

**Effect of Fruit Bagging on Yield and Quality of Guava
(*Psidium guajava* L.) cv. 'Allahabad Safeda'**

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izHkko**

SUDESH KUMAR

**THESIS
Master of Science in Agriculture
(HORTICULTURE)**



2020

**DEPARTMENT OF HORTICULTURE
RAJASTHAN COLLEGE OF AGRICULTURE**

MAHARANA PRATAP UNIVERSITY OF AGRICULTURE AND
TECHNOLOGY

UDAIPUR-313001 (RAJ.)

**Effect of Fruit Bagging on Yield and Quality of Guava
(*Psidium guajava* L.) cv. 'Allahabad Safeda'**

**bykgkckn IQsnk ve:n $\frac{1}{4}$ flfM;e xqtkok ,y- $\frac{1}{2}$ ds
Qyksa dh iSnkokj o xq.koYkk ij FkSyh ca/ku dk
izHkko**

Thesis

Submitted to the

**Maharana Pratap University of Agriculture and Technology,
Udaipur**

In partial fulfillment of the requirements for the Degree of

Master of Science in Agriculture

(HORTICULTURE)



By

SUDESH KUMAR

2020

CERTIFICATE – I

CERTIFICATE OF ORIGINALITY

The research work embodied in this thesis titled “**Effect of fruit bagging on yield and quality of Guava (*Psidium guajava* L.) cv. Allahabad Safeda**” submitted for the award of degree of **Master of Science in Agriculture** in Agriculture in the subject of **Horticulture**, to Maharana Pratap University of Agriculture and Technology, Udaipur (Raj.) is original and bona fide record of research work carried out by me under the supervision of **Dr. S.S. Lakhawat**, Associate Professor & Head of Department of Horticulture, Department of Horticulture, Rajasthan College of Agriculture. The content of the thesis, either partially or fully, have not been submitted or will not be submitted to any other institute or University for the award of any degree or diploma.

The work embodied in the thesis represents my ideas in my words and where others’ ideas have been included; I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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This is to certify that **Mr. Sudesh Kumar** student of **Master of Science in Agriculture, Department of Horticulture**, Rajasthan College of Agriculture, Udaipur has made all corrections/ modifications in the thesis entitled “**Effect of fruit bagging on yield and quality of Guava (*Psidium guajava* L.) cv. Allahabad Safeda**” which were suggested by the external examiner and the advisory committee in the oral examination held on 19/03/2020. The final copies of the thesis duly bound and corrected were submitted on / /2020 are enclosed here with for approval.

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ACKNOWLEDGEMENT

*I take it to my proud privilege to avail this opportunity to express my sincere sense of gratitude to my learned Major advisor **Dr. S.S. Lakhawat**, Associate Professor & Head, Department of Horticulture, for his stimulating guidance, constructive suggestion, keen and sustained interest and incessant encouragement bestowed during the entire period of investigation, as well as critically going through the manuscript, whose unceasing interest, constant endeavour, valuable guidance, healthy criticism and personal affection made this work a success.*

*I am gratified to record sincere thanks to the member of my Advisory Committee, **Dr. Shalini Pilonia**, Assistant Professor, Department of Horticulture, **Dr. B. Upadhyay**, Professor, Department of Agriculture Statistics and Computer Applications and DRI Nominee **Dr. P.P. Jani**, Professor, Department of Agronomy, Rajasthan Collage of Agriculture, Udaipur for their generous gestures and valuable suggestions in planning and execution of this study.*

*The author is indebted to **Dr. S.S. Lakhawat**, Associate Professor & Head, Department of Horticulture, Rajasthan College of Agriculture for providing me facilities and encouragement during the course of investigation.*

*I am privileged to express sincere and deep sense of gratitude to **Dr. Arunabh Joshi**, Dean, Rajasthan College of Agriculture, Udaipur for his due attention and encouragement during the study period and also for providing me the necessary facilities during the course of research.*

*Words can hardly register the sincere and heartfelt feeling which I have for **Dr. R.A. Kaushik**, **Dr. Virendra Singh**, **Dr. L.N. Mahawer**, **Dr. Shalini Pilonia**, **Dr. H.L. Bairwa** and other staff members for their kind cooperation and help as and when needed.*

*I wish to accord my cordial thanks to all my seniors including **S. Kudi**, **Mithilesh Meena**, **S. Khan**, **V. Meena**, **Somdutt**, **B. Harkesh**, and **J. Tak** for their help and encouragement. I use this opportunity to sincerely thank my dearest classmates. All these acknowledgements would be incomplete if I do not make a special mention of my friends **Ram Singh**, **Saroj**, **Mahendra**, **Hiralal**, **Bansilal**, **Pintoo**, **Gopal**, and **Sanjay**, for their friendship, unending support and care and for making the two year study very much enjoyable and memorable. Thanks to one and all you are the people who shaped me from a student to an acad emician. I cannot forget to thank my juniors **Mohit**, **Ankit**, **Vijay**, **Pawan**, **Saroj**, **Simran**, **Karan**, **Tanpreet**, **Vimal** and **Manoj** for their ever whiling cooperation.*

*I feel short of words to express my deep sense of reverence and indebtedness to my beloved Father **Mr. Brij Lal**, Mother **Mrs. Tara Devi**, Brother **Radheshyam** and other family members who sustained my spirit and endeavor at every critical justice in my educational career. The ever smiling face of my loving parents remained in my eyes and in my heart throughout the research work.*

*Last but not the least, I pray obeisance to “**GOD**” with whose grace and blessing, I could be able to accomplish this task.*

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ACRONYMS

/	:	Per	K₂SO₄	:	Potassium sulphate
%	:	Per cent	Max.	:	Maximum
&	:	And	Min.	:	Minimum
°C	:	Degree Celsius	Mg	:	Miligram
B:C	:	Benefit cost ratio	ml	:	Milliliter
CD	:	Critical difference	MSS	:	Mean sum of square
cv	:	Cultivar	Mt	:	Million tone
d.f.	:	Degree of freedom	NaOH	:	Sodium hydroxide
DAT	:	Days after transplanting	t	:	Tone
DAS	:	Days after sowing	T	:	Treatment
<i>et al.</i>	:	(<i>et alibi</i>) and other people	No.	:	Number
etc.	:	Et cetera	NS	:	Non significant
Fig.	:	Figure	RH	:	Relative humidity
G	:	Gram	SE_m±	:	Standard error of mean
Ha	:	Hectare	TSS	:	Total soluble solids
HCL	:	Hydro chloric acid	T₀	:	Control
HNO₃	:	Nitric acid	T₁	:	Brown paper bag
i.e.	:	That is	T₂	:	White paper bag
TA	:	Titrateable acidity	T₃	:	Yellow polyethylene bag
kg	:	Kilogram	T₄	:	Green polyethylene bag
Kg/ha	:	Kilogram per hectare	T₅	:	Muslin cloth bag
TSS	:	Total soluble solids	T₆	:	Non-woven bag
<i>viz.</i>	:	(<i>Videlicet</i>) namely	T₇	:	News paper bag

1. INTRODUCTION

Guava (*Psidium guajava* L.), a member of family Myrtaceae, is one of the most important tropical or subtropical fruit crops popularly known as “Apple of Tropics”. It is popular fruit widely grown in the tropical and subtropical regions of the world. Guava tree is characterized by the smooth bark, greenish brown to brown in color and scaly, angular young shoots, numerous stamens, actinomorphic white flowers, inferior ovary with globose berries. The flesh is white, yellow, pink or red with embedded numerous seeds. The genus ‘*Psidium*’ consists of about 150 species, out of which only 20 species produce edible fruits. The fruit originated in Tropical America and comprises about 100 genera and approximately 3000 species, stretching from Mexico to Peru gradually getting distributed to several countries of the world. Guava got domesticated due to its excellent adaptability to different climatic conditions, hardy nature and prolific bearing. It is the fourth most important fruit crop of India after mango, citrus and banana and it is believed to be introduced in India at a very early date. Guava has adopted in India so well that it appears to be an Indian fruit.

India shares 4 per cent of the world production of guava producing 3.826 million tons under 0.260 million hectares area with the productivity of 14.7 t ha⁻¹. Uttar Pradesh, Bihar, Rajasthan, Madhya Pradesh and Maharashtra are the major guava growing states in the country. Uttar Pradesh occupies first position in area and production of guava in India. In Rajasthan, guava is grown in an area of 4.10 thousands hectare with production of 42.50 thousand tons and productivity is 10.37 tons per hectare (Anonymous, 2017).

Guava has become popular fruit on account of its high consumption, demand and profit in the market. It is considered as one of the exquisite, nutritionally valuable and remunerative crops. The fruit is a climacteric, delicious and nutritious. Guava is excellent source of vitamin -C, and also contains minerals like calcium, and phosphorus, etc. and dietary fiber. It is rich source of pectin, hence suitable for jelly making. It also contains the group of major antioxidants like polyphenes, carotenoids, omega-3 and omega-6 which belong to unsaturated group of fatty acids. The dietary fiber is one of the most important constituents of its seed (Anonymous, 2009).

Guava fruits are used as fresh as well as for making jam, jelly, paste, toffees, candy etc. Its fruits, leaves and roots are used for curing diarrhoea, dysentery as well as an ingredient for making other traditional medicines. Being a hardy fruit guava it can be grown in poor alkaline or poorly drained soils with minimum manuring and irrigation. It can be grown in soil with the pH range from 4.5 to 8.2. In North Indian agro-climate conditions, guava flowers twice in a year-first in February- March for rainy season crop and then, in June-July for winter season crop. Generally, fruit yield is more in rainy season crop as compared to winter season (Rathore *et al.* 2006), but fruits of rainy season crop are insipid in taste and poor in quality and have more infestation of pests and diseases. On the contrary, in winter season fruits are of superior quality and fetches high monetary returns.

Allahabad Safeda is the most famous variety grown in Uttar Pradesh for table purpose. Tree is medium in height (5.8-6.5 m) with vigorous branching and dense foliage. Fruits are medium in size (150 g), round in shape with few seeds. Fruit is white fleshed with good keeping quality.

Recently, the high qualities of guavas rein great demand to obtain a good return price. But due to climate change such as abnormal rains, sudden fluctuations in the temperature, fog, the quality is reduced up to a great extent. Pre-harvest fruit bagging is a phytosanitary procedure widely used to improve the visual quality by promoting fruit coloration and also to enhance internal fruit quality. It reduces the incidence of insects, pests and diseases also. In this technique, individual fruit or fruit bunch is bagged on the tree for a specific period to get desired results. The pre-harvest bagging affect the fruit size, maturity, peel color, flesh mineral content and fruit quality, which may be due to the differences in the type of bag used. It contributes to eliminate the use of insecticides and fungicides. Bagging has effect on the physico-chemical quality of the produce by changing micro-environment of fruit during its development period. The practice of pre-harvest bagging has been extensively used in several fruit crops to improve skin color and to reduce splitting, mechanical damage, and sunburn of the skin of the fruits (Ram *et al.* 2013).

Fruit bagging is an effective way to promote anthocyanin synthesis and other chemical parameters like sugars, acids, fruit coloration in fruits. It is believed that bagging increase light sensitivity of fruits and stimulate anthocyanin synthesis when fruit are re-exposed to light after removal. The anthocyanin content the activity of

enzyme involved in phenolic metabolism are significantly reduced in the peel of bagged fruits but increased significantly after the bag removed compared the un-bagged ones. Bagging, especially with blue polyethylene bags, possibly accumulate higher heat units than other bags. Consequently, accumulated heat might induce higher respiration rates and carbon dioxide accumulation within bags might lead to more acetaldehyde production and removal of astringency. Another, the fruit bagged with biodegradable plastic bags and polypropylene bags had enhanced quality. Bagging caused early ripening compared to open ones. Pre-harvest bagging induced early ripening in winter guava, may possible due to reduced winter stress under super-optimal condition which perhaps resulted in early fruit maturation.

Guava bagging materials included polyethylene (in various colours), kraft paper, aluminum foil and polyester. Most bagging materials could protect gases and humidity exchange to some extent. Various packaging materials *viz.* black polythene, white polythene, tissue paper, brown paper, newspaper has been reported in use in guava by various workers. Though few experiments have been carried out with the principal aim to study the effect of bagging on influence of fruit fly attack and pests/diseases several results also showed that fruit bagging influenced the fruit growth and development *i.e.* maturity as well as quality parameters of guava fruits. Keeping this view the present study entitled “**Effect of fruit bagging on yield and quality of guava (*Psidium guajava* L.) cv. Allahabad Safeda**” was carried out with following objectives:

1. To study the effect of bagging on fruit yield of guava.
2. To study the effect of fruit bagging on physico-chemical properties of guava fruit.
3. To evaluate the economic feasibility of the treatments.

2. REVIEW OF LITERATURE

The present investigation entitled “**Effect of fruit bagging on yield and quality of guava (*Psidium guajava* L.) cv. Allahabad Safeda**” was executed during the year August, 2018 to January, 2019. Pre-harvest fruit bagging has potential to improve physical and chemical characteristics of fruits. An attempt has been made to review the earlier works carried out on the impact of pre-harvest fruit bagging on guava fruit quality. Since, the literature pertaining to the subject is limited; therefore, this chapter contains the research findings on other fruit crops also.

EFFECT OF PRE-HARVEST BAGGING ON MATURITY AND PHYSICO-CHEMICAL PROPERTIES OF FRUITS

2.1 Guava

Wanichkul and Harach (2002) performed a study on growth and quality of unbagged and bagged fruits of guava cv. ‘Yen Song’. The bagging materials included polyethylene (white, blue or yellow in color), kraft paper, aluminum foil and polyester. The growth period of a guava fruit from anthesis to maturity was 15 weeks. During 1-11 weeks, more rapid fruit growth was obtained when polyethylene bags were used. Fruit bagging decreased the defects caused by diseases and insects, and increased flesh firmness and flavour. Bagging did not significantly influence sensory evaluation. Bagging with blue polyethylene resulted in the highest pulp thickness, TSS/TA and ascorbic acid content while, bagging with yellow polyethylene resulted in the highest fruit width, TSS and heat unit accumulation.

Abbasi *et al.* (2014) studied the effect of different covering materials *viz.*, newspaper bags, perforated polyethylene bags, muslin cloth bags and netted cloth bags on tree bagging of guava fruit to improve fruit quality. Their results revealed that maturity of the fruit remained at par in bagged and unbagged fruits except newspaper bags where it was delayed significantly. Bagged fruit had shown less damage from fruit fly. Polyethylene bags reduced the damage by fruit fly to a maximum extent followed by that of newspaper and muslin cloth bags. Economic analysis indicated that all bagging techniques were cost effective and fruit covered with perforated polyethylene bags exhibited maximum benefit cost ratio with better fruit quality and newspaper bagged fruit exhibited the lowest weight loss, maximum fruit firmness and

highest pH during storage. Un-bagged fruits had the highest value for weight loss, while least value for fruit firmness. Highest values for reducing sugars, non-reducing sugars and total sugars were observed in fruit covered with perforated polyethylene bags. Among the various bagging treatments, the perforated polyethylene was found to be the best in terms of sensory evaluation.

