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Influence of Pre-harvest Fruit Bagging on Ripening and Physico-chemical Characteristics of Guava *(Psidium guajava L.)* cv Gwalior-27

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Abstract

An experiment was conducted during 2024–25 under the Malwa plateau in Western part of Madhya Pradesh at 23.45° to 24.13° North latitude, 74.44° to 75.18° East longitudes and at an altitude of 435 meters above mean sea level. This region falls under Agro-climatic zone No.11 of the State to study the influence of pre-harvest fruit bagging on ripening and physico-chemical characteristics of guava (*Psidium guajava* L.) var. Gwalior-27. The study consisted of eight treatments (T_1–brown paper bag, T_2–yellow paper bag, T_3–blue paper bag, T_4–green paper bag, T_5–white paper bag, T_6–red paper bag, T_7–newspaper bag, and T_8–control without bag) arranged in a Randomized Block Design with three replications. Observations were recorded on fruit length (cm), diameter (cm), volume (ml), weight (g), pulp thickness (mm), pulp weight (g), specific gravity (wt/volume). seed parameters, Total soluble solids, titratable acidity (%), sugar contents (%), and sensory qualities. The results revealed that the brown paper bag (T_1) significantly improved fruit length (7.46 cm), fruit diameter (7.34 cm), volume (211.90 ml), fruit weight (263.87 g), specific gravity (1.093), TSS (9.89 °Brix), reducing sugar (4.16%), total sugar (8.38%), and non-reducing sugar (4.22%), with superior sensory evaluation as compared to the control. The lowest values of these parameters were recorded in unbagged fruits. Economically, T_1 gave the highest net returns (₹2,64,924.59 ha^{-1}) and benefit-cost ratio (3.33). Therefore, brown paper bagging is recommended to enhance fruit quality, storability, and profitability of guava cv. Gwalior-27.

Key words: *Guava fruit, bagging, brown paper bag, physico-chemical quality, sensory evaluation, economics*

Introduction

Guava (*Psidium guajava* L.) is an important fruit crop of the tropics and subtropics, often referred to as the "apple of the tropics" due to its high nutritive value, wide adaptability, and popularity among consumers. It belongs to the family Myrtaceae and is cultivated extensively in tropical, subtropical, and arid regions of India. Guava fruits are rich in minerals, pectin, dietary fibre, and ascorbic acid (vitamin C), containing about 82.5% moisture, 9.73% total soluble solids, and 260 mg vitamin C per 100 g pulp (Dinesh and Vasugi, 2010). Because of its high vitamin C content and medicinal value, guava is regarded as one of the most remunerative fruit crops. India is the largest producer of guava in the world, accounting for more than 50% of global production, yielding 3.6 million tonnes from an area of 0.27 million hectares (FAO STAT, 2020; NHB, 2023).

Major guava-producing states in India include Uttar Pradesh, Madhya Pradesh, Maharashtra, and Bihar, with Madhya Pradesh alone accounting for about 17% of the country's total production (NHB, 2018). Guava is consumed fresh and is also widely processed into jams, jellies, beverages, and candies, giving the fruit both nutritional value and significant commercial importance.

Guava cultivation often faces challenges such as fruit fly attack, blemishes, cracking, and uneven ripening, particularly during the rainy season crop. Such defects reduce both market value and consumer acceptability. Pre-harvest fruit bagging is a simple, eco-friendly practice that modifies microclimate around the developing fruit by regulating light, temperature, and humidity. This practice has been found to protect fruits from mechanical injury and pests, improve external colour, and enhance chemical composition and sweetness (Sharma et al., 2018; Saxena et al., 2022). Therefore, the present investigation was undertaken to assess the influence of different bagging materials on the ripening behaviour, physico-chemical properties, and sensory quality of guava cv. Gwalior-27. The economic feasibility of the bagging practice under the Malwa plateau conditions was also evaluated.

Materials and Methods

The present investigation was carried out during the year 2024–25 at the Instructional-cum-Research Fruit Orchard, Department of Fruit Science, College of Horticulture, Mandsaur, affiliated to Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India. The experimental site is situated at 24.07° N latitude and 75.07° E longitude with an elevation of about 440 m above mean sea level, representing the subtropical climate of the Malwa plateau region. The soil of the orchard was medium black clay loam, moderately fertile, and well-drained with a pH of 7.4.

Experimental Details

The experiment consisted of eight treatments, each representing a different type of bagging material like T_1- Brown Paper bag, T_2- Yellow Paper bag, T_3- Blue Paper bag, T_4- Green Paper Bag, T_5-White paper bag, T_6-Red paper Bag, T_7- Newspaper bag and T8-control

The treatments were laid out in a Randomized Block Design (RBD) with three replications. Each replication comprised one tree, and sixteen fruits per treatment per tree were tagged for observations. The bags were of standard size (20 × 25 cm) and made of single-layer paper, perforated with fine needle holes to maintain aeration.

