

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(4): 1043-1051
www.biochemjournal.com
Received: 14-01-2026
Accepted: 16-02-2026

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Impact of Pre-harvest Bagging on Fruit Quality and Post-harvest Shelf Life

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DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i4Sm.8282>

Abstract

An innovative horticultural method that improves fruit quality and encourages long-term pest and disease control is pre-harvest fruit bagging. This technique protects developing fruits from biotic and abiotic stresses by enclosing them in protective bags. This leads to better visual characteristics like uniform coloration, smoother texture, and larger size, as well as better internal characteristics such as appropriate sugar-acid ratios, improved scent, and superior flavor retention. In addition to improving the fruit's appearance by promoting skin coloration and reducing flaws, bagging can change the microenvironment for growth of fruits, which can have a number of beneficial effects on the fruit's internal quality. In line with integrated pest control tactics, the practice avoids mechanical damage, increases shelf life, decreases post-harvest losses and lessens dependency on synthetic pesticides. Advances in biodegradable and crop-specific solutions offer intriguing alternatives to traditional bagging materials, despite obstacles like labour difficulty, cost and environmental concerns. Mango, banana, guava, grape, apple and litchi are just a few of the fruits that use it extensively throughout the world. Pre-harvest bagging offers a practical way to boost efficiency and sustainability in contemporary fruit production as the demand for premium, residue-free produce rises globally. To maximize this method for broader adoption and support robust, sustainable and profitable horticulture operations, interdisciplinary research and innovation must continue.

Keywords: Bunch bagging, Pesticide Residue Reduction, Fruit quality, bagging material, Insect & diseases infestation, Good agricultural practices

Introduction

A popular horticultural technique that significantly improves fruit quality, aesthetic appeal and post-harvest performance is pre-harvest fruit bagging. Fruit bagging's main goal is to create a controlled microenvironment around growing fruits, hence lowering their exposure to a variety of biotic and abiotic challenges. The bags act as a physical barrier, providing defence against fungal infections, insect pests, wind and hail-related mechanical damage and physiological conditions like sunburn and russeting (Kolb *et al.*, 2001; Ju, 1998) [38, 43]. By reducing the prevalence of pests and diseases, this barrier function lessens the need for chemical pesticides and makes it possible to grow residue-free fruits that meet consumer safety regulations (Zhang *et al.*, 2018; Ding & Syakirah, 2010) [19, 75]. Fruit bagging also alters the temperature, humidity and light exposure of the microclimate that surrounds the fruit. This results in improved surface colouration, smoother skin texture and more consistent size and shape, all of which are highly desired characteristics in commercial fruit production (Ali *et al.*, 2021) [1]. Finding alternative ways to improve fruit quality and aesthetics becomes more important as consumer concern over the use of artificial agrochemicals and environmental awareness increases. In order to safeguard the environment, worker safety, and consumer health, it is becoming more crucial to reduce the use of pesticides (Sharma *et al.*, 2009) [62]. One of these strategies that has worked well in several parts of the world is pre-harvest fruit bagging. Often applied to a range of fruits, it improves their look by promoting peel coloration. The inner fruit quality can be affected in a number of ways by reducing the frequency of fruit russeting and cracking while simultaneously changing the fruit development microenvironment. It is connected to organic.

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academics and extension agents working in this field, we have made an effort to gather all the disparate material on fruit bagging.

