushalappa (1985) [35] in Robusta Guava and Waskar and Roy (1993) [52] in Basrai Guava.

Table 4: Effect of packaging and ethylene absorbent on titratable acidity (%) of Guava fruits cv. Khaja

	Treatment	Days				
		0	3	6	9	12
T_1	1% perforated HDPE+$KMnO_4$	0.15	0.41	0.33	0.32	0.3
T2	2% perforated HDPE+ $KMnO_4$	0.15	0.33	0.27	0.27	0.21
T_3	Un-perforated HDPE+ $KMnO_4$	0.15	0.53	0.45	0.43	0.38
T_4	1% perforated LDPE+$KMnO_4$	0.15	0.39	0.34	0.32	0.27
T_5	2% perforated LDPE+$KMnO_4$	0.15	0.30	0.28	0.26	0.19
T_6	Un-perforated LDPE+ $KMnO_4$	0.15	0.46	0.42	0.4	0.35
T_7	Control(no packaging)	0.15	0.25	0.23	0.22	0.17
	SEm(+)	-	0.011	0.013	0.012	0.006
	CD (0.05%)	-	0.033	0.041	0.036	0.018

Ascorbic acid (mg/ 100 gm pulp)

Data in the table-5 shows that there was a significant variation for the effect of different treatments on the ascorbic acid content of Guava fruits.

The ascorbic acid contents of the fruits increased initially from 0 to 6 days after that decreased gradually during the storage in all treatments. The highest retention of ascorbic acid content was seen in treatment T3 (5.82 mg/100 g pulp) on the 12th day of storage. On the 3rd and 12th day of storage T3 (6.17mg) was at par with T6 (6.00mg). 0n the 9th day of storage T3 (6.33 mg) was at par with T6, T1, T4 with 6.22, 6.08 and 5.90 mg/100 gm pulp respectively. The maximum loss was observed in T7 (4.37 mg/ 100 gm pulp) on the 12th day of storage.

The Ascorbic acid of fruits showed an increasing trend from the beginning of the storage period. When ripening progresses, the AA content became decreased. The present result was in line with the report of Kader (1986) [33] that, the role of packaging was primarily to reduce respiration rate of fruit and vegetables by retarding metabolic activities. Greater decrease of AA content in control may be due to the fact that ascorbic acid is very susceptible to oxidative deterioration (Piga *et al.*, 2003), which occurred at accelerated rate in control due to the presence of higher concentrations of O2 as compared to polyethylene packages

The loss in ascorbic acid content with the progress of storage period could be attributed to rapid conversion of L-ascorbic acid into dihydro-ascorbic acid in the presence of L- ascorbic acid oxidase (Basir and Abu-Goukh., 2002) [10]. During storage, other oxidizing enzymes like peroxidase, catalase and polyphenol oxidase might also help in reducing the ascorbic acid of the fruits (Mapson, 1970).

Table 5: Effect of packaging and ethylene absorbent on ascorbic acid (mg/100g)

	Treatment	Days				
		0	3	6	9	12
T1	1% perforated HDPE+$KMnO_4$	4.29	5.77	8.00	6.08	5.25
T_2	2% perforated HDPE+ $KMnO_4$	4.29	5.14	7.05	5.63	4.82
T_3	Un-perforated HDPE+ $KMnO_4$	4.29	6.17	8.51	6.33	5.82
T4	1% perforated LDPE+$KMnO_4$	4.29	5.43	7.63	5.90	5.04
T_5	2% perforated LDPE+$KMnO_4$	4.29	4.93	6.73	5.55	4.42
T_6	Un-perforated LDPE+ $KMnO_4$	4.29	6.00	8.22	6.22	5.60
T_7	Control(no packaging)	4.29	4.67	6.03	5.04	4.37
	SE.m(+)	-	0.097	0.093	0.155	0.097
	CD (0.05%)	-	0.295	0.282	0.471	0.294

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