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Effect of Pre-Harvest Fruit Bagging on Fruit Quality Characteristics of Different Guava Cultivars during Rainy Season

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Authors' contributions

This work was carried out in collaboration among all authors. Authors MB and RKG did the conceptualization, methodology, investigation, writing-original draft preparation of the manuscript. Author CV did the reviewing and editing of the study. Authors Vikalp, Sukrampal and AS did the reviewing the final draft and editing of the manuscript. All authors contributed to the article and approved the submitted version. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was carried out on 6-7 years old grafted guava plants at Guava Demonstration Centre, Bhuna, Haryana, India during the rainy season (2019-20). During the experiment, the fruits of different guava cultivars *viz*. Hisar Safeda, Hisar Surkha, Allahabad Safeda, and Shweta were bagged with different bagging materials immediately after the fruit set.

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Results showed that the fruits bagged with blue polythene exhibited maximum fruit volume (113.96 ml) and organoleptic score (8.8), while the minimum (95.30 ml and 6.3, respectively) values were observed in the control. The highest fruit firmness (6.62 Kg/cm^2) was observed with green polythene, while the minimum (5.03 Kg/cm^2) was in control. Additionally, bagged fruits showed better peel colour development. The fruit drop was also reduced in all treatments except for the control (20%), yellow paper (12.78%), and green paper (11.66%). Fruit drop was minimum in transparent polythene (5.55%) and green polythene. On the other hand, Decay loss was eliminated in yellow paper, green paper, blue paper, cotton cloth, and muslin cloth bags, and significantly reduced in all the treatments except the control (8.88%). Among the cultivars, the maximum fruit firmness (5.98 Kg/cm^2) was recorded in Hisar Safeda, whereas the least firmness (5.64 Kg/cm^2) was in Allahabad Safeda. In conclusion, pre-harvest bagging of fruits was found promising in enhancing the quality attributes of various guava cultivars which can also be applied in real farm situations to enhance the yield as well as the quality of guava crop.

Keywords: Cloth bags; infected fruits; polythene bags; paper bags.

1. INTRODUCTION

Guava (*Psidium guajava* L.), a member of the family Myrtaceae, is also known as 'Apple of tropics' as its nutritive value is equivalent to that of an apple. It is widely grown in the tropical and subtropical regions of the world. It is one of the most common and well-distributed fruit crops in the Indian subcontinent. Concerning its area and production, it ranks next to mango, banana and citrus. During its growth and developmental periods, the fruits became highly susceptible to insect-pest infestations, diseases, birds as well as mechanical damage, resulting in the reduction of their commercial value and ultimately causing significant economic losses [1].

Under North-Indian conditions, guava produces two crops *i.e.*, rainy and winter season crops annually. The winter season crop is generally, superior in quality to the rainy season crop as it is severely infested with the fruit fly (*Bactrocera correcta* Bezzi), anthracnose (*Colletotrichum gloeosporioides* Penz.) disease, and bird's attacks [2,3]. In the month of April, the population of fruit flies starts to build up in the orchards and continues up to November in different fruit crops. Due to the presence of a wide range of hosts, a large number of generations per year, high mobility of adults, and high fecundity; their management become very difficult in the orchards. Moreover, all the developmental stages of fruit flies are unexposed *viz.* eggs and larvae are present inside the fruits, whereas, pupae are buried in the soil [4,5]. Therefore, the application of insecticides does not prove effective against fruit flies. Hence, bagging is considered an eco-friendly alternative, which can act as a physical barrier between fruit and the environment, subsequently protecting the fruit from fruit flies, diseases, mechanical damage, sunburning as well as bird damage [6,1,7]. This technique generally applied to many fruits improves the visual quality of fruits not only through the promotion of colour, however, also through the reduction of the incidence of cracking and russeting [1]. This technique confers the bagging of individual fruit or a fruit bunch on the tree for a specific period. Bagging beneficially changes the micro-environment inside the bag which also exerts a beneficial impact on fruit size and internal fruit quality [8,9,10]. However, the selection of bagging material and time of fruit bagging is of utmost importance for getting better results [11,12]. Thus, the present investigation was conducted to evaluate the use of different bagging materials on various quality parameters of guava fruits.

2. MATERIALS AND METHODS

2.1 Experimental Site

The present study was carried out at the farms of the Guava Demonstration Centre, Bhuna, Haryana, India. Which is situated at 29° 32' latitude, 75° 42' and longitudes 222 m above mean sea level. The temperature varies from 40 °C to 48 °C during summer to as low as to freezing point accompanied by chilling frost in winter. The approximate average rainfall is 450 mm, most of which is received mainly during the South-West monsoon (i.e., July to September), while few showers also occur from December to February due to western disturbances. The physiological analysis of fruits was done at PG-Lab (Department of Horticulture), CCS Haryana Agricultural University, Hisar.

