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Research Article

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Fruit Bagging: An Approach for Control of Fruit Fly Infestation and Quality Improvement in Guava

Sahar Rashid[1], Hira Faiz[1*], Muhammad Maaz Aziz[1], Komal Aslam[1], Humaira Kausar[2], Obaid Ullah Khan[3], Allah Bakhsh[1]

[1]Horticultural Research Institute, Faisalabad, Punjab, Pakistan
[2]Food Technology Section, Post Harvest section, Postharvest Research Center, Ayub Agricultural Research Institute, Faisalabad, Punjab, Pakistan,
[3]Office of Chief Scientist Agriculture (Research), Ayub Agricultural Research Institute, Faisalabad, Punjab, Pakistan
Corresponding author's email address: hirafaiz2094@gmail.com

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Abstract

This study was executed at experimental site of Horticultural Research Institute, Faisalabad (Central Punjab) during March- July 2020-2021 to scrutinize the impact of fruit bagging to control fruit fly infestation and overall quality of guava fruit. Three bagging materials viz. butter paper, brown paper (Chinese), non-woven selected for the research purpose and unwrapped fruits were taken as control treatment (T_o). The research was planned according to randomized complete block design (RCBD) replicated thrice. All the treatments exhibited significant impact on different traits evaluated. Enhanced fruit firmness, fruit size, ascorbic acid contents and fruit weight was noted in wrapped fruits in comparison to un-wrapped fruit. Fruits attained maximum size (3108.25mm^2) and weight (133.25a g) under brown paper bag followed by non-woven bag (3091mm^2) and (131g) respectively. Total soluble solid (TSS) contents of the fruit were observed maximum (10.18 Brix) in non-woven bag whereas highest titratable acidity (0.77%) was recorded under control treatment. Highest ascorbic acid contents (214.25mg /100g) were recorded in non-woven bag. Disease incidence (2.25%) and fruit fly infestation (2.13%) were found minimum in non-woven bag. Among all the treatments, non-woven material was observed to be the best to control fruit fly infestation as well as overall improvement in Guava fruit quality.

Key words: Fruit wrapping, Eco-friendly, Bagging material, Fruit fly, Disease incidence, Organoleptic evaluation

Introduction

The guava botanically known as *Psidium guajava* L. of the family Myrtaceae, most significant species in *Psidium* genus is a prevalent fruit crop of Pakistan that is full of ascorbates. Guava cultivation is gaining momentum in tropics as well as in subtropical conditions, giving production of high commercial value fruits. The fruit also packed with several nutraceutical constituents (Oliveira *et al*., 2019). It is amongst the greatly nutritive fruits of the world especially Central Asia (Indo-Pak subcontinent). The guava fruit contains vitamin C above 200 mg per100 g of fresh weight, almost quadruple of citrus, a handsome quantity of other vitamins (A&B) and minerals (potassium, magnesium) makes it a wonderful low-caloric foodstuff. It is one of the most common and well-distributed fruit crop cultivated both as commercial and home garden plantation in Pakistan. The on- tree fruit wrapping practice, that was performed in Japan during 20th century on grape berries and pear fruits (Sharma *et al*., 2014), is now extensively practiced in Asia (China, Korea, Japan), America and Australia, shielding fruits from the adjacent environment (mainly from pathogens, then temperature stress, humidity/water, and wind velocity) with a kind of protection—a physical fence around the fruits (Sharma *et al*., 2014). Though the bag production cost is high and the technique is labor exhaustive, wrapping with different materials gave out class outcomes. Any bagging material around the fruit manages temperature, sunlight, evaporation, humidity and mechanical damages. Bagging technique may also standardize time of fruit maturity and harvest (Kim *et al*., 2008), and it can also avoid pest attacks, especially fruit fly, hence, minimizing pesticide residual effects (Frank *et al*., 2008, Xu *et al*., 2018), which is predominantly important during the summer-season (Sharma *et al*., 2020). Therefore, bagging of fruit is an exceptional way to yield fruits with little inputs or residues of pesticide. Regardless of insect management, bagging technique also impacts the post-harvest life and quality of the fruits, and may even increase fruit weight, improves fruit skin color (Tokairin *et al*., 2014), as well as increase in size of fruit, soluble solid contents and vitamin C contents (Hossain *et al*., 2018). Improvement in biochemical

