



Impact of pre-harvest fruit bagging on visual appeal, texture and yield attributes of guava (*Psidium guajava* L.) cv. Lucknow-49

Abdullah Zaid¹, Bijendra Kumar Singh^{2*}, Anand Singh³, Vigya Mishra⁴ and Bhawna Singh⁵

^{1&5}Research Scholars, Department of Fruit Science, Banda University of Agriculture & Technology, Banda 210001, Uttar Pradesh, India

ABSTRACT

Pre-harvest fruit bagging is an eco-friendly technique that can improve fruit quality and appearance by modifying the microenvironment surrounding developing fruits. The present investigation was conducted during 2022–23 at Banda University of Agriculture and Technology, Banda, Uttar Pradesh, to evaluate the effects of different bagging materials on the visual appeal, texture, and yield attributes of guava (*Psidium guajava* L.) cv. Lucknow-49. Eight treatments, including newspaper, butter paper, transparent polythene, black polythene, yellow polythene, brown paper, non-woven bags, and an unbagged control, were evaluated in a randomized block design with three replications. Significant differences were observed among treatments for fruit colour, texture, and yield attributes. Transparent polythene bagging produced the brightest fruits ($L^* = 60.45$), while brown paper bags recorded the highest redness ($a^* = 5.62$). Unbagged fruits exhibited the highest yellowness ($b^* = 23.45$). Yellow polythene bags produced the firmest fruits, with maximum hardness (987.09), gumminess (609.92), and chewiness (693.78). Non-woven bagging proved superior for most yield attributes, resulting in earlier maturity (66.00 days), highest yield (27.61 kg/plant), fruit length (8.98 cm), diameter (9.07 cm), weight (201.04 g), volume (199.88 cc), flesh thickness (4.27 cm), and pulp weight (152.83 g). Brown paper bags recorded the highest seed number (169.00). Overall, non-woven bags were most effective for improving yield and physical attributes, whereas transparent polythene and brown paper enhanced fruit colour and market appeal. Thus, pre-harvest bagging offers an effective non-chemical approach for improving guava yield and quality.

Key words: Bagging, guava, yellow polythene, non-woven bag, yield attributes.

INTRODUCTION

Guava (*Psidium guajava* L.) is a highly valued nutritional fruit crop belonging to the family Myrtaceae and is widely cultivated in tropical and subtropical regions of the world. It is often referred to as the “poor man’s apple” due to its affordability and exceptionally high nutritional value (Zaid *et al.*, 18). The guava fruit is an abundant source of vitamin C, dietary fiber, pectin, and other bioactive components like phenolic compounds and carotenoids which make them antioxidants (Srivastava *et al.*, 16). Because of the versatility in soil and weather, production efficiency, and short gestation period, guava holds a respectable position in the Indian fruit sector (Mitra & Bose, 10). The cultivation of guava in India is carried out under diverse agronomic and climatic zones resulting in the development of fruits in various seasons such as rain-fed, winter, and summer. Among these, the rain-fed guava fruit is of low quality because of moisture content, pest infestation, and diseases while

the winter crop yields fruits that are high quality with improved taste and shelf-life (Sharma *et al.*, 13). Another important factor limiting guava production includes infestations by fruit flies (*Bactrocera* spp.), other pests, diseases, and injuries that cause a reduction in yield as well as fruit quality. The traditional methods of controlling fruit flies include using chemical insecticides, but these have negative impacts on the environment and consumers due to accumulation of residues in the fruits (Singh, 14). Thus, sustainable practices are now being emphasized in order to increase fruit quality and decrease losses. One such practice includes pre-harvest bagging, which refers to a non-chemical method of encasing fruits in bags made of materials like paper, polyethylene, and non-woven fabric. Fruit bagging creates changes in the microclimate surrounding the fruit by affecting factors such as light intensity, temperature, and humidity. It results in improvement in fruit quality through reductions in pest and disease incidence as well as mechanical injuries and also produces better looking fruit (Amarante *et al.*, 1; Sharma *et al.*, 13). Bagging causes change in micro environment around growing guavas, thus affecting pigment formation and color of peel of fruit. Hunter colour Lab system

