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On Tree Fruit Bagging Influences Quality of Guava Harvested at Different Maturity Stages during Summer

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Abstract

Fruit fly infestation adversely affects guava crop especially during summer and resulted in significant economic losses. Bagging techniques can protect fruits from pests and eliminates the use of pesticides, thus improves the quality of fruit. In the present study, different materials (newspaper bags, perforated polyethylene bags, muslin cloth bags and netted cloth bags) were used for on-tree bagging of guava fruit to improve fruit quality. The maturity of the fruit remained at par in bagged and unbagged fruits except newspaper bags where it was delayed significantly. Bagged fruit had shown less damage from fruit fly, other pests and diseases in comparison to controls where hardly any fruit was without pest attack. Polyethylene bags reduced the damage by fruit fly to maximum extent followed by newspaper and muslin cloth bags. Economic analysis indicated that all bagging techniques were cost effective. However, fruit covered with perforated polyethylene bags exhibited maximum BCR (benefit cost ratio) with better fruit quality. Moreover, newspaper bagged fruit exhibited the lowest weight loss (2.72%), maximum fruit firmness (84.1N) and highest pH (4.35) during storage. Un-bagged fruits had the highest value for weight loss (5.46%), while least value for fruit firmness (50.3 N). Highest values for reducing sugars (3.45%), non-reducing sugars (3.03%) and total sugars (7.34%) were observed in fruit covered with perforated polyethylene bags. Amongst various bagging treatments the perforated polyethylene was found to be the best regarding sensory evaluation. In case of harvest maturity, yellow ripe stage performed better in the organoleptic characteristics at the time of ripening but had the shortest storage life in comparison to green mature and green yellow stages, therefore suitable only for local market.

Keywords: Guava; Fruit bagging; Fruit quality; Fruit fly; Summer crop; Food safety

Introduction

Guava (*Psidium guajava* L.) is an important fruit crop of tropical and subtropical areas of the world. Major guava producing countries are South Africa, India, Brazil, Egypt, Mexico, Venezuela, Columbia and Pakistan. In Pakistan, it is grown on an area of 62.3 thousand hectares and yields 512.3 thousand tons of fruits (Hassan *et al.*, 2012). It ranks fifth after citrus, mango, banana and apple in Pakistan, with respect to area under cultivation (Anonymous, 2011).

Punjab province contributes the major share of guava production comprising 49.7 thousand ha area (80%) and 422.3 thousand tons (82%) of production (Anonymous, 2011). The major guava producing areas in Pakistan includes Kasur, Lahore, Sheikhupura, Sanglah Hills, Gujranawala, Kohat, Haripur, Larkana and Hyderabad (Hassan *et al.*, 2012).

Guava is one of the most nutritious fruit crops of the Indo-Pak sub-continent. Depending on species, it contains vitamin C (over 200 mg 100^{-1} g) 4 times more than oranges, vitamin A, vitamin B, magnesium, potassium and considered as low-caloric food (Jimenez-Escrig *et al*., 2001). It also contains the group of major antioxidants like polyphenols and carotenoids, which are responsible for its high nutritional value (Hassimotto *et al.*, 2005). Omega-3 and omega-6 fatty acids which belong to unsaturated group of fatty acids and dietary fiber are one of the most important constituents of its seed (Anonymous, 2009). Guava fruit has high demand but severe fruit fly infestation during summer by *Anastrepha striata* Schiner and *Bactrocera zonata* Saunders badly reduces the marketable yield. Which results in significant economic losses to growers. Fruit fly prefers guava as a host and larvae causes the main damage by feeding inside the fruit during their growth and development (Stonehouse *et al.*, 2005).

Rottening of infested fruit results in excessive fruit drop and also make it inedible for the consumers. Mostly, farmers defoliate and de-blossom guava trees during summer due to heavy attack of fruit fly, to get only winter crop. The farmers who harvest summer crop generally use heavy sprays of pesticides to limit the attack of fruit fly, which results in higher levels of chemical residues in fruits.