characteristics by using bagging technique has been reported in peach (Kim *et al*., 2008); loquat (Xu *et al*., 2010); pear (Lin *et al*., 2012) and mango (Singh *et al*., 2017a; guava fruit (Rahman *et al*., 2017b). Bagging practice lead to production of more eye-catching fruits due to less or zero blemishes and visible scars (Sharma *et al*., 2014) particularly in guava (Morera-Montoya,*et al*., 2010). Also, (Sharma *et al*., 2020) pomegranate, (Hamedi-Sarkomi *et al*., 2019) mango, (Sarker *et al*., 2009; Mathooko *et al*., 2011) apple, (Sharma *et al*., 2013; Rajametov *et al*., 2020), pear (Jing *et al*., 2008; Foro *et al*., 2020), peach fruits (Jia *et al*., 2005; Kim *et al*., 2008), loquat (Xu *et al*., 2010; Ni *et al*., 2011). In Pakistan, approximately a dozen strains of guava are grown but 'Gola' leads the others due to its attractive fruit color, size, better quality, taste with reasonable shelf life. Guava plants usually flower twice annually under climatic conditions of Central Punjab. Commencement of first flowering in April-May, which produces fruits in the monsoon season (July-August), and the 2nd flowering commences in August-September produces fruits in cool season (November-January). The cool season crop is of superior quality than the monsoon season crop because summer crop faces a serious attack of insect pests in rainy season. In spite of the high demand of guava fruit during summers, severe infestation of fruit fly *Bactrocera dorsalis* (Hendel) and *Bactrocer azonata* (Saunders) badly diminishes the marketable yield and fruit quality resulting considerable economic losses to the farmers. Like all fruits guava requires an explicit type of climatic conditions. Various environment related factors and other biotic factors affect the fruit growth and development process, such as, insect pest attack that deteriorates its quality hence, reduced its marketability. Guava receives heavy doses of pesticides as phyto-sanitary measures as it is among the mostly affected fruit species by pathogens and insects, especially for the management of fruit fly (*Drosophila melanogaster*) in conventional cultivation systems, whose main problem is fruit contamination. When it comes to organic fruit production, along with the use of toxic plants extracts and the Bordeaux and sulfur-lime combination in controlling fruit fly infestation (Pinheiro, 2006), wrapping of fruits have proved an effective and greatly practiced method for insect management (Pinheiro, 2006; Nascimento *et al*., 2011; Moura *et al*., 2011). Due to use of bagging technique, growers also being able to avoid mechanical damages and losses by disease incidences (Teixeira *et al*., 2011; Fernandes *et al*., 2019; Edirimanna *et al*., 2015; Meena *et al*., 2016).

Materials and Methods

This study was executed at experimental site of Horticultural Research Institute, Faisalabad (Longitude 74.09°E, Latitude 31.42°N, Elevation 188 m) during 2020-2021 in the month of March-July. Climate of the research site is categorized as subtropical having cold winter with hot dry summer. Soil of the research site was characterized as loamy with 8.1 pH (Basic), having low Potash (204 ppm), low accessible phosphorus (8.2 ppm) and very low organic carbon (0.85 %). The metrological data during the study period is presented in the following tabl

Table.1. Detailed weather parameters of the months during the experimentation

Month	Average Temperature (ºC)				Average Humidity (%)		Average Rain fall (mm)	
	Maximum		Minimum					
	2021	2022	2021	2022	2021	2022	2021	2022
April	34.5	40.3	18.4	21.5	52.4	43.0	15.4	1.0
May	38.6	41.5	24.0	26.8	54.4	41.1	11.2	Traces
June	39.0	40.3	25.6	25.9	60.0	54.2	14.2	91.2
July	37.3	35.0	26.9	27.2	69.0	78.4	241.6	235.1
August	37.7	36.3	26.8	27.0	69.4	75.6	5.0	21.8