*Corresponding author email: bijendrahort@gmail.com

²Assistant Professor, Department of Fruit Science, Banda University of Agriculture & Technology, Banda

³Professor, Department of Fruit Science, Banda University of Agriculture & Technology, Banda

⁴Assistant Professor, Department of Post Harvest Technology, Banda University of Agriculture & Technology, Banda

is extensively employed for assessing the changes in coloration of the peels of fruits via L^* (brightness), a^* (red green), and b^* (yellow blue) scales. Guava peel color determination with Hunter Color Lab results in accurate measurement compared with visual assessment. Use of different bagging materials leads to changes in light penetration, temperature, and humidity, and hence affects the formation of chlorophyll in the peel of guavas. Thus, the use of Hunter Lab proves to be useful for assessing the effects of bagging on quality of guavas. Along with the protective role, pre-harvest bagging also affects texture of fruits for determining the preferences of consumers and the manner of handling fruits after harvest. Texture profile analysis (TPA) involves a number of quality criteria like firmness, cohesiveness, and chewiness to provide information on the structure of fruits. These traits have direct connections with the nature of cell walls, turgor pressure, and enzymic activities in fruits during the process of ripening. Pre-harvest measures like fruit bagging affect these traits because of changes brought about in the growing conditions of the fruits.

Lucknow-49 (Sardar) guava is an economically important cultivar widely grown in India because of its high productivity and desirable fruit characteristics, including round fruits, smooth skin, and good-quality pulp. However, under open-field conditions, guava fruits are often exposed to insect pests and adverse environmental conditions, which can adversely affect their external appearance, physical quality, and market value. Pre-harvest fruit bagging is an eco-friendly and non-chemical technique that modifies the microenvironment around developing fruits and has been reported to improve fruit size, weight, colour, maturity, and other quality attributes (Rahman *et al.*, 12).

Previous studies have demonstrated improvements in fruit maturity, yield, fruit length, diameter, weight, and volume following pre-harvest bagging. Improvements in these attributes may also influence related characteristics such as flesh thickness, seed cavity size, pulp weight, seed cavity weight, and seed number. However, although several studies have evaluated the effects of fruit bagging on yield and physical and physicochemical attributes, limited information is available on its influence on the detailed texture profile of guava fruits, particularly in cv. Lucknow-49. Recent studies have examined firmness and sensory texture, but comprehensive texture-profile analysis remains relatively less explored.

Therefore, the present study was undertaken to evaluate the effect of different pre-harvest fruit bagging materials on the visual appearance, texture profile, and yield attributes of guava cv. Lucknow-49.

MATERIALS AND METHODS

This study was carried out from 2022–2023 on guava cv. L-49 (Sardar), which were five years old and planted at 4 m × 4 m distance, at the Instructional Farm, College of Horticulture, Banda University of Agriculture and Technology, Banda, Uttar Pradesh, India. All trees were grown by following same cultural practices. The experiment consisted of a Randomized Block Design having seven treatments and three replications with control (non-bagged fruits). The healthy fruits without any injuries and pest attacks were chosen and covered with different bags after 60 days of fruit setting; each tree had 20 fruits. These treatments included T_1 : newspaper bag, T_2 : butter paper bag, T_3 : transparent polythene bag, T_4 : black polythene bag, T_5 : yellow polythene bag, T_6 : brown paper bag, T_7 : non-woven bag, and T_8 : uncovered fruits. The physical characteristics were assessed during harvesting. Fruit skin color was determined by using Hunter Color Lab (Flex EZ Spectrophotometer), set in reflectance mode ($45^\circ/0^\circ$ angle) with D65 illuminant and 10° standard observer settings. The spectrophotometer was calibrated with the help of standard white and black tiles prior to measurement of color. L^* , a^* and b^* value for skin color was determined; L^* value corresponds to lightness, a^* value corresponds to red (+) to green (-) while b^* value corresponds to yellow (+) to blue (-). Furthermore, texture profiles of guava fruit samples were analyzed by using a Texture Analyzer (TA.XT Express Connect) working on compression mode and provided with a compression platen probe with a diameter of 75 mm (P/75). This analysis was performed under a distance based trigger system where pre-test speed was 1.0 mm s^{-1} , test speed was 0.5 mm s^{-1} , and post-test speed was 5.0 mm s^{-1} . The compression distance of 5.0 mm representing 10% strain with 5 g trigger force and 25 points per second data rate was taken into consideration. The test sequence selected for texture analysis was “3 Hold Until Time”. Days taken to fruit maturity were counted in days. Fruit yield per tree was calculated by total number of fruits harvested from each experimental tree was recorded and multiplied by the average fruit weight to determine yield per plant. Fruit length was measured from the stalk side up to the calyx side through digital vernier calipers. On the other hand, the fruit's width was measured at its broadest point. Fruit weight was recorded using an electronic balance while the fruit volume was calculated based on the water displacement method. Specific gravity was computed as a ratio of the weight of the fruit to its volume. The flesh thickness was evaluated through measuring the transverse cut fruits using

