**Impact of Pre-Harvest Fruit Bagging on Physical and Organoleptic Qualities of Guava var. Lucknow 49 under Ultra High Density Planting**

**ABSTRACT**

**Aim:**

This study aimed to investigate how various pre-harvest bagging materials impact the physical and sensory qualities of Guava (*Psidium guajava L*.) variety Lucknow-49 under Ultra-High-Density Planting (UHDP).

**Study Design:**

The research utilized a Randomized Block Design (RBD).

**Place and Duration of Study:**

The experiment was conducted from February to June at SRM College of Agricultural Sciences in Chengalpattu**.**

**Methodology:**

Guava trees were planted at 4 × 2 meter spacing with drip irrigation. Eight bagging treatments were tested: T1 (brown paper bag), T2 (double-layered bag), T3 (transparent bag), T4 (white non-woven bag), T5 (butter paper bag), T6 (yellow polythene bag), T7 (white polythene bag), and T8 (unbagged control). Each treatment was applied to five trees, and fruits were bagged at the marble stage and harvested at around 85% maturity. We measured various physical attributes, including weight, size, firmness, and seed count, along with sensory qualities using a hedonic scale rated by a panel. Data was analyzed using ANOVA at P ≤ 0.05.

**Results:**

Among the treatments, T4 (white non-woven bag) significantly outperformed others in fruit weight, firmness, specific gravity, pulp weight, pulp thickness, total soluble solids (TSS), and sensory scores for taste, texture, colour, and aroma. Furthermore, T4 reduced seed count and enhanced the pulp-to-seed ratio, highlighting its commercial benefits over unbagged fruits.

**Conclusion:**

Pre-harvest bagging, especially with white non-woven bags, significantly improves the quality and marketability of guava, while also minimizing seed load and blemishes. This technique offers an effective and sustainable approach to enhance guava production within UHDP systems.

**Keywords:** Fruit quality, Guava, Organoleptic evaluation, Pre-harvest bagging, Ultra-High-Density Planting

1. **INTRODUCTION**

Guava (*Psidium guajava* L.) is the key species of the *Psidium* genus and is distributed in tropical and subtropical regions and produces nutritionally valuable fruits due to the high content of vitamin C, minerals, and medicinal effects (Oliveira *et al*., 2019). A nutrient dense fruit guava is especially in low to middle income countries like those in the Indo-Pak subcontinent which contains more than 200 mg of vitamin C per 100 g being the fruit very high in this nutrient, even 4 times more than that present in citrus, apart from other valuable vitamins A, B and minerals potassium and magnesium. India leads the world in guava production with a share of 45% of world production, followed by China and Thailand. The crop is grown on an area of 357.64 Mha with 5262.73 MT of production, having a productivity of 14.72 MT/ha (Indiastat, 2024). Madhya Pradesh leads in national production, followed by Uttar Pradesh and Andhra Pradesh, but Allahabad is known for producing high-quality guavas (Maji, 2010). In Tamil Nadu, the area under guava is 14.56 Mha with a productivity of 25.26 MT/ha (Indiastat, 2024). Being a climacteric fruit, guava is a good source of dietary fiber, pectin, and ascorbic acid, and is consumed either fresh or in processed form, such as jam, jelly, and candies. Its popularly known as the ‘poor man’s apple’.

The cultivar “Sardar” (Lucknow-49), which was a selection from open-pollinated Allahabad Safeda seed, rose into prominence for its vigorous trees, primrose yellow skin, sweet pulp and high vitamin C content. It is interesting to note that higher content of pectins exists in winter fruits as compared to monsoon fruits (Salunke and Kadam, 1995). Guava is, however, one of the most susceptible to fruit fly attacks, a pest in which the female lays its eggs in the fruits when developing, resulting in internal rot, premature fall, and a lower commercial value. Pesticides are often used as a phytosanitary measure, which is not always effective or desirable. On-tree fruit wrapping or bagging, a promising alternative, which was first described in Japan for grapes and pears (Sharma *et al*., 2014), has gained worldwide acceptance in Asia, the Americas, and Australia. Bagging creates a covering between fruits and the environmental conditions (pests, diseases, sunburn and mechanical damage). It has performed admirably across crops despite being expensive and material-reliant. It helps in reducing pest damage as well as enhances the postharvest life and fruit quality, such as weight, colour, size, and nutrition (Tokairin *et al*., 2014; Hossain *et al*., 2018).