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Bagging, a physical protection technique, not only protects fruit from pests and diseases but also effects the quality of the produce by changing microenvironment of fruit during development (Son and Lee, 2008). Bagging of different fruits during development can reduce the chances of physical damage, improve colour at harvest (Byers and Carbaugh, 1995; Muchui *et al*., 2010) and yields high-quality fruit (Kitagawa *et al*., 1992). Several countries have adopted this technique to control the damage caused by fruit fly. The preharvest bagging reduces agrochemical residual effects, prevents sunburn, decreases the mechanical damage and controls the insect pest damage in the fruits (Amarante *et al*., 2002a). In Taiwan this practice is regularly used to protect different fruits (mango, passion fruit and guava) from oriental fruit fly *Bactrocera dorsalis* (Lee, 1988).

Quality of fruit is also associated with the stage of harvest maturity. Guava is harvested at three different maturity levels; mature green, green yellow and yellow ripe (Silva *et al*., 1998). The fruit fly and bird attack also increases with increase in fruit softening and ripening. Shelf life of tree ripened fruit is short but the quality is superior while the earlier stages result in certain level of compromise in quality.

The present investigation was conducted to evaluate the use of bagging techniques to protect the summer grown guava fruit quality from the adverse effects of fruit fly attack. In addition the suitable maturity stage for optimum quality was also determined.

Materials and Methods

The present study was conducted at a private guava orchard "Riaz Farm" at Dhok Gujjran (lat. 33°58′N; long. 73°05′E), Rawalpindi, Punjab, Pakistan. For evaluation of fruit quality, the harvested fruits were shifted to the Post Harvest Laboratory, Department of Horticulture, PMAS - Arid Agriculture University, Rawalpindi. Thirty, uniform guava trees of ten years age were selected for the study, considering two trees as a replication unit. Ten trees in each block/ replication were selected and bagging treatments (control/no bagging, newspaper bags, perforated polyethylene bags, muslin cloth bags and netted cloth bags) were allocated randomly to each tree. Fifty fruits of uniform size around each tree canopy were bagged as per treatment allocation except on six control trees. Twelve hundred fruits of different bagging treatments were harvested, washed with distilled water, air-dried and separated into three groups according to maturity stages based on differences in skin colour and firmness as described by Silva *et al.* (1998), including stage I = mature green and firm texture; stage II = green yellow and semi-firm texture; and stage III = yellow ripe and soft texture. Fruits were allowed to ripe for 15 days at 15°C to evaluate the fruit quality both in laboratory and organoleptically. Following quality parameters were studied:

Percent weight loss was determined at ripe stage by following equation:

$$\%\ \text{Weight loss} = \frac{\text{Weight of fruit at harvest (g)} - \text{Weight after storage (g)}}{\text{Weight of fruits at harvest (g)}} * 100$$

For firmness, three fruits per treatment per replication were used. Fruit firmness was determined by peeling the fruit at two equatorial sites and measuring firmness (N) by means of a Wagner Fruit Firmness Tester (Model FT-327 Japan) equipped with an 8 mm plunger. These fruits used to determine the fruit firmness were then cut into smaller pieces and juice was extracted in juicer for analysis of ascorbic acid, titratable acidity, pH, total soluble solids and sugars. Ascorbic acid contents (mg 100 mL^{-1} of juice) were determined at each harvesting stage according to the method described by Hans (1992).

To determine the titratable acidity, 10 ml extracted guava juice was mixed with 40 mL distilled water, and 2-3 drops of phenolphthalein were added in the juice. A 10 mL aliquot was taken in a titration flask and titrated against 0.1 N NaOH until permanent light pink colour appeared. Three consecutive readings were taken and percent acidity was calculated by using the following formula:

$$\%\ \text{Titratable Acidity} = \frac{\text{N/10 NaOH used x 0.0064}}{\text{Volume of sample used}} * 100$$

The pH of fruit juice was recorded by using digital pH meter (Model: Knick: 646) according to Association of Official Analytical Chemists (AOAC) method No.981.12-b. Total soluble solids (TSS) were measured according to AOAC (1990) using hand refractometer at room temperature. Total and reducing sugars of juice were estimated by the method described by Hortwitz (1960) and non-reducing sugars were calculated by the following formula:

Non-reducing sugars (%) = [Total sugars (%)-Reducing sugars (%)] × 0.95

Organoleptic evaluation of the fruit for pulp colour, flavor, aroma, taste and texture was done using Hedonic scale method of Peryam and Pilgrim (1957).