**Table 1:** Impact of pre-harvest fruit bagging on visual appeal of guava cv. L-49.

Treatment	L*	a*	b*
T ₁	28.81	-0.03	12.96
T ₂	35.73	3.59	15.43
T ₃	60.45	4.96	22.56
T ₄	40.92	-6.14	17.22
T ₅	35.11	-5.01	14.63
T ₆	52.68	5.62	22.31
T ₇	51.42	-3.24	21.29
T ₈	52.82	-5.03	23.45

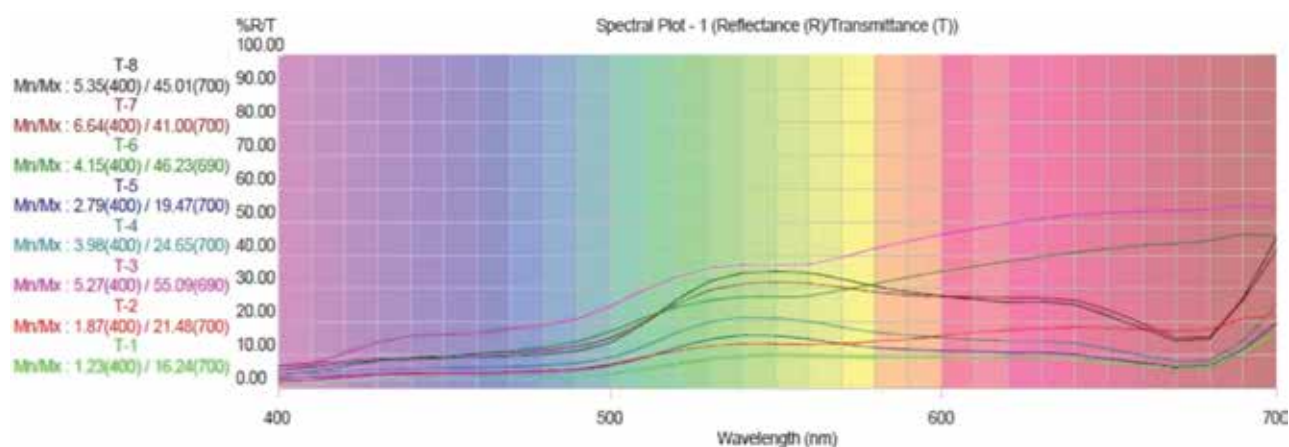
vernier calipers. Lastly, seed cavity was measured as the diameter of the seed cavity. Pulp weight was measured by the difference between total fruit weight and seed cavity weight. Seed cavity weight was recorded through electronic balance upon separation of seeds from pulp. Counting the seeds was done manually after separation of five fruits from their pulp for each replication.

RESULTS AND DISCUSSION

The visual appeal (L*, a*, b*) value differed markedly among treatments (Table 1 & Fig. 1). The highest lightness (L*) was recorded in Transparent polythene bag (T₃) (60.45) followed by control (T₈) (52.82), while the lowest value was observed in Newspaper bag (T₁) (28.81), indicating darker fruit appearance. Higher L* values under T₃ and T₆ suggest enhanced brightness and uniformity of peel colour, which is associated with advanced ripening and

improved market appeal (Lancaster *et al.*, 8; Pathare *et al.*, 11).

