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INFLUENCE OF PRE-HARVEST BAGGING MATERIALS ON FRUIT QUALITY, SENSORY ATTRIBUTES, AND ECONOMIC RETURNS OF GUAVA (*Psidium guajava* L.) CV. ALLAHABAD SAFEDA

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ABSTRACT

Pre-harvest bagging is a sustainable technique to enhance fruit quality and mitigate pest damage. This study evaluated the efficacy of various bagging materials on the physico-chemical, sensory, and economic parameters of guava cv. Allahabad Safeda during the Hasth bahar season. A field experiment was conducted using a Randomized Block Design with nine treatments and three replications. The treatments included eight bagging materials (yellow, white, black, transparent polythene; butter paper; muslin cloth; brown paper; newspaper) and an unbagged control. Data on physical parameters (fruit weight, length, diameter, volume), biochemical attributes (TSS, acidity, ascorbic acid, sugars), sensory evaluation (9-point hedonic scale), and economic viability (Benefit-Cost Ratio) were recorded and analyzed. Yellow polythene bagging (T_1) emerged as the most effective treatment, producing fruits with significantly higher weight (163.67 g), length (6.63 cm), diameter (7.01 cm), TSS (12.81 °Brix), total sugar (7.54%), and the lowest acidity (0.31%), resulting in an excellent TSS: acid ratio (40.95). It also received the highest sensory scores for taste (8.02), flavour (8.20), and overall acceptability (8.67). White polythene (T_2) was best for ascorbic acid content (182.11 mg/100g). Economically, T_1 yielded the highest Benefit-Cost Ratio (2.39), followed by T_2 (1.85) and muslin cloth (T_6, 1.74). All bagging materials provided complete protection from pests and diseases. Pre-harvest bagging with yellow polythene is recommended for producing premium-quality guava with superior marketability and profitability in the Chhattisgarh region.

***Key words*:** *Psidium guajava*, fruit quality, non-chemical protection, benefit-cost analysis, sustainable horticulture, postharvest

Introduction

Guava (*Psidium guajava* L.) is a significant fruit crop in India, valued for its nutritional richness and adaptability. However, fruits from the rainy season (Ambé bahar, the region's main monsoon-timed guava crop) often suffer from poor quality, high pest incidence, and low

market value compared to the winter crop (Amarante *et al*., 2002). Increasing consumer demand for clean, residue-free, and high-quality fruit necessitates eco-friendly production technologies (González-Salinas *et al*., 2022). Pre-harvest bagging is a simple, protective cultural practice that involves covering developing fruits with various materials to modify their microclimate (Hossain *et al*., 2017). This technique has been shown to reduce pest and disease infestation, prevent physical damage, improve fruit appearance, and enhance internal quality attributes like sugar and vitamin C content in various fruits, including guava (Kim *et al*., 2008; Meena *et al*., 2016). The choice of bagging material is critical, as it influences light penetration, temperature, humidity, and gas exchange around the fruit, thereby affecting its development (Neto *et al*., 2020). While studies have confirmed the benefits of bagging on guava, the optimal material can vary with cultivar, climate, and season (Hossain *et al*., 2017; Sharma *et al*., 2020; Singh *et al*., 2024). There is a scarcity of comprehensive studies under the specific agro-climatic conditions of Chhattisgarh that integrate physical, biochemical, sensory, and economic analyses. Therefore, this study was designed to evaluate the effect of different bagging materials on the overall quality and profitability of guava cv. Allahabad Safeda during the Hasth bahar season (the winter-initiated guava fruiting cycle, harvested February–April), aiming to identify the most suitable and economically viable option for local growers.

Materials and Methods

Experimental Site and Plant Material

The study was conducted during the Hasth bahar season (February–April) of 2024-25 at the Research and Instructional Farm, Bharregaon, Rajnandgaon, Chhattisgarh, India (20°57' N, 80°58' E, 307 m above MSL). The experiment was laid out on eight-year-old, uniformly growing guava trees of cv. Allahabad Safeda. Each treatment was replicated three times, with one uniformly bearing tree constituting each replication unit, and all experimental trees were maintained under uniform recommended irrigation, fertilization, and plant-protection schedules throughout the study period so that treatment effects could be attributed to the bagging material alone. The Hasth bahar cropping cycle in this agro-climatic zone spans the relatively dry, mild-winter-to-warm-summer transition from February to April, conditions generally conducive to steady fruit development and to microclimate modification by bagging.