Various kraft paper, polyester, and polyethylene (often in different colours) have been employed for guava bagging (Meena *et al*., 2016). Other materials such as tissue paper, newspaper, and brown and white polyethylene and muslin cloth are also used for various fruits. In addition to pest control, pre-harvest bagging rearranges the fruit microenvironment and influences parameters such as temperature, relative humidity, and light conditions (Mendes *et al*. 2022 Isaza *et al*. 2017). This affects maturity, fruit weight, shape, and quantity of characters. Several researchers have demonstrated that bagging decreases biotic stresses such as insects (Teixeira *et al*., 2011), birds (Jia *et al*., 2005; Sharma *et al*., 2014), pathogens (Hofman *et al*., 1997), and mechanical damage (Muchui *et al*., 2010). The resulting fruit frequently has improved skin finish and marketability owing to less blemishing. In addition, the properties of bagging material, such as heat conductivity, light transmission, and vapor permeation, associated with fruit cultivar, fruiting stage, and period after bag removal, decide fruit quality (Niu *et al*., 2003; Son and Lee, 2008; Ali *et al*., 2021). The current study aimed to assess the effectiveness of different bagging materials on the physical and organoleptic qualities of guava var. Lucknow-49, under Ultra-High-Density Planting.

1. **MATERIALS AND METHODS**

The experiment was conducted at the College Orchard, Department of Fruit Science, SRM College of Agricultural Sciences, Baburayanpettai, Chengalpattu, India, positioned between 12°23’N latitudes and 79°44’E longitudes. The research was carried out from February to June. A spacing of 4 × 2 m was used for cultivating guava in clay soil, supported by a drip irrigation system. The experimental setup followed a Randomized Block Design (RBD), consisting of eight treatments and three replications. Throughout the duration of the study, the plants were kept under consistent cultural practices. Bagging was done on each fruit individually at the marble stage. Small, malformed and clustered fruits were thinned out, and healthy fruits were kept for bagging. The treatments are T1: Single-layered brown paper bag, T2: Double-layered bag, T3: Transparent bag, T4: Non-woven bag, T5: Butter paper bag, T6: Yellow polythene bag, T7: White polythene bag, T8: Control (Unbagged). A total of five trees per block/replication were chosen, and different bagging treatments were randomly assigned to each tree. Twenty-five uniform-sized fruits from around each tree canopy were covered according to the designated treatment, except for the control trees. Fruits were harvested at approximately 85% maturity, retaining a 3 cm stalk, using a sharp secateur to ensure minimal damage. Soon after harvesting, the fruits were promptly transported to the laboratory, where they were subjected to analysis for physical characteristics and sensory evaluation.

**2.1 Quality Parameters**

**2.1.1 Fruit weight and pulp weight (g)**

Each fruit was weighed separately using an automated scale, and the average weight in grams per fruit was recorded. The pulp was measured using the same technique.

**2.1.2 Fruit length (cm)**

* Fruit length (cm) Five randomly chosen harvested fruits from each treatment per replication were selected to record fruit characteristics. The length was measured vertically from the pedicel attachment to the tip of the fruit using a Vernier caliper (Mitutoyo Digital Vernier Caliper 0-150mm 500-196 Advanced Onsite Sensor Absolute), and the average was calculated in centimetres.

**2.1.3 Fruit width (cm)**

* Five harvested fruits from each treatment per replication were chosen at random to note the fruit parameters. The width was measured at the widest point of the fruit using a Vernier caliper (Mitutoyo Digital Vernier Caliper 0-150mm 500-196 Advanced Onsite Sensor Absolute), and the average was calculated.

**2.1.4 Specific gravity**

The specific gravity of guava fruits was calculated by dividing the weight of the fruit by its volume, which was measured using the water displacement method.