Positive a* values, indicating redness, were highest in Brown paper bag (T₆) (5.62) followed by Transparent polythene bag (T₃) (4.96), whereas negative a* values in Black polythene bag (T₄) (-6.14), Yellow polythene bag (T₅) (-5.01), and control (T₈) (-5.03) reflect greener peel colour and delayed chlorophyll degradation. The increase in a* values under T₃ and T₆ suggests greater synthesis of carotenoid pigments during ripening, contributing to improved visual quality and consumer preference (Gross, 3; Kays and Paull, 7). The highest b* values, representing yellowness, were recorded in control (T₈) (23.45) followed by Transparent polythene bag (T₃) (22.56) and Brown paper bag (T₆) (22.31), indicating enhanced carotenoid accumulation and optimum maturity development. Lower b* values in Newspaper bag (T₁) (12.96) suggest incomplete pigment transformation and relatively immature fruit colour development (Lancaster *et al.*, 8; Pathare *et al.*, 11). Collectively, treatments T₃, T₆, and T₈ improved peel brightness and yellow-red tonal

**Fig. 1.** Spectral reflectance and transmittance profiles of guava samples (Hunter Color Lab Analysis, 400–700 nm).

development, reflecting more effective chlorophyll degradation and carotenoid biosynthesis during ripening, thereby enhancing fruit marketability and consumer acceptance.

The results obtained by texture profile analysis revealed considerable variations among the different treatments in hardness, adhesiveness, cohesiveness, gumminess, and chewiness (Fig. 2). Yellow polythene bag (T_5) had the highest value in hardness (987.09) while the lowest value was found in black polythene bag (T_4) (268.91) and Transparent polythene bag (T_3) (297.33) (Table 2). The increased hardness value found in yellow polythene bag (T_5) implies that there is high rigidity in the fruit cell walls, as well as higher levels of structural polysaccharides like cellulose and pectin, leading to increased firmness and post-harvest longevity (Harker *et al.*, 4; Vicente *et al.*, 17). Fruits with increased hardness have been known to be more durable for long-term shelf-life and easy to handle during transport (Kays and Paull, 7). Adhesiveness was found to vary from -26.22 in Transparent polythene bag (T_3) to -1284.29 in yellow polythene bag (T_5). This indicates that there are significant differences between the different treatments in terms of fruit pulp stickiness and soluble pectin content. Furthermore, Newspaper bag (T_1) exhibited the highest cohesion (0.931) as it possessed the highest level of internal strength bonding among fruit tissues, while Transparent polythene bag (T_3) and (T_7) had lower levels of cohesion, implying that these treatments had weak structures, which could be attributed to high rates of enzyme decomposition of middle lamella pectins (Harker *et al.*, 4; Brummell and Harpster, 2). In addition, highest gumminess was

Table 2: Impact of pre-harvest fruit bagging on texture profile of guava cv. L-49.

Treatment	Hardness	Adhesiveness	Cohesiveness	Gumminess	Chewiness
T_1	669.905	-130.046	0.931	623.688	623.841
T_2	432.525	-46.192	0.151	65.486	65.502
T_3	297.325	-26.223	0.150	44.542	45.427
T_4	268.910	-32.440	0.181	48.653	48.665
T_5	987.088	-1284.291	0.618	609.915	693.778
T_6	919.648	-271.736	0.296	271.792	271.859
T_7	330.721	-33.453	0.152	50.155	50.167
T_8	840.934	-749.754	0.364	305.991	306.066
Average	593.382	-321.767	0.355	252.528	263.163
S.D.	296.742	459.660	0.283	247.697	265.999
C.V.	50.009	-142.885	79.595	98.087	101.078

observed in Newspaper bag (T_1) (623.688) followed by yellow polythene bag (T_5) (609.915) whereas lowest gumminess was observed in Transparent polythene bag (T_3) (44.542) and highest chewiness were observed in Yellow polythene bag (T_5) (693.778) followed by Newspaper bag (T_1) (623.841) and lowest chewiness was observed in Transparent polythene bag (T_3) (45.427). The higher gumminess and chewiness values in T_1 and T_5 indicate better physical stability and resilience of the fruit texture against deformation. On the other hand, the lower values