Table 1: The benefits of bagging fruit crops

Sl. No.	Fruit Crop	Advantages of Fruit Bagging	Reference
01	Peach	Minimizes insect damage and enhances flavour profile	(Bacelar <i>et al.</i> , 2024)
02	Mango	Improves fruit colouration, size and shape	(Singh <i>et al.</i> , 2012)
03	Guava	Decreases scarring and pest incidence	(Matsumoto <i>et al.</i> , 2018)
04	Apple	Increases fruit size and color while lowering pest and disease susceptibility.	(Cheng <i>et al.</i> , 2007)
05	Litchi	Prevents fruit borer infection and lessens fruit cracking	(Mitra & Pathak, 2010)
06	Dragon Fruit	Protects against sunburn and bird damage	(Hoa <i>et al.</i> , 2006)
07	Grape	Protects against sunburn and enhances the quality of wine	(Kassem, 2011)
08	Pear	Enhances overall quality and reduces surface blemishes	(Campbell <i>et al.</i> , 2021)
09	Fig	Protects fruits from bird and insect attacks	(Frank, 2018)
10	Cherry	Prevents bird damage and intensifies colour development	(Fumuro & Gamo, 2001)
11	Kiwifruit	Increases fruit size and minimizes fungal infections	(Ferguson & Huang, 2007)
12	Plum	Lowers pest infestation and improves flavor attributes	(Usenik <i>et al.</i> , 2010)
13	Pomegranate	Stops the development of fungal patches and fruit splitting.	(Melgarejo <i>et al.</i> , 2004)
14	Papaya	Reduces damage caused by fruit flies	(Aluja <i>et al.</i> , 2011)
15	Persimmon	Prevents bird damage and enhances fruit sweetness	(Ma <i>et al.</i> , 2021)
16	Banana	Protects from thrips, beetles, and sunburn	(Semple & Frio, 1992)

Importance of pre-harvest fruit bagging in fruits

A popular and successful horticultural technique for enhancing fruit quality and reducing the effects of various biotic and abiotic challenges is pre-harvest fruit bagging. In order to create a controlled microenvironment that improves aesthetic appeal and post-harvest durability, this technique entails enclosing developing fruits in bags often made of paper, plastic films, or non-woven textiles during early fruit development (Huang *et al.*, 2009; Morandi *et al.*, 2010) [30, 52]. Fruits are protected from environmental risks such as UV-induced sunburn, raininduced cracking, wind damage and mechanical abrasion by bagging, which serves as a physical barrier (Chaves-Silva *et al.*, 2018; Lima *et al.*, 2020) [13, 44].

Historical Background of the Fruit Bagging Technique

Fruit bagging is an ancient horticultural technique that dates back to East Asia. Farmers in ancient China and Japan used basic materials like paper, cloth and bamboo to shield developing fruits like pears, peaches and persimmons from biological and environmental dangers (Vignati *et al.*, 2022) [68]. By the early 20th century, the method had advanced considerably in Japan, where double-layered paper bags were used in apple orchards to enhance fruit consistency and appearance while discouraging pests and reducing weather-related damage (Issarakraisila, 2018) [33]. Bagging was

modified for crops including citrus, grapes and persimmons after these improvements quickly made their way to Korea, Taiwan and other East Asian countries (Kim *et al.*, 2019)^[40]. Biodegradable and sensor-enabled "smart" bags are examples of recent inventions that improve sustainability and environmental responsiveness (Wu *et al.*, 2012)^[71]. Fruit bagging is a crucial and versatile method for improving fruit quality, reducing pesticide use and promoting sustainable horticulture globally. Its development, therefore, demonstrates the blending of traditional agricultural expertise with contemporary scientific discoveries.

Types of Bagging based on physical structure

- **Nets:** Nets can be positioned over specific tree branches or directly on the plants. To keep fruit flies out of the net, anchor nets at ground level using a strong frame and stakes or pegs. Additionally, establish dwarf fruit trees or prune trees to make it easier to deploy nets. Insecticide-treated nets can occasionally be used on plants to protect crops and eradicate fruit flies. Promising methods include covering individual fruits, fruiting clusters or complete fruiting plants, netting, nylon stockings, or paint strainer bags.
- **Bags and Sleeves:** Try covering the fruit you want to preserve inside with bags and sleeves, then fasten them to the plant using string, tie wire, or clothes pegs. When bagging, it is crucial to cover the fruit with paper. It has an impact on numerous characteristics that improve the paper bag's quality. It works best because it produces a microclimate where the temperature rises gradually, improving the fruit's aroma and total sugar content (Zhou and Guo, 2005; Watanawan *et al.*, 2008)^[70, 77].
- **Cloth-Based Bags:** Options for cloth bagging, such as sophisticated non-woven textiles and loosely woven cotton, balance protection and breathability. They are perfect for delicate fruits like peaches and mangoes because of their lightweight and flexible structure, which protects them from mechanical damage. These textiles' porous structure guarantees steady airflow and moisture release, lowering the possibility of heat buildup and microbiological contamination (Chaves *et al.*, 2021)^[12].