Specific gravity = Weight of fruit(g) / Volume of fruit (cc)

**2.1.5 Fruit firmness (kg/cm²)**

The firmness of the fruit was assessed using a fruit penetrometer (Model I: GY-3), with capacities of 1-12 kg/cm² and 2-24 kg/cm², and the results were recorded in kg/cm² (Deepthi *et al.,* 2016).

**2.1.6 Organoleptic evaluation**

The organoleptic characteristics of the fruits, including Colour, Flavour, Texture, and Taste, were assessed using an arbitrary scale. The fruits were organized accordingly based on replication in designated areas. Eight fruits underwent tasting by different person, while others were peeled for evaluation using the Hedonic scale. A panel of 10 judges was tasked with conducting the sensory assessment. The mean score was calculated for each replication.

*Chart 1: Hedonic Scale*

|  |  |
| --- | --- |
| **Rating** | **Description** |
| 1 | Disliking exceptionally |
| 2 | Disliking very much |
| 3 | Disliking moderately |
| 4 | Disliking slightly |
| 5 | Neither liking nor disliking |
| 6 | Liking marginally |
| 7 | Liking moderately |
| 8 | Liking very much |
| 9 | Liking extremely |

**2.1.7 Statistical Analysis**

The experimental data were analysed statistically using the General R-Based Analysis Platform for Empirical Statistics (GRAPES), developed by the Department of Agricultural Statistics at Kerala Agricultural University in Kerala (www.kaugrapes.com). To evaluate the means, an Analysis of Variance (ANOVA) was performed, with a significance level set at P ≤ 0.05.

1. **RESULTS AND DISCUSSION**

**3.1 Effect of preharvest bagging on fruit characters of guava var. Lucknow 49.**

The physical indices (weight, width, and length) of fruit in all bagging materials were significantly higher than those in the control (T8). The greatest values were obtained from T4 (white non-woven bag), followed by T3 (transparent bag), and the least from T8 (control). These results are consistent with those of other authors (Yang *et al*., 2009; Zhou *et al*., 2012; Sharma *et al*., 2014; Mishra *et al*., 2017), who have also indicated that bagging improves fruit development by altering the microenvironment. The increase in fruit weight may be attributed to the altered temperature, humidity, and light penetration inside the bags (Kutinyu, 2014; Yang *et al*., 2009), which induce favorable physiological and biochemical changes. Non-woven bags, in particular, are effective in filtering sunlight and creating an ideal microclimate that promotes cell expansion and reduces external stress, thus enhancing fruit growth (Azevedo *et al*., 2016; Hossain *et al*., 2018). Bagged fruits are protected from excessive heat, pests, and other stresses that elevate respiration and starch oxidation, contributing to mass loss. In contrast, unbagged fruits are more prone to rapid ripening and epidermal weakening, increasing moisture loss and reducing fruit mass (Jain *et al*., 2003).

**3.2 Effect of preharvest bagging on fruit firmness and specific gravity of guava var. Lucknow 49.**

Fruits enclosed in T4 (white non-woven bags) exhibited the highest firmness, while the lowest TSS was observed in T8 (control). The findings mentioned earlier align with the research, which found that fruits bagged with non-woven bags yielded the highest values for firmness by Rashid *et al*. (2024); Hossain *et al*. (2020) on mangoes and Sharma *et al*. (2016) in ‘Royal Delicious’ apples. The enhancement in fruit firmness of bagged fruits could be attributed to the creation of a controlled atmosphere that offers a more favourable environment. This increase in firmness may also result from reduced transpiration, lower vapor pressure, decreased water exchange, and limited calcium buildup, as noted by Asrey *et al*. (2020) in pomegranate.

The specific gravity of guava fruits was significantly influenced by different bagging treatments. T4 (white non-woven bag) showed the highest specific gravity, followed by T5 (butter paper bag) and T2 (double-layered brown paper bag), while the lowest was recorded in the control (T8). In general, bagged fruits exhibited higher specific gravity, likely due to more compact tissue development, leading to a smaller increase in fruit volume relative to weight (Zaid, 2023). The conversion of insoluble starch to soluble sugars during fruit development may also contribute to variations in specific gravity. Pre-harvest bagging helped retain higher specific gravity, possibly due to improved nutrient uptake and water retention. Similar results have been reported by Mishra *et al*. (2017), Rahman *et al*. (2018), Saroj *et al*. (2018), Carpenter *et al*. (2019), Kanpure *et al*. (2018), Poojan *et al*. (2020), and Vani *et al*. (2021).

