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ORIGINAL ARTICLE

Effect of pre-harvest fruit bagging on post-harvest quality of guava cv. Swarupkathi

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ABSTRACT

The investigation was carried out at Germplasm Centre (BAU-GPC), Bangladesh Agricultural University, during March to July 2016 in order to investigate the effect of pre-harvest fruit bagging on post-harvest quality of guava cv. Swarupkathi. Four different bagging materials *viz.* brown paper bag, white paper bag, white polythene bag, and black polythene bag were included for the study and uncovered fruits were used as control treatment. The experiment was laid out in a randomized complete block design with three replications. Fruit bagging treatments showed significant effects on different parameters studied. It was observed that fruit size, fruit weight, vitamin C concentration, and moisture content increased due to fruit bagging. Fruits gained the maximum in size (6.59 cm length, 5.86 cm diameter) and weight (164.26 g) under white paper bag followed by white polythene bag (131.3 g). The skin color of fruits was very attractive in case of white paper bag than that of other treatments. Total soluble solid concentration of the fruit was found to be the maximum (12.33% Brix) under brown paper bag while the maximum vitamin C concentration (162.14 mg 100 g⁻¹) was recorded under white paper bag. Uncovered fruits showed the maximum total sugar, non-reducing sugar, and reducing sugar concentrations (10.13%, 6.05%, 4.08%, respectively). The results also revealed that fruit bagging in general, improved the growth and quality of guava fruits as compared to the control (no bagging). Among the various fruit covering materials, white paper bag was found to be the best for overall improvement of physical and chemical quality of guava cv. Swarupkathi.

Keywords: Fruit bagging, skin color, nutritional quality, guava (*Psidium guajava* L.)

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1 Introduction

Guava is a berry like fruit of the genus *Psidium*, especially *Psidium guajava* L. belongs to the family Myrtaceae. It was originated in tropical America (Mex-

ico to Peru) but at present the major guava producing countries are the USA, Cuba, Taiwan, Mexico, Peru, China, Malaysia, India, Pakistan, Thailand and Bangladesh. Guava is often called the 'apple of the tropics'. It claims to be the most important fruit in

respect of area and production after mango, banana, jackfruit, pineapple, and melon in Bangladesh. It grows everywhere in Bangladesh in the homestead gardens even without or little care but commercially cultivated in Barisal, Chittagong, Dhaka, Khulna, Rajshahi, Natore, Chapainawabganj, Rangpur, and Sylhet (BBS, 2016). According to BBS (2016), Bangladesh produced 214000 tons of guava fruits in the year 2015-2016.

Guava is a popular fruit irrespective of the rich and the poor people of Bangladesh due to its comparative lower price, especially in summer, nourishing values and good taste than some other fruits. It is a delicious and nutritious fruit rich in vitamin-C (200~300 mg 100 g⁻¹ of pulp), calcium, mineral, and phosphorus (Mitra and Sanyal, 2004). It contains an appreciable amount of vitamin-A, calcium, phosphorus, potassium, sulphur, sodium, chlorine, iron, magnesium (FAO, 2009), pantothenic acid, riboflavin, thiamin, and niacin in guava (Sing and Sing, 2005).

Guava fruits relished when mature or ripe, and freshly plucked from the tree. It is used for various purposes. The roots, bark, leaves, and immature fruits are commonly administered to control gastroenteritis, diarrhoea and dysentery because of their astringency throughout the tropics (Anonymous, 2010). Fresh and mature guava is taken by chewing. Salad and pudding are prepared from shell of the ripe fruit. Processed products like jam, jelly, cheese, juice, nectar etc. are prepared commercially from ripe guava.

The production of guava is greatly hampered due to the attack of different pests like fruit flies (*Bactrocera dorsalis*, *B. zonata*). Crop loss varies from a few percent to 100% depending on fruit fly population, locality, variety, and season (Kumar et al., 2011). The female fruit fly punctures the fruits by its ovipositor and lays six or more banana shaped eggs into healthy, ripening fruits just beneath the skin. The sting sites appear as discolored or blackish spots, which may exude distinctive blobs or filaments of gum. As the fruit skin is breached, secondary infection by bacteria induces decaying of fruit tissue. Eggs are hatched within two to three days and the maggots feed on the decaying fruit tissue (Kumar et al., 2011). If host fruits are profusely available, a single female fly can lay eggs throughout her life, which may last for two or three months. Infested fruits are not generally marketed.