Effects of bagging on fruit crops

Physiological factors influenced by fruit bagging

Fruit size, weight and colour

Once the fruit sets, it grows slowly until it reaches maturity. Fruit growth and size may be impacted by covering them with a bag at a specific developmental period (Table 02). There have been conflicting reports on how fruit bagging affects fruit weight and size. This could be because of variations in the type of bag used, the age of the fruit at bagging, the responses of the fruit and cultivar, the current climate and/or the storage conditions of the fruit after harvest (Huang *et al.*, 2007; Chen *et al.*, 2012)^[14, 30].

Fruit weight and size may rise, decrease, or remain unchanged after fruit bagging. According to Yang *et al.* (2009)^[74] and Zhou *et al.* (2012)^[76], bagging improves fruit growth, size and weight. For instance, Xu *et al.* (2008)^[72]

found that applying plastic bags 10 days after full bloom doubled fruit weight in carambola. The effects of pre-harvest bagging with various wavelength-selective bags on 'Nam Dok Mai' mangos in Taiwan were examined by Chonhenchob *et al.* (2011)^[16], who found that bagging increased fruit weight, size and sphericity compared to unbagged fruit. Pre-harvest fruit bagging has been shown to decrease the weight and size of various fruits. For example, Xu *et al.* (2010)^[73] tried bagging "Baiyu" and "Ninghaibai" loquat and found that bagging reduced fruit weight. Additionally, bagging pomegranates has been shown to decrease fruit weight and size (Hussein *et al.*, 1994)^[32]. According to certain research, bagging does not affect fruit weight or size. For instance, polyethene covers did not affect banana bunch or total fruit weights, according to Rodrigues *et al.* (2001)^[57].

Fruit maturity & Fruit ripening

Fruit ripeness can be affected by bagging; conflicting findings have been documented. In contrast to fruit wrapped with newspaper bags or unbagged fruit, Kim *et al.* (2008)^[41] found that fruit maturation in "Janghowon Hwangdo" peaches bagged with white paper occurred six days earlier. According to Wang *et al.* (2010)^[69], pre-harvest fruit bagging in the late-ripening peach cultivar "Wanmi" enhanced fruit maturity by about ten days.

Fruit ripening is impacted by pre-harvest bagging. According to Awad (2007)^[5], bunch bagging greatly accelerated the rate of fruit ripening in the late-season date palm cultivar "Helali". Pre-harvest bagging postponed the ripening of the black table grape "Perla", according to Signes *et al.* (2007)^[64]. In comparison to no bagging, Kassem *et al.* (2011)^[39] found that spathe-bagging using transparent or blue polyethene bags during pollination resulted in noticeably earlier fruit ripening in "Zaghloul" dates.

Fruit appearance & colour development

Fruit is vulnerable to physical flaws and damage during cultivation, harvesting, packing and shipping. Customers find them less appealing as a result. Customers are drawn to fruit that is free of flaws, scratches, or damage. Fruit has been bagged in order to increase its commercial worth. Pre-harvest bagging of "Doyenne du Comice" pears boosted the proportion of fruit allowed for export, according to Amarante *et al.* (2002)^[3], mainly by lowering bird damage and skin imperfections.

The primary characteristic that draws customers is the colour of the fruit. The fruit's physical appearance is enhanced by an appealing colour, which helps it command higher pricing in both home and international markets. Fruits can grow more evenly because of the bags' protective environment. Pre-harvest fruit bagging may either encourage or impede the development of fruit colour, according to several studies. In order to satisfy market demands and raise the general quality of the fruit, this consistency is essential. Additionally, by reducing bruising and other damage that frequently happens during growth, bagging can improve fruit texture (Zhuang & Chen, 2018).