Treatments and experimental design: Fruit covered with bagging material were used as treated while fruit without bagging material (open fruit) was considered as control. Hence, the experiment comprised of four treatments, i-e. Control (open fruit, T_0), brown paper (with inner carbon layer) (T_1), butter paper (T_2) and non-woven material (T_3). The fruits were wrapped with different materials at green hard but physiological mature stage. Brown paper (30 × 20) and butter paper (23×18) bags were imported from china (Demeter china association) while non-woven (24×19) material was acquired from the local shop and the bags were made manually. After one month of fruit setting 50 fruits per treatment on each plant were selected having uniform size and wrapped/bagged according to treatment allocation excluding control plant. To avoid entrance of insects and water, bags were tied firmly with rope. Uniform and proper cultural practices were applied to maintain all trees during this study period. Fruit harvesting was done at proper maturity stage after 3-4 months of fruit setting. The maturity of fruits was assessed by the visual indicators like disappearance of fruit ridges as well as variation in fruit color from green to pale yellow.

Physical quality assessment: Fruits were shifted to laboratory after harvesting for physical quality assessment. Fruit weight of all treatments was recorded with the help of electric balance (SF-400) having

capacity of 5000g*1g/1770.1oz. Fruit size was measured by using vernier caliper (Astore, 300 Germany) having capacity of 0-150mm. Firmness of fruit was recorded by using penetrometer. Number of Days was counted from fruit setting to maturity for assessment of days taken to fruit maturity. Disease incidence was calculated with the help of the following formula.

$$\textbf{Disease incidence } \% = \frac{\textbf{No of fruits infected}}{\textbf{Total no of fruits covered}} * \mathbf{100}$$

Fruit fly infestation was calculated by following formula.

$$\textbf{Fruit fly infestation } = \frac{\textbf{No of fruits infected}}{\textbf{Total no of fruits covered}} * \mathbf{100}$$

Fruits organoleptic characters (Color, Flavor, Texture and Taste) were also evaluated through arbitrary scale (Peryam and Pilgrim, 1957). Fruits were properly arranged according to replication on marked places. Six fruits were presented for tasting while others were peeled for Hedonic scale assessment. By using the Hedonic scale, a panel consist of 10 judges was requested to execute sensory assessment. For each replication, mean score determined.

Hedonic scale assessment

Product name :……. Variety/Strain--------
Date ……
Name of Judge: …… Signature: ……
Guidelines: (kindly read the guidelines carefully)

1. This form is for organoleptic assessment of guava fruit.
2. Use the numerical method for scoring the fruit samples.
3. Do not alter the arrangement of the given samples.
4. Before testing next fruit sample, wash the tongue with water.

Disliking exceptionally =1 Liking marginally = 6
Disliking very much =2 Liking moderately =7
Disliking moderately =3 Liking very much = 8
Disliking slightly = 4 Liking extremely = 9
Neither liking nor disliking =5

Chemical quality assessment: Juice of guava fruits was extracted for chemical quality assessment. Total soluble solids (TSS), Ascorbic acid contents, titratable acidity, sugars and pH were analyzed. Vitamin C contents (mg 100ml) were analyzed by using method narrated by Hans (1992). Total soluble solids (TSS) were determined with the help of digital refractometer (BX-1, Atago, Japan). Total sugars were assessed by using the methodology of Hurwitz (1960). Digital pH meter was used to evaluate the juice pH.

To assess the Titratable acidity, the extracted juice (10ml) was mixed with distilled water (40 mL). Afterwards 3-4 drops of phenolphthalein indicator were also added in the juice. An aliquot (10 mL) was taken in a flask and titrated was done against 0.1N NaOH until appearance of light pink color. Three repeated readings were taken and acidity was calculated with the help of following formula

$$\textbf{Titratable acidity } = \frac{\frac{N}{10}\textbf{NAOH} * \mathbf{0.0064}}{\textbf{Volume of sample used}} * \mathbf{100}$$

Statistical Analysis: The data was scrutinized statistically with the help of software (Statistics 8.1). To assess the significance of data, Analysis of Variance (ANOVA) technique was employed, whereas Tuckey test ($P \leq 0.05$) was employed to evaluate the variances among the mean values of treatments tested

Results and Discussion

Effect of bagging Physical characteristics of fruit: Physical appearance of a fruit is of great importance in its acceptance to consumers. Different parameters like fruit weight is an important attribute of 'Gola' guava. Most consumers prefer the 'Gola' guava compared to 'Surahi' varieties. Thus, the production of quality fruit could potentially improve the income and profit of fruit farmers.