Several researchers (Gupta et al., 1992; Chinariyawong et al., 2003; Sood and Sharma, 2004; Singh et al., 2008; Sapkota et al., 2010; Oke, 2008) advocated various management options including use of hydrolyzed protein and sugar spray, pheromone trap, spraying of botanicals and chemical insecticides, field sanitation, poison food trap, and bagging of fruits for management of fruit fly. Among these, bagging or wrapping fruits has been found more practicable and better fruit growth and development were found un-

der fruit covering than the open condition in guava (Fumuro and Gamo, 2001; Wanichkul and Harach, 2002; Kim et al., 2003; Patil, 2003).

Bagging is the best option for fruit fly management over conventional practice of pesticide spray for its efficacy and zero pesticidal residue in the fruit. Bagging, a physical protection technique, not only protects fruit from pests and diseases but also affects the quality of the produce by changing microenvironment of fruit during development (Son and Lee, 2008). Bagging of fruits during development can reduce the chances of physical damage, improve colour at harvest (Byers and Carbaugh, 1995; Muchui et al., 2010) and yields high quality fruit (Kitagawa et al., 1991). Guava fruits bagged with biodegradable polyfilms, 6-9 weeks before harvesting, effectively controlled fruit fly (*Anastrepha* spp.) and guava weevil (*Conotrachelus psidii*) (Bilck et al., 2011). Bagging not only keeps the female flies away from the fruits but also improves the texture, colour and quality of the fruits (Singh et al., 2008). Martins et al. (2007) observed that wrapping of guava fruit with paper bag one month prior to harvesting reduced black spot (*Guignardia psidii*) and anthracnose (*Colletotrichum* spp.) infestation. However no noticeable research works have been conducted on safe guava production and handlings.

Therefore this study has been undertaken to explore the effects of different bagging materials on physical and chemical quality of guava in a view to judge the potential of fruit bagging technology for safe guava production in Bangladesh.

2 Materials and Methods

The experiment was conducted at BAU Germplasm Centre (24°43'3.6"N, 90°25'51.6"E), Bangladesh Agricultural University (BAU) during March to July 2016. The experimental area was under the subtropical climate characterized by heavy rainfall during the months of May to July 2016 and scanty rainfall during the rest period of the year (Table 1).

2.1 Treatments and experimental design

Fruit bagging materials was considered the treatments and no fruit bagging (open fruit) was treated as control. Therefore, the experimental consisted of five treatments, viz. control (open fruit, T₀), brown paper bag (T₁), white paper bag (T₂), white polythene bag (T₃), and black polythene bag (T₄). Brown paper and polythene sheets were purchased from the local market and the bags were handmade. There were 15 fruits of two guava trees under one bagging treatment in one replication. So there were 6 trees for 3 replications under each treatment and 30 trees for 5 treatments. The experiment was conducted in Randomized Complete Block Design (RCBD) with

Table 1. Monthly record of temperature (maximum, minimum, and average), relative humidity (RH), rainfall, and total sunshine hours (TSH) of the experimental site during the study period (February – July 2016)

Month	Temperature (°C)			RH (%)	Rainfall (mm)	TSH (hour)
	Max.	Min.	Average			
February	31.20	11.00	21.10	80.14	8.40	137.80
March	33.50	16.50	25.00	74.04	104.80	190.20
April	37.00	20.50	28.75	81.20	53.20	171.20
May	30.79	22.77	26.78	82.86	172.30	168.20
June	32.36	25.94	29.15	86.33	255.00	129.50
July	31.10	26.15	28.63	88.74	447.80	124.14

three replications. After one month of fruit setting, the fruits were wrapped with respective bagging materials as per the treatments. A small portion of two corner of each bag was cut in order to prevent water deposition inside the bag. The bags were tied tightly with the help of rope so that water and insect could not enter into the bag. All trees were maintained under uniform cultural practices during the course of investigation. Fruits were harvested at fully mature stages after three months of fruit setting. The maturity of guava fruits were confirmed by the visual symptoms, for example, disappearance of the fruit ridges and changes of fruit colour from green to pale green.