Meena *et al.* (2016) revealed the effect of bagging with various polyethylene covers with different colours *viz.*, silver, white, yellow, green, black and pink improved the growth and quality of guava fruits as compared to un bagging. Among the various fruit covering materials, bagging with yellow coloured polythene was found to be the best for overall improvement of physico-chemical quality of winter season guava cv. 'Lalit'.

Mishra *et al.* (2017) reported that the combined application of CaCl₂ (2%) + K₂SO₄ (2%) + Bagging (Blue colour polythene) improved fruit weight, fruit diameter, specific gravity, fruit size (length and width), fruit firmness, TSS, acidity, reducing sugar, non-reducing sugar, total sugar and organoleptic quality of rainy season guava and decreased insect damage.

Rahman *et al.* (2017) studied the effect of fruit bagging on the yield and quality of guava var. BARI Peyara-2. The experiment comprised of three types of bagging *viz.*, bagging with white polythene (B₁), and bagging with blue polythene (B₂) and without bagging (B₃). They concluded the overall costs of the bagging treatments affordable and the greater benefits as the bad quality untreated fruit could not get customer's attention while, perforated polyethylene bagging technique on tree gave maximum protection to fruit from the ultra violet light thus leading to better quality of guava fruit.

Rahman *et al.* (2018) investigated the effect of different bagging materials *viz.*, brown paper bag, white paper bag, white polythene bag, and black polythene bag on post-harvest quality of guava cv. 'Swarupkathi'. Fruit bagging treatments showed significant effects on different parameters. It was observed that fruit size, fruit weight, vitamin C content and moisture content increased due to fruit bagging. Among the various covering materials, white paper bag was found to be the best for overall improvement of both physical and chemical quality.

2.2 Tropical and Subtropical Fruits

Hofman *et al.* (1997) reported that the bagging improved fruit ripening and fruit quality (vitamin C, titratable acids, soluble solids, sucrose, glucose) in mango cv. 'Keitt' in bagged fruits.

According to Shorter *et al.* (1997) the fruits of mango cv. Sensation were bagged with plastic bag and paper bag seven weeks before normal harvest. They observed increased fruit weight in plastic bags after harvest. In plastic bagged mango fruits, softening and colouring of fruits were also improved.

Debnath and Mitra (2000) conducted trial in litchi to assess the effect of panicle bagging in litchi and reported that both brown paper (BP) and newspaper (NP) bags showed an increased fruit weight (23.20 g) compared to control (22.51 g). The cellophane paper also influenced the maturity 12 days earlier, while maturity was delayed by about 10 days using brown paper or newspaper (biodegradable) bags. The fruit quality was significantly improved under cellophane paper bags, with respect to colour development and TSS/acid ratio in comparison with the unbagged fruits.

Hu *et al.* (2000) studied the effect of pre-harvest bagging on the fruit quality of 'Feizixiao' litchi cultivar and reported that the bag made of sulphuric acid paper increased fruit colour, and ascorbic acid and soluble solids content; however, acidity of the fruit was reduced.

Hwang *et al.* (2004) analyzed the effect of bagging on grape fruit cv. Ruby with black paper and reported the transversal and longitudinal diameter differed non significantly.

You Gn and Jin Yin (2004) conducted an experiment to study the effect of pre-harvest fruit bagging on physico-chemical properties of litchi fruit and found that the bagging treatments improved fruit firmness, vitamin C, and ethylene production and softening. Further, they noticed the beneficial effects were obtained in double layer bags as compared to control.

Signes *et al.* (2007) studied the effect of fruit bagging on the black grape and they suggested that soluble solid, titratable acidity, sugar, organic acid composition and volatile aroma composition increased and grape ripening was delayed by the bagging operation.

Watanawan *et al.* (2008) investigated that different bagging materials (two-layer paper, newspaper and golden paper bags) significantly increased fruit weight and peel colour of mango fruits while 2-layered paper bag had the highest weight as compared to other treatments.

Hongxia *et al.* (2009) reported that the effect of pre-harvest bagging in Zill mango with single white layer bag tended to produce fruit with best internal quality consisting of maximum total soluble solids, titrable acid and vitamin C.

Sarkar *et al.* (2009) noticed that fruit bagging with the brown paper bag was the best treatment in mango fruits. They also reported that brown paper bags increased total soluble solids (TSS) and physical fruit characteristics compared to the un-bagged fruits. According to Gang and Ru Lin (2009) the bagging with single white bag at green maturity and full pink maturity stage on mango cv. 'Zill' resulted that single white paper produced fruit with best quality, high content of ascorbic acid, titratable acidity, total soluble solids and sugars.

Li Xing *et al.* (2009) studied the effect of various bagging materials on physical and chemical characteristics of grape var. 'Red Globe'. The fruit was covered with black film, white film, single layer and double layer sunshine shading film. The black and white ground film bags greatly enhanced the total soluble solids (10⁰Brix, 12.0⁰Brix respectively), as compared to the control (9⁰Brix, 10⁰Brix, respectively) while, conducting an experiment on bagging in loquat fruits.

Similarly, Ding and Syakirah (2010) while, conducting an experiment on pre-harvest bagging in 'Harumanis' mango, found that the different colours of paper did not affect mango pulp colour, carotenoid content, weight loss, pulp firmness, soluble solid concentration (SSC), pH, titratable acidity (TA), ascorbic acid, skin glossiness. While bagging with brown and black paper showed significant effect on skin colour and chlorophyll content of 'Harumanis' mango fruit. The application of bagging with brown and black paper significantly improved the skin colour, pulp firmness, pulp colour, ascorbic acid, chlorophyll content and minimum weight loss in mango fruit as compared to other treatments.

Ani and miftahul (2011) revealed that blue coloured bagging had greater influence than the transparent polythene bagging on banana but the differences were not significant. They suggested that bagging had no effect on the fruit skin hardness,

total soluble solids, total titratable acidity, edible portion, length of fruit, fruit diameter, age of harvest in *Musa paradisiaca* var. 'Typica' (AAB group).

Chonhenchob *et al.* (2011) studied the effect of pre-harvest fruit bagging and found that bagging improved fruit development and fruit quality. It significantly reduced diseases and infection. While, plastic bagging enhanced mango ripening as well as growth maturity. The fruit bagging with plastic bag reached maturity stage at 95 days after fruit bagging when compared to control *i.e.*, at 105 days after fruit bagging in mango cv. 'Nam Dok Mai'.

Grassi (2011) analyzed the effect of pre-harvest fruit bagging on loquat cv. 'Mizumo', 'Mizauto', 'Centennial', 'Crystal Nectar', and Selection IAC NE-3. He evaluated the fruit length, fruit diameter, fruit mass and presence of internal and external damages. The bagging was done when fruits reached diameter of 0.5 cm, 1.0 cm and 1.5 cm. He concluded that the effect of fruit bagging was interfered at different developmental stages of loquat fruits. The bagged fruits with their diameter between 0.5 and 1.0 cm were the ones best commercial quality.

Mathooko *et al.* (2011) assessed the impact of fruit bagging in mango and found that bagged fruits had significant improvement in the organoleptic score, appearance, colour, post-harvest life and reduced weight loss.

Senanan *et al.* (2011) conducted an experiment on Litchi fruit cv. 'Hong Huay' and bagged the fruits with newsprint paper, kraft paper, soon fong bag, re may bag, transparent plastic bag and unclear plastic bag, whereas non-bagging fruit was used as control. They found that bagging materials made from kraft and newsprint papers enhanced the peel colour of litchi fruits. However, the bagging materials did not affect the fruit weight and size, peel, pulp and seed, total soluble solids, titratable acidity, TSS-acid ratio and vitamin C content of litchi fruits.

Xianglin *et al.* (2011) observed the effect of fruit bagging on 'Novel orange'. They reported decreased TSS content, total sugars, and vitamin C. However, these differed significantly with single and double paper bags.

Dutta and Majumder (2012) reported the effect of poly bagging of mango fruits at different stages of fruit development (35, 45, 55 and 65 days after fruit set). Fruits were harvested at different stages of maturity (75, 85 and 90 days after fruit set) and allowed to ripen at room temperature (34-36°C, RH 85-90%). The use of bagging

at different stages of fruit development improved the appearance of fruit, fruit weight and size through other effects such as increased relative humidity and a consequently reduced fruit water loss. The maturity of fruits, at all stages of fruit harvest, was delayed with increasing bagging duration. Early bagging of fruit (35 days after fruit set) delayed the development of ripening characteristics in comparison to delayed bagging and un bagged control fruit, which ripened earliest Anthracnose and stem-end rot (SER) caused by *Colletotrichum* and *Diplodia* spp. respectively were reduced by bagging in both years through a reduction in contact between disease propagules and fruits. These results indicate that bagging can improve fruit quality by reducing disease, lead to a better appearance of fruit and increase fruit weight and size.

Wu *et al.* (2013) observed that the mango fruits cv. 'Zill' bagged with single white had significantly better vitamin C, titratable acidity, total soluble solids, sucrose, glucose and fructose as compared to other treatments.

Zhao *et al.* (2013) reported that pre-harvest bagging enhanced the total soluble solids, carbohydrate content, total sugar ascorbic acid content in mango fruit than control in cvs. 'Chinhuang', 'Baixiangya', 'Hongyu' and 'Guifei'.

Nagaharshita *et al.* (2014) assessed the effect of bagging on growth and development of mango (*Mangifera indica* L.) cv. 'Alphonso'. The results showed that the physical parameters viz. fruit weight, length, diameter, pulp weight, pulp to the stone ratio of Alphonso mango varied significantly due to bagging compared to control treatment.

Ghanekar (2014) conducted an experiment to investigate the effect of scurting bag over growth and development of mango fruit (*Mangifera indica*) cv. 'Alphonso' and found that pre harvest bagging had significant effect on fruit retention.

Haldanker *et al.* (2015) conducted an experiment at marble stage of mango fruits which were bagged (30 days after fruit set) with different types of bags. They observed that bagging with newspaper bag and brown paper bag improved fruit retention, fruit weight, diameter of fruit, pulp weight, total soluble solids and reducing sugars at ripe stage.

Tran *et al.* (2015) evaluated the bagging materials (paper-white bag, net screen-black bag, polyethylene plastic-black bag and polyethylene plastic-white bag)

on three varieties of papaya and reported that the polyethylene plastic-black bag increased the fruit firmness as compared to other bagging materials.

According to Jakhar and Pathak (2016) the pre-harvest treatment of mango fruits cv. 'Amrapali' with 2 per cent CaCl_2 + 1 per cent K_2SO_4 + bagging was found superior to improve the quality of fruits in respect of highest fruit weight, firmness, TSS, ascorbic acid, total sugars, and β -carotene content. Fruits treated with 2 per cent CaCl_2 + 1 per cent K_2SO_4 + bagging showed shelf life up to 12 days with lowest weight loss and highest organoleptic quality as against 6 days of untreated fruits.

Joshi *et al.* (2016) carried out an investigation on litchi fruit utilizing the pre-harvest bagging method. They evaluated fruit weight and size of whole fruit, total soluble solids (TSS), titratable acidity (TA), ascorbic acid, sugar content and sensory evaluation and found that both brown paper bag and butter paper bag were effective in increasing days to maturity, maximum fruit weight and size, total soluble solids (19.50⁰Brix), ascorbic acid (21.56 mg/100g), reducing sugar (11.31%) and total sugar (13.13%), while minimum acidity (0.51%) were found in fruits bagged with green polyethylene bag. Therefore, brown paper bags, butter paper bags and green polyethylene bags were found effective in improving fruit colour and maintaining fruit quality at harvest.

Mohapatra *et al.* (2016) conducted an experiment to study the effect of different types of bags on physicochemical parameters and duration of harvesting on mango fruit (*Mangifera indica* L.) cv. 'Ratna' and concluded that the fruit bagging with newspaper showed best performance for fruit retention (94.00%), length (11.96 cm), weight (503.20 g), pulp weight (449.10 g), ascorbic acid (76.00 mg/100 g), TSS (22.40⁰Brix), reducing sugar (4.87%), total sugar (12.12%) and shelf life (18 days) as compared to other treatments.

Islam *et al.* (2017) performed an investigation trial on influence of bagging on physico-chemical properties and shelf life of mango cv. 'Mallika'. Mango fruits were bagged at marble stage with different types of bags which constituted various treatments *viz.*: T₁: Brown paper double layered bag (BPB), T₂: White paper single layered bag (WPB), T₃: Muslin cloth bag (MCB) and T₀: Non-bagged (control). They found that bagging with brown paper bag and white paper bag improved fruit retention, weight of fruit, diameter of fruit, pulp weight, total soluble solids, ascorbic

acid, percent citric acid, reducing sugars and β -carotene at harvest and ripening stage over control. Moreover, brown paper bag had improved fruit colour, texture, appearance and sweetness. In all cases, good quality, cleaner, disease and insect free fruits could be harvested. Further, the sensory qualities in fruits treated with brown, white and muslin cloth bags had improved over control. Fruits treated with brown paper bag showed shelf life up to 18 days with lowest weight loss and good physical quality as against 15 days in case of untreated fruits (control). Pre-harvest bagging reduced occurrence of spongy tissue and the incidence of mealy bugs.

Malshe and Parulker (2017) reported that maximum fruit weight (230.67 g), highest ascorbic acid content (55.00 mg/100g), highest reducing and total sugars (2.28 per cent and 6.78 per cent, respectively) were found in bagging at marble stage and bags were removed 75 days after bagging of mango fruits cv. 'Alphonso' as compared to control.

Kireethi *et al.* (2018) assessed the influence of fruit bagging on mango fruits cv. Kesar. They found that various physical parameters were affected significantly due to bagging. Fruits covered with newspaper bag showed best performance for fruit retention (91.11%) while, fruits bagged with newspaper bag and brown paper bag recorded maximum fruit length (12.78 and 12.29 cm), fruit weight (263.67 g and 248.22 g) and pulp weight (188.83 g and 179.76 g), respectively.

Tendulkar *et al.* (2018) conducted an experiment to study the effect of different types of bags on chemical properties and sensory parameters of mango fruit cv. Alphonso. The results indicated that pre-harvest bagging by using various types of bags influenced the chemical composition of fruits at ripe stage over the non-bagged fruits. However, the trend was not consistent. The T.S.S. and reducing sugars were improved by plastic bags whereas opaque coloured bags enriched ascorbic acid of the fruits. All bags improved sensory quality over non-bagged fruits in mango cv. Alphonso.