Economics of different fruit bagging materials is determined by BCR (benefit cost ratio). If the BCR is more than 1 in case of any bagging materials, it means that they are most cost effective and benefiting the farmers. BCR were estimated by formula: BCR = TR/TC, where TR and TC represent total revenue from experimental fruits and total cost of using each bagging technique, respectively.

Statistical Analysis

The experiments were designed according to randomized complete block design (RCBD) with factorial arrangement and the data were subjected to analysis of variance technique using MSTAT-C software (Michigan State University, 1988). Means were compared using least significant difference (LSD) test at 5% probability level (Steel *et al*., 1997).

Results

Effect of Different Bagging Treatments on Fruit Maturity

Fruit from each replicate (tree) were harvested when the color of the fruit turned to light green. Effect of bagging treatments on fruit maturity of guava fruit is presented in Table 1. News paper bagged fruit took 98 days after fruit set to be commercially mature. Whereas control, perforated polyethylene bags, muslin cloth bags and netting bags fruits took 91 days to become mature.

Effect of Different Bagging Treatments on the Fruit Fly Damage

Among various treatments the fruits developed in perforated polyethylene bags had minimum fruit fly damage (3.93%), followed by newspaper bags (5.71%) and muslin cloth bags (7.65%), while the maximum attack (96.02%) was occurred on control (un-bagged) fruits.

Effect of Different Bagging Treatments on the Physical Damage/Blemishes/Disease Attack

The bagging treatments significantly lowered damage, blemishes and disease attack in comparison to control (Table 1). Perforated polyethylene bags and newspaper bags had minimum disease attack (7.69%, 7.88%) and were at par with each other. On the other hand maximum damage (93.94%) was observed in control fruits.

Effect of Fruit Maturity and Bagging on Quality of Guava Fruit at Ripe Stage

Yellow ripe fruit reached at ripe stage after 3 days, green yellow after 7 days and green mature after 15 days of harvest.

Fruit Weight Loss

Fruit bagged with perforated polyethylene bags on tree were harvested at mature green-firm texture stage showed highest fruit weight loss (5.44%), which was at par with control fruit (5.22%). Fruits developed in newspaper bags had significantly lower losses in weight (2.88%) followed by fruit developed in muslin cloth bags (3.87%) and netting bags (4.22%). Fruit harvested at green yellow and semi-firm texture stage, un-bagged fruits and the fruits developed in perforated polyethylene bags showed significantly higher losses in weight (5.46%, 5.28%), while least weight loss was recorded in the fruits developed in newspapers bags (3.76%). In yellow ripe and soft texture fruit, the highest weight loss (4.18%) occurred in control and netting bags, while lowest weight loss was recorded in newspapers bags (2.72%) and muslin cloth bags (3.05%), which were at par with each other (Table 2). The results clearly showed that the fruits bagged with newspaper on tree exhibited least weight loss regardless of harvest maturity.

Fruit Firmness

The firmness values decreased during the storage and ripening of the guava fruits irrespective of the treatments. Fruit firmness was significantly higher in the bagged fruits as compared to un-bagged control fruits. Table 2 reflects that maximum values in all the three stages (mature green, green yellow and yellow ripe) were exhibited by fruits which were having newspaper bags on tree (84.1 N, 81.1 N and 66.5 N, respectively) while the lowest firmness was shown by the control treatments (58.1, 50.3 and 46.8 N) at fully ripened stage.