2.2 Physical quality assessment

Immediately after harvesting of mature guava fruits, weight of harvested fruits was taken by using an electrical balance. The length and breadth of fruits were measured manually by using a slide calipers. Skin colour was determined at fully mature stage by comparing with a reference colour chart and expressed in language as light green, yellow green. An approximately 10 g portion sample from each guava was taken from each freshly harvested guava in porcelain crucible oven dried at 70 °C until the constant weight was attained. Percent moisture and dry matter contents were calculated from the weight loss of initial sample weight (before drying).

2.3 Chemical quality assessment

2.3.1 Total, reducing and non-reducing sugars

Extraction of sugar from guava pulp was done by using the following method of [Loomis and Shull \(1937\)](#). Two grams of guava pulp was cut into small pieces and immediately plunged into boiling ethylalcohol and was allowed to boil for 5~10 minutes (10~20 ml of alcohol was used per g of pulp). The extract was filtered through two layers of cloths and the ground tissue was re-extracted for 3 minutes in hot 80% alcohol, using 2~3 ml of alcohol per g of tissue. The

second extraction was ensured complete removal of alcohol with suitable substances. The extract was cooled and passed through two layers of cloths. Both of the extracts were filtered through Whatman No.1 filter paper. The volume of the extract was evaporated to about 25% of the volume over a steam bath and cooled. This reduced volume of extract was transferred to a 100 ml volumetric flask and was made up to the mark with distilled water.

Total sugar content of guava fruit was determined calorimetrically by the anthrone method ([Jayaraman, 1981](#)). An aliquot of 1 ml of pulp extract was pipetted in test tubes and 4 ml of anthrone reagent was added to each of this solution and mixed well. Glass marbles were placed to top of each test tube to prevent loss of water through evaporation. Then the tubes were placed in a boiling water bath for 10 minutes and then it was recovered and cooled. A reagent blank was prepared by taking 1 ml of water and 4 ml of anthrone reagent in a tube and treated similarly. The absorbance of blue-green solution was measured at 620 nm in a colorimeter and total sugar concentration was estimated from a standard curve of a series of glucose solutions.

Reducing sugar concentration of guava fruit extract was determined by dinitrosalicylic acid (DNS) method. For the determination of reducing sugar concentration, an aliquot of 1ml of the extract was pipetted into a test tube and 3 ml of DNS reagent was added to each of these solutions and mixed well. The test tube was heated for 5 minutes in a boiling water bath. After the development of color, 1 ml of 40% rochelle salt was added when the contents of the tubes were still warm. The test tubes were then cooled under a running tap water. A reagent blank was prepared by taking 3 ml of distilled water and 3 ml DNS reagent in a tube and treated similarly. The absorbance of the solution was measured at 575 nm in a colorimeter.

The amount of reducing sugar was calculated from the standard curve of glucose. Non-reducing sugar concentration of guava was calculated by using

Table 2. Effect of fruit bagging treatments on weight, length and breadth of guava

Treatment	Fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)
Control (open fruit)	108.58 b	5.36 b	4.95 c
Brown paper bag	110.57 b	5.60 b	5.41 b
White paper bag	164.26 a	6.59 a	5.86 a
White polythene bag	131.03 ab	6.02 ab	5.54 ab
White polythene bag	104.15 b	5.55 b	5.12 b

† Any two values within a column which are not identified by a common letter differ significantly ($p \leq 0.05$).

the following equation:

$$\%NRS = \%TS - \%RS \quad (1)$$

where, NRS = Non-reducing sugar, TS = total sugar, and RS = reducing sugar.