Experimental Design and Treatments

The experiment was arranged in a Randomized Block Design (RBD) with nine treatments and three replications. The treatments were as follows:

T_0: Control (No bagging)

T_1: Yellow polythene bag

T_2: White polythene bag

T_3: Black polythene bag

T_4: Transparent polythene bag

T_5: Butter paper bag

T_6: Muslin cloth bag

T_7: Brown paper bag

T_8: Newspaper bag

Bags were applied 35 days after fruit set and secured gently to the pedicel.

Data Collection

At commercial maturity, five tagged fruits per replication were harvested for analysis.

- **Physical Parameters:** Fruit weight (g), length and diameter (cm, using Vernier calipers), and volume (cc, by water displacement).
- **Biochemical Parameters:** Total Soluble Solids (TSS, °Brix) with a hand refractometer; Titratable Acidity (% citric acid) by titration; Ascorbic acid (mg/100g pulp) using 2,6-dichlorophenolindophenol dye; Total, reducing, and non-reducing sugars (%) by Lane and Eynon method (Ranganna, 1986).
- **Sensory Evaluation:** A semi-trained panel of five judges evaluated colour and appearance, taste, flavour, texture, and overall acceptability using a 9-point hedonic scale. Sensory scores were subjected to Analysis of Variance following standard procedures for organoleptic quality evaluation of horticultural produce (Ranganna, 1986), with treatment means compared at the 5% probability level.
- **Economic Analysis:** The Benefit-Cost Ratio (BCR) was calculated based on the total cost of cultivation (fixed + treatment cost) and gross returns (yield × market price), with premium prices for bagged fruits.

Statistical Analysis

Data on physical, biochemical, sensory, and economic parameters were subjected to Analysis of Variance (ANOVA) appropriate for a Randomized Block Design. Treatment means were compared using the Critical Difference (CD) test at the 5% probability level ($p \leq 0.05$).

Table 1: Effect of pre-harvest bagging on physical parameters of guava fruit. (n = 3 replications).

Treatment	Description	Fruit Weight (g)	Fruit Length (cm)	Fruit Diameter (cm)	Fruit Volume (cc)
T_0	Control	124.80	5.27	5.68	115.67
T_1	Yellow Polythene	163.67	6.63	7.01	156.33
T_2	White Polythene	151.57	6.36	6.63	143.67
T_3	Black Polythene	127.77	5.62	5.89	122.00
T_4	Transparent Polythene	143.30	6.14	6.47	134.00
T_5	Butter Paper	134.73	5.79	6.10	125.00
T_6	Muslin Cloth	157.90	6.51	6.78	148.67
T_7	Brown Paper	146.03	6.45	6.76	137.00
T_8	Newspaper	132.83	5.85	6.10	126.00
SE(m)±		**1.72**	**0.04**	**0.04**	**2.05**
CD (p=0.05)		**5.15**	**0.13**	**0.11**	**6.14**

Results

Physical Parameters of Guava Fruits

Pre-harvest bagging significantly ($p<0.05$) influenced all the physical parameters of guava fruits compared to the unbagged control (T_0). Among the treatments, T_1 (yellow polythene bagging) resulted in the highest fruit weight (163.67 g), fruit length (6.63 cm), fruit diameter (7.01 cm), and fruit volume (156.33 cc). This treatment did not differ significantly from T_6 (muslin cloth bagging), which recorded a fruit weight of 157.90 g, length of 6.51 cm, diameter of 6.78 cm, and volume of 148.67 cc. The lowest values for all physical parameters were consistently observed in the control treatment (T_0), which was statistically similar to T_3 (black polythene bagging) and T_8 (newspaper bagging) for most attributes (Table 1).