**Table 1. Effect of preharvest bagging on fruit weight (g), fruit width (cm), fruit length (cm), specific gravity and fruit firmness (Kg/cm2)of guava var. Lucknow 49.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Treatment details | Fruit weight (g) | Fruit width (cm) | Fruit length (cm) | Specific gravity | Fruit firmness(kg/cm²) |
| T1: Single-layered brown paper bag | 276.81 | 6.98 | 6.34 | 0.99 | 2.62 |
| T2: Double-layered bag | 298.00 | 7.89 | 7.18 | 1.04 | 3.06 |
| T3: Transparent bag | 313.48 | 8.08 | 7.22 | 0.98 | 3.39 |
| T4: White non-oven bag | 316.00 | 8.49 | 7.39 | 1.06 | 3.33 |
| T5: Butter paper bag | 296.75 | 7.83 | 7.06 | 1.04 | 3.26 |
| T6: Yellow polythene bag | 281.10 | 7.27 | 6.42 | 0.98 | 2.85 |
| T7: White polythene bag | 287.23 | 7.71 | 6.86 | 0.97 | 2.74 |
| T8: Control | 272.34 | 6.75 | 6.18 | 0.96 | 2.24 |
| SE(d) | **5.41** | **0.139** | **0.112** | **0.027** | **0.057** |
| C.D. | **11.60** | **0.298** | **0.240** | **0.058** | **0.123** |

**3.3 Effect of preharvest bagging on pulp thickness (mm), pulp weight (g), weight of seed per fruit (g), number of seeds and pulp seed ratio of guava var. Lucknow 49.**

The better fruit pulp quality improves the palatability and acceptability of guava fruits to the consumers (Kumar, 2020). The weight of the pulp is directly related to the weight of the fruit; if the fruit weight increases in a specific treatment, the pulp weight will also rise in line with the overall fruit weight. T4 (white non-woven bag) fruits had the highest pulp weight, followed by T3 (Transparent bag), while T8 (control) had the lowest pulp weight.

The effect of fruit bagging on pulp thickness was observed to be significant. The maximum pulp weight was recorded in T4 (white non-woven bag), followed by T3 (Transparent bag), whereas the minimum pulp thickness was recorded in T8 (Control). Zaid (2023) reported that pre-harvest fruit bagging significantly increased pulp thickness in guava. The highest pulp thickness was observed in fruits bagged with non-woven bags, followed by yellow polythene bags; all bagging treatments outperformed the control, likely due to the associated increase in fruit weight and diameter, which directly influence flesh development.

The type of bagging materials utilized had a significant effect on the quantity of seeds per fruit and also the weight of seeds per fruit. The lowest seed count was recorded in T4 (non-woven bag), followed by T3 (transparent bag), while the control group exhibited the highest number of seeds. As for the weight of seeds, T4 (non-woven bag) has the lowest weight, followed by T3 (transparent bag), whereas the maximum was recorded in T8 (control). All treatments outperformed the control group regarding the number of seeds per fruit. This improvement may be related to the fact that seed characteristics are connected to the growth and development of the fruit, with a lower seed count per fruit being favoured by customers. These results align with the studies conducted by Rahman *et al*. (2017) and Meena *et al*. (2016) on guava. The pulp-to-seed ratio varied across treatments, with the highest value observed in T4 (non-woven bag), followed by T3 (Transparent bag). while the lowest ratio was recorded under T8 (control). The results align with the study by Pandey *et al*. (2025), who found that the control treatment had the lowest pulp-to-seed ratio.