2.3 Temperate Fruits Crops

Walter and Mario (1992) observed the effect of pre-harvest fruit bagging on 'Granny Smith' cultivar of apple and stated that brown paper bags significantly reduced sunburned fruits but improved fruit firmness and sweetness.

Fallahi *et al.* (2001) studied the influence of three rates of nitrogen (N) and fruit bagging on fruit peel and flesh mineral concentrations and fruit quality in 'BC-2 Fuji' apple (*Malus domestica* Borkh.) trees on Malling 9. They observed that bagging of fruit reduced fruit peel red colour, soluble solids concentrations, dry weight, nitrogen, potassium and copper as compared to unbagged fruit. Fruit peel had a greater percentage of dry weight and higher concentrations of all tested minerals compared to fruit flesh.

Jia *et al.* (2005) carried out an investigation in two sequential years 2002 and 2003. The fruits were covered with orange paper bags before pit hardening and with single and triple parchment paper bags and orange paper bags 15 days before harvest. The result suggested earlier ripening through bagging even though, fruit maturity did not show any significant differences among the treatments in 2003. Fruit weight, soluble solids content and titratable acidity were not affected by bagging treatments.

Bin *et al.* (2006) revealed the effect of pre-harvest bagging on peach cv. Hujingmilu and they observed that total soluble solids concentration in juice of peach fruit was higher in single-layer bagged fruit than in other double-layer bagged fruit and unbagged fruit at the full-ripe stage. Flesh firmness of un-bagged (control) fruit was higher than that of bagged fruit from 114 days after full bloom to 120 DAFB. The highest fruit firmness was found in triple-layer bagged fruit than that of un-bagged fruit at full-ripe stage 124 days after full bloom of bagged fruit. They also revealed the fruit length of un-bagged fruit was smaller than triple layer bagged fruits when measured at 117 and 124 days after full bloom stage. Skin colour was significantly influenced by pre-harvest fruit bagging, while the brightness of skin was least in un-bagged fruit.

Justus *et al.* (2006) reported that bagging of peach fruits with cheese cloth increased total soluble solids of fruit (12.46⁰Brix) followed by net cover (12.15⁰Brix) and the lowest total soluble solids (11.93⁰Brix) was noticed in control, while maximum acidity per cent was recorded in control fruits (0.23%) which was followed by net cover (0.17%) and cheese cloth cover (0.15%).

Chunhui *et al.* (2009) assessed the effect of bagging on quality improvement and physiology of red chinese sand pear during fruit maturation and found that the

bagging treatments significantly affected the concentration of anthocyanin and the visual characteristic of pear fruit compared to unbagged fruit.

Jing *et al.* (2009) assessed the effect of pre-harvest bagging on the quality factors of 'Jiangsu Red Fuji' apple and observed that total soluble solids, soluble sugars and reducing sugar in bagged fruits were lesser than unbagged.

Huang *et al.* (2009) studied the effects of fruit bagging under different levels of sunlight on Red Chinese Sand pears (*Pyrus pyrifolia* Nakai) and found that the bagging decreased organic acids contents in fruit.

Teixeira *et al.* (2011) reported that pre-harvest bagging advanced fruit maturity in 'Fuji Suprema' apples, especially in a transparent micro-holed plastic bag.

According to El-Alakmy (2012), combinations of calcium application and wrapping treatments had significant effect on fruit weight of 'Earle Grande' peach trees. Peach fruit weight (85.55 g) was significantly higher compared to control (52.87 g). Further, CaCl₂ with polyethylene wrapping treatment was effective in increasing fruit weight, flesh weight and flesh thickness.

Hudina *et al.* (2012) evaluated the effect of fruit bagging on the quality of the European pear cv. 'Concorde'. Bagging of pear fruit after June drop until harvest significantly reduced fruit length in both observed years. The fruit bagging increased firmness of the fruit only in 2006 and total soluble solids content was significantly lower in bagged fruit in (2006) while, bagging had no influence on firmness and soluble solids content in 2005. They also found the significant influence of bagging on total sugars content and on ascorbic acid.

Feng *et al.* (2013) recorded that the concentration of starch, glucose and ascorbic acid increased with bagging as compared to unbagged fruit in Jonagold apple.

Ram *et al.* (2013) noticed that pre-harvest fruit bagging in apple cv. 'Red delicious' significantly influenced the colour development and anthocyanin synthesis in apples. The bagged apples with light-yellow bags resulted in the attractive development of red colour over non-bagged apples, on contrary, yellow or green colour development was suppressed by bagging. Bagging also improved light sensitivity of fruit and anthocyanin pigment enhanced when fruits were re-exposed to light after bag removal.

Sharma and Pal (2013) conducted an experiment to study the effect of pre-harvest bagging with spun-bound fabric bags on the colour and quality of Delicious apple. They observed that bagged fruits had better colour development, maximum storage life and maximum ascorbic acid contents than non-bagged fruits.

Fenga *et al.* (2014) stated that the bagged fruit of apple had less sugar like glucose and galactose.

Zhu *et al.* (2014) reported that fruit bagging in apple significantly decreased the sugar contents and increased total soluble solids in ripening fruit with a foliar spray of aqueous solution than in non-bagged fruit.

Zhang *et al.* (2015) observed that the yellow/black colour bags 4 days before harvest improved skin colour, fruit firmness, higher fruit weight and better quality in nectarine as compared to other treatments.

2.4 Arid Fruit Crops

Harhash and Al-obeed (2010) reported that effect of bunch bagging colour on yield and fruit quality of date palm. Results showed that bunches bagging significantly increased bunch weight, accelerated ripening and improved fruit quality compared with the control. Blue colour increased fruit weight, flesh weight, fruit size, fruit length and fruit diameter of succary and khalas cultivars. Finally it can be recommended that bunch bagging with blue colour is benefits for maintain high yield and fruit quality.

Hussein *et al.* (2011) conducted an experiment on date palm fruit covered with brown paper bags. They noted significant increase in the fruit weight, fruit diameter, total soluble solids, total sugars, sucrose and dry matter as compared to other treatments.

Kassem *et al.* (2011) assessed that in general, polyethylene bagging at later growth stages caused a significantly increased weight, length, diameter in date palm.

Awad and Al-Qurashi (2012) and Omar *et al.* (2014) conducted research trials on date palm cv. 'Barhee' and cv. 'Rotana', respectively and observed that bagging increased fruit diameter and fruit length significantly over control.

Mohamed *et al.* (2012) while analyzing the effect of bunch bagging in date palm cv. Barhee noted the highest total soluble solids concentration (34.8⁰Brix) in

bagged fruits and the lowest (31.3⁰Brix) in control. Bagging also significantly affect the fruit and flesh weight, fruit length, number of seed per fruit, titratable acidity, ascorbic acid than control.

El-Wafa *et al.* (2014) observed the effect of bagging on quality improvement and reducing pomegranate fruit disorders. They pointed out that bagging fruits with prgmen bag increased fruit length, fruit diameter, grain weight percentage, fruit weight (g), yield/tree (kg), TSS, total soluble sugars, vitamin C content and total anthocyanin content in fruit juice. While, bagged fruits with plastic bags increased peel weight percentage and total acidity percentage.

Salama *et al.* (2018) conducted an experiment to investigate the effect of fertilizer and bagging on 'Wonderful' pomegranate trees (*Punica granatum* L.) and applied five potassium fertilization rates (390, 487, 585, 682 and 780 g K₂O per tree) either with or without fruit bagging with butter paper. They observed highest yield, fruit weight per tree. Average fruit weight, size, diameter and height were recorded when trees treated with 780 g potassium sulphate per tree and bagging treatments. It improved soluble solids concentration, total acidity, and anthocyanin content, whereas the lowest tannin content in the juice was recorded at 682 g potassium sulphate per tree and bagging treatment.

2.5 Minor Fruit Crops

Xu *et al.* (2008) studied the effect of pre-harvest fruit bagging on physical and chemical characteristics parameters of carambola fruit and reported increased fruit length, weight, total sugar and total soluble solids (TSS) as compared to unbagged fruits.

Yang *et al.* (2008) conducted an experiment on longan fruits revealed that bagging with different types of bags *viz*, perforated translucent plastic bag (TPB), white adhesive-bonded fabric bag (WAFB) and black adhesive-bonded fabric bag (BAFB) had significant effect on fruit development and quality in cross-winter off-season longan (*Dimocarpus longan* Lour.). The vitamin C level was affected considerably by pre-harvest bagging of fruits. Concentration of malic acid, the dominant organic acid in longan, was 605.6, 830.0, 1161.0 and 1428 mg/g FW in TPB, BAFB, WAFB and the control, respectively. Vitamin C in the aril was significantly reduced by BAFB (108.4 mg/g FW), slightly increased by WAFB

(183.9 mg/g FW) and significantly increased by TPB (264.5 mg/g FW) as compared with the control (174.7 mg/g FW). Pericarp of fruit bagged with TPB had a slightly higher content of Vitamin C (1337 mg/g FW), while those bagged with BAFB (873.6 mg/g FW) and WAFB (787.4 mg/g FW) had significantly lower vitamin C contents than the control (1243 mg/g FW).

Junhui *et al.* (2012) studied the effect of bagging on fruit quality of *Canarium album* for two years and found that colour and smoothness were better, the ascorbic acid concentration was higher after bagging as compared to control. Bagging fruits showed golden yellow colour, added smoothness, increased fruit weight and more delicate flesh but the bags needed size specifications and modification with a few holes at the bottom.

Tuan *et al.* (2016) conducted an experiment to study the effect of bagging time on fruit yield and quality of 'red pitaya' and they found that bagging the fruits after 7 days of anthesis had a positive effect on fruit quality (total soluble solids increase 15 per cent over control).

Costa *et al.* (2017) conducted an experiment to study the effect of different bagging materials {newspaper bag, kraft paper bag, waxed paper bag and non-woven bag (NW)}. They evaluated percentage of damaged fruits, fruit diameter, pulp yield, peel thickness, soluble solids content (SSC), titratable acidity (TA) and TSS/TA ratios. Non-woven and newspaper bags were more effective in bagging 'red pitaya' with respect to physico-chemical properties of the fruits.

Prabha *et al.* (2018) conducted an experiment to study the effect of different bagging materials on fruit yield and quality of pineapple cv. Mauritius. They found that the fruit covering of paper bag and plastic bag improved the fruit length, weight, total sugar and total soluble solids (TSS) as compared to unbagged fruits.

3. MATERIALS AND METHODS

The details of experimental materials used, procedures and techniques followed during the course of the investigation are described in this chapter.

3.1 EXPERIMENTAL SITE

The present experiment entitled “**Effect of fruit bagging on yield and quality of guava (*Psidium guajava* L.) cv. ‘Allahabad Safeda’**” was carried out at the horticulture farm of Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur during winter season of the year 2018-2019. The Rajasthan College of Agriculture, Udaipur is located in the semi-humid southern plains and Aravallis hills region of Rajasthan adjoining the western dry region of India at an altitude of 582.17 meters above the mean sea level and at 24.35° N latitude and 73.42°E longitudes.

3.2 CLIMATE AND WEATHER CONDITIONS

Udaipur has a typical sub-tropical climate characterized by mild winters and summer. The average rainfall of this tract ranges from 760 to 900 mm per year. More than 90 per cent rainfall received during mid June to September with scanty showers during winter months.

3.3 EXPERIMENTAL MATERIAL

3.3.1 Bagging

For the experiment, six years old uniform tress of guava cv. Allahabad Safeda was selected at the Horticulture farm of Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur. All the experimental trees were subjected to the same cultural practices such as irrigation, fertilization and weeding, insect pest and disease management. The uniform sized fruits were wrapped with different bags as per treatment.

3.4 EXPERIMENTAL DETAIL

The experimental details are given as under:

1. Fruit crop : Guava
2. Cultivar : Allahabad Safeda

3. Plant age : Six years
4. Planting distance : 6.0 m x 6.0 m
5. Period of the experiment : From August, 2018 to January, 2019
(winter season crop)
6. Experimental design : One way analysis of variance (CRD)
7. Site of experiment : Horticulture Farm, Rajasthan College
of Agriculture, Maharana Pratap
University of Agriculture and
Technology, Udaipur
8. No. of replication : 06
9. No. of treatment : 08
10. Stage of bagging : 35 days after fruit set
11. Type of bag : 07
- : Brown paper bag
- : White paper bag
- : Yellow polyethylene bag
- : Green polyethylene bag
- : Muslin cloth bag
- : Non-woven bag
- : News paper bag
12. Total number of plants : 48
13. Size of fruit at the time of bagging : 2.8-3.0 cm diameter of fruit

Table 3.1 Treatment Details

S. No.	Treatments	Notation
1.	Control (without bagging)	T ₀
2.	Brown paper bag	T ₁
3.	White paper bag	T ₂
4.	Yellow polyethylene bag	T ₃
5.	Green polyethylene bag	T ₄
6.	Muslin cloth bag	T ₅
7.	Non-woven bag	T ₆
8.	News paper bag	T ₇

Perforations were made both sides of the bags for proper ventilation required for fruit growth and development. Fruits at 35 days after fruit set were selected for bagging. The healthy fruits were selected for bagging. The different material bags were tied with thread properly, so that it will not fall down as well as there was no any open space for entry of insects or rain water *etc.*

3.5 OBSERVATIONS RECORDED

3.5.1 YIELD ATTRIBUTES

3.5.1.1 Maturity (%)

Percentage of maturity was calculated by total number of bagged fruits matures from initial fruit set to harvesting maturity

$$\text{Maturity (\%)} = \frac{\text{Number of mature fruits}}{\text{Number of total bagged fruits}} \times 100$$

3.5.1.2 Fruit drop (%)

Percentage of fruit drop was calculated by total number fruits dropped from initial fruit set to harvesting maturity

$$\text{Fruit drop (\%)} = \frac{\text{Number of drop fruits}}{\text{Number of total bagged fruits}} \times 100$$

3.5.1.3 Fruit weight (g)

Each fruit selected in each treatment during harvesting was weighed with the help of an electronic balance and the mean weight of fruits was calculated and expressed in gram.

3.5.1.4 Fruit length (cm)

The length was measured from the stalk end to the calyx end with the help of vernier calipers in centimeter and average was calculated.

3.5.1.5 Fruit diameter (cm)

Fruit diameter was measured with the help of vernier calipers at the widest point of the fruit and expressed in centimeters.

3.5.1.6 Specific gravity (g/cc)

The specific gravity of guava fruits was determined by dividing the weight of the fruit in the air by the volume of the fruit as obtained by the water displacement method.