2.2 Experimental Details

In the present investigation, well-grown grafted plants of 4 different cultivars *viz.* Hisar Safeda, Hisar Surkha, Allahabad Safeda and Shweta were selected for the experiment. All the selected plants were of the same size and vigour with an age of 6 to 7 years old, planted at a geometry of 3 x 6 m on raised bunds with drip irrigation facilities. Trees were well maintained, regularly pruned and subjected to the recommended cultural practices i.e., irrigation, fertilization, weeding, insect pest and disease management.

Table 1. Treatments details

Treatments	Description
T_1	White paper bag
T_2	Red paper bag
T_3	Yellow paper bag
T_4	Green paper bag
T_5	Blue paper bag
T_6	Brown paper bag
T_7	Newspaper bag
T_8	Transparent polythene bag
T_9	White polythene bag
T_{10}	Pink polythene bag
T_{11}	Yellow polythene bag
T_{12}	Green polythene bag
T_{13}	Blue polythene bag
T_{14}	Cotton cloth bag
T_{15}	Muslin cloth bag
T_{16}	Control (unbagged)

Fifteen uniform-sized fruits were bagged immediately after fruit set each on three plants (replications) with different materials as per treatment schedule (Table 1). Five fruits from each plant, *i.e.,* 15 fruits (from 3 replications) were harvested from each cultivar for each treatment and subsequently analysed for different parameters as mentioned in the next section. The harvesting time of fruits among the treatments was same, however, varied among cultivars.

2.3 Evaluation of Physiological Parameters

2.3.1 Fruit volume (ml)

Fruit volume was measured by the water displacement method in which the fruits were dipped in a calibrated measuring cylinder filled with water and an increase in the water level after dipping of the fruit was recorded and the values were expressed as milliliters.

2.3.2 Fruit firmness (kg/cm^2)

A penetrometer with a cylindrical plunger probe of 4 mm was used for measuring the fruit's firmness. It is measured by making a puncture on the fruit's stem end and expressed in kg/cm^2.

2.3.3 Decay loss (%)

The decay of fruits was decided based on visual observations. Decay loss was evaluated by simply counting the number of spoiled fruits displaying fungal mycelia or sporulation and expressed as per cent spoilage of fruits.

$$Decay\ loss\ (\%) = \frac{Number\ of\ spoiled\ fruits}{Total\ number\ of\ fruits} x\ 100$$

2.3.4 Fruit drop (%)

The fruit drop percentage was calculated by counting the number of bagged fruit present on the plant at the time of harvest. Fruit drop (%) was calculated by the following formula:

$$Fruit\ drop\ (\%) = \frac{Initial\ number\ of\ fruits\ bagged - Bagged\ fruit\ remained\ on\ plant}{Initial\ number\ of\ fruits\ bagged} x\ 100$$

2.3.5 Organoleptic quality

The fruits were evaluated for organoleptic quality based on their appearance, taste, mouthfeel, aroma, and overall acceptability by a panel of 10 semi-trained members (5 males and 5 females, 23-45 years old) from the Department of Horticulture, CCSHAU, Hisar, India using a 9-point hedonic scale. On the scale, 9 stands for Liked extremely and 1 stands for dislike extremely [13].

Table 2. The ranking based on 9 points hedonic rating scale is given below

Acceptability	Marks
Extremely desirable	9
Very much desirable	8
Moderately desirable	7
Slightly desirable	6
Neither desirable nor undesirable	5
Slightly undesirable	4

2.3.6 Fruit colour

Colour of the fruit was observed visually by a team of 10 judges. The colour observations *i.e.,* greenish yellow, yellowish green, light yellow and light green were recorded.

2.4 Statistical Analysis

The data were statistically analyzed in Randomized Block Design using SPSS software (IBM, SPSS Inc., USA). The p-values were calculated and the results were expressed as CD at 5% level of significance. Data were subjected to two-way ANOVA.