Biochemical Parameters

The biochemical quality of the fruits was markedly improved by bagging treatments (Table 2). T_1 (yellow polythene) recorded the highest Total Soluble Solids (12.81 °Brix), which did not differ significantly from T_7 (brown paper, 12.69 °Brix) and T_6 (muslin cloth, 12.53 °Brix). The same treatment (T_1) also resulted in the lowest Titratable Acidity (0.31%), leading to the most favourable TSS:Acid ratio (40.95), a key indicator of fruit sweetness. T_2 (white polythene) was the most effective treatment for preserving Ascorbic Acid content (182.11 mg/100g pulp). Furthermore, T_1 also led to the highest accumulation of Total Sugar (7.54%), Reducing Sugar (4.29%), and Non-Reducing Sugar (3.92%). The control treatment (T_0) consistently showed the least desirable biochemical profile.

Sensory Evaluation

Sensory evaluation revealed a strong preference for bagged fruits (Table 3). T_1 (yellow polythene) received the highest scores for Taste (8.02), Flavour (8.20), and Overall Acceptability (8.67). T_2 (white polythene) scored highest for Texture (7.83). For Colour and Appearance, T_1 (7.88) and T_6 (muslin cloth, 7.87) were statistically superior. In contrast, the control fruits (T_0) were the least preferred across all sensory attributes.

Pest Incidence and Economic Viability

A universal and significant advantage of all bagging treatments (T_1 to T_8) was visible protection from pest and disease infestation: bagged fruits showed no external fruit-fly puncture marks or fungal lesions at harvest,

Table 2: Effect of pre-harvest bagging on biochemical parameters of guava fruit. (n = 3 replications).

Treatment	Description	TSS (°Brix)	Acidity (%)	Ascorbic Acid (mg/100g)	Total Sugar (%)	TSS:Acid Ratio
T_0	Control	10.51	0.58	141.40	6.41	18.11
T_1	Yellow Polythene	12.81	0.31	181.07	7.54	40.95
T_2	White Polythene	11.16	0.40	182.11	7.43	27.94
T_3	Black Polythene	10.25	0.55	142.16	6.50	18.77
T_4	Transparent Polythene	11.53	0.45	149.53	6.86	25.73
T_5	Butter Paper	10.85	0.52	178.48	6.73	23.69
T_6	Muslin Cloth	12.53	0.34	171.33	7.23	36.54
T_7	Brown Paper	12.69	0.46	173.07	6.74	30.67
T_8	Newspaper	10.72	0.46	160.45	6.58	23.34
SE(m)±		**0.08**	**0.01**	**2.22**	**0.03**	**1.18**
CD (p=0.05)		**0.24**	**0.04**	**6.65**	**0.10**	**3.53**

Table 3: Sensory evaluation scores (9-point hedonic scale) of guava fruits under different bagging treatments. (n = 3 replications).

Treatment	CA	TA	FV	TX	OA
T_0	5.24	5.33	5.36	4.65	5.47
T_1	7.88	8.02	8.20	7.35	8.67
T_2	6.53	6.47	7.72	7.83	8.13
T_3	5.94	5.49	5.69	5.53	6.10
T_4	7.26	6.73	6.13	6.55	6.90
T_5	6.78	5.90	5.98	5.70	6.43
T_6	7.87	6.95	7.86	7.21	7.60
T_7	7.26	7.32	7.59	6.81	7.47
T_8	7.04	6.21	6.94	6.11	7.53
CD (p=0.05)	**1.03**	**0.12**	**0.32**	**0.16**	**0.58**

CA: Colour and Appearance; TA: Taste; FV: Flavour; TX: Texture; OA: Overall Acceptability

consistent with the physical barrier the bags provided against fruit flies, borers, and fungal pathogens. The unbagged control (T_0) fruits exhibited significant damage. Economic analysis demonstrated that pre-harvest bagging was a profitable intervention (Table 4). The highest Benefit-Cost Ratio (BCR) of 2.39 was recorded for T_1 (yellow polythene), followed by T_2 (white polythene, 1.85) and T_6 (muslin cloth, 1.74). The superior profitability of T_1 was due to its high marketable yield of premium-quality fruit, which commanded a 50% higher market price, effectively offsetting the initial investment. The lowest BCR was observed in the control T_0 (1.24). Treatments like T_3 (black polythene) and T_5 (butter paper) showed poor economic returns (BCR of 1.12 and 1.03, respectively).