3.5.1.7 Insect damage fruit (%)

For assessing the amount of fruit fly damage to guava fruits, recording of fruit fly oviposition marks on fruits was the first step to carry out study of infestations. For making this estimation, from the various trees a minimum of 25 fruits were randomly observed for fly oviposition punctures. Whenever, this practice was avoidable, in addition to the fruits observed from the tree, only freshly fruits fallen on ground were collected and examined by avoiding old fallen fruits, which might be damaged on the ground by other insect pests. The different species of guava fruits were not mixed together, but all of them kept separately. For assessing infestations each sampled guava fruit was examined in good light conditions and counted how many of these showed oviposition marks of fruit fly. Usually, whenever fresh oviposition punctures were not visible to the naked eye then a magnifying hand lens was used to aid in detecting the damage. The percentage of fruit fly infestation (%) for all fruits crop at the time of sampling was calculated by counting total number of fruits showing fruit fly oviposition marks divided by total number of fruits examined or collected and multiplying by 25. After dissecting or cut opening fruit to look for larvae and counting the numbers of larvae if any fruit, even with one fruit fly larva in it was considered infested.

$$\text{Insect damage fruit (\%)} = \frac{\text{Number of fruit infested fruit fly}}{\text{Number of bagged fruit}} \times 100$$

3.5.1.8 Pulp and seed weight

The data on weight of pulp and seed were taken by weighing randomly selected fruits under each treatment. The seeds were extracted and weighed. The average weight of pulp and seeds was worked out separately.

3.5.1.9 Pulp: Seed

In order to determine pulp seed ratio, the pulp weight of a fruit was divided by corresponding seed weight.

3.5.1.10 Fruit colour (visual observation basis)

The colours of the fruits were compared with Royal Horticulture Society Colour Charts and classified into many groups. Along with this fruits colour was also recorded on the basis of visual observation and genotype were categorize as yellow, green and light green.

3.5.2 Quality Attributes

3.5.2.1 Total soluble solids (⁰Brix)

Total soluble solids (TSS) of the fruit were determined by using a Hand Refractometer of 0-32 ⁰ Brix range where in one drop of fruit juice was put on the prism of the Refractometer and the ⁰Brix TSS were recorded directly. The values were corrected at 20⁰C room temperature and expressed as per cent total soluble solids of the fruits (A.O.A.C., 2007).

3.5.2.2 Acidity (%)

The total titratable acidity of guava fruit was determined by diluting the known volume of guava fruit juice with distilled water and titrating the same against standard N/10 sodium hydroxide solution, using phenolphthalein (1-2 drops) as an indicator (A.O.A.C., 2007). Later on, titration was carried out by sodium hydroxide (NaOH) drop by drop till the colour change of diluted guava fruit sample to light pink. The acidity is expressed in terms of per cent.

$$\text{Ascorbic acid (mg 100 g}^{-1}\text{)} = \frac{\text{@Titer} \times 0.0064 \times \text{Normality of alkali} \times 100}{\text{Volume of a sample taken} \times 1000}$$

3.5.2.3 TSS: Acid

The TSS: acid ratio is taken according to Ranganna, 1986. The TSS: acid ratio was calculated by the following formula:

$$\text{TSS: Acid ratio} = \frac{\text{Total soluble solids (0Brix)}}{\text{Titratable acidity (\%)}}$$

3.5.2.4 Ascorbic acid (mg 100 g⁻¹ fruit weight)

Standardization: Standardization of the dye 2, 6-dichlorophenol indophenol was done by titrating it against the standard ascorbic acid solution. The standard was prepared by dissolving 100 mg of pure L-ascorbic acid in 100 ml of three per cent

metaphosphoric acid. Then 1 ml of ascorbic acid solution (aliquot) was used for titration.

Estimation: The ascorbic acid content in guava juice was estimated by reduction of 2, 6 dichlorophenol indo phenol dye expressed in terms of milligram (mg) of ascorbic acid per 100 g of fruit juice (Ranganna, 1986). For this, 10-20 ml guava juice sample was taken and diluted to 100 ml with 3 per cent Meta phosphoric acid which is prepared from 30 g pallets of Meta phosphoric acid (H_3PO_3) in one liter of distilled water. Then making the volume up to 100 ml, solution was filtered and aliquot was collected. The aliquot 10 ml of the sample was titrated against the standard 2, 6 dichlorophenol indophenol until pink colour appeared (end point) that persist for at least 15 seconds. The titer value was recorded and calculated by the formula:

$$\text{Ascorbic acid (mg 100 g}^{-1}) = \frac{\text{@Titrate} \times \text{Dye factor} \times \text{Volume make up}}{\text{Aliquot of extract} \times \text{Volume of a sample taken}}$$

3.5.2.5 Total sugars (%)

The total sugars content of the guava fruit juice sample was determined as per “Lane and Eynon method” described by (Ranganna, 1986). Fifty ml aliquot prepared during estimation of reducing sugar was taken in a 250 ml volumetric flask and was left overnight (24 hours) at room temperature ($20^{\circ}C$ or above) after adding 5 ml 1 N HCL. Then it was neutralized with next day with concentrate Sodium hydroxide (NaOH) solution after adding few drops (2-3 drops) of phenolphthalein indicator till pink end point and volume was made up to 250 ml with distilled water and this solution was transferred into a burette. Thereafter, 10 ml of Fehling solution (5 ml of the Fehling solution A + 5 ml of Fehling solution B) was pipetted into a 250 ml conical flask and volume was made up to 50 ml and kept on a hot plate for boiling. Then few drops (2-3 drops) of methylene blue indicator were added and titration was carried out neutralized aliquot in the burette drop by drop until change the colour of mixture of Fehling’s solution (blue to brick red). The titre value was calculated using the formula given below:

$$\text{Total sugars (\%)} = \frac{\text{Fehling factor} \times \text{Dilution} \times 100}{\text{Titre value} \times \text{Volume of sample}}$$

3.5.2.6 Reducing sugar (%)

The method of reducing sugar on the principle of reduction of copper present in the Fehling solution to insoluble cuprous oxide which reaches till last end red in colour. The sugar content in a fruit juice sample is estimated by determining the volume of unknown sugar solution (Ranganna, 1986). The guava juice sample was taken and titrated against 10 ml of mixed Fehling reagent solution (5 ml Fehling solution A and 5 ml Fehling solution B) by using methylene blue as indicator. Mixed Fehling solution boiled for two minutes then 2-3 drops of methylene blue indicator was added and the extract was titrated against this solution till brick red colour appeared. The reducing sugar was calculated using the following formula:

$$\text{Reducing sugar (\%)} = \frac{\text{Fehling factor} \times \text{Dilution} \times 100}{\text{Titre value} \times \text{Volume of sample}}$$

3.5.2.7 Non-Reducing sugar (%)

Non-reducing sugars was calculated by subtracting the value of reducing sugar from the value of total sugar for the particular treatment.

$$\text{Non-reducing sugar (\%)} = \text{Total sugars} - \text{Reducing sugar}$$

3.5.2.8 Pectin content (%)

Pectin content was calculated by the addition of calcium chloride result in the precipitation of pectin as calcium pectate from an acid solution, calcium pectate is washed with water to make free from chloride and is dried and weighed.

$$\text{Pectin content (\%)} = \frac{\text{Weight of calcium pectate}}{\text{Weight of the sample}} \times 100$$

3.6 Statistical Analysis:

The data obtained in the present investigation were subjected to the analysis of variance by 'F' test for one way analysis of variance (Gomez and Gomez, 1984).

3.7 Benefit Cost Ratio:

The cost incurred in treating the fruits and profit (benefit) earned from various treatments was calculated taking into account the prices of commodities that existed in the market during the course of investigation.

4. EXPERIMENTAL RESULT

The result pertaining to “**Effect of fruit bagging on yield and quality of guava (*Psidium guajava* L.) cv. ‘Allahabad Safeda’**” Department of horticulture, Rajasthan College of Agriculture, Udaipur is presented in this chapter. The data obtained with regard to the various bagging treatments has been found statistically significant, which are presented in the tabular as well as graphical form. The analysis of variance for different components is given in appendices at the end. The results are presented under the following heads:

4.1 Yield Attributes

4.2 Quality Attributes

4.3 Economics

4.1 YIELD ATTRIBUTES

4.1.1 Maturity (%):

The data regarding effect of fruit bagging on maturity (%) is presented in Table 4.1, depicted in Fig 4.1 and the analysis of variance is presented in Appendix- I.

The data with respect to maturity of fruits clearly indicate the significant effect of bagging on maturity of fruits during course of investigation. The maximum fruit maturity (89.33%) was recorded in non-woven bag (T₆) whereas; minimum fruit maturity (80.33%) was recorded in fruits without bagging *i.e.* in control (T₀). Hence, 11.20% increased maturity was noticed by use of non –woven bag over control.

4.1.2 Fruit drop (%)

The data related to the effect of fruit bagging on fruit drop is presented in Table 4.1 & Fig.4.1 while, the analysis of variance is presented in Appendix- I.

It is evident from the data that significantly minimum fruit drop (10.67%) was recorded in non-woven bag (T₆) whereas, maximum fruit drop (19.67%) was reported in fruits kept without bagging (T₀) *i.e.* control.

4.1.3 Fruit weight (g)

The data regarding effect of fruit bagging on fruit weight (g) have been given in Table 4.1, and the analysis of variance is presented in Appendix- I.

The keen observation of the data clearly reveals significantly highest fruit weight (150.92 g) in non-woven bag (T₆) while, the lowest fruit weight (124.65 g) was recorded in fruits remained without bagging (T₀). Further, 21.07% increment in fruit weight was achieved by T₇ treatment over control (T₀) while, T₅ treatment *i.e.* muslin cloth was noticed significantly at par with T₇ treatment.

Table-4.1 Effect of fruit bagging treatments on maturity, fruit drop and fruit weight

S. No.	Treatments	Maturity (%)	Fruit drop (%)	Fruit weight(g)
1.	T ₀ = Control (without bagging)	80.33	19.67	124.65
2.	T ₁ = Brown paper bag	84.33	15.67	136.62
3.	T ₂ = White paper bag	83.00	17.00	136.37
4.	T ₃ = Yellow polyethylene bag	85.33	14.67	131.92
5.	T ₄ = Green polyethylene bag	83.33	16.67	139.78
6.	T ₅ = Muslin cloth bag	85.00	15.00	145.56
7.	T ₆ = Non-woven bag	89.33	10.67	150.92
8.	T ₇ = Newspaper bag	82.33	17.67	128.14
SEm±		0.97	0.97	3.54
CD (P=0.05)		2.76	2.76	10.11

4.1.4 Fruit length (cm)

The data with respect to effect of fruit bagging on fruit length (cm) is presented in Table 4.2, depicted in Fig 4.2 and its analysis of variance is presented in Appendix- II.

The close view of data indicates significant effect of bagging on fruit length during the course of investigation. The maximum fruit length (6.83 cm) was recorded in non-woven bag (T₆) treatment while, the minimum fruit length (4.96 cm) was recorded in fruits of without bagging (T₀) treatment.

4.1.5 Fruit diameter (cm)

The data with regard to effect of fruit bagging on fruit diameter (g) have been given in Table 4.2, displayed in Fig 4.2 and the analysis of variance is presented in Appendix- II.

The effect of fruit bagging treatment was found significant on fruit diameter. The highest fruit diameter (6.87 cm) was recorded in non-woven bag (T₆) whereas, the lowest fruit weight (4.87 cm) was observed in (T₇) treatment *i.e.* news paper bag.

4.1.6 Specific gravity (g cc⁻¹)

The data in respect to the effect of fruit bagging on Specific gravity (g cc⁻¹) is presented in Table 4.2, and its analysis of variance is given in Appendix- II.

The bird eye view of data clearly reveals that bagging treatment showed its significant effect on the specific gravity of fruits. The maximum specific gravity (1.24 g cc⁻¹) was recorded in white paper bag (T₂) while, the minimum specific gravity (0.92 g cc⁻¹) was recorded in fruits without bagging *i.e.* under control (T₀).

Table-4.2. Effect of fruit bagging treatments on fruit length, diameter and specific gravity

S. No.	Treatments	Fruit length (cm)	Fruit diameter (cm)	Specific gravity (g cc ⁻¹)
1.	T ₀ = Control (without bagging)	4.96	5.11	1.00
2.	T ₁ = Brown paper bag	5.24	5.13	1.07
3.	T ₂ = White paper bag	5.36	5.98	1.24
4.	T ₃ = Yellow polyethylene bag	5.51	5.81	1.04
5.	T ₄ = Green polyethylene bag	6.01	5.85	0.92
6.	T ₅ = Muslin cloth bag	5.36	5.41	0.99
7.	T ₆ = Non-woven bag	6.83	6.87	1.08
8.	T ₇ = Newspaper bag	5.14	4.87	1.07
SEm±		0.17	0.16	0.05
CD (P=0.05)		0.49	0.46	0.15

4.1.7 Insect damaged fruit (%)

The data regarding effect of fruit bagging on insect damaged fruit (%) is being given in Table 4.3, and its analysis of variance is presented in Appendix- III.

The keen inspection of data speaks significantly highest insect damaged 13.67(%) fruit under control (T₀) *i.e.* without bagging while, the lowest minimum insect damaged (0.33%) was recorded in T₆ treatment *i.e.* non-woven bag.

4.1.8 Pulp weight (g)

The data in relation to the effect of fruit bagging on pulp weight (g) have been presented in Table 4.3, and the analysis of variance is presented in Appendix- III.

Significantly maximum pulp weight (134.54 g) was reported under T₆ treatment *i.e.* non-woven bag while, the minimum pulp weight (75.46 g) was recorded in T₁ treatment *i.e.* brown paper bag.

4.1.9 Seed weight (g)

The data with regard to effect of fruit bagging on seed weight (g) is being presented in Table 4.3, depicted in Fig 4.3 and the analysis of variance is presented in Appendix- III.

The close observation of data indicates significantly highest seed weight (7.47 g) with T₂ treatment *i.e.* white paper bag whereas, the lowest seed weight (4.73 g) was recorded in non-woven bag (T₆).

4.1.10 Pulp: Seed (g)

The data regarding effect of fruit bagging on pulp to seed ratio has been given in Table 4.3, depicted in Fig 4.3 and its analysis of variance is produced in Appendix- III.

The keen view of data clearly reveals maximum pulp: seed ratio (30.42) under (T₆) treatment *i.e.* non-woven bag where as minimum pulp: seed ratio (12.73) recorded in (T₀) treatment *i.e.* without bagging.

Table-4.3. Effect of fruit bagging treatments on insect damaged fruits, pulp weight, seed weight and pulp seed ratio

S. No.	Treatments	Insect damaged fruits (%)	Pulp weight (g)	Seed weight (g)	Pulp seed ratio
1.	T ₀ = Control (without bagging)	13.67	93.65	7.41	12.73
2.	T ₁ = Brown paper bag	4.00	75.46	5.39	14.21
3.	T ₂ = White paper bag	3.67	107.60	7.47	15.22
4.	T ₃ = Yellow polyethylene bag	3.33	94.63	6.78	14.12
5.	T ₄ = Green polyethylene bag	2.00	100.97	7.23	14.25
6.	T ₅ = Muslin cloth bag	4.00	120.43	6.97	17.87
7.	T ₆ = Non-woven bag	0.33	134.54	4.73	30.42
8.	T ₇ = Newspaper bag	2.67	85.35	6.25	13.72
SEm±		0.63	3.62	0.47	1.66
CD (P=0.05)		1.80	10.34	1.34	4.75

4.1.11 Fruit color (visual observation basis)

The data regarding effect of fruit bagging on fruit color (visual observation basis) has been presented in Table 4.4.