3. RESULTS AND DISCUSSION

3.1 Fruit Volume (ml)

It is evident from Table 3 that different treatments influenced the fruit volume significantly. The maximum volume was observed in the fruits bagged with blue polythene, it was statistically at par with fruits bagged in green polythene (112.63 ml), cotton cloth (111.7 ml) and yellow polythene (109.32 ml), whereas the minimum fruit volume (95.3 ml) was in unbagged (control) fruits, it was statistically at par with fruit bagged in pink polythene (96.52 ml), white polythene (99.98 ml) and white paper (100.38 ml). The maximum fruit volume (127.81 ml) among the cultivars was observed in fruits of Shweta as compared to Hisar Surkha which had minimum fruit volume (92.28 ml). The improved fruit volume might be due to increased relative humidity and development of a favorable microclimate inside the bags, which resulted in better growth and development of fruits [14]. These results were in close conformity with the earlier findings of [15] in bagged date palm fruits.

3.2 Fruit Firmness (Kg/cm^2)

The data pertaining to fruit firmness is presented in Table 3 showed that the maximum fruit firmness was observed in fruits bagged in green polythene bags (6.62 Kg/cm^2) as compared to the control (5.03 Kg/cm^2), it was statistically at par with fruits bagged in blue polythene bag (5.15 Kg/cm^2). Among the cultivars, the maximum firmness was reported in fruits of Hisar Safeda (5.98 Kg/cm^2), while the minimum firmness was in fruits of Allahabad Safeda (5.64 Kg/cm^2). Breakdown of starch, cell wall or reduction in the middle lamella by solubilization of pectic substances leads to a reduction in fruit firmness. Whereas, increased fruit firmness might be due to the better stability of the cell wall, middle lamella and increase in pectin content under bagging conditions [14]. The results of the present study were in line with [16] in bagged 'Granny Smith' apples and [17] in bagged 'Delicious' apples.

3.3 Decay Loss (%)

The data on infected fruits, as influenced by different bagging treatments in different cultivars, have been presented in Table 4. The revealed that the infected fruits (decay loss) were observed at maximum (8.88%) in unbagged fruits, whereas it had been completely controlled in the fruits bagged with yellow paper or green paper or blue paper or cotton cloth and muslin cloth, it was statistically at par with fruits bagged in other bagging materials *i.e.,* white paper (0.56%), red paper (0.56%), brown paper (0.56%), newspaper (0.56%), yellow polythene (0.56%), blue polythene (1.11%) and pink polythene (1.67%). As per previous documentation, bagging maintains a physical barrier between fruits and the environment, leading the fruits to be free from damage by fruit flies, birds, pests and diseases, which results in the reduction of infected fruits [1]. Similar results were obtained by [18] and [10] in guava fruits.

3.4 Fruit Drop (%)

The fruit drop varied significantly with different treatments as shown in Table 4. The maximum fruit drop (20%) was observed in unbagged fruits, whereas the minimum fruit drop was observed in fruits bagged with transparent polythene and green polythene (5.55%), it was at par with fruits bagged in blue polythene bags (6.11%), muslin cloth bags (6.66%), cotton cloth bags (7.22%), newspaper bags (8.33%), red paper bags (8.88%), white paper bags (9.44%), blue paper bags (9.44%), brown paper bags (9.44%), white polythene bags (9.44%), pink polythene bags (9.44%) and yellow polythene

Table 3. Effect of pre-harvest fruit bagging on volume (ml) and firmness (Kg/cm^2) of different guava cultivars in rainy season crop (2019-20)

Sr. No	Treatments	Volume (ml)					Firmness (Kg/cm^2)				
		Hisar Safeda	Hisar Surkha	Allahabad Safeda	Shweta	Mean	Hisar Safeda	Hisar Surkha	Allahabad Safeda	Shweta	Mean
T_1	White paper bag	95.88	87.13	92.58	125.93	100.38	5.83	5.68	5.55	5.66	5.68
T_2	Red paper bag	105.84	93.30	97.88	129.99	106.75	6.42	6.23	6.08	6.22	6.24
T_3	Yellow paperbag	103.06	91.99	96.82	129.45	105.33	5.67	5.56	5.46	5.53	5.56
T_4	Green paper bag	107.41	95.79	98.74	132.65	108.65	6.47	6.31	6.23	6.38	6.35
T_5	Blue paper bag	109.96	97.56	100.26	127.27	108.76	5.98	5.75	5.61	5.74	5.77
T_6	Brown paper bag	98.78	86.64	90.74	126.54	100.68	6.11	5.78	5.74	5.75	5.85
T_7	Newspaper bag	98.37	88.11	93.78	122.08	100.59	5.47	5.29	5.18	5.35	5.32
T_8	Transparent polythene bag	100.21	92.33	91.47	123.02	101.76	6.38	6.15	5.95	6.03	6.13
T_9	White polythene bag	97.52	89.21	90.36	122.83	99.98	6.31	5.89	5.83	5.89	5.98
T_{10}	Pink polythene bag	93.86	84.45	87.73	120.04	96.52	5.54	5.43	5.27	5.48	5.43
T_{11}	Yellow polythene bag	108.85	97.33	99.47	131.63	109.32	6.61	6.44	6.29	6.49	6.46
T_{12}	Green polythenebag	111.32	100.72	102.20	136.27	112.63	6.82	6.56	6.49	6.59	6.62
T_{13}	Blue polythene bag	112.13	99.92	105.76	138.02	113.96	5.27	5.13	4.96	5.23	5.15
T_{14}	Cotton cloth bag	111.94	97.45	103.56	133.84	111.70	5.42	5.23	5.06	5.11	5.21
T_{15}	Muslin cloth bag	101.14	91.62	95.65	126.89	103.82	6.24	5.91	5.73	5.77	5.91
T_{16}	Control (unbagged)	92.40	83.00	86.29	117.51	95.30	5.21	4.99	4.88	5.02	5.03
Treatment Mean		103.04	92.28	95.89	127.81		5.98	5.77	5.64	5.77	
C.D. (p=0.05)		**Treatments (T)** =5.08, **Cultivars (C)** = 2.54, **T x C** = NS					**Treatments (T)** = 0.12, **Cultivars (C)** = 0.06, **T x C** = NS				