Discussion

The results confirm that pre-harvest bagging is an effective practice for enhancing the quality and marketability of guava cv. Allahabad Safeda. The superior performance of yellow polythene (T_1) can be attributed to the favourable microclimate created within the bag, which likely reduced transpirational water loss and respiratory losses while shielding fruits from external stress factors such as temperature fluctuation, wind, and direct sunlight, thereby promoting better growth and sugar accumulation (Hossain *et al.*, 2017; Neto *et al.*, 2020). The higher ascorbic acid retention under white polythene (T_2) may be explained by its capacity to filter specific light wavelengths responsible for the photo-oxidative degradation of vitamin C (Meena *et al.*, 2016). Since ascorbic acid is highly sensitive to light and heat, the diffused-light microenvironment beneath white polythene appears to minimize its breakdown relative to darker or more heat-retentive covers. The improved sensory scores of bagged fruits can be attributed jointly to their enhanced

Table 4: Economic viability of different pre-harvest bagging treatments for guava. (n = 3 replications).

Treatment	TC	GR	NR	BCR
T_0	150	336.9	186.9	**1.24**
T_1	260	883.8	623.8	**2.39**
T_2	260	743.4	483.2	**1.85**
T_3	260	551.7	291.7	**1.12**
T_4	260	638.1	378.1	**1.45**
T_5	280	569.7	289.7	**1.03**
T_6	290	795.6	502.6	**1.74**
T_7	250	670.05	420.05	**1.68**
T_8	250	585.45	335.45	**1.34**

TC: Total Cost (Rs/tree); GR: Gross Return (Rs/tree); NR: Net Return (Rs/tree); BCR: Benefit-Cost Ratio (BCR)

biochemical composition and blemish-free external appearance, both of which are known to influence consumer acceptability. In particular, the high TSS:acid ratio recorded under T_1 corresponds closely with its superior taste and flavour ratings, reinforcing the established relationship between this ratio and perceived fruit quality. These findings are consistent with Singh *et al.*, (2024), who reported similar quality improvements under polythene bagging in guava cv. Allahabad Safeda, lending further support to the present findings under the agro-climatic conditions of Chhattisgarh. The complete protection from insect-pest infestation and disease incidence observed across all bagging treatments corroborates the findings of González-Salinas *et al.*, (2022), who identified fruit bagging as an effective non-chemical strategy for pest and disease management in fruit crops. This physical barrier effect not only preserved fruit quality but also reduced dependence on chemical pesticide applications, aligning with sustainable production goals. Economically, the superior BCR values recorded for T_1, T_2, and T_6 (Table 4) indicate that the additional investment in bagging materials and labour was more than compensated by the price premium associated with high-quality, blemish-free produce. This confirms bagging as a cost-effective and economically viable intervention for guava growers.

Conclusion

Pre-harvest bagging significantly improved fruit quality, marketable yield, and profitability of guava cv. Allahabad Safeda during Hasth bahar under Chhattisgarh conditions. Yellow polythene (T_1) was the superior treatment overall, producing the highest fruit weight, size, volume, TSS, sugars, and TSS:acid ratio (40.95), along with the best sensory scores and BCR (2.39). White polythene (T_2) recorded the highest ascorbic acid content (182.11 mg/100g pulp), while muslin cloth (T_6) performed comparably on several quality parameters with a BCR

of 1.74. All bagged treatments outperformed the control (BCR: 1.24) due to higher marketable yield and a 50% price premium, which offset material and labour costs. Bagging also provided complete protection from pests and diseases, reducing dependence on chemical pesticides. Yellow polythene bagging is thus recommended as the optimal practice for maximizing quality and profitability, white polythene where ascorbic acid enrichment is prioritized, and muslin cloth as a breathable, economically viable alternative.

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