Color is one of the most important criteria of quality of most fruits. It was observed that the different bagging materials had great effect on fruit color of guava. The result showed that the color of without bagged fruits was light green with spotted and the surface was rough while fruits were yellowish green color and smooth surface under non- woven bag (T₆), white paper bag (T₂), yellow polythene bag (T₃) and muslin cloth bag (T₅) treatments.

Table-4.4. Effect of fruit bagging treatments on fruit color (visual observation basis)

S. No.	Treatments	Fruit skin colour and smoothness
1.	T ₀ = Control (without bagging)	Light green and spotted
2.	T ₁ = Brown paper bag	Green and smooth
3.	T ₂ = White paper bag	Light green and smooth
4.	T ₃ = Yellow polyethylene bag	Yellowish green and smooth
5.	T ₄ = Green polyethylene bag	Yellowish green and smooth
6.	T ₅ = Muslin cloth bag	Light yellowish and
7.	T ₆ = Non-woven bag	Light yellowish and smooth
8.	T ₇ = Newspaper bag	Light green and smooth

4.2 QUALITY ATTRIBUTES

4.2.1 Total soluble solids (°Brix)

The data with respect to TSS of fruit as affected by bagging treatments is presented in Table-4.5, displayed in Fig-4.4 and its analysis of variance is given in Appendix-IV.

The keen observation of data clearly confirms that the effect of bagging treatment was significant upon TSS of the fruits. The maximum TSS content (12.68°Brix) was recorded in non-woven bag (T₆) while, minimum TSS (9.64°Brix) was observed under control *i.e.* without bagging. Further, T₆ treatment was found statistically at par with muslin cloth bag (T₅), newspaper bag (T₇), and brown paper bag (T₁) treatments.

4.2.2 Acidity (%)

It is obvious from the data given in Table 4.5 that all the bagging treatment had a significant difference in overall per cent of total acid content of the cv. Allahabad Safeda. The highest acid content (0.46%) was observed under T₀ treatment *i.e.* without bagging. whereas, the lowest acidity and (0.37%) was recorded in T₆ treatment *i.e.* non-woven bag.

4.2.3 TSS: Acid ratio

The data regarding effect of fruit bagging on TSS and Acid ratio has been presented in Table 4.5, depicted in Fig 4.4 and the analysis of variance is given in Appendix- IV.

The maximum TSS: Acid ratio (38.3) was recorded in T₅ *i.e.* muslin cloth bag whereas, minimum TSS: Acid ratio (20.8) was found under T₀ treatment *i.e.* without bagging.

4.2.4 Reducing sugar (%)

The data related to effect of bagging treatment on reducing sugar is presented in Table 4.5, and its analysis of variance is presented in Appendix- IV.

The effect of bagging treatment was noted significant on reducing sugar content of fruits. The highest reducing sugar content (4.67%) was noted in muslin cloth bag (T₅) while, the lowest reducing sugar content (3.26%) was observed in T₇ treatment *i.e.* newspaper bag.

Table-4.5. Effect of fruit bagging treatments on TSS, acidity, TSS: acidity and reducing sugar

S. No.	Treatments	TSS (°Brix)	Acidity (%)	TSS : Acid	Reducing sugar (%)
1.	T ₀ = Control (without bagging)	9.64	0.46	20.8	3.35
2.	T ₁ = Brown paper bag	12.33	0.39	31.7	4.65
3.	T ₂ = White paper bag	11.21	0.40	28.5	4.53
4.	T ₃ = Yellow polyethylene bag	12.68	0.41	31.0	4.90
5.	T ₄ = Green polyethylene bag	11.58	0.38	31.2	4.21
6.	T ₅ = Muslin cloth bag	12.58	0.39	38.3	4.67
7.	T ₆ = Non-woven bag	12.41	0.37	34.0	4.30
8.	T ₇ = Newspaper bag	12.47	0.45	28.0	3.26
SEm±		0.40	0.06	2.21	0.15
CD (P=0.05)		1.16	0.17	6.32	0.42

4.2.5 Total sugar (%)

The research data with regard to the effect of bagging treatment on total sugar is given in Table 4.6 displayed in Fig-4.5 and the analysis of variance is presented in Appendix- V.

The close observation of data indicates significant superior its T₅ treatment *i.e.* muslin cloth bag in value of total sugar content (8.28%) whereas, the inferior value of total sugar content (6.59%) was observed in newspaper bagging (T₇).

4.2.6 Ascorbic acid (mg/ 100 g pulp)

The data related to effect of bagging treatment on guava fruit ascorbic acid content is presented in Table 4.6, and its analysis of variance is presented in Appendix- V.

It is evident from data that significantly maximum ascorbic acid content (199.92 mg/ 100 g pulp) was noted in T₅ treatment *i.e.* muslin cloth bag while, minimum ascorbic acid content (175.83 mg/ 100g pulp) was observed under control (T₀) *i.e.* without bagging.

4.2.7 Pectin content (%)

The data regarding the effect of fruit bagging on pectin content is given in Table 4.6, exhibited in Fig-4.5 and the analysis of variance is presented in Appendix- V.

The bird eye view of data indicates significantly maximum pectin content (1.24%) in T₃ treatment *i.e.* yellow polyethylene bag while, the lowest pectin content (0.95%) under T₇ treatment *i.e.* Further, the T₃ treatment was found statistically at par with white paper bag (T₂), green polyethylene bag (T₄), brown paper bag (T₁) and non-woven bag (T₇) treatments.

Table-4.6. Effect of fruit bagging treatments on total sugar, ascorbic acid and pectin content

S. No.	Treatments	Total sugar (%)	Ascorbic acid (mg/100g pulp)	Pectin content (%)
1.	T ₀ = Control (without bagging)	7.19	175.83	0.99
2.	T ₁ = Brown paper bag	6.59	181.57	1.16
3.	T ₂ = White paper bag	7.39	183.06	1.20
4.	T ₃ = Yellow polyethylene bag	7.01	181.84	1.24
5.	T ₄ = Green polyethylene bag	7.26	190.29	1.19
6.	T ₅ = Muslin cloth bag	8.28	199.92	0.98
7.	T ₆ = Non-woven bag	7.84	197.47	1.16
8.	T ₇ = Newspaper bag	7.09	179.51	0.95
SEm±		0.14	2.55	0.05
CD (P=0.05)		0.39	7.30	0.13

4.3 Benefit: Cost Ratio

The economic analysis of the treatments is given in Table 4.7 and the details regarding cost of production is given in Appendix- VI

From economic feasibility point of view the data clearly confirms that T₆ treatment *i.e.* non-woven bag was found to be the best with the highest incremental benefit cost ratio of Rs. 1.319 against per rupee investment along with maximum net return of Rs. 547.70 as compared to other treatment.

Table-4.7. Economics of fruit bagging treatments

S.N.	Notation	Fixed cost (Rs.)	Treatment cost (Rs.)	Total cost (Rs.)	Total No. of fruit	Fruit drop (%)	Number of mature fruit	Average fruit weight (g)	Total weight (kg)	Selling price per (kg)	Gross return (Rs.)	Net return (Rs.)	Incremental B:C ratio
1.	T ₀	35	0	35	150	19.67	120.50	124.65	15.02	30	450.60	415.00	1
2.	T ₁	70	30	100	150	15.67	126.50	136.62	17.00	35	595.00	495.00	1.192
3.	T ₂	70	30	100	150	17.00	124.50	136.37	16.97	35	593.95	493.95	1.190
4.	T ₃	70	45	115	150	14.67	128.00	131.92	16.88	35	590.80	475.80	1.146
5.	T ₄	70	45	115	150	16.67	125.00	139.78	17.47	35	611.45	496.45	1.196
6.	T ₅	70	75	145	150	15.00	127.50	145.56	18.55	35	649.25	504.25	1.215
7.	T ₆	70	90	160	150	10.67	134.00	150.92	20.22	35	707.70	547.70	1.319
8.	T ₇	70	15	85	150	17.67	124.00	128.14	15.88	35	555.80	470.80	1.134

5. DISCUSSION

The experimental discussion presented in preceding chapter entitled “**Effect of fruit bagging on yield and quality of Guava (*Psidium guajava* L.) cv. ‘Allahabad Safeda’**” showed significant variation in physical characteristics, quality characteristics and other related parameters. Efforts have been made to discuss the significant findings of the experimental results and discussion in this chapter. Pertinent literature of other workers has been cited in order to support the findings of the present investigation.

The discussion is presented under the following heads:

5.1 Yield Attributes

5.2 Quality Attributes

5.3 Economics

5.1 YIELD ATTRIBUTES

5.1.1 Maturity (%):

Effect of fruit bagging on maturity of fruits was found significant and the maximum maturity (89.33%) was recorded in T₆ treatment *i.e.* non-woven bag where as minimum maturity (80.33%) was recorded in fruits under control *i.e.* without bagging (T₀). Thus 11.20% higher maturity over control (T₀) was achieved under T₆ treatment *i.e.* Non –woven bag .This might be due to the fact that temperature and relative humidity are the most important environmental factors affecting fruit growth and development. The warmer temperature in bagged fruit compared to un bagged fruits might perhaps have contributed for early harvesting. Light and air play important role in growth and development of fruit. The control fruits were exposed to natural light and air, whereas the bagged fruits intercept the light. The above findings are in accordance with the finding of Debnath and Mitra (2000) in litchi, Chonhenchob *et al.*, (2011) in mango and Teixeira *et al.*, (2011) in 'Fuji Suprema' apples.

5.1.2 Fruit drop (%)

Significant effect of fruit bagging on fruit drop (%) was observed during experimentation. The lowest fruit drop (10.67%) was recorded in non-woven bag (T₆)

whereas; the maximum fruit drop (19.67%) was obtained under control *i.e.* without bagging (T₀). This might be due to the reason that bagging material intercept the natural force of air while, under control fruits were directly exposed to natural light and wind flow, which could be reason of higher fruit drop as it is well known fact that light and air play important role in fruit drop. Similar result of effect of fruit bagging on Longn cv. 'Chuliang' in fruit drop reduction was noted by Yang *et al.* (2008).

5.1.3 Fruit weight (g)

The data regarding effect of fruit bagging on fruit weight clearly revealed significantly maximum fruit weight (150.92 g) in non-woven bag (T₆) while, the minimum fruit weight (124.65 g) was recorded in fruits under control (T₀). Further, (21.07%) additional fruit weight was observed through use of non-woven bag (T₆) as compared to control. According to Dutta and Majumdar (2012), pre-harvest fruit bagging improved the fruit weight and size through the conducive effects such as increased relative humidity and a consequently reduced fruit water loss. A similar result was observed by Xu *et al.*, (2008) bagging with plastic bags increased fruit weight in carambola.

5.1.4 Fruit length (cm)

Significant effect of fruit bagging on fruit length was observed during investigation. The highest fruit length (6.83 cm) was noted in (T₆) treatment *i.e.* recorded in non-woven bag whereas, the lowest fruit length (4.96 cm) was observed in fruits without bagging. The results indicating that all bagged treatments were superior to un-bagged (control) fruits. This might be due to the micro climate surrounding the fruit changed favorably by fruit bagging that leads to more fruit length. The abiotic factors viz., temperature and humidity play critical role in fruit growth and development. Bagging on fruits alters the micro environment around fruits. Similar results were obtained by Harhash and Al-Obeed (2010) in that date palm cv. Saccary and Khalas when bagged with blue colour to obtain the maximum fruit length. Though, Senanan *et al.* (2011) noticed that bagging had no significant effect on fruit length in litchi cv. Hong Huay.

5.1.5 Fruit diameter (cm)

The fruit diameter was significantly affected by bagging treatments. Maximum fruit diameter (6.87 cm) was recorded in non-woven bag (T₆) while, minimum fruit

weight (4.87 cm) was noted T₈ (*i.e.* news paper bag). Increased fruit diameter might be due to rapid cell division and expansion due to favorable microclimate. The above findings are in accordance with the finding of Harhash and Al-Obeed (2010) and Kassem *et al.*, (2011) in date palm, and Xu *et al.*, (2008) in carambola who also reported improved fruit diameter as of fruit bagging.

5.1.6 Specific gravity (g cc⁻¹)

The effect of fruit bagging on specific gravity was found significant. The maximum specific gravity (1.24 g cc⁻¹) was recorded in (T₃) *i.e.* white paper bag whereas, the minimum specific gravity (0.92 g cc⁻¹) recorded in fruits without bagging (T₀). The specific gravity of bagged fruits also showed higher value in general that might be due to more compact tissues under bagging and hence slight increase in volume of fruits in comparison with the increase in intercellular spaces resulting into less increase in volume of fruits in comparison with increase in fruit weight. The above findings are in accordance with the finding of Mishra *et al.*, (2017) in guava.

5.1.7 Insect damage fruit (%)

Significantly maximum insect damage (13.67%) was reported in control (T₀) *i.e.* without bagging while, minimum insect damage (0.33%) was recorded in non-woven bag (T₆). Bagging of many fruits is one of the necessary techniques for producing quality fruits and had been universally adopted in the fruit production. The results of the study indicate that the treated fruit significantly had reduced incidence of disease and damage by fruit fly and diseases. Fruit in paper is used in several Asian countries for fruit fly control. The results are in line with the findings of Mishra *et al.*, (2017) in guava. who reported that bagging is used in guava varieties to control the insect pest problem as the bags act as a physical barrier between the fruit flies and the fruit.

5.1.8 Pulp weight (g)

The effect of fruit bagging on pulp weight was observed significant. The maximum pulp weight (134.54 g) was recorded non-woven bag (T₆) whereas; the minimum pulp weight (75.46 g) was recorded in (T₈) treatment *i.e.* brown paper bag. According to Meena *et al.* (2016) yellow color polythene might enable very good light movement or allow the light intensity and or good quality light which had very good effect on development of fruit pulp. The better fruit pulp quality also improves

the palatability and acceptability of guava fruits to the consumers. However, the guava fruit under treatment white polythene also had the maximum fruit core weight.

5.1.9 Seed weight (g)

The data showed significant effect of fruit bagging on seed weight during course of investigation. The maximum seed weight (7.47 g) was recorded in (T₃) treatment *i.e.* white paper bag while, minimum seed weight (4.73 g) was recorded in (T₆) *i.e.* non-woven bag. This might be due to the fact that seed character was also associated with fruit growth and development. The above findings are in agreement with the findings of Rahman *et al.*, (2017) and Meena *et al.*, (2016) in guava.