**Table 2. Effect of preharvest bagging on pulp thickness (mm), pulp weight (g), weight of seed per fruit (g), number of seeds and pulp seed ratio of guava cv. Lucknow 49.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Treatment details | Pulp thickness (mm) | Pulp weight (g) | Weight of seed per fruit (g) | No. of seeds | Pulp to seed ratio |
| T1: Single-layered brown paper bag | 3.15 | 236.14 | 4.22 | 224.00 | 55.95 |
| T2: Double-layered bag | 4.34 | 250.67 | 4.56 | 236.00 | 54.97 |
| T3: Transparent bag | 4.65 | 267.66 | 3.91 | 192.00 | 68.45 |
| T4: White non-oven bag | 4.85 | 277.72 | 3.79 | 186.00 | 73.27 |
| T5: Butter paper bag | 4.26 | 247.68 | 4.38 | 215.00 | 56.54 |
| T6: Yellow polythene bag | 3.87 | 239.33 | 5.20 | 251.00 | 46.02 |
| T7: White polythene bag | 3.93 | 241.00 | 4.36 | 217.00 | 55.27 |
| T8: Control | 3.09 | 220.34 | 5.28 | 259.00 | 41.73 |
| SE(d) | **0.097** | **5.582** | **0.113** | **4.418** | **1.483** |
| C.D. | **0.207** | **11.972** | **0.243** | **9.476** | **3.181** |

**3.4 TSS**

Total soluble solids (TSS) significantly contribute to sweetness, flavour, and consumer preference (Asrey *et al*., 2020). The different fruit bagging treatments significantly affected the TSS. Fruits bagged in T4 (White non-woven bag) showed the maximum TSS, and the least was recorded in T8 (Control) (Fig. 1). These findings align with previous research, which showed that white non-oven bagging significantly increases TSS by Zaid (2023) and Islam *et al*. (2017) in guava. Pre-harvest fruit bagging, a physical protection approach, modifies the fruit's quality by changing its microenvironment throughout development (Son and Lee, 2008). Nanyakkara *et al*. (2005), in mango, reported improved total soluble solids because of fruit bagging.

**3.5 Organoleptic evolution**

The sensory characteristics of fruit, known as organoleptic properties, are significantly affected by various bagging techniques. Key attributes of guava, such as its taste, colour, texture, and aroma, play a crucial role in its marketability. In particular, the yellow ripe stage exhibits far superior organoleptic qualities compared to the green-yellow stage. The treatment T4 (White non-woven bag) received the highest score for taste, followed by the treatment T3 (Transparent bag). In terms of colour, the top rating was awarded to T4 (white non-woven bag), followed by T5 (butter paper bag). For texture, T4 (non-woven bags) achieved the highest score, followed closely by T3 (transparent bag). In the aroma category, T4 (white non-woven bags) also received the highest rating, followed by T3 (transparent bag) (Fig. 1). Meanwhile, the control sample scored the lowest in all four aspects: taste, colour, texture, and aroma. Brar *et al*. (2019) observed that the organoleptic rating improved significantly in all the non-woven bagged fruits as compared to unbagged fruits. Earlier studies have demonstrated that fruit bagging can enhance the quality of fruit mainly by maintaining its appearance and promoting consistent colour development, as noted by Sarker *et al*. (2009) and Singh *et al*. (2017) in their research on mangoes.

**Fig.1 Effect of preharvest bagging on TSS and Organoleptic evaluation of guava var. Lucknow 49**

1. **CONCLUSION**

In conclusion, the study on the influence of various bagging methods on the physical qualities and shelf life of guava var. Lucknow-49 has illuminated the significant benefits of pre-harvest bagging as an effective strategy to improve the fruit quality. The diverse bagging treatments demonstrated varying degrees of effectiveness in protecting guava fruits from fruit fly infestations while also enhancing overall fruit quality, including aspects such as weight, colour, and marketability. The results indicate that certain materials, particularly those with optimal properties for temperature and humidity control, can significantly improve the quality of the harvested fruit. This approach not only contributes to higher commercial value but also aligns with sustainable pomological practices by reducing the reliance on chemical pesticides. The findings underscore the importance of using appropriate fruit bagging materials in guava cultivation to optimize production and ensure high-quality yields. Future research should continue to explore innovative bagging techniques and materials to further enhance the resilience of guava fruits against biotic stresses while maintaining their nutritional and aesthetic qualities.

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during the writing or editing of this manuscript.

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