2.3.2 Vitamin-C concentration

Ten grams of fresh pulp was taken in 100 ml beaker with 50 ml 3% metaphosphoric acid and then it was transferred to a blender and homogenized with same concentration of metaphosphoric acid. After blending it was filtered and transferred to a 100 ml volumetric flask and was made up to mark with 3% metaphosphoric acid. Five ml of the aliquot was taken in a conical flask and titrated with 2,6-dichlorophenol indophenol dye. Phenolphthalein was used as indicator which gave pink colour end point, persisted at least 15 seconds. The ascorbic acid content of the samples was calculated by following formula:

$$\text{Vit-C} = \frac{T \times D \times V_1}{V_2 \times W} \times 100 \quad (2)$$

where, Vit-C = Vitamin-C content ($\text{mg } 100 \text{ g}^{-1}$), T = titre, D = dye factor, calculated in separate titration with standard ascorbic acid solution, V_1 = volume made up (ml), V_2 = aliquot of extract taken for estimation (ml), and W = weight of sample taken for estimation (g).

2.3.3 Titratable acidity

Three mature samples of guava fruits were taken and homogenized. Fifty gram of the homogenized sample was balanced in waring blender with sufficient amount of distilled water for 5 minutes. The supernatant was pooled together and transferred to a 250 ml conical flask and constant volume was made with distilled water and filtered. An aliquot of 10 ml was taken from the stock solution and titrated with 0.1 N NaOH solution using 2~3 drops of phenolphthalein as indicator. The titration was done in triplicate and percent titratable acidity content was calculated using the following formula:

$$\% \text{Titratable acidity} = \frac{T \times N \times V_1 \times E}{V_2 \times W \times 1000} \times 100 \quad (3)$$

where, T = titre, N = normality, V_1 = volume made up to (ml), V_2 = volume of sample taken for estimation (ml), W = weight of sample taken for estimation (g), and E = equivalent weight of acid (normality).

2.3.4 Total soluble solid concentration

Total soluble solids (TSS) concentration of guava was estimated using a portable digital refractometer (NR 151, Rose Scientific Ltd., Canada). A drop of guava juice squeezed from the fruit pulp was taken into the refractometer and TSS content was recorded as %Brix from direct reading of the instrument. Temperature corrections were made using the temperature correction chart.

2.3.5 Statistical analysis

The collected data on various parameters were statistically analyzed using MSTAT-C statistical package. The means for all the treatments were calculated and analysis of variances (ANOVA) for all the parameters was performed by F -test. The significance of difference between the pair of means was compared by least significance difference (LSD) test at 5% and 1% level of probability (Gomez and Gomez, 1984).

3 Results

3.1 Fruit weight

There was a significant influence of different bagging materials on fruit weight of guava ($p < 0.05$). It is evident from the result that the treatment white paper bag had better effect on weight of fruits among the different bagging treatments of guava fruits showing the maximum fruit weight (164.26 g) which was statistically identical to white polythene bag (131.03 g) (Table 2). The lowest fruit weight (104.15 g) was obtained from black polythene bag.

3.2 Fruit size

Fruit size *i.e.* length and diameter of fruits under white paper bag was also found maximum among the different bagging of guava fruits under this study.

Table 3. Influence of different bagging materials on skin color of guava

Treatment	Fruit skin colour and smoothness
Control (open fruit)	Light green with spotted
Brown paper bag	Yellowish green and smooth
White paper bag	Yellowish green and smooth
White polythene bag	Yellowish green and smooth
White polythene bag	Yellowish green and smooth

Table 4. Effect of treatment on moisture, reducing sugar, non-reducing sugar, and total sugar contents of guava

Treatment	Moisture (%)	Reducing sugar (%)	Non reducing sugar (%)	Total sugar (%)
Control (open fruit)	81.66 b	4.08 a	6.05 a	10.13 a
Brown paper bag	83.40 a	4.05 a	5.39 b	9.44 b
White paper bag	83.60 a	4.03 ab	5.35 b	9.38 c
White polythene bag	84.43 a	3.99 bc	5.36 b	9.35 c
White polythene bag	83.70 a	3.97 c	5.50 b	9.48 b

† Any two values within a column which are not identified by a common letter differ significantly ($p \leq 0.05$).

The guava fruit under white paper bag had the maximum length (6.59 cm) and diameter (5.86 cm) which was statistically identical to white polythene bag (6.02 cm and 5.54 cm) (Table 2). The lowest fruit length (5.36 cm) and breadth (4.95 cm) was obtained from control condition.