Table 4. Effect of pre-harvest fruit bagging on decay loss (%) and fruit drop (%) of different guava cultivars in rainy season crop (2019-20)

Sr. No	Treatments	Decay loss (%)					Fruit drop (%)				
		Hisar Safeda	Hisar Surkha	Allahabad Safeda	Shweta	Mean	Hisar Safeda	Hisar Surkha	Allahabad Safeda	Shweta	Mean
T_1	White paper bag	2.22	0.00	0.00	0.00	0.56	8.88	8.89	8.88	11.11	9.44
T_2	Red paper bag	0.00	0.00	2.22	0.00	0.56	8.88	11.11	6.66	8.88	8.88
T_3	Yellow paper bag	0.00	0.00	0.00	0.00	0.00	13.33	13.33	11.11	13.33	12.78
T_4	Green paper bag	0.00	0.00	0.00	0.00	0.00	13.33	11.11	11.11	11.11	11.66
T_5	Blue paper bag	0.00	0.00	0.00	0.00	0.00	8.88	13.33	6.66	8.88	9.44
T_6	Brown paper bag	0.00	0.00	2.22	0.00	0.56	6.66	11.11	6.66	13.33	9.44
T_7	Newspaper bag	0.00	2.22	0.00	0.00	0.56	6.66	6.66	13.33	6.66	8.33
T_8	Transparent polythene bag	2.22	2.22	2.22	2.22	2.22	4.44	4.44	6.66	6.66	5.55
T_9	White polythene bag	4.44	6.66	2.22	2.22	3.89	13.33	6.66	8.88	8.88	9.44
T_{10}	Pink polythene bag	2.22	0.00	0.00	4.44	1.67	11.11	4.44	13.33	8.88	9.44
T_{11}	Yellow polythene bag	0.00	0.00	2.22	0.00	0.56	13.33	6.66	11.11	8.88	10.00
T_{12}	Green polythene bag	0.00	2.22	4.44	2.22	2.22	6.66	4.44	4.44	6.66	5.55
T_{13}	Blue polythene bag	2.22	2.22	0.00	0.00	1.11	4.44	6.66	6.66	6.66	6.11
T_{14}	Cotton cloth bag	0.00	0.00	0.00	0.00	0.00	8.89	8.89	6.66	4.44	7.22
T_{15}	Muslin cloth bag	0.00	0.00	0.00	0.00	0.00	4.44	6.67	8.88	6.66	6.66
T_{16}	Control (unbagged)	8.88	11.11	8.88	6.66	8.88	20.00	15.55	22.22	22.22	20.00
Treatment Mean		1.39	1.67	1.53	1.11			8.75	9.58	9.58	
C.D. (p=0.05)		**Treatments (T)** = 2.18, **Cultivars (C)** = NS, **T x C** = NS					**Treatments (T)** = 4.68, **Cultivars (C)** = NS, **T x C** = NS				

Table 5. Effect of pre-harvest fruit bagging on the organoleptic score and fruit colour of different guava cultivars in rainy season crop (2019-20)