Table 2: Effect of bagging in fruit size and weight of fruit crops

Fruits/cultivar	Bagging material	Effect	Reference
Carambola	Plastic bags	Increased fruit weight	Xu <i>et al.</i> , 2008
Mango (Nam Dok Mai)	2-layer paper bags (black & brown)	Increased fruit weight	Watanawan <i>et al.</i> , 2008
Longan	Paper bags	Larger-sized fruit	Yang <i>et al.</i> , 2009
Date palm (Khalas & Sukari)	Blue bag	Increase fruit size and bunch weight	Harhash <i>et al.</i> , 2010
Litchi	Brown and butter paper bags	Increase in fruit size and weight	Joshi <i>et al.</i> , 2016a
Mango (Langra and Pant Sinduri)	Brown paper bag	Increase in fruit weight and volume	Joshi <i>et al.</i> , 2016b
Guava	White polyethylene	Increases the fruit weight and size	Meena <i>et al.</i> , 2016
Guava (Bari Peyara-2)	White polyethylene	Increases fruit weight and size	Rahman <i>et al.</i> , 2017
Guava (Swarupkathi)	White polyethylene	Increases fruit weight and diameter	Rahman <i>et al.</i> , 2018
Papaya	Polythene bags	Minimum loss in weight of fruit	Mia, 2003
Pear (Conference)	Paper bags	Reduced fruit weight	Hudima and Stamper, 2011
Loquat (Baiyu)	-	Reduced fruit weight	Xu <i>et al.</i> , 2010

Biotic factors influenced by fruit bagging

Pest control

A useful method for keeping the environment and the crop physically apart is pre-harvest fruit bagging. Protection from insect pest damage is one of the most important benefits of fruit bagging (Table 03). According to several studies, bagging decreased the prevalence of fruit flies in guava

(Morera-Montoya *et al.*, 2008) ^[53], mango (Sarker *et al.*, 2009) ^[59], woolly aphids in apple (Teixeira *et al.*, 2011) ^[66], fruit borers in litchi (Debnath and Mitra, 2008) ^[18] and San Jose scale in apple (Sharma *et al.*, 2013) ^[63]. Therefore, it seems that pre-harvest fruit bagging can be a helpful strategy to lessen the losses brought on by insects, which would otherwise necessitate the use of many insecticides.

Table 3: Effect of pre-harvest fruit bagging on insect infestation

Fruit crop/cultivar	Bagging material	Insect-pest controlled	References
Apple "Granny Smith"	Brown paper bags	Reduction in fruit infested by codling moth	Bentley and Viveros, 1992
Apple- 'Royal Delicious'	Spun bounded light-yellow harvesting-coloured bags	Reduction in San Jose Scale incidence	Sharma <i>et al.</i> , 2013
Guava	Biodegradable films	Guava weevil (<i>Conotrachelus psidii</i>)	Bilck <i>et al.</i> , 2011
Guava	Waxed paper, nylon fabric, Taiwan bag and telephone book paper	Fruit fly	Morera-Montoya <i>et al.</i> , 2010
Pomegranate ('Mridula', 'Ganesh', 'Jyoti')	Parchment bags	Nearly 90% reduction in the incidence of anar butterfly, <i>Deudorix Virachola</i>	Bagle, 2011
Mango 'Langra' and 'Khirshapat'	Bagging materials (black polybag, transparent polybag, brown paper bag)	100% Control of fruit fly	Sarker <i>et al.</i> , 2009
Litchi	Cellophane paper bags, brown and newspaper bags (biodegradable)	Reduced incidence of stalk-end borer (<i>Conopomorpha cramerella</i>)	Debnath and Mitra, 2008

Disease control

Additionally, fruit bagging keeps viruses from getting to the developing fruit, shielding it from several diseases that could result in significant losses. Certain fruits can be protected from many infections by bagging (Table 04), whereas other fruits may not benefit at all (Senghor *et al.*, 2007; Chonhenchob *et al.*, 2011) ^[16, 61]. Fruit bagging has

been shown to lower the occurrence of fly speck and sooty blotch in apples (Sharma *et al.*, 2013) ^[63] and anthracnose and stem-end rot in mangos (Senghor *et al.*, 2007; Chonhenchob *et al.*, 2011). Fruit bagging, therefore, can be a useful method for growing better fruit without or with reduced usage of chemicals to prevent disease.