Ascorbic Acid Content

Highest ascorbic acid contents were observed (Table 2) in fruits developed in newspaper bags on tree (265.6, 266.2, 263.4 mg/100 mL) for all three maturity stages respectively during ripening followed by muslin cloth bags, perforated polyethylene bags and netted cloth bags, while the lowest was observed in control fruits (261.4, 261.9 and 258.0 mg/100 mL).

Titrable Acidity

The fruit which was developed in newspaper bags and harvested during mature green and green yellow stage had significantly higher values of acidity (0.66 and 0.68%) respectively in comparison to un-bagged or control fruit treatments (0.54 and 0.55%). Regarding the yellow ripe and soft texture the highest titratable acidity 0.67% was observed in the fruit developed in perforated polyethylene bags and lowest (0.55%) by the netting bags.

pH of Fruit Juice

The highest pH was observed in fruits covered with newspaper bags on the tree. The pH is 4.34, 4.34 and 4.35 at mature green, green yellow and yellow ripe stages respectively while the lowest was observed in the netting bags with values of 4.23, 4.20 and 4.20 respectively at three levels of maturity (Table 2).

Total Soluble Solids

The highest total soluble solid (TSS) contents were observed in fruits bagged with perforated polyethylene bags. The TSS was 8.62, 9.40, 4.45 °Brix, while the lowest was observed in the control fruits with values of 7.42, 8.23 and 4.19 °Brix in mature green stage, green yellow stage and yellow ripe stage respectively.

Table 1: Effect of different bagging treatments on fruit fly damage and disease attack

Treatments	Days to maturity	Fruit fly damage	Physical damage/ disease attack
Control	91	96.02 a	93.94 a
Newspaper bags	98	5.71 d	7.88 d
Perforated polyethylene bags	91	3.93 e	7.69 d
Netted cloth bags	91	7.65 c	19.65 c
Muslin cloth bags	91	32.61 b	29.52 b
LSD		1.673	2.549

Means within a column having same letters are statistically non-significant using Least Significant Difference Test

Table 2: Effect of different bagging treatments on different quality parameters of guava fruit at ripening stage*

Treatments	Maturity stages	FWL (%)	Fruit Firmness (N)	AA (mg/100g)	TSS (°Brix)	TA (%)	pH	RS (%)	NRS (%)	TS (%)
Control	Mature green	5.22a	58.7e	261.4c	7.42d	0.54c	4.27ab	3.12b	2.17c	6.76e
	Green yellow	5.46a	50.3e	261.9c	8.23c	0.55b	4.26ab	3.11b	2.44c	6.77e
	Yellow ripe	4.18a	46.8d	258.0b	4.19c	0.65a	4.26b	3.26ab	2.35c	6.92e
Newspaper bags	Mature green	2.88c	84.1a	265.6a	7.94bc	0.66a	4.35a	2.82c	2.42b	6.97c
	Green yellow	3.76d	81.1a	266.2a	8.80b	0.68a	4.34a	2.81c	2.73b	6.99c
	Yellow ripe	2.72c	66.5a	263.4a	4.34ab	0.63ab	4.34a	2.94bc	2.62b	7.13c
Perforated polyethylene bags	Mature green	5.44a	61.7d	262.7bc	8.62a	0.58bc	4.28ab	3.45a	2.69a	7.18a
	Green yellow	5.28a	57.6d	263.2bc	9.40a	0.59ab	4.25ab	3.44a	3.03a	7.20a
	Yellow ripe	3.58b	52.0c	259.2b	4.45a	0.67a	4.25bc	3.42a	2.90a	7.34a
Muslin cloth bags	Mature green	3.87b	74.0b	263.7b	7.76c	0.63ab	4.32ab	2.40e	2.27c	6.86d
	Green yellow	4.17c	74.0b	264.2b	8.43c	0.63ab	4.30a	2.39e	2.55c	6.88d
	Yellow ripe	3.05c	62.8ab	259.3b	4.31ab	0.59ab	4.31ab	2.51d	2.46c	7.03d
Netted cloth bags	Mature green	4.22b	66.6c	261.7c	8.07b	0.62ab	4.23b	2.61d	2.53b	7.07b
	Green yellow	5.04b	66.5c	262.3c	9.06b	0.65a	4.20b	2.60d	2.85b	7.09b
	Yellow ripe	3.92ab	60.5b	257.9b	4.20c	0.55b	4.20c	2.73cd	2.73bc	7.24b
LSD values		0.3841	0.4164	2.116	0.3917	0.0863	0.0865	0.2151	0.1527	0.0530