5.1.10 Fruit color (visual observation basis)

The data regarding effect of fruit bagging on fruit color (visual observation basis) has been presented in Table 4.4. As color is one of the most important criteria of quality of most of fruits. It was observed that the different bagging materials had great effect on fruit color of guava. The result showed that the color of without bagged fruits (*i.e.* control) was light green with dark spot and the fruit surface was rough while, the fruits were observed yellowish green colored with smooth surface under non- woven bag (T₆), white paper bag (T₂), yellow polythene bag (T₃) and muslin cloth bag(T₅).

5.2 QUALITY ATTRIBUTES

5.2.1 Total soluble solids (°Brix)

The effect of bagging treatments was found to be significant on TSS of the fruits. The maximum (12.68° Brix) TSS content was recorded in (T₆) *i.e.* non-woven bag whereas, the minimum TSS content (9.64°Brix) was observed under control (T₀). This was found statistically at par with muslin cloth bag (T₅), newspaper bag (T₇) and brown paper bag (T₁) treatments. This might be due to the fact that pre-harvest fruit bagging, a physical protection technique affects the qualitative character of the fruits by changing micro-environment inside the bags. When the fruit growth activities were on peaks during fruit development further, due to bagging high temperature favors the conversion of starch into sugars. Such result is partially supported by Mishra *et al.*, (2017) in guava.

5.2.2 Acidity (%)

Significantly maximum acid content (0.46%) was observed under control *i.e.* without bagging in comparison to the minimum acid content (0.37%) as recorded in non-woven bag (T₆). The above findings are in accordance with the findings of Meena *et al.*, (2016), and Rahman *et al.*, (2018) who also found the highest titratable acidity content in open condition compare to bagged fruits in guava.

5.2.3 TSS: Acid ratio

The data regarding effect of fruit bagging on TSS: Acidity ratio clearly indicates its significant effect. The maximum TSS: acid ratio (38.3) was recorded under (T₅) treatment *i.e.* muslin cloth bag while, the minimum TSS: acid (20.8) was reported under control *i.e.* without bagging (T₀). TSS: acid ratio is combined parameter of TSS and titratable acidity of the fruits in percentage, hence, when TSS was high and acidity was observed less, the TSS to acid ratio was more and vice versa. But, acidity is inversely proportion to TSS to acid ratio. This statement is justified in light of research carried out by Meena *et al.*, (2016) and Prabha *et al.*, (2018) in guava and pineapple respectively.

5.2.4 Reducing sugar (%)

The reducing sugar (%) of fruits significantly affected by bagging treatments. The maximum reducing sugar content (4.67%) was noted in muslin cloth bag (T₅) in comparison to (T₇) treatment *i.e.* newspaper bag where, the minimum reducing sugar content (3.26%) was observed.

This might be due to the fact that temperature and solar radiation are the environmental factors which give variation in sugar accumulations. It also affected the rate of respiration and helped in steady control. The increased reducing sugar may be due to conversion of sucrose into glucose inside the bags. It is due to more sucrose syntheses and sucrose phosphate syntheses activity inside the bags. The above findings are in accordance with the findings of Meena *et al.*, (2016) in guava, Harhash and Al-Obeed (2010) in date palm and Zhao *et al.*, (2013) in mango who also reported improved reducing sugar as of fruit bagging.

5.2.5 Total sugar (%)

It is evident from data that total sugar content of fruits significantly affected by bagging treatments. The maximum total sugar content (8.28%) was noted in muslin cloth bag (T₅) while the minimum total sugar (6.59%) was observed in newspaper bag (T₈). This might be due to the breakdown of polysaccharides into water soluble sugars such as glucose, fructose and sucrose. This increase in total sugars of bagged fruits could be attributed to enhanced carbohydrate metabolism. The pre-harvest fruit bagging creates a microclimate in which temperature increases and it ensure good fruit quality which helps in improving the total sugars. The enhanced level of total sugars inside the bagged fruits may be due to enzymatic activity like sucrose synthases and sucrose phosphate synthases. The sucrose synthases is an enzyme, plays a key role in sucrose decomposition. The activity of sucrose synthases in the bagged fruits rises during fruits development and was found higher than that in the unbagged fruits. The above result corroborate the findings as reported by Harhash and Al-Obeed (2010) in date palm and Wu *et al.*, (2013) in mango who also reported improved total sugars as of fruit bagging.

5.2.6 Ascorbic acid (mg/ 100g pulp)

The data clearly indicates that bagging treatment significantly influenced the ascorbic acid content of fruits during investigation. The highest ascorbic acid content (199.92 mg/ 100g pulp) found in muslin cloth bag (T₅) whereas, the lowest ascorbic acid content (175.83 mg/ 100g pulp) was observed in control *i.e.* without bagging (T₀). It might be due to the fact that their temperature rises inside the bags which helped in more activation of phytochemical reactions and their synergistic effect, therefore, increasing the level of ascorbic acid of bagged fruits. The findings of present study are in close agreement with findings of Meena *et al.*, (2016) in guava.

5.2.7 Pectin content (%)

Significant effect of bagging treatment on pectin content of guava was clearly observed during experimentation. The maximum pectin content (1.24%) was noticed in yellow polyethylene bag (T₃) whereas, minimum pectin content (0.95%) was observed in newspaper bag (T₇). This was found statistically at par with white paper bag (T₂), green polyethylene bag (T₄), brown paper bag (T₁) and non-woven bag (T₆)

respectively. This might be due to the fact that temperature and relative humidity are the most important environmental factors affecting fruit growth and pectin content.

5.3 Benefit: Cost Ratio

The benefit: cost ratio of all the treatments has been given in table 4.7 and appendix-VI. From economic feasibility point of view the non-woven bag *i.e.* (T₆) treatment was found to be best with maximum return per rupee investment expenditure (1.319).

This might be due to the reason that the newspaper bags (T₆) were the cheapest material though having lesser durability as compared to perforated polyethylene bags *i.e.* (T₃) & (T₄) treatments. In case of news paper bags (T₇) repeated bagging was done (increasing material as well as labour cost) whenever were torn off by rains and winds, so raised the cost than polyethylene. The overall costs of the bagging treatments are affordable and the benefits are greater as the bad quality of the untreated fruit could not get customers attention. Further, the bagging technique on tree gives maximum protection to fruit from the heavy attack of fruit fly during summer leading to better quality of guava fruit with maximum benefit cost ratio (BCR). Further, research on canopy management by pruning can help to facilitate the bagging operation. This technique can be helpful for production of organic fruits. As far as harvest maturity is concerned; green yellow with semi-firm stage is more acceptable for sensory attributes as well as reasonable storability. The findings of present study are in accordance with the findings as reported by Abbasi *et al*, (2014) in guava.

6. SUMMARY

The present experiment entitled “**Effect of fruit bagging on yield and quality of guava (*Psidium guajava* L.) cv. ‘Allahabad Safeda’**” was carried out at the horticulture farm of Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur during winter season of the year 2018-2019. The salient findings obtained during course of study have been briefly summarized below.

- Effect of various bagging materials significantly influenced the maturity (%). Out of 08 treatments evaluated, the maximum maturity (89.33%) was noted under non-woven bag (T₆) and minimum maturity (80.33%) was recorded in control (T₀). All the treatments proved significantly superior over control with respect to fruit maturity.
- The yield attributes of fruit like fruit weight, length, and diameter were also affected significantly by various bagging materials. Maximum fruit weight (150.92 g), fruit length (6.89 cm), and fruit diameter (6.87 cm) was reported in non-woven bag (T₆). On the other hand, the minimum values for these physical traits were recorded in control (T₀). All the treatments proved significantly superior over control with respect to the above mentioned physical parameters of fruits.
- Various bagging materials significantly influenced the fruit drop (%) and insect damaged fruit (%). Out of 08 treatments evaluated, the maximum values for fruit drop (10.67%) and insect damaged fruit (13.67%) were observed in control (T₀) while, minimum values for these parameters were noticed under non-woven bag (T₆).
- Various bagging materials significantly influenced the pulp weight, seed weight and pulp: seed ratio. Out of 08 treatments evaluated, the maximum values for pulp weight (134.54 g), pulp: seed ratio (30.42) were obtained with in non-woven bag (T₆), and mean while, maximum seed weight (7.47%) was recorded in white paper bag (T₂), while, the minimum values for pulp weight (93.65 g) and pulp: seed ratio (12.73) were noticed in control (T₀) and minimum seed weight (4.73 g) recorded in non-woven bag (T₆).

- Specific gravity (g cc^{-1}) was significantly influenced by the bagging materials. The maximum specific gravity (1.24 g cc^{-1}) was observed in white paper bag (T_2) and the minimum fruit specific gravity (0.92 g cc^{-1}) was recorded under green polyethylene bag (T_4). All the treatments proved significantly superior over control with respect to Specific gravity (g cc^{-1}).
- Color is one of the most important criteria of quality of most fruits. It was observed that the different bagging materials had great effect on fruit color of guava. The result showed that the color of without bagged fruits was light green with spotted skin and the surface was rough while, fruits were yellowish green in color and having smooth surface under non- woven bag (T_6), white paper bag (T_2), yellow polythene bag (T_3) and muslin cloth bag (T_5).
- Various quality characteristics of guava fruits were also positively affected by fruit bagging. The highest TSS (12.68°Brix) were reported in yellow polyethylene bag (T_3), maximum acidity (0.46%) in control (T_0), the maximum TSS: acidity ratio (38.3) in the muslin cloth bag (T_5), and the maximum reducing sugar (4.90%) in the yellow polyethylene (T_3) while the minimum values (0.37%) for acidity was obtained in non-woven bag (T_6) and for the parameters TSS and TSS acid ratio the minimum values were recorded in control (T_0) while, minimum and acidity ($\%$) was rescored news paper bag (T_7).
- The maximum ascorbic acid ($199.92 \text{ mg}/100\text{g}$) was obtained in muslin cloth bag (T_5), while minimum ascorbic acid ($175.83 \text{ mg}/100\text{g}$) was observed in control (T_0). All the treatments proved significantly superior over control with respect to ascorbic acid.
- Total sugars along with reducing and non- reducing sugar in guava fruits were also significantly affected by different bagging materials. Maximum total sugar (8.28%) was recorded in muslin cloth bag (T_5) and minimum values were obtained in newspaper bag (T_7) whereas, the maximum pectin content (1.24%) was observed in yellow polyethylene bag (T_3) while, the minimum values of pectin content (0.95%) were obtained in newspaper bag (T_7).
- From economic feasibility point of view the maximum return per rupee investment (1.319) was found for net return (547.70 Rs.) in non-woven bag (T_6) while, minimum values was obtained in control (T_0).

CONCLUSION

It is concluded that pre-harvest fruit bagging exhibited the beneficial effects on fruit development. The desirable effect of bagging depended upon type of bag, stage of fruit development, time of bag removal, and/or types of fruit and cultivar.

In guava, non-woven bags as well as muslin cloth bag used at 35 days after fruit set were found the most effective in quality production of fruits. Non-woven bag (T₆) was found best for maintaining yield attributes *i.e.* maturity (89.33%), fruit drop (10.67%), fruit weight (150.92 g), fruit length (6.83 cm), fruit diameter (6.87 cm), specific gravity (1.08 g cc⁻¹), Insect damage fruit (0.33%), Pulp weight (134.54 g), Seed weight (4.73 g), fruit colour light yellowish green smooth skin and with best quality attributes *i.e.* TSS (12.68° Brix), Acidity (0.37%), reducing sugar (4.30%), Total sugar (7.84%), and Ascorbic acid (197.47 mg/100g pulp), Pectin content (1.16%), and maximum the B: C ratio (1.319). It is recommended that on bagging of guava fruits with non-woven bag can maintain disease resistancy, with economic feasibility and good quality parameters.

In guava, wrapping of individual fruit with transparent bags as partial cover against sunlight was found to be the best option for guava fruit fly management and reducing yield loss. Non-woven bag also has beneficial effect on improvement in yield attributes and quality production of fruits.

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APPENDIX

Appendix I: ANALYSIS OF VARIANCE

Source of variation	d.f.	MSS		
		Maturity (%)	Fruit drop (%)	Fruit weight (%)
Treatment	7	9726.57	366.57	25873.04
C v/s R	1	67988.64	2468.64	180018.07
Among rest	6	16.22	16.22	182.20
Error	40	2.80	2.80	37.57
Total	47	1451.02	56.98	3885.40

Appendix II: ANALYSIS OF VARIANCE

Source of variation	d.f.	MSS		
		Fruit length (cm)	Fruit diameter (cm)	Specific gravity (g cc ⁻¹)
Treatment	7	43.34	44.71	1.54
C v/s R	1	296.99	305.25	10.59
Among rest	6	1.06	1.28	0.03
Error	40	0.09	0.08	0.01
Total	47	6.53	6.72	0.24

Appendix III: ANALYSIS OF VARIANCE

Source of variation	d.f.	MSS			
		Insect damaged fruits (%)	Pulp weight (g)	Seed weight (g)	Pulp: seed ratio
Treatment	7	72.66	15236.97	61.46	477.21
C v/s R	1	476.74	99268.34	411.78	2685.59
Among rest	6	5.32	1231.74	3.07	109.15
Error	40	1.18	39.29	0.66	8.28
Total	47	11.83	2302.77	9.72	78.12

Appendix IV: ANALYSIS OF VARIANCE

Source of variation	d.f.	MSS			
		TSS(° Brix)	Acidity (%)	TSS : Acidity	Reducing sugar (%)
Treatment	7	196.24	0.17	1347.87	25.72
C v/s R	1	1368.09	1.59	9214.93	174.84
Among rest	6	0.93	0.07	36.69	0.87
Error	40	0.49	0.01	14.69	0.07
Total	47	29.65	0.03	213.25	3.89

Appendix V: ANALYSIS OF VARIANCE

Source of variation	d.f.	MSS		
		Total sugar (%)	Ascorbic acid (mg/100g pulp)	Pectin content (%)
Treatment	7	74.53	47770.92	1.73
C v/s R	1	516.04	333160.63	11.84
Among rest	6	0.94	205.97	0.04
Error	40	0.06	19.58	0.01
Total	47	11.15	7131.48	0.26

Appendix VI: COST OF PRODUCTION

Total fruits use for per treatment: Rs.150

Cost of labour bagging per treatments: Rs.35

Cost of bagging on tree

1. Cost of labour (1 man day required for bagging of 1400 fruit): Rs. 210
2. Material cost
 - ❖ Cost of Brown paper bag - (Rs.0.20 /bag): for 150 fruits cost Rs. 30
 - ❖ Cost of white paper bag (Rs. 0.20/bag): for 150 fruits cost Rs. 30
 - ❖ Cost of yellow polyethylene bag (Rs. 0.30/bag): for 150 fruits cost Rs. 45
 - ❖ Cost of green polyethylene bag (Rs. 0.30/bag): for 150 fruits cost Rs. 45
 - ❖ Cost of muslin cloth bag (Rs.0.50/kg): for 150 fruits cost Rs. 75
 - ❖ Cost of non-woven bag (Rs. 0.60/bag): for 150 fruits cost Rs. 90
 - ❖ Cost of News paper bag (Rs. 0.10/bag): for 150 fruits cost Rs. 15

Other cost:

- Labour cost- one day labour Rs.210/-

“Effect of fruit bagging on yield and quality of guava (*Psidium guajava* L.) cv. ‘Allahabad Safeda’”

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ABSTRACT

The present investigation entitled “**Effect of fruit bagging on yield and quality of guava (*Psidium guajava* L.) cv. ‘Allahabad Safeda’**” was carried out at horticulture farm of Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur during winter season of the year 2018-2019. The Rajasthan College of Agriculture, Udaipur. Fruits at 35 days after fruit set were selected for bagging. The healthy fruits were selected for bagging. The different material bags were tied with thread properly, so that it will not fall down as well as there will not be open space for entry of insects or rain water *etc.*

Twenty-five fruits in all direction selected from each plants for each treatment were considered for observations of different characters *viz.*, Effect of various bagging materials significantly influenced the maturity (%), fruit weight (g), fruit length (cm), fruit diameter (cm), fruit drop (%) and insect damaged fruit (%), pulp weight (g), seed weight (g) and pulp: seed ratio, Specific gravity (g cc^{-1}), fruit color, and quality attributes TSS ($^{\circ}\text{Brix}$), acidity (%), TSS acid ratio, ascorbic acid (mg/100g), total sugars (%), reducing sugar (%), and pectin content (%) and increased B: C ratio (1.319). It is recommended that bagging of guava fruits with non-woven bag can maintain disease resistancy, with economic feasibility and good quality parameters. In guava, wrapping individual fruit with transparent colour bags as partial cover against sunlight is the best option for guava fruit fly management and reducing yield loss. Non-woven bag was found beneficial for yield attributes and quality production of fruits.