Table 4: Impact of pre-harvest fruit bagging on fruit disease incidence

Fruit crop/cultivar	Bagging material	Disease incidence	References
Apple 'Fuji Suprema'	Transparent micro-perforated plastic or non-textured fabric bags	No effect on apple scab, bitter rot, and mouldy corer	Teixeira <i>et al.</i> , 2011
Apple 'Royal Delicious'	Spun bounded light-yellow coloured bags	Reduction in fly speck and sooty blotch	Sharma <i>et al.</i> , 2013
Mango 'carabao'	Plastic bags	Reduction in the incidence of most of the PHT diseases	Buganic <i>et al.</i> , 1997
Mango 'Keitt'	White paper bags	Control of <i>Colletotrichum gloeosporioides</i>	Hofman <i>et al.</i> , 1997
Guava	Paper bags	Reduction in black spot and anthracnose	Martins <i>et al.</i> , 2007
Loquat	Plastic bags	Reduction in fruit rot	Ko <i>et al.</i> , 2010
Pear 'Huangguan'	Three-layered bags	Increase in the incidence of browning spot	Wang <i>et al.</i> , 2011

Bird damage

Birds are significant pests during the ripening period of fruits like bananas, mangoes, apples and dates, resulting in significant losses. Birds are controlled using a variety of methods, including extending reflective ribbons in the field

and thumping drums, although they quickly grow accustomed to these methods (Sharma, 2009) ^[62]. If applied at the proper stage of fruit growth, we believe that fruit bagging may be the ideal method for producing healthy, bird-damage-free fruit.



Fig 1: Pre-harvest fruit bagging using a butter paper bag in *Annona* cv. Arka Sahan

Physiological and biochemical factors influenced by bagging

Physiological disorders

Physiological diseases are abnormalities in fruit that are not brought on by pathogen invasion or insect damage, but rather by a lack or excess of a nutrient, hot or low temperatures, or high or low rates of respiration or ethylene production (Sharma, 2009) ^[62]. Numerous methods have

been used to manage these illnesses, which have been documented to have an impact on fruit quality and yield. Fruit bagging may be used to lower the prevalence of some fruit illnesses, according to studies (Table 05). As a result, fruit bagging has been widely employed in several nations to lessen sunburn and fruit breaking issues. Additionally, it decreased the frequency of apple russetting (Teixeira *et al.*, 2011) ^[66] and sunburn (Bentley and Viveros, 1992) ^[8].

Table 5: Pre-harvest fruit bagging's impact on fruit hysiological problems

Fruit crop/cultivar	Bagging material	Disorder	References
Apple 'Fuji Suprema'	Transparent micro-perforated plastic or non-textured fabric bags	Reduction in bitter pit incidence	Teixeira <i>et al.</i> , 2011
Apple Granny Smith	Brown paper bags	Reduction in sun-burn	Bentley & Viveros, 1992
Carambola	Plastic bags	Reduction in fruitdrop	Xu <i>et al.</i> , 2008
Date palm 'Zaghloul'	Transparent and blue polythene bags	Reduction in tip cracked fruit	Kassem <i>et al.</i> , 2011
Longan 'Chuliang'	White adhesive-bonded fabric bag (WAFB), Black adhesive-bonded fabric bag (BAFB)	Reduction in fruit drop	Yang <i>et al.</i> , 2209
Mango	White bags	Reduction in lenticel discolouration	Mathooko <i>et al.</i> , 2011
Nectarine	Plastic bags	Reduction in fruit splitting	Ding <i>et al.</i> , 2003
Pear 'conference'	Plastic bags	Reduction in Sun burn	Amarante <i>et al.</i> , 2002
Pear 'Cuiguan'	Paper bags	Reduction in Stone cells	Lin <i>et al.</i> , 2008
Persimmon 'Shinsyu'	Paper bags	No black stain	Fumuro & Gamo 2001

Biochemical changes in bagged fruits

Numerous nutrients are present in fruits, which enhance their quality. Fruit bagging may affect the nutrient composition of fruit because it is typically done in the

orchard during the fruit development stage. *Apple* fruit wrapped in paper bags, for example, had the lowest calcium (Ca) concentration; however, other bags enhanced this. Bagging reduced the quantities of K, Ca, and Mg in pear

fruit by 9.6%, 38.9% and 6.7%, respectively, but had no discernible effect on the concentrations of N and P (Lin, 2008) [45]. The development of flavour (Table 06) and scent, two important sensory characteristics that impact consumer preference, is also greatly influenced by the microclimate created by fruit bagging. By promoting ideal ripening conditions and shielding the fruit from environmental pressures that could otherwise cause premature ethylene production or interfere with normal metabolic pathways,

bagging can improve the natural sweetness of fruits like apples, according to studies. Producing fruit of superior quality is the grower's ultimate goal. Additionally, consumers desire fruit of the highest calibre. The edible quality is determined by factors like titratable acidity (TA) and total soluble solids content (TSSC). Research has shown that fruit bagging affects the fruit is edible quality (Table 06).