*mature green after 15 days, green yellow after 7 days and yellow ripe after 4 days
Means within a column having same letters are statistically non-significant using Least Significant Difference Test
FWL= Fruit Weight Loss; AA= Ascorbic Acid; TSS= Total Soluble Solids; TA= Titratable Acidity; RS= Reducing Sugars; NRS= Non Reducing Sugars; TS= Total Sugars

Reducing Sugars (%)

From the data presented in the Table 2 it is evident that highest reducing sugar contents were observed in fruits developed under perforated polyethylene bags on trees before harvest (3.45%, 3.44% and 3.42%) and followed by uncovered fruits (3.12%, 3.11% and 3.26%) in mature green, green yellow and yellow ripe stage, respectively. The lowest reducing sugars content was observed in muslin cloth bagged fruits with values of 2.40%, 2.39% and 2.51% in three stages respectively, at ripening.

Non Reducing Sugars

The highest non reducing sugar contents were observed in case of fruit covered with perforated polyethylene bags on the tree (2.69, 3.03 and 2.90%) in mature green, green yellow stage and yellow ripe stage, respectively. The lowest was observed in the control fruit treatments (2.17%, 2.44% and 2.35%) and the fruits developed under muslin cloth bags (2.27%, 2.55% and 2.46%, respectively).

Total Sugars

Data in Table 1 shows that highest total sugar contents were observed in case of fruit covered with perforated polyethylene bags on trees (7.18%, 7.20% and 7.34%) for all three harvesting stages. The lowest was observed in the un-bagged fruits with values of 6.76%, 6.77% and 6.92% in the three stages respectively (Table 2).

Organoleptic Evaluation

Among the treatments perforated polyethylene bagged fruit had significantly higher scores in terms of taste, flavor, texture, aroma and pulp color, followed by the fruits developed under news paper bags (Table 3). However, control fruits had lowest values for organoleptic characteristics. Yellow ripe stage had significantly higher organoleptic values followed by green yellow and mature green stage.

Economics of Bagging Materials

The BCR indicated that all bagging techniques were cost effective, benefiting the farmer, yielding crop with optimum profits and incurring lesser costs to the farmers. BCR indicator varies with bagging technique. BCR was the highest for perforated polyethylene bags (21.02) followed by newspapers bags having BCR of 4.53.

Table 3: Effect of different bagging treatments on organoleptic evaluation of guava fruit at ripening stage*

Treatments	Maturity stages	Flavor	Aroma	Taste	Texture	Pulp colour
Control	Mature green	6.17 d	5.96 d	5.21 d	6.10 e	5.80 c
	Green yellow	6.52 cd	6.50 cd	6.77 b	6.50 e	6.56 bc
	Yellow ripe	6.62 c	6.40 e	7.15 c	6.66 e	6.83 c
Newspaper bags	Mature green	6.68 b	6.70 ab	6.44 ab	6.45 d	6.03 b
	Green yellow	7.00 b	6.88 b	7.14 a	7.13 b	6.92 b
	Yellow ripe	7.18 ab	7.07 b	7.39 b	7.11 b	6.99 bc
Perforated polyethylene bags	Mature green	7.05 a	7.02 a	6.70 a	7.14 a	6.22 a
	Green yellow	7.47 a	7.34 a	7.40 a	7.39 a	7.31 a
	Yellow ripe	7.64 a	7.58 a	7.85 a	7.59 a	7.66 a
Muslin cloth bags	Mature green	6.51 bc	6.48 bc	6.20 bc	6.74 b	5.61 d
	Green yellow	6.40 d	6.42 d	6.52 b	6.69 d	6.71 bc
	Yellow ripe	6.95 bc	6.63 d	6.82 e	6.73 d	7.81 b
Netted cloth bags	Mature green	6.28 cd	6.20 cd	5.95 c	6.59 c	5.83 c
	Green yellow	6.72 bc	6.71 bc	6.68 b	6.91 c	6.49 c
	Yellow ripe	6.86 bc	6.79 c	6.96 d	6.92 c	6.89 c
LSD values		0.39	0.23	0.22	0. 65	0.38