3.3 Skin colour

Colour is one of the most important criteria of quality of most fruits. It was observed that the different bagging materials had great effect on skin colour of guava fruit. The result showed that the colour of open fruits was light green and the surface was rough while fruits were yellowish green color and smooth surface under brown paper bag, white paper bag, white polythene bag and black polythene bag (Table 3).

3.4 Moisture

Moisture content of guava fruits under different bagging materials was statistically significant ($p < 0.05$). The highest moisture content was obtained from white polythene bag (84.43%) and the lowest was in control condition (81.66%) (Table 4).

3.5 Sugar contents

Statistically significant variation was observed in case of reducing sugar, non-reducing sugar and total sugar content among the bagging materials ($p < 0.05$). The highest reducing sugar content was in open condition (4.08%) and the lowest was in black polythene bag (3.97%) (Table 4). The highest non-reducing sugar content was (6.05%) in control condition and the lowest was in white paper bag (5.35%) (Table 4). And

the highest total sugar content (10.13%) was observed in open condition and the lowest in white polythene bag (9.35%) (Table 4).

3.6 Dry matter content

In case of percent dry matter content, statistically significant variation was observed among the bagging materials ($p < 0.05$). The highest dry matter content was found in control condition (18.30%) was statistically identical to white paper bag (17.6%) and the lowest in white polythene bag (15.56%) (Fig. 1).

3.7 Vitamin-C content

Highly significant variation in relation to vitamin-C content was noticed among the bagging materials ($p < 0.05$). Vitamin-C content was the highest in white paper bag (162.78 mg 100g⁻¹), while the lowest vitamin-C content was found in black polythene bag (119.61 mg 100g⁻¹) (Fig. 1).

3.8 Titratable acidity

There were highly significant variations in content of titratable acidity among the bagging materials ($p < 0.05$). The result showed that the highest titratable acidity content of guava fruit (2.02%) was found in open condition and the lowest (1.33%) was in white polythene bag (Fig. 2).

3.9 Total soluble solids

Total soluble solids content of guava fruits were measured at mature stage. It was observed that the variation in TSS content of fruits in different bagging

materials were statistically significant ($p < 0.05$). The mature fruit of brown paper bag contained the highest TSS (12.33%) and among the treatments white paper bag contained the lowest (11.00%) (Fig. 2).

4 Discussion

Pre-harvest bagging with brown paper bag, white paper bag, white polythene bag and black polythene bag improved physical parameters *viz.* weight of fruit, length of fruit, diameter of fruit and pulp weight over control fruits, and the variation was statistically significant. The bagged fruits produced the highest fruit weight (164.26 g) the highest length (6.59 cm) and the highest breadth (5.86 cm). They reported the effectiveness of bagging to accelerate growth of fruits and increase fruit size and weight of guava.

Changes of weight and circumferences by covering of different colour polythene might be due to interaction between different light intensity and temperature inside the bag (Kutinyu, 2014). Weight loss occurs due to the respiration loss of stored starch in guava and increase of respiration in positively correlated with the increase of temperature. As temperature was low at bagging condition so weight loss was the minimum at bagging condition. Covering fruit with a bag at a particular developmental stage may influence their growth and size. Reports on effects of fruit bagging on fruit size and weight opined that it may be due to differences in the type of bag used, fruit and cultivar responses (Shimada and Ko, 2008).

Colour is one of the most important criteria for good quality fruits. The change in guava colour from light green to yellowish green was very distinctive. The result showed that the colour of open fruits was light green and the surface was rough while fruits were yellowish green color and smooth surface under bagging condition. Change of colour during ripening and senescence of fruits involves chlorophyll degradation or qualitative and quantitative alteration of the green pigment into other pigments. Fruit colour is the fundamental feature that attracts consumers. An attractive colour improves the physical appearance of the fruit, which helps to get better price in domestic and export markets. Several studies have indicated that pre-harvest fruit bagging can promote or inhibit fruit colour development. This is possibly due to the effect of temperature which slowed down the activity of enzymes that are responsible for chlorophyll breakdown resulting the colour change. The surface of the covered fruits was smooth due to no attack of insect and pest. Edirimanna et al. (2015) reported yellowish green colour under all treatments.