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^^bykgkckn IQsnk ve:n $\frac{1}{4}flfM$;e xqtkok ,y- $\frac{1}{2}$ ds Qykسا dh iSnkokj o xq.koÙkk ij FkSyh ca/ku dk izHkko**

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orZeku v/;u esa ^^bykgkckn IQsnk ve:n $\frac{1}{4}flfM$;e xqtkok ,y- $\frac{1}{2}$ ds Qykسا dh iSnkokj o xq.koÙkk ij FkSyh ca/ku dk izHkko** jktLFkku d`f"k egkfo+[ky;] mn;iqj ds cKxokuh QkeZ esa o"KZ 2018&2019 ds 'khrdkyhu ekSle esa fd;k x;k FkKA ikS/ks ij Qy yxus ds i'pkr~ 35 fnuksا ds ckn Qykسا dh FkSyh ca/ku ds fy, pquk x;k A LoLFk o jksx jfgr Qykسا dks FkSyh ca/ku ds fy, pquk x;k FkKA fofHkUu lkexzh dh FkSyh dks vPNs <ax ls Qy dks <ddj vPNs ls /kkxs esa cka/kk x;k FkK rkfd og uhps ughا fxjs vkSj lKfK gh dhM+s ;k cjLkr dk ikuh vkfn FkSyh ds vUnj izos'k u djsا A

izR;sd mipkj ds fy, izR;sd ikS/kksا ds fy, lHkh fn'kkvksا esa iPphl Qy dks pquk x;k rFkk fofHkUu ekudksا ds lECU/k esa fofHkUu y{k.kksا dks ntZ fd;k x;k A Øe'k% fofHkUu FkSfy;ksا dh lkexzh us ifjiDork $\frac{1}{4}\%$ Qy otu $\frac{1}{4}xzk\frac{1}{2}$] Qykسا dh yEckbZ $\frac{1}{4}lseh\frac{1}{2}$] Qykسا dk O;kl $\frac{1}{4}lseh\frac{1}{2}$] vkSj Qy dk >M+uk $\frac{1}{4}\%$ dhV {kfrxzLr Qy $\frac{1}{4}\%$ xwnk otu $\frac{1}{4}xzk\frac{1}{2}$] cht otu $\frac{1}{4}xzk\frac{1}{2}$ xwnk ,oa cht vuqikr] fof'k"V xq:Ro $\frac{1}{4}th-lh-lh^{\frac{1}{2}}$ vkSj Qy jax] vkSj xq.koÙkk xq.k Øe'k% dqy ?kqyu'khy Bksl (%), vEyrk (%)] dqy ?kqyu'khy vEy vuqikr] ,DldkfcZd vEy $\frac{1}{4}feyh$ xzke@100 xzke $\frac{1}{2}$ dqy 'kdZjk (%), ?kVh gqbZ 'kdZjk (%), isfDVu (%) vkSj c<+k gqvk ykHk&vuqikr $\frac{1}{4}1$ %

319½ dks izHkkfor fd;k A ;g lykg nh tkrh gS fd xSj&cquk cSx ds lkFk FkSyh ca/ku djus ij ve:n ds Qyksa dh iSnkokj] vkfFkZd O;ogk;Zrk vkSj vPNh xq.koRrk ds ekin.Mksa dks c<+krk gS rFkk lkFk gh jksx o dhV {kfrxzLr {kerk dks de djrk gSA ve:n esa lwjt dh jks'kuh ds f[kykQ vkaf'kd vkPNknu ds :i esa ikjn'khZ vyx cSx ds lkFk O;fDrxr FkSyh ca/ku ve:n Qy] eD[kh izca/ku ds fy, lcls vPNk fodYi gS vkSj mit gkfu dks de djrk gS A xSj&cquk cSx Hkh mit fo'ks"krkvksa vkSj Qyksa ds xq.koRrk rFkk mRiknu ds fy, lcls vf/kd ykHkizn ik;k x;k A