Crop Management and Bagging Procedure

Uniform, healthy guava trees of cv. Gwalior-27, aged around 7 years and maintained under uniform cultural practices, were selected for the study. Normal orchard management practices such as irrigation, manuring, and plant protection were followed as per recommended package of practices. When the fruits reached marble stage (approximately 60 days after fruit set), they were dipped for 2 minutes in a 2% ascorbic acid solution to prevent surface infections and enhance colour development. After drying, the fruits were enclosed in their respective bagging materials. Each bag was tied securely at the pedicel using soft jute twine to avoid fruit damage. The bags were inspected every 6–7 days, and any torn or damaged bags were replaced immediately. The control fruits were left uncovered.

Data Collection

At the time of harvest (physiological maturity), six fruits per treatment were randomly sampled for physico-chemical analysis. The following observations were recorded:

Physical parameters

Fruit length and diameter (cm) were measured using digital Vernier calipers, while fruit weight (g) was recorded with a precision electronic balance. Fruit volume (ml) was determined using the water displacement method. After separating the pulp from the peel and seeds, pulp thickness (mm) and pulp weight (g) were measured. The number of seeds per fruit and their total seed weight (g) were also recorded. Specific gravity was calculated as the ratio of fruit weight to fruit volume. Additionally, the percentage of infected and overripe fruits was assessed visually based on external appearance and texture

Chemical parameters

Total soluble solids (TSS) were measured using a hand refractometer and expressed in °Brix. Titratable acidity was determined by titration with 0.1 N NaOH using phenolphthalein as an indicator and expressed as percent citric acid following the AOAC (2005) method. Reducing, non-reducing, and total sugars were estimated using the Lane and Eynon method, with non-reducing sugar calculated by difference. Ascorbic acid content, if recorded, was determined using the 2,6-dichlorophenol indophenol titration method as described by AOAC (2005).

Sensory evaluation

A panel of ten semi-trained judges evaluated the fruit samples for taste, colour, appearance, flavour, and aroma using the 9-point Hedonic scale (Peryam and Pilgrim, 1957)

Economic analysis

The economics of each treatment were computed based on the total cost of cultivation, gross return, net return, and Benefit–Cost (B:C) ratio per hectare, following standard agricultural economics procedures.

Statistical Analysis

The recorded data were statistically analyzed using analysis of variance (ANOVA) as per the method of Panse and Sukhatme (1985). The treatment means were compared using the critical difference (CD) at 5% level of significance. All statistical computations were carried out using standard OPSTAT software and expressed as mean values for replication-wise data.

Results and Discussion

The findings of the study revealed that pre-harvest fruit bagging markedly influenced the physical, biochemical, and sensory characteristics of guava cv. Gwalior-27. The variation among treatments was primarily due to the type and colour of the bagging material, which created distinct microclimatic conditions around developing fruits by altering light penetration, humidity, and temperature.

Data presented in Table 1 shows that fruit bagging significantly affected all physical attributes of guava fruits. The highest mean fruit length (7.46 cm), fruit diameter (7.34 cm), fruit weight (263.87 g), and fruit volume (211.90 ml) were recorded under T_1 (brown paper bag), followed closely by T_7 (newspaper bag). The control treatment (T_8, no bag) produced the smallest fruits with 6.87 cm length, 6.43 cm diameter, 207.06 g weight, and 195.27 ml volume. Likewise, pulp thickness (12.93 mm) and pulp weight (199.28 g) were highest in T_1 and lowest in the control (10.69 mm and 124.12 g, respectively). The improvement in fruit size and weight under brown paper bagging may be attributed due to reduced transpiration losses, moderated fruit surface temperature, and better distribution of assimilates, which together enhanced cell expansion and pulp development. Similar trends were also reported by Sharma et al. **(2018)** and Singh et al. (2023), who observed that paper bagging favoured larger and heavier guava fruits. Deepak et al. (2023) further suggested that bagging reduces direct solar radiation on fruits, resulting in improved growth uniformity and shape.

Bagging also influenced seed and fruit characteristics (Table 1). The minimum number of seeds per fruit (359.15) and seed weight (5.44 g) were obtained under T_1, while the control had the maximum seed number (401.43) and seed weight (6.08 g). A notable reduction in the number of infected fruits (3.47 %) was observed in brown paper bagging (T_1), compared to 7.33 % in unbagged fruits. The percentage of overripen fruits was highest (7.55 %) in T_1, indicating more uniform and complete ripening. The physical barrier provided by the bag prevented direct attack of fruit flies, fungal spores, and dust particles, resulting in clean and marketable fruits. These observations align with those reported by Rahman *et al.* (2017), Yadav *et al.* (2024), and Samy *et al.* (2023), who concluded that bagging reduces pest infestation and enhances shelf life in guava and mango fruits.