*Mature green after 15 days, green yellow after 7 days and yellow ripe after 4 days
Means within a column having same letters are statistically non-significant using Least Significant Difference Test

Table 4: Economics of on tree fruit bagging materials for 1 acre land

Technique/ Control	Fixed cost (Rs.)	Variable cost (Rs.)	Total cost/TC (Rs.)	Yield per tree (kg)	Yield per acre (kg)	Price (Rs./kg)	Total return/TR (Rs.)	Profit TR-TC (Rs.)	Benefit cost ratio (BCR)
Control	2000	11070	13070	14.08	1591.04	30	47731.2	34661.2	3.65
Perforated polyethylene bags	2500	21686	24186	56.25	6356.25	80	508500	484314	21.02
Newspaper bags	2500	102535	105035	56.25	6356.25	75	476718.75	371683.75	4.53
Netted cloth bags	2500	203663	206163	56.25	6356.25	75	476718.75	270555.75	2.31
Muslin cloth bags	2500	130073	132573	56.25	6356.25	75	476718.75	344145.75	3.60

Discussion

Bagging of many fruits is one of the necessary techniques for producing quality fruits and had been universally adopted in the fruit production (Zhai *et al*., 2006). Nearly all fruit fly species are quarantine pests (Abbasi *et al*., 2009). Most of the countries importing the fruit require the fruit must be bagged (Qin *et al*., 2012). The results of the study indicate that the treated fruit significantly reduced the incidence of disease and damage caused by fruit fly and diseases which causes direct damage by puncturing the fruit skin to lay eggs. Fruit in paper is used in several Asian countries for fruit fly control. The results are in line with the findings of Jackson (1980) who reported that bagging is used in late mango verities to control the insect pest problem. The results clearly revealed that the bags act as a physical barrier between the fruit flies and the fruit, hence, minimizing the attack and losses to the fruit. Moreover, it is also reported that damage level may be reduced from 15-100% by bagging (Allwood, 2001). Similarly, Sierra *et al*. (2001) described bagging an effective control method for fruit fly, achieving 100% control in two season's star fruit.

Large number of physiological, biochemical and structural changes occur during the ripening of fruit which include the degradation of starch or other stored polysaccharides, production of sugars, synthesis of pigments and volatile compounds and the partial solubilization of cell wall (Dhawan *et al*., 2003). All these changes lead towards the weaker epidermis and ultimately the loss of water from the commodity. Less weight loss in fruits during postharvest period which were previously covered with newspaper bags on tree might be due to firmer fruit and delay in ripening.

Softening and weight loss are considered as the major issues during storage of the fruit. In the present study bagging treatments significantly reduced softening, weight loss and other physiological and biochemical activities of the fruit during ripening. Puncturing of the fruit by fruit fly is very common especially in case of guava which accelerates the softening as any physical injury can stimulate the production of ethylene. Bagging has been shown to protect fruits from insect attack (Amarante *et al*., 2002b), which could possibly the main reason of firmness maintenance in the treated fruit. Bagging of fruit reduced fruit firmness in the postharvest stage for bananas (Berill, 1956), while it had no effect on firmness at harvest although it enhanced loss of firmness during cold storage for pears (Amarante *et al*., 2002a). The variable results reported on the effect of bagging on fruit firmness at harvest and postharvest stage may reflect differences in the cultivar, type of bag, duration of cover and storage conditions. In mangoes, opaque white plastic bags hastened softening of the skin while white waterproof paper bags did not have this effect (Joyce *et al*., 1997).