* 'kks/kdrkZ] m|ku foKku foHkkx] jktLFkku d`f"k egkfo|ky; mn;iqj ¼jkt½

** vkpk;Z] m|ku foKku foHkkx] jktLFkku d`f"k egkfo|ky; mn;iqj ¼jkt½

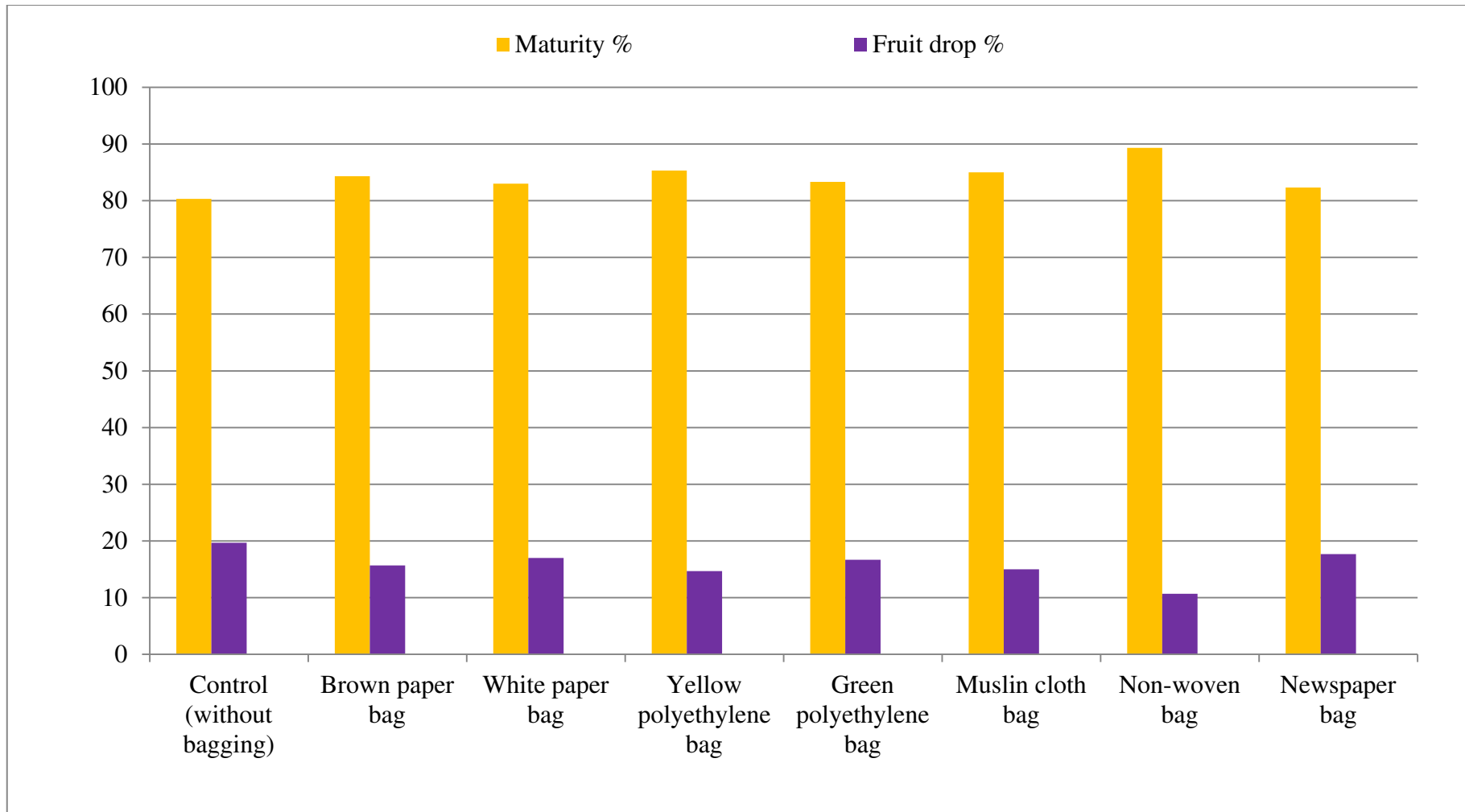


Fig-1. Effect of fruit bagging treatments on maturity and fruit drop

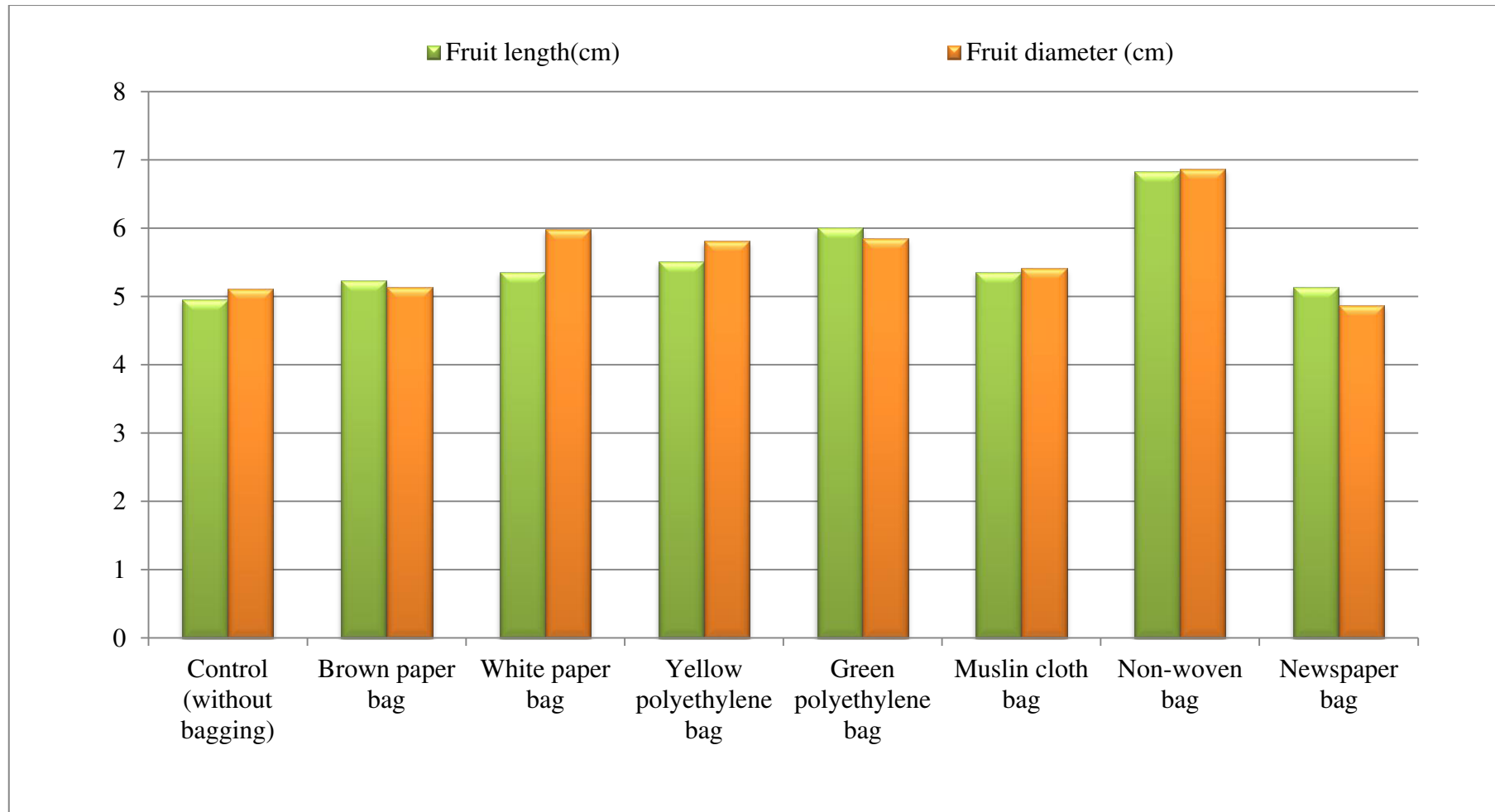


Fig-2. Effect of fruit bagging treatments on fruit length and diameter

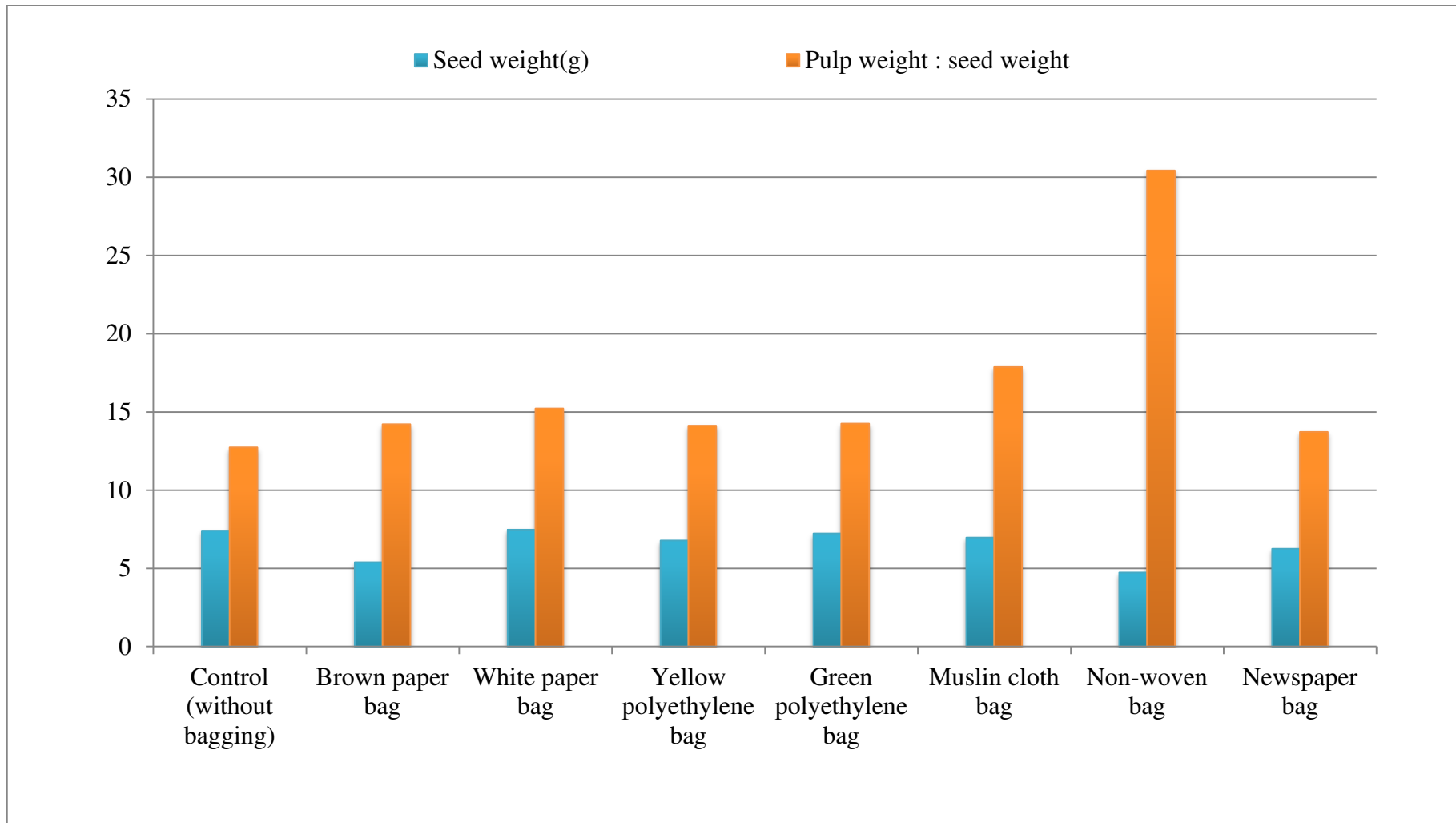


Fig-3. Effect of fruit bagging treatments on seed weight and pulp: seed ratio

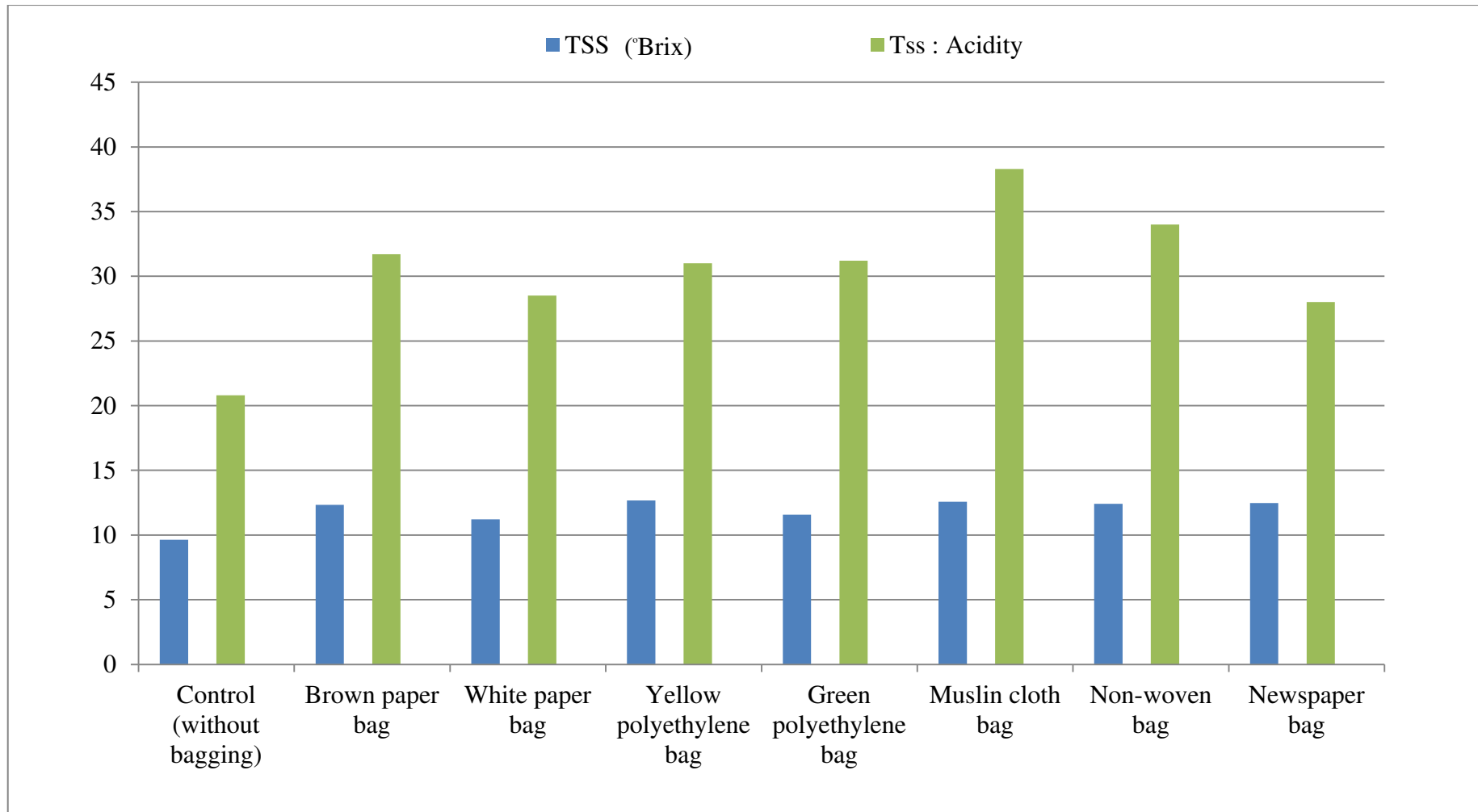


Fig-4. Effect of fruit bagging treatments on TSS and TSS: acidity ratio

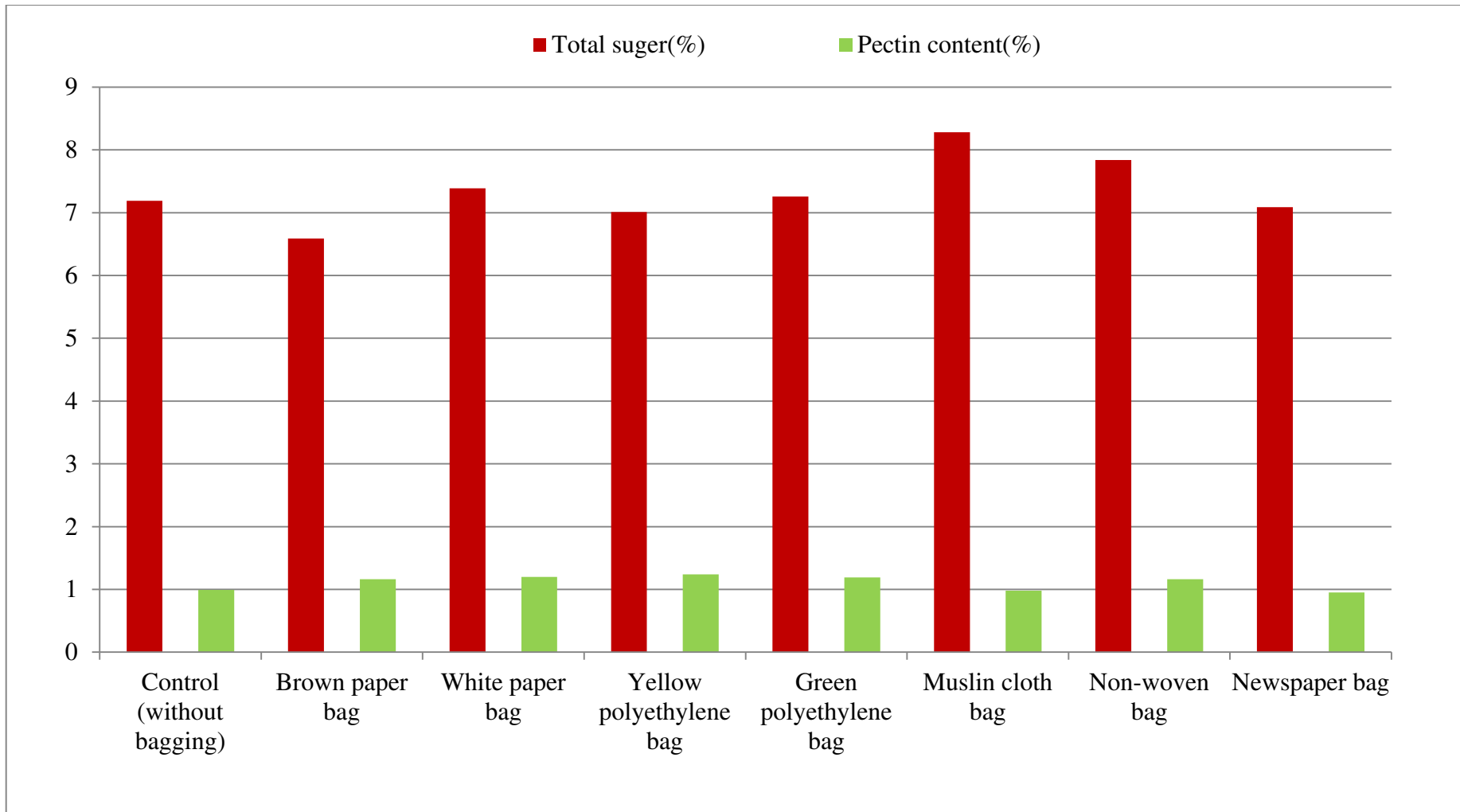


Fig-5. Effect of fruit bagging treatments on total sugar and pectin content

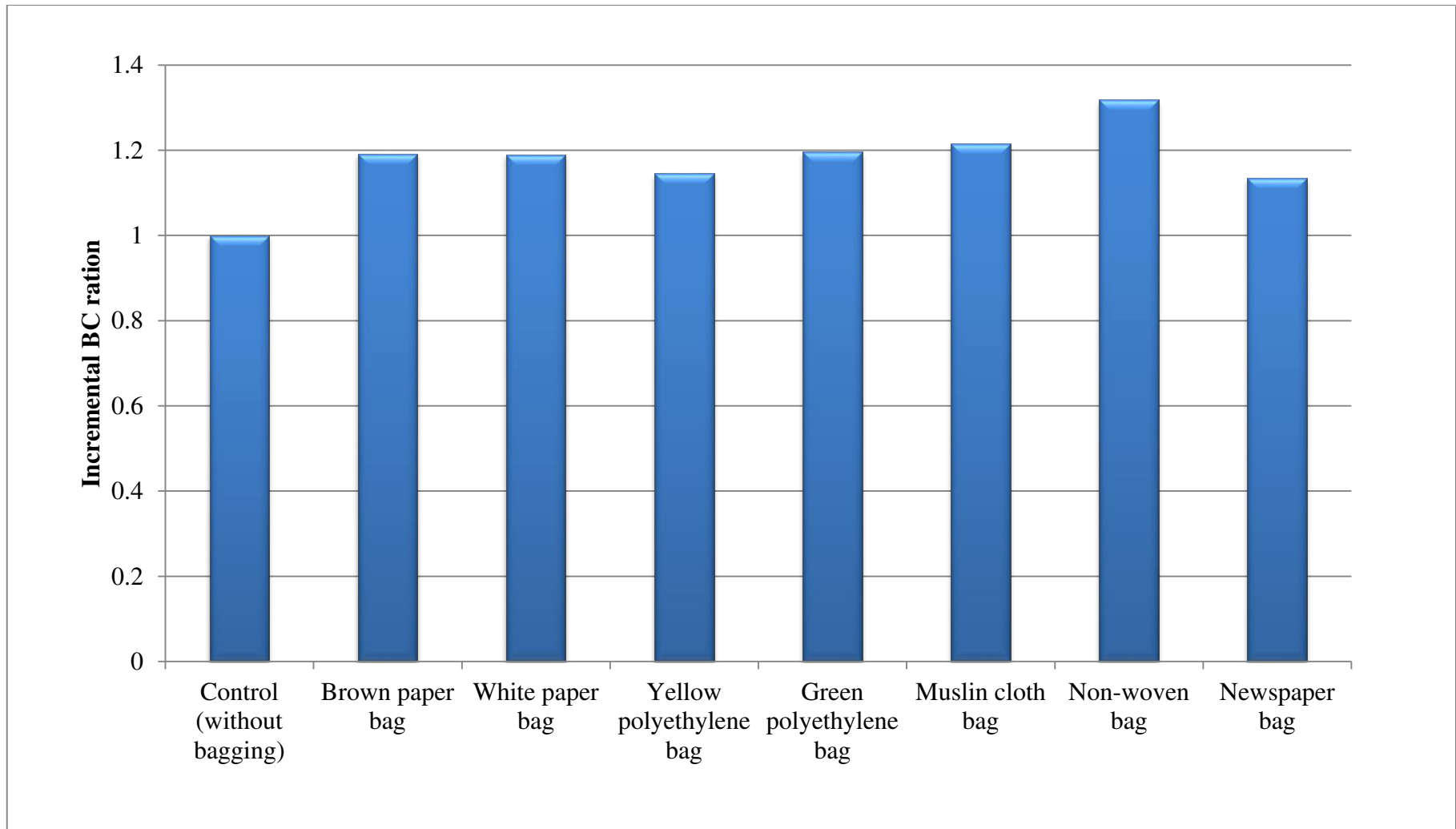


Fig-6. Effect of fruit bagging economics of treatments



T₀ (Control)



T₁ (Brown Paper Bag)



T₂ (White Paper Bag)



T₃ (Yellow Polyethylene)



T₄ (Green Polyethylene)



T₅ (Muslin Cloth Bag)



T₆ (Non-woven Bag)



T₇ (Newspaper Bag)

Plate-1: Effect of fruit bagging treatments on guava cv. Allahabad Safeda