Table 6: Influence of pre-harvest fruit bagging on the eating quality of different fruit

Fruit	Quality attribute(s) affected	Reference(s)
Apple	Improvement in fruit sweetness	Bentley and Viveros (1992)
	Slight reduction in total soluble sugar (TSS) content	Chen <i>et al.</i> (2012)
	Reduction in carotenoid contents in skin and flesh	Jia <i>et al.</i> (2011)
	Increasing total soluble solids and ascorbic acid contents	Sharma <i>et al.</i> (2013)
	No effects on the content of soluble sugars, reducing sugar and titratable acidity (TA)	Xia <i>et al.</i> (2009)
Banana	No adverse effect on total soluble solids, TA, and fruit firmness	Muchui <i>et al.</i> (2010)
Guava	Improvement in soluble solids concentration	Singh <i>et al.</i> (2007)
Grape	Increase in soluble sugars	Zhou and Guo (2005)
Litchi	Significant improvement in TSS:TA ratio	Debnath and Mitra (2008)
Longan	No significant effect on sugar content	Yang <i>et al.</i> (2009)
Loquat	Increase in soluble solids and decline in acidity	Liu <i>et al.</i> (2004)
	Content of sucrose, glucose and soluble solids increased, while the content of fructose, sorbitol and titratable acidity decreased	Ni <i>et al.</i> (2010)
	Improvement in total sugar content	Xu <i>et al.</i> (2010)
Mandarin	Reduction in sugar and organic acid content	Hiratsuka <i>et al.</i> (2012)
Mango	Significant effects on total soluble solids, TA, TSS: TA ratio, vitamin C	Watanawan <i>et al.</i> (2008)
Nashi pear	No effect of total soluble solids	Faoro and Marcia(2004)
Orange	Increase in flesh lycopene and β -carotene contents	Wang <i>et al.</i> (2006)
Peach	No effect of total soluble solids and titratable acidity	Jia <i>et al.</i> (2005)
	Improvement in soluble solids concentration	Kim <i>et al.</i> (2008b)
Pear	Reduction in soluble solids and an increase in TA	Lin <i>et al.</i> (2008)
	Negative impact on sucrose and sorbitol content	Hudima and Stamper (2011b)
	Double increase in soluble solids	Lin <i>et al.</i> (2012)
	Reduction in the content of sugars and acids	Xin and Zhang (2003)
	Reduction in soluble solids concentration	Murray <i>et al.</i> (2005)

Effect of bagging on fruit microclimate

Although bagging alters the microclimate surrounding the fruit, very few precise measurements have been conducted because the technique's primary objective has always been to preserve or enhance the fruit is appearance, preventing a decrease in texture, soluble solids, and ascorbic acid. Furthermore, a lot relies on the type of material used for the bags, and the comparison is made more difficult by the absence of uniformity.

Positive effects of pre-harvesting bagging in fruit crops Pesticide Residue Reduction

By lowering the need for chemical pesticides, the use of fruit bagging (*Fig. 02*) as a protective measure offers a clear route to more environmentally friendly horticultural practices. Farmers can greatly reduce the frequency of pesticide applications while still providing good crop protection since bagged fruits are protected from external pest threats (Sakuraba & Yanagisawa, 2018) [58]. To ensure food safety, safeguard consumer health, and adhere to international trade rules, this decrease in pesticide use

results in reduced levels of chemical residue on the fruit's surface.

Improving post-harvest life of bagged fruits

Fruit deterioration after harvest is largely caused by temperature changes, dryness, and mechanical damage, all of which can be mitigated by bagging. Bagging helps maintain fruits' physiological integrity by shielding them from various environmental stresses during the growing period, which delays ripening and prolongs their freshness after harvest. Post-harvest fruit loss is largely caused by latent diseases, pest infestations, and mechanical damage. Bagging reduces post-harvest deterioration and bruising by offering physical protection throughout crucial fruit development phases (Dutta & Majumder, 2012) [20]. According to studies comparing bagged and non-bagged fruits in the production of apples and grapes, bagged fruits have much lower rates of post-harvest losses than those grown in traditional open-field settings, both in terms of microbial spoiling and physical damage (Grasswitz & Fimbres, 2013) [25].