The highest dry matter content was found in control condition (18.30%) and the lowest in white polythene bag (15.56%) (Fig. 1). This might be due to high photosynthesis rate and chlorophyll content in controlled fruit caused the highest dry matter con-

tent. The highest moisture content was obtained from white polythene bag (84.43%) and the lowest was in control condition (81.66%) (Table 4). The result of the present study is in support of the findings of Shahjahan et al. (1994). He reported that controlled fruits contain lower moisture content than bagging fruits. The protection of fruits from direct sun light and temperature inside the poly bag might be the cause of maximum moisture content.

The highest reducing sugar content was in open condition (4.08%) and the lowest was in black polythene bag (3.97%) (Table 4). The highest non-reducing sugar content was (6.05%) in control condition and the lowest was in white paper bag (5.35%) (Table 4) and the highest total sugar content (10.13%) was observed in open condition and the lowest in white polythene bag (9.35%) (Table 4). The observation was different from the observation of Meena et al. (2016). They observed better result of total sugar (11.14%), reducing sugar (8.85%) and non-reducing sugar (2.45%) under yellow polyethylene bag. It might be happened due to the different climatic condition, variety and different poly bag. When the fruits become mature, acids are converted into sugars making guavas sweeter. But due to low concentration of O_2 in the bag hampered the acid to sugar conversion process. This might be the cause for lowering the sugar content in bagged fruits.

Vitamin-C content was the highest in white paper bag (162.78 mg $100g^{-1}$), while the lowest vitamin-C content was found in black polythene bag (119.61 mg $100g^{-1}$) (Fig. 1). The results coincided with the findings of Meena et al. (2016). They found the highest vitamin-C content (171.14 mg $100g^{-1}$) under white poly bag. The decrease of vitamin-C content is attributed to the oxidation of ascorbic acid in to dehydro-ascorbic acid by the enzyme ascorbic acid oxidase (Shimada and Ko, 2008). The bagging after one month of fruit setting improved the physico-chemical quality and micro environment of fruits.

The highest titratable acidity content of guava fruit (2.02%) was found in open condition and the lowest (1.33%) was in white polythene bag (Fig. 2). Meena et al. (2016) also reported that the highest titratable acidity content was in control condition and the lowest was in white polythene bag. The decrease of titratable acidity might be attributed to the utilization of organic acids in respiration process and other bio-degradable reactions (Ulrich, 1970).

The mature fruit of brown paper bag contained the highest TSS (12.33%) and among the treatments white paper bag contained the lowest (11.00%) (Fig. 2). These might be attributed due to different treatments and sunlight. Such results partially supported by the findings of Meena et al. (2016). They reported that maximum TSS content was found in yellow polythene bag (30.07%) and the minimum was in control condition (14.46%). The increase of TSS content is due