Fruit weight (g): Present research revealed that the fruit weight was significantly affected by fruit bagging. In case of fruit weight, statistically significant variability was observed among the bagging materials ($p<0.05$).The fruit weight was ranged from 86.75- 133. 25 grams. Fruit weight was maximum (133.25g) when the fruits were bagged with butter paper bags and minimum (86.75) fruit weight was observed in case of control treatment (Table.2). Rahman *et al.* (2017) reported similar increase in weight of bagged guava fruits with white polythene and proposed that it might be due to the protection of fruit from ultra violet rays; as a result, the cell division in the fruits increased and proper availability of photosynthates to the fruits on the plant was ensured. The findings of current studies are in line with Rahman *et al.* (2017). Similar increasing trend in fruit weight and fruit size was also observed earlier by some researchers (Abbasi *et al*., 2014;)

Table 2: Effect of on-plant fruit bagging on physical characteristics of Guava "Gola"

Treatment	Fruit weight (g)	Fruit size (mm^2)	Days taken to fruit maturity (days)	Disease incidence %age	Fruit fly infestation %age	Fruit firmness (kg)
Control	86.75c	2685.25c	87.25b	70.25a	78.25a	1.28d
Brown paper bags	133.25a	3108.25a	89.25ab	4.25b	7.25c	1.95c
Butter paper bags	111.75b	2875.25b	90.50a	5b	9.5b	2.48b
Non-woven bag	131ab	3091ab	90.75a	2.25c	2.13d	3.05a
Means	**115.6±0.9**	**2939.5±0.3**	**89.4±0.5**	**20.4±0.4**	**24.2±0.6**	**2.1±0.09**
CV:	**1.69**	**2.41**	**1.24**	**4.63**	**5.30**	**8.24**
LSD value(p<0.05)	**3.13**	**113.2**	**1.7**	**1.5**	**2.05**	**0.2**

Fruit size (mm^2): Fruit size of guava was significantly influenced by bagging of fruits. Maximum size of fruits (3108.25mm^2) was recorded for brown paper bag which is at par to that of non-woven bags (3191mm^2). However, minimum fruit size (2685.25mm^2) was recorded in the fruits that receives no bagging treatment (control) (Table.2). Paper bags are thermos-insulators, so, it tolerates the heat and maintain the micro- environment in which transverse separation takes place. Yang *et al*., (2009) published that fruit wrapping encouraged fruit development in longan, producing large-sized fruit with reasonably good diameter. Parabha *et al*., 2018 also stated the similar assessments when evaluating a number of bagging materials in pineapple fruits quality improvement.

Days to reach maturity: All kinds of bags enhanced the maturity of 'Gola' cultivar over un-wrapped (control) ones. Statistically significant variation was detected among bags regarding days taken to fruit maturity (Table 2). Our results indicated that maturity starts later in bagged fruits in comparison to that of fruits without bagging. Number of days with the bagging process as in control treatment minimum days were observed for maturity onset. Maximum days (90.75) were taken by the fruits to reach maturity in case of non-woven bagging material whereas minimum time (87.25) was taken by the fruits that were kept without any bagging. Wang *et al*. (2010) described that on- tree fruit bagging in a peach cultivar 'Wanmi' (late-ripening), speeded fruit maturity by approximately ten days.

Disease incidence percentage (%): Fruit wrapping in guava crop also decreased the fruit fly infestation and disease occurrence such as anthracnose and pest (bird etc.) attack issues (Mitra *et al*. 2008, Morera-Montaya *et al*. 2010, Abbasi *et al.*, 2014, Mondal *et al*., 2015, and Sharma and Nagraja, 2016).