Physico-chemical composition of fruits was significantly influenced by different bagging treatments (Table 2). The highest total soluble solids (9.89 °Brix), total sugars (8.38 %), reducing sugars (4.16 %), and non-reducing sugars (4.22 %) were recorded under T_1 (brown paper bag), while the lowest values (9.16 °Brix, 5.73 %, 3.24 %, and 2.49 %, respectively) were observed in the control. In contrast, titratable acidity was the lowest (0.323 %) in T_1 and the highest (0.397 %) in T_8. Increased sugar accumulation and higher TSS under bagging could be due to the restricted respiration and transpirational losses within the microclimate of the bag, allowing higher retention of carbohydrates and reduced organic acid content. These results are in agreement with Saxena et al. (2022), Meena *et al.* (2016), and Rahman et al. (2018), who reported significant improvement in the sugar-acid balance of guava under paper bagging conditions. According to Afroz et al. (2023), bagging enhances sucrose-synthase activity, resulting in greater sugar accumulation. Similar trends were also found in mango by Haldankar et al. (2015).

Table 1: Physical parameters of guava fruits

	Treatments	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Fruit volume (ml)	Pulp thickness (mm)	Pulp weight (g)	Number of seeds fruit^{-1}	Seed weight (g)	Infected fruits (%)	Specific gravity
T_1	Brown paper bag	7.46	7.34	263.87	211.90	12.93	199.28	359.15	5.44	3.47	1.047
T_2	Yellow paper bag	7.09	7.02	218.10	201.19	11.15	153.19	395.70	5.99	4.15	1.077
T_3	Blue paper bag	7.10	6.95	220.05	204.08	11.47	145.41	382.49	5.79	4.11	1.080
T_4	Green paper bag	7.08	6.86	211.53	203.67	11.33	149.14	395.04	5.98	5.52	1.087
T_5	White paper bag	7.30	6.89	216.67	209.34	12.61	147.01	392.40	5.94	3.79	1.057

Table 2: Bio-chemical parameters of guava fruit

	Treatments	Acidity (%)	TSS (° Brix)	Total sugar (%)	Reducing sugar (%)	Non reducing sugar (%)
T_1	Brown paper bag	0.323	9.89	8.38	4.16	4.22
T_2	Yellow paper bag	0.387	9.31	6.92	3.39	3.54
T_3	Blue paper bag	0.353	9.30	6.53	3.47	3.06
T_4	Green paper bag	0.392	9.29	6.91	3.86	3.06
T_5	White paper bag	0.370	9.85	6.87	3.64	3.23
T_6	Red paper bag	0.353	9.31	6.58	3.35	3.23
T_7	Newspaper bag	0.351	9.42	7.73	4.01	3.72
T_8	Control (No bag)	0.397	9.16	5.73	3.24	2.49
S.Em. ±		**0.014**	**0.146**	**0.218**	**0.167**	**0.175**
C.D. at 5%		**0.042**	**0.442**	**0.662**	**0.506**	**0.532**

The sensory evaluation scores varied significantly amongst the fruit bagging treatments. Fruits from T_1 (brown paper bag) achieved the highest average scores for taste (8.07), colour (8.13), appearance (8.33), flavour (8.00), and aroma (8.17), followed by T_7 (newspaper bag). The lowest sensory ratings were recorded in the control fruits for all parameters. Superior sensory attributes of the brown-bagged fruits can be attributed to their smooth peel surface, attractive colour, high sugar content, and away from sunburn blemishes. The improvement in consumer appeal observed in the present study is in conformity with Brar et al. (2019) and Bishnoi et al. (2023), who reported that pre-harvest fruit bagging enhances visual appearance and flavour development in guava.

Economic analysis revealed that brown paper bagging (T_1) resulted in the highest gross return (₹ 3,44,580 ha^{-1}), net return (₹ 2,64,925.59 ha^{-1}), and benefit-cost ratio (3.33). Although red paper bagging (T_6) involved slightly higher cultivation cost (₹ 81,033.77 ha^{-1}), its B:C ratio (2.30) was comparatively lower. The lowest gross return (₹ 2,41,255.34 ha^{-1}) and B:C ratio (2.20) were obtained under the control treatment. The B:C ratio is highest in the brown paper bagging treatment (T_1) because the additional income generated from superior-quality fruits is much greater than the cost of bagging. Brown paper bags improve fruit appearance, reduce pest and disease damage, and minimize post-harvest losses, resulting in a higher proportion of marketable and premium-grade fruits. Since the cost of applying brown paper bags is relatively low, but the increase in market price and saleable yield is substantial, the overall economic return rises sharply. This wide gap between high returns and modest input cost leads to the highest B:C ratio in T_1. The enhanced profitability of brown paper bagging may be attributed to improved fruit quality, better market acceptance, and reduced post-harvest losses. Similar economic advantages of fruit bagging have been documented by Suman et al. (2016) and Sohag et al. (2023), emphasizing that the additional cost of bagging is minimal compared to the increased revenue obtained from premium-quality fruits.

Conclusion

Brown paper bagging (T_1) proved to be the most effective treatment, producing larger, heavier fruits with better pulp development and lower infection compared to other bagging materials and the control. It also resulted in higher sugar content and improved overall fruit quality. Economically, T_1 recorded the highest gross and net returns along with the best B:C ratio. The findings clearly show that brown paper bagging enhances guava quality and profitability, making it the most suitable option for commercial cultivation.

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