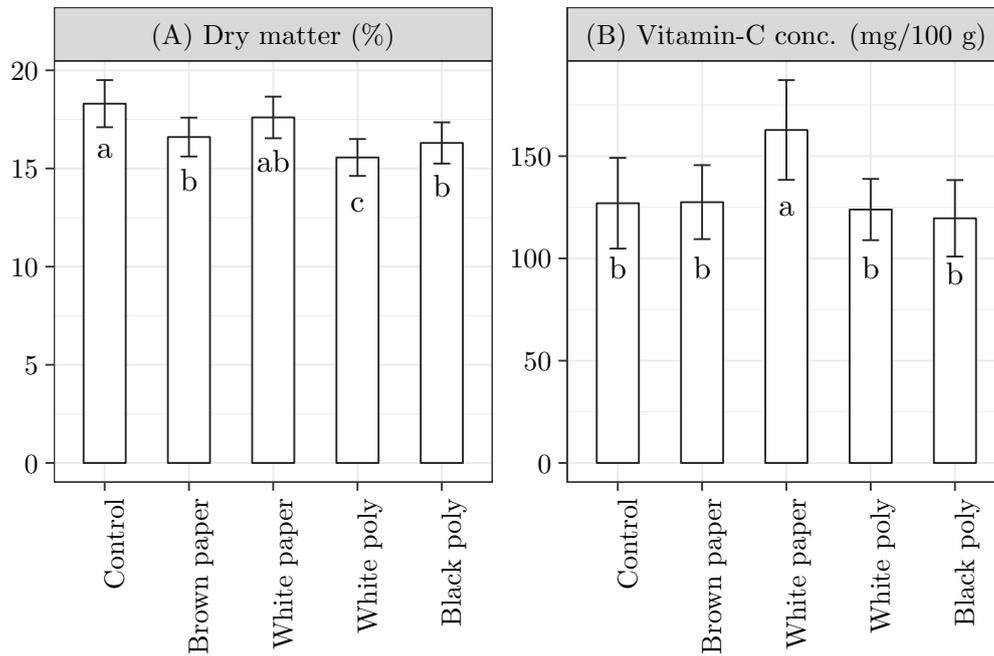


Figure 1. Effects of different bagging materials on (A) dry matter, and (B) vitamin-C concentrations of guava fruit. Vertical bars indicate mean±SD.

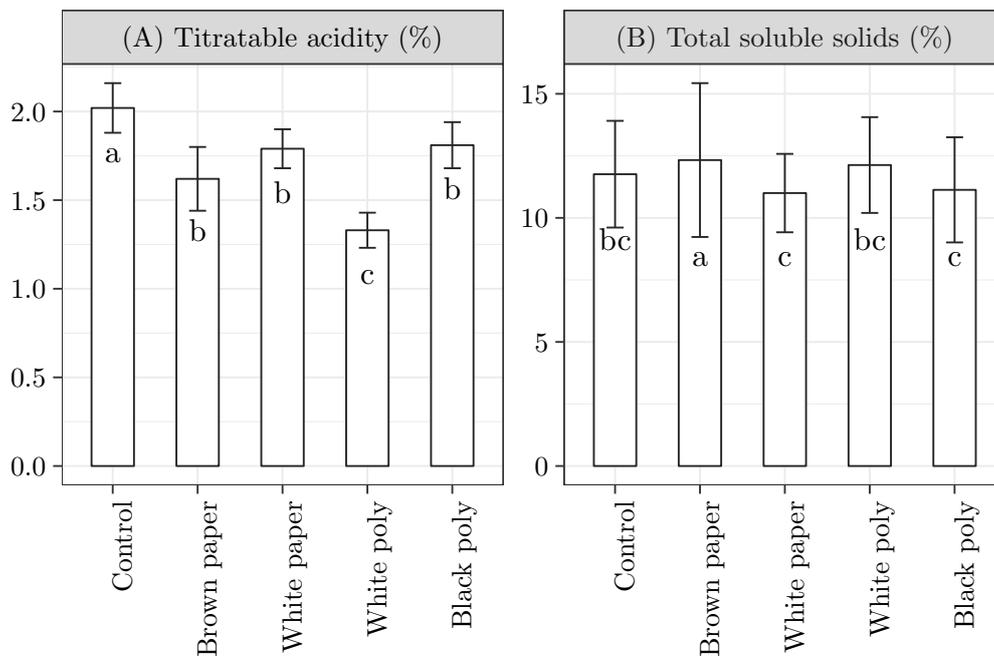


Figure 2. Effects of different bagging materials on (A) titratable acidity, and (B) total soluble solid concentrations of guava fruit. Vertical bars indicate mean±SD.

to the conservation of complex carbohydrates into simple sugars. Edirimanna et al. (2015) reported that the highest TSS content was found in white polythene bag (13.6%) and the lowest was in control condition (9.9%).

5 Conclusion

Considering the findings it may be concluded that significant variation existed among the different pre-harvest fruit bagging treatments in respect of weight and size of fruit, skin colour, total soluble solids content, vitamin-C content, sugar contents (reducing, non-reducing and total). From the experimental findings, it might be concluded that, among the five bagging materials, white paper bag showed the best result compared to other. The fruits covered with white paper bag showed maximum weight, diameter, vitamin-C content and less titratable acid and attractive color which increased its market value. Considering the above stated findings, further studies are suggested to carry out to examine the effects of other promising non-chemical botanical pesticides with series of concentrations on quality of guava fruits. The nutritional and taste test should also be included in under to explicitly recommend the technology.

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