Highest incidence of disease occurred in fruits of control treatment (without bagging), whereas, the incidence of disease remained minimum (2.25%) in fruits wrapped with non-woven bagging material, followed by fruits in brown paper bags (4.25%). Maximum percentage of disease occurrence (70.25%) was noted in non-bagged fruits (Table.2).

Fruit fly infestation percentage (%): The key objective of the research study was to control the infestation of fruit fly. In this regard, statistically significant variability was found among the tested wrapping materials ($p<0.05$). Non woven bags performed best in controlling infestation of fruit fly during the growing period of the fruits as lowest percentage of infestation (2.13%) was determined in non-woven bagged fruits. Moreover, highest fruit fly infestation (78.25%) was found in case of un-treated (control) fruits (Table.2). Fruit flies and a lot other pests affect about 50% of the production capacity in the horticulture segment, consequentially substantial losses in quality and yield of fruits (Badii *et al*., 2015). It has been observed that fruit flies infestation caused 40 percent crop loss in citrus fruit and 70 percent confirmed losses in mango fruit (Badii *et al*., 2015).

Wrapping of guava fruit also decreased the fruit fly attack and disease occurrence like (anthracnose) and bird damage issues (Mitra *et al*., 2008; Morera-Montaya *et al*., 2010; Abbasi *et al.*, 2014; Mondal *et al*., 2015 and Sharma and Nagraja, 2016).

Fruit Firmness (kg): Bagging treatment influenced fruit firmness as fruit remained harder as compared to control treatment. There were highly significant variation regarding fruit firmness among the bagging materials ($p<0.05$). Fruits bagged with non-woven bags gave the highest values (3.05 kg) for firmness, while, lowest values (1.28 kg) were recorded in control treatment (Table.2). Bagging of fruits has been reported to shield perishable crop from insect pest attacks (Amrante *et al*., 2002), which could probably be the core cause of firmness conservation in the wrapped fruit. Sharma *et al*., (2013) reported the improved anthocyanin and lycopene synthesis in bagged fruits that might be the reason of higher fruit firmness. Similar finding were also published strengthening this statement (Srivastava *et al*., 2023).

Effect of bagging on Bio-chemical characteristics of fruit: Soluble solid contents (ºBrix): In case of soluble solid contents, statistically significant variability was witnessed among the bagging materials ($p<0.05$). Soluble solid contents were found highest (10.18 brix) in non woven bag**,** followed by butter paper bag (9.55 brix) and lowest value (8.68 brix) for SSC was recorded in control treatment. (Table.3).

Improvement in TSS with bagging has been reported in guava (Rahman *et al.*, 2017); peach (Kim *et al.*, 2008); loquat (Xu *et al.*, 2010); pear (Lin *et al.*, 2012) and mango (Singh *et al.*, 2017).

Titratable Acidity (%): The taste of fruit assessed by consumers did not merely depends on the TA (titratable

acidity) or SSC (soluble solid contents) of the fruit. Both of these biochemical traits have simultaneous impact on the taste of 'Gola' cultivar of guava (Susanto *et al*., 2019). There were great significant differences observed in titratable acidity content (%) among the treatments (bagging material) ($p<0.05$). The results of this study revealed that the highest percentages for titratable acidity (0.77%) of guava fruits were found in open fruit treatment (control) and the lowest (0.14%) was found in non-woven bags (Table.3). Singh *et al*., (2007) also published low acidity in wrapped fruits than un-wrapped ones, this happens might be due to the fact that bagging deferred the process of ripening and transpiration rate, hence, fruit produces less titratable acid. As the fruit wrapping is an imperative technique of covering the fruit with paper, it affects its various characteristics that enhance the quality. Here paper bag is tested best as it create a micro- climate with raised temperature inside but instantaneously it confirm the temperature elevating slowly that affect the fruit in a valuable way by refining the total sugar and aroma. This can be standardized by numerous research studies i.e (Zhou and Guo, 2005); (Meena *et al*., 2016); (Watanawan *et al*., 2008) in grapes, guava, and mango.