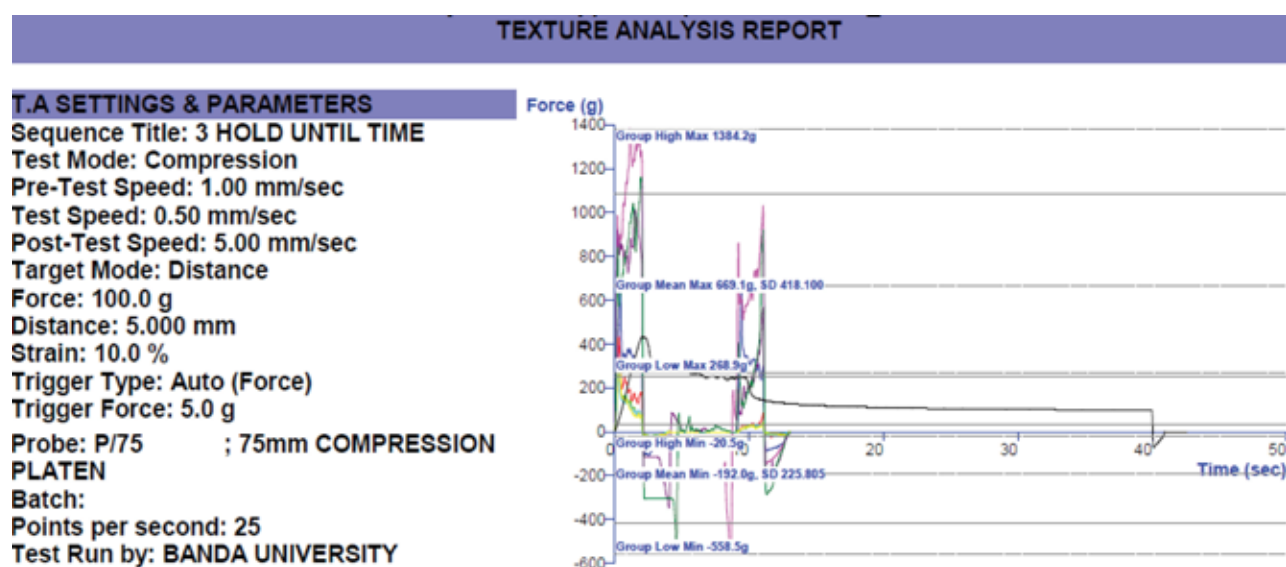


Fig. 2. TPA curve of guava showing force–time relationship under compression.

found in T_3 could signify poorer tissue organization and strength due to weaker interactions between cells, possibly resulting from their different genetic and environmental characteristics (Jain *et al.*, 6; Mitra, 9).

It is evident from (Table 3 & Fig. 3) that different bagging materials had significant effect on fruit maturity. Non-woven bags (T_7) mature earliest in 66 days followed by yellow polythene bag (T_5) in 70 days whereas control (T_8) takes maximum number of days (82) to mature. The non-woven bags (T_7) has maximum fruit per tree yield of (27.61 kg/plant) followed by yellow polythene (T_5) at (25.96 kg/plant), while the control (T_8) has the minimum yield of fruit (16.10 kg/plant). The yields are in direct accordance with fruit weight and size, if the size of the fruit increases the yield per tree will also increase. Significant variation was observed among the treatments for fruit length and fruit diameter (Table 3). The maximum fruit length (8.98 cm) and fruit diameter (9.07 cm) were observed in non-woven bag (T_7), followed by yellow polythene bag (T_5) (7.35 cm and 7.58 cm) and brown paper bag (T_6) (7.27 cm and 7.23 cm), while the minimum fruit length (5.57 cm) and fruit diameter (5.69 cm) were observed in control (T_8). The large fruit size is due to the application of bags may be explained by the fact that the micro-environment around the fruits is conducive as there is reduced evaporation. Assimilates tend to move to the fruit easily, facilitating development hence larger fruit size. These results are consistent with those of Singh *et al.* (15) and Islam *et al.* (5). Fruit weight, fruit volume, and specific gravity varied significantly among the treatments (Table 3). The maximum fruit weight (201.04 g) and fruit volume (199.88 cc) were achieved in the case of non-woven bag (T_7), followed