Sr. No	Treatments	Organoleptic score					Fruit Colour			
		Hisar Safeda	Hisar Surkha	Allahabad Safeda	Shweta	Mean	Hisar Safeda	Hisar Surkha	Allahabad Safeda	Shweta
T_1	White paper bag	6.8	6.9	6.5	7.2	6.9	Yellowish green	Yellowish green	Yellowish green	Yellowish green
T_2	Red paper bag	7.5	7.9	7.9	7.8	7.8	Yellowish green	Yellowish green	Yellowish green	Yellowish green
T_3	Yellow paperbag	7.8	7.5	7.9	7.8	7.8	Greenish Yellow	Yellowish green	Greenish Yellow	Yellowish green
T_4	Green paper bag	8.1	7.9	7.2	8.1	7.8	Greenish Yellow	Yellowish green	Greenish Yellow	Yellowish green
T_5	Blue paper bag	8.1	8.2	8.2	7.5	8.0	Light Yellow	Light green	Light Green	Greenish Yellow
T_6	Brown paper bag	7.1	6.9	6.9	7.3	7.0	Greenish Yellow	Yellowish Green	Yellowish green	Yellowish green
T_7	Newspaper bag	6.8	6.9	7.5	6.9	7.0	Yellowish green	Yellowish green	Yellowish green	Yellowish green
T_8	Transparent polythene bag	7.5	7.5	7.2	6.5	7.2	Light Yellow	Yellowish green	Yellowish green	Yellowish green
T_9	White polythene bag	6.8	7.1	6.9	6.6	6.9	Yellowish green	Yellowish green	Yellowish green	Yellowish green
T_{10}	Pink polythene bag	6.8	6.9	6.9	6.2	6.7	Yellowish green	Greenish Yellow	Yellowish green	Yellowish green
T_{11}	Yellow polythene bag	8.1	8.1	7.5	8.1	8.0	Light Yellow	Light green	Light Green	Greenish Yellow
T_{12}	Green polythene bag	8.5	8.5	8.2	8.6	8.5	Light Green	Light Yellow	Light Green	Light Yellow
T_{13}	Blue polythene bag	8.8	8.9	8.9	8.5	8.8	Light Green	Light Green	Light Green	Light Green
T_{14}	Cotton cloth bag	8.5	8.9	7.9	8.9	8.5	Light Green	Light Yellow	Light Green	Light Yellow
T_{15}	Muslin cloth bag	7.8	7.8	7.9	7.3	7.7	Greenish Yellow	Yellowish green	Greenish Yellow	Yellowish green
T_{16}	Control (unbagged)	6.5	6.5	6.2	6.1	6.3	Greenish Yellow	Greenish Yellow	Greenish Yellow	Greenish Yellow
Treatment Mean		7.6	7.6	7.5	7.5					
C.D. (p=0.05)		**Treatments (T)** = 0.35, **Cultivars (C)** = NS, **T x C** = 0.70								

bags (10%). It might be due to perforations made in these bags allowing free circulation of air and did not allow to build up an excess temperature and relative humidity in bags [10]. The results of the present study were in agreement with [19,20] in bagged mango fruits.

3.5 Organoleptic Score

Organoleptic score varied significantly among the treatments and the highest organoleptic score was assigned to fruits bagged in blue polythene bags (8.8), which was statistically at par with the fruits bagged in cotton cloth (8.5) and green polythene (8.5) as compared to the minimum in fruits of control (6.3) (Table 5). Among various cultivars, the organoleptic score was found non-significant, while the interaction was found significant. It might be due to the fact that pre-harvest bagging improves the internal fruit quality by reducing blemishes and micro-environment alterations within fruits during fruit development phase [1]. Similar results were also obtained by [21] in bagged guava and [22] in mango fruits.

3.6 Fruit Colour

Data presented in Table 5 showed that fruits bagged with blue paper, yellow polythene, green polythene, blue polythene, and cotton cloth showed better peel colour (Light green and light yellow) development as compared to the other treatments. The peel colour of fruit has a close relationship with the sensitivity of fruits to light and the rate of anthocyanin biosynthesis in fruit peel during fruit development phase. Bagging modifies the light quality and quantity inside the bag which might result in better peel colour development [23]. Similar results were obtained by [24] in bagged guava, [6,25] in mango and [26] in 'Perla' grapes.

4. CONCLUSION

The study demonstrated that pre-harvest bagging of guava fruits with different materials can significantly improve the quality attributes of various guava cultivars. The use of blue polythene bags resulted in the highest fruit volume and organoleptic score, while green polythene bags exhibited the highest fruit firmness. The bagged fruits also showed better peel color development, reduced fruit drop, and decay loss. These findings suggest that pre-harvest bagging can be an effective technique to enhance the yield and quality of guava crops, and can be practically applied in real farm situations. However, further research is needed to explore the long-term effects of pre-harvest bagging on the guava crop and its economic feasibility.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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