Total Sugar contents (%): In case of total sugar contents, significant variation was found among the bagging materials when analyzed statistically ($p<0.05$). Highest contents of total sugars (3.85%) were obtained from non-woven bag whereas fruits of control treatment gave the lowest sugar contents (2.64%) (Table. 3). Sunlight and temperature are two key environmental factors that generally alters the sugar accumulation percentages in fruits. The microclimate developed inside the bag around the fruit maintains the temperature rise in a gradual manner instead of abrupt rise or fall that definitely improves sugar contents of the fruits. Meena *et al*., (2016) publicized similar results after wrapping of guava fruit. Other reports also justified our results such as (Zhou and Guo, 2005) in grapes, (Watanawan *et al*., 2008) in mango. There is also contrasting research published by (Jing *et al*., 2020) whose findings demonstrate the reduction in sugar contents of the bagged fruits.

Vitamin C contents (mg/100g^{-1}): Vitamin C is required in higher amounts for good human health (Lee and Kader, 2000) as it plays a vital role as antioxidant in the body (Macan *et al*., 2019). Highly significant difference was noticed with respect to vitamin C contents among various wrapping materials tested during the study ($p<0.05$). The maximum vitamin C contents (214.25mg/100g^{-1}) were found in the fruits of non-woven bags, followed by that of butter paper bag (206.50 mg/100g^{-1}), whereas the minimum vitamin c contents (196.75 mg/100g^{-1}) were obtained from the fruits of control treatment (Table. 3)

Table 3: Effect of on-plant fruit wrapping on bio-chemical characteristics of Guava Var. "Gola"

Treatment	Soluble Solid Contents (Brix)	Titratable Acidity (%)	Total sugars (%)	Ascorbic acid (mg100g^{-1})
Control	8.68c	0.77a	2.64c	196.75d
Brown paper bags	9.63b	0.21bc	3.52ab	202.00c
Butter paper bags	9.55ab	0.30b	3.275b	206.50b
Non-woven bag	10.18a	0.14c	3.85a	214.25a
Means CV:	**9.50±0.13.40**	**0.35±0.0213.1**	**3.32±0.16.2**	**204.8±0.70.73**
LSD value(p<0.05)	**0.51**	**0.07**	**0.33**	**2.3**

Table 4: Effect of on-plant fruit bagging on organoleptic characteristics of Guava Var. "Gola"

Treatment	Skin color	Flavor	Texture	Taste
Control	3.75c	3.75c	3.375c	3.75c
Brown paper bags	6.25b	7.5a	7.5a	7.125b
Butter paper bags	6.75ab	6.75b	6.25b	6.85b
Non-woven bags	7.5a	7.5a	7.5a	7.5a
Mean CV:	**6.06±0.311.74**	**6.34 ±0.15.91**	**6.14±0.310.5**	**6.3 ±0.14.17**
LSD value(p<0.05)	**1.13**	**0.59**	**1.03**	**0.42**

Organoleptic properties: mong the various treatments, non-woven bags of different colours recorded significantly higher scores in terms of appearance, smoothness, taste, flavor, color, aroma and texture as compared to other bagging treatments. However, in case of control fruits the palatability rating was not recorded owing to complete damage of fruits due to fruit fly. It is apparent from the data presented in Table 4, perforated non- woven wrapped fruit had significantly greater scores concerning skin color, flavor, texture and taste (7.5), followed by the fruits developed inside brown paper bags ($p<0.05$). However, control fruits had lowest values for organoleptic characteristics (Table.4). Bagging of fruits maintained the physicochemical characteristics and the organoleptic rating of fruits which might be due to slowing down of the metabolic activities, sustained ripening, smooth and shining fruits free from any pest and bird damage. Improvement in appearance of papaya fruit was observed after bagging (Tran *et al*., 2015). Red color development also witnessed in green

apple cultivar (granny smith) in a research study conducted by (Wang *et al*., 2010).

Conclusion

It can be concluded from the current research finding that on-plant fruit bagging at early fruit development stage with non-woven bags can be a good choice to avoid diseases incidence as well as fruit fly infestation control in guava summer crop. Bagging practice will not only help in producing high quality blemish free guava fruit but will also prove a good way to enhance profit of guava growers especially it is a strongly recommended practice for those who are involved in organic fruit production.

Conflict of interest

All the authors have no conflict of interest.

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