Benefits and Challenges of Pre-Harvest Fruit Bagging



Fig 2: Benefits and challenges of pre-harvest fruit bagging

Conclusion

Pre-harvest fruit bagging is a straightforward, safe and grower-friendly procedure that improves fruit quality and appearance in a number of ways. Additionally, it is the safest way to keep fruit secure from viruses, insect infestations and other problems. In several places of the world, this method is essential to fruit production. It is a time-consuming procedure that requires the creation of biodegradable bags that break down after usage. For producers to take advantage of this technology, we also need to standardise the requirements for the kind of bag to be used, the date of bagging and the date of bag removal. Pre-harvest bagging stands out as a scalable method for providing high-quality fruit with a lower environmental impact as agriculture moves toward greater sustainability. The mainstreaming of bagging technologies will depend on further advancements in automation, materials science and grower education. This will enable producers to satisfy changing consumer needs and support a more robust food system.

Authorship contribution statement

- **S.K.R.:** Writing-review & editing, Writing-original draft, Visualization, Conceptualization.
- **T.B.:** writing review and editing.
- **A.K.P.:** Writing review and editing.
- **K.P.G.:** Editing the draft.
- **R.S.M.:** Writing-review & editing, Writing-original draft, Visualization.
- **S.S.:** Writing- review & editing, Writing-original draft, Visualization.
- **S.G.:** Writing-review & editing, Writing-original draft.

- **L.B.:** Writing-review & editing, Writing-original draft, Visualization.
- **M.K.D.:** Writing-review & editing

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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References

1. Ali MM, Anwar R, Yousef AF, Li B, Luvisi A, De Bellis L. Influence of bagging on the development and quality of fruits. *Plants*. 2021;10(2):358-358.
2. Aluja M, Birke A, Ceymann M, Guillén L, Arrigoni E, Baumgartner D, *et al.* Influence of bagging on the behaviour and control of the Mexican fruit fly in mango. *Journal of Economic Entomology*. 2011;104(5):1557-1565.
3. Amarante C, Banks NH, Max S. Preharvest bagging improves packout and fruit quality of pears (*Pyrus communis*). *New Zealand Journal of Crop and Horticultural Science*. 2002;30(2):93-98.
4. Asrey R, Kumar K, Sharma RR, Meena NK. Fruit bagging and bag color affects quality and consumer acceptability of pomegranate arils. *Journal of Food Science and Technology*. 2020;57:1469-1476.
5. Awad MA. Increasing the rate of ripening of date palm fruit (*Phoenix dactylifera* L.) cv. Helali by preharvest and postharvest treatments. *Postharvest Biology and Technology*. 2007;43(1):121-127.
6. Bacelar E, Pinto T, Anjos R, Morais MC, Oliveira I, Vilela A, *et al.* Impacts of climate change on fruit growth and quality. *Plants*. 2024;13(14):1942-1942.
7. Bagle BG. Studies on anar butterfly in pomegranate. *Acta Horticulturae*. 2011;890:557-563.
8. Bentley W, Viveros M. Brown-bagging Granny Smith apples on trees stops codling moth damage. *California Agriculture*. 1992;46(4):30-32.
9. Bilck PA, Roberto SR, Maria VEG, Yamashita F. Biodegradable films as pre-harvest covering material for guava. *Scientia Horticulturae*. 2011;130:341-343.
10. Buganíc Jr RD, Lizada MCC, De-Ramos MB. Disease control in mango with pre-harvest bagging. *Acta Horticulturae*. 1997;455:797-804.
11. Campbell D, Sarkhosh A, Brecht JK, Gillett-Kaufman JL, Liburd O, Melgar J, *et al.* Bagging organic peaches reduces injuries and decay. *HortScience*. 2021;56:52-58.
12. Chaves I, Silva L, Almeida A. Influence of pre-harvest bagging on grape quality for wine production. *Food Chemistry*. 2021;345:128813-128813.
13. Chaves-Silva S, Dos Santos AL, Chalfun-Júnior A, Zhao J, Peres LE, Benedito VA. Understanding the genetic regulation of anthocyanin biosynthesis in plants—tools for breeding purple varieties of fruits and vegetables. *Phytochemistry*. 2018;153:11-27.
14. Chen CS, Zhang D, Wang YQ, Li PM, Ma FW. Effects of fruit bagging on the contents of phenolic compounds in the peel and flesh of ‘Golden Delicious’, ‘Red