It is clearly visible from the data that as fruit moves from mature green towards yellow ripe, there is slight increase in the contents of ascorbic acid and ultimately there is a decline in the overall content. This specially relates to guava, which contains a large pool of ascorbic acid as compared to most fruits. Ascorbic acid in mature green guavas of spring summer season increased during storage followed by a decrease in over ripe fruit (Silva *et al*., 1998). Ascorbic acid contents of stored fruits decreased due to utilization of organic acids during respiration (Kader, 2002). The reason for the lower changes in ascorbic acid and titratable acidity in fruits developed in bags could be the fact that in bagged fruits, metabolic activities were slower due to modified atmosphere and in turn the delay of ripening. During ripening of fruits, carbohydrates undergo metabolic trpansformation, both qualitatively and quantitatively. Starch is completely hydrolysed to glucose, fructose and sucrose in climacteric fruits including apple, mango and banana as ripening progresses (Mattoo *et al*., 1975; Tafera *et al*., 2008). Padmavathamma and Hulamani (1996) also found that sugars varied significantly in pomegranate fruit with different polyethylene bagging treatments.

Sugars and acidity is frequently used as a sign of maturity (Bhattacharya, 2004). Fruit with higher acidity retains the flavor (Ulrich, 1970). Organic acids which are found in fruit are malic, citric and quinic acid. These have a significant effect on taste and flavor of fruit. With the passage of time these organic acids and sugars are consumed during ripening in the process of respiration ultimately affecting the taste and flavor of fruit. During the storage period it is observed that acidity decreases with the advancement of ripening. Ramana *et al*. (1979) observed that during the storage, change in acidity occurs due to increase in metabolic activities of living tissues. It is also studied that malic acid degrades first followed by citric acid, ultimately reducing titratable acidity (Mattoo *et al*., 1975; Salunkhe and Desai, 1984). From the results it is clear that bagging treatments significantly retained physico-chemical properties ultimately maintaining the organoleptic characteristics. The possible reason might be the change in the microenvironment caused by the bagging treatments on the tree which ultimately led to slow down the metabolic activities during storage. Degradation of AA proceeds both aerobic and anaerobic pathways (Huelin, 1953; Johnson *et al*., 1995) and depends upon many factors such as exposure to light (Robertson and Samaniego, 1986), storage temperature and storage time (Fellers, 1988; Gordon and Samaniego-Esguerra, 1990). The results from this study indicate that newspaper bagging maintained higher levels of ascorbic acid which might be because of protection of the fruit from light, whereas perforated polyethylene and netted clothed bagging could not protect the fruit hence the fruit bagged with these treatments lost the amount of ascorbic acid significantly along with the control.

From the results it is clear that the yellow ripe fruit is liked by the consumer because of better sensual characteristics, but due to short shelf life the yellow ripe fruit is only approachable in the local market. On the other hand green yellow and mature green, performed better in the context of shelf life. Keeping in view it can be concluded that mature green and green yellow can be ideal stages for transportation of the fruit to the distant markets.

The newspaper bags were having cheapest material but lesser durability as compared to perforated polyethylene bags. In case of news paper bags repeated bagging was done (increasing material as well as labour cost) whenever were torn off by rains and winds, so raised cost than polyethylene (Table 4). The overall costs of the bagging treatments are affordable and the benefits are greater as the bad quality of the untreated fruit could not get customers attention.

This study concludes that perforated polyethylene bagging technique on tree gives maximum protection to fruit from the heavy attack of fruit fly during summer leading to better quality of guava fruit with maximum benefit cost ratio (BCR). Further research on canopy management by pruning can help to facilitate the bagging operation. This technique can be helpful for production of organic fruits. As for as harvest maturity is concerned, green yellow with semi-firm stage is more acceptable for sensory attributes as well as reasonable storability.

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