by yellow polythene bag (T_5) (182.10 g and 178.87 cc) and brown paper bag (T_6) (173.07 g and 173.55 cc), while the lowest fruit weight (132.58 g) and fruit volume (135.57 cc) were observed in the control (T_8). The maximum value of specific gravity was found in yellow polythene bag (T_5) (1.01) followed by non-woven bag (T_7) (1.00), whereas the minimum value was obtained in control (T_8) (0.95). The increase in fruit weight and volume under bagging treatments is attributed to enhanced cell enlargement and greater assimilate accumulation resulting from protection against biotic and abiotic stresses. Bagging creates a favorable microenvironment around the developing fruit by reducing insect infestation, disease incidence, excessive solar radiation, and moisture loss. These conditions improve photosynthate translocation to the fruit and support better growth and development, ultimately leading to increased fruit weight and

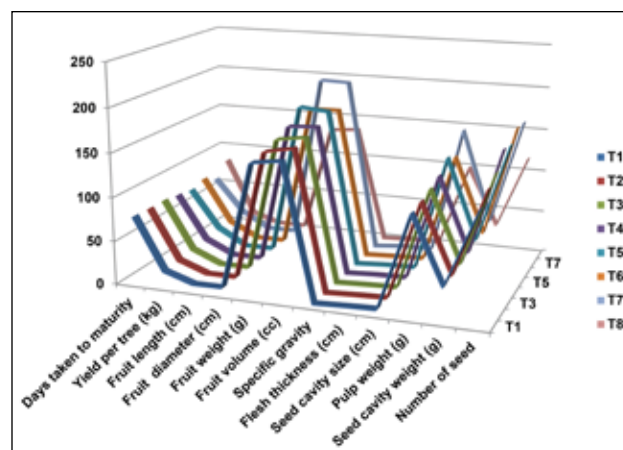


Fig. 3. Impact of pre-harvest fruit bagging on yield attributes of guava cv. L-49.

Table 3: Impact of pre-harvest fruit bagging on yield attributes of guava cv. L-49.

Treatment	Days taken to maturity	Yield per tree (kg)	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Fruit volume (cc)	Specific gravity	Flesh thickness (cm)	Seed cavity size (cm)	Pulp weight (g)	Seed cavity weight (g)	Number of seed
T_1	77.00	17.11	5.93	6.24	149.68	154.32	0.97	2.54	3.70	112.25	37.42	123.00
T_2	76.00	18.79	6.39	6.49	153.32	160.00	0.97	2.59	3.90	114.98	38.32	135.00
T_3	76.00	20.73	6.61	6.72	159.28	164.12	0.97	2.65	3.97	119.46	39.82	143.00
T_4	73.00	22.35	6.87	7.10	166.63	168.40	0.98	2.85	3.81	124.97	41.65	160.33
T_5	70.00	25.96	7.35	7.58	182.10	178.87	1.01	3.43	4.50	136.70	45.39	156.67
T_6	75.00	23.83	7.27	7.23	173.07	173.55	0.99	2.88	4.37	129.80	43.27	169.00
T_7	66.00	27.61	8.98	9.07	201.04	199.88	1.00	4.27	4.71	152.83	48.22	167.33
T_8	82.00	16.10	5.57	5.69	132.58	135.57	0.95	2.38	3.31	100.15	32.44	116.67
SEm±	1.59	0.30	0.16	0.17	3.07	2.32	0.01	0.03	0.11	2.36	0.76	3.29
CD @ 5%	4.84	0.92	0.48	0.51	9.30	7.04	0.03	0.10	0.34	7.14	2.30	9.97