- Delicious', and 'Royal Gala' apples. *Scientia Horticulturae*. 2012;142:68-73.
15. Cheng ZH, Zhao Y, Meng HW, Guan ZH. Effects of fruit bagging on cucumber quality. *Acta Ecologica Sinica*. 2007;27:732-739.
 16. Chonhenchob V, Kamhangwong D, Krueenate J, Khongrat K, Tangchantra N, Wichai U, *et al*. Preharvest bagging with wavelength-selective materials enhances development and quality of mango (*Mangifera indica* L.) cv. Nam Dok Mai# 4. *Journal of the Science of Food and Agriculture*. 2011;91(4):664-671.
 17. Debnath S, Mitra SK. Panicle bagging for maturity regulation, quality improvement and fruit borer management in litchi (*Litchi chinensis*). *Acta Horticulturae*. 2008;773:201-208.
 18. Ding P, Syakirah MN. Influence of fruit bagging on mango quality. *Acta Horticulturae*. 2010;877:169-174.
 19. Dutta P, Majumder D. Influence of bagging on fruit quality and mineral composition of Himsagar mango grown in new alluvial zones of West Bengal. *Advances in Horticultural Science*. 2012;26(3/4):158-162.
 20. Fan X, Mattheis JP. Bagging 'Fuji' apples affects colour and storage quality. *HortScience*. 1998;33:1235-1238.
 21. Faoro ID, Marcia M. Bagging of Nashi pear. *Revista Brasileira de Fruticultura*. 2004;26:86-88.
 22. Frank DL. Fruit bagging as pest management in apple. *Insects*. 2018;9(4):178-178.
 23. Fumuro M, Gamo H. Bagging effects on persimmon skin disorder. *Journal of the Japanese Society for Horticultural Science*. 2001;70:261-263.
 24. Grasswitz TR, Fimbres O. Efficacy of a physical method for control of direct pests of apples and peaches. *Journal of Applied Entomology*. 2013;137(10):790-800.
 25. Griñán I, Morales D, Galindo A, Torrecillas A, Pérez-López D, Moriana A. Effect of bagging on pomegranate quality. *Journal of the Science of Food and Agriculture*. 2019;99:1425-1433.
 26. Harhash MM, Al-Obeed RS. Effect of bagging colour on date palm yield and quality. *American-Eurasian Journal of Agricultural & Environmental Sciences*. 2010;7:312-319.
 27. Hiratsuka S, Yokoyama Y, Nishimura H, Miyazaki T, Nada K. Fruit photosynthesis affected by bagging in mandarin. *Journal of the American Society for Horticultural Science*. 2012;137:215-220.
 28. Hofman PJ, Smith LG, Joyce DC, Johnson GI, Meiburg GF. Bagging of mango fruit influences quality. *Postharvest Biology and Technology*. 1997;12(1):83-91.
 29. Huang CH, Chai ML, Pan ZM, Yu B, Jiang ZM, Hu JL, *et al*. Effects of bagging on fruit skin features and quality of Cuiguan pear cultivar. *Journal of Fruit Science*. 2007;24(6):742-746.
 30. Huang C, Yu B, Teng Y, Su J, Shu Q, Cheng Z, *et al*. Effects of fruit bagging on coloring and related physiology, and qualities of red Chinese sand pears during fruit maturation. *Scientia Horticulturae*. 2009;121(2):149-158.
 31. Hudima M, Štampar F. Bagging of pear influences fruit quality. *Acta Horticulturae*. 2011;909:625-630.
 32. Hussein AA, Abdel-Rahman AG, Ahmed RB. Effectiveness of fruit bagging on yield and fruit quality of pomegranate (*Punica granatum*, L.). *Annals of Agricultural Sciences*. 1994;32:949-957.
 33. Issarakraisila M. Effect of types