volume. This data is also supported by the research of Rahman *et al.* (12) and Islam *et al.* (5). Significant differences were also observed between treatments with respect to flesh thickness and seed cavity size (Table 3). The maximum flesh thickness and seed cavity size were observed in non-woven bag (T_7) (4.27 cm, 4.71 cm) followed by yellow polythene bag (T_5) (3.43 cm, 4.50 cm), and brown paper bag (T_6) (2.88 cm, 4.37 cm), respectively, while the minimum flesh thickness and seed cavity size were found in control (T_8) (2.38 cm, 3.31 cm) (Table 3). The increase in flesh thickness and seed cavity size seen in response to different bagging treatments could be explained by the alteration in the microenvironment surrounding the fruits induced by the bags. The non-woven bag had the greatest flesh thickness and seed cavity size probably because it was able to provide an optimal environment with regard to the temperature, humidity, and light around the growing fruits, hence stimulating cell division and expansion. Likewise, yellow polythene and brown paper bags would have provided the right environment for the growth of the fruits through protecting the fruits from outside disturbances. Conversely, the lowest values were recorded for the control treatment since unbagged fruits would have been subjected to unfavorable conditions from the environment, limiting their growth. These data are in accordance with the results of Singh *et al.* (15). There were significant differences found between the treatments regarding pulp weight and seed cavity weight (Table 3). Maximum pulp weight (152.83 g) and seed cavity weight (48.22 g) were found in the non-woven bag (T_7), whereas the highest seed cavity weight (136.70 g and 45.39 g) was found in yellow polythene bag (T_5). The lowest pulp weight (100.15 g) and seed cavity weight (32.44 g) were found in control (T_8). Increase in pulp and seed cavity weight in bagged fruits is an indicator of increased biomass production due to improved fruit development. This trend has also been reported previously by Rahman *et al.* (12). There was significant influence on the number of seeds per fruit due to different bagging treatments (Table 3). Highest numbers of seeds per fruit (169.00) were obtained from the brown paper bag (T_6) followed by non-woven bag (T_7) with 167.33 number of seeds per fruit, while the lowest seed number per fruit (116.67) was recorded in control (T_8). The increased in seed number is due to better environment that the bag provided for the fruits to develop. This might have helped to moderate changes in temperature and humidity as well as protect the fruits against various environmental stress factors, resulting in more efficient fertilization and fewer embryo abortions.

Therefore, a good seed set was obtained in the treated group as compared to the control.

The present investigation clearly demonstrated that pre-harvest fruit bagging is an effective and environmentally friendly technique for improving the quality and yield of guava cv. Lucknow-49. Significant variations were observed among different bagging materials with respect to peel colour, texture profile, and yield-related attributes. Transparent polythene and brown paper bags enhanced fruit appearance by promoting higher brightness and improved red-yellow colour development, thereby increasing the market appeal of fruits. Texture profile analysis revealed that yellow polythene bagging produced firmer fruits with higher hardness, gumminess, and chewiness values, indicating better structural integrity and potential for improved handling and storage. Among all treatments, non-woven bags performed best for most yield and physical characteristics, resulting in earlier fruit maturity, greater fruit size, higher fruit weight and volume, increased flesh thickness, pulp weight, and maximum yield per plant. The favourable microenvironment created by non-woven bags likely enhanced fruit growth and assimilates accumulation, leading to superior fruit development. Furthermore, brown paper bags recorded the highest number of seeds per fruit, indicating improved reproductive success under protected conditions. Overall, the study highlights that the choice of bagging material can be strategically used to achieve specific production goals. Non-woven bags are recommended for maximizing yield and fruit growth, whereas transparent polythene and brown paper bags are suitable for enhancing fruit colour and visual quality. The findings also provide novel information on the influence of pre-harvest bagging on texture profile attributes measured through TA.XT texture analysis, an aspect that has received little attention in guava research. Therefore, pre-harvest fruit bagging can be adopted as a sustainable non-chemical approach to improve the marketability, quality, and productivity of guava fruits.

AUTHOR'S CONTRIBUTION

Conceptualization of research (BKS, AS); Designing of the experiments (BKS, AS); Contribution of experimental materials (VM); Execution of field/lab experiments and data collection (AZ); Analysis of data and interpretation (AZ, BKS); Preparation of the manuscript (AZ, BS).

DECLARATION

The authors have no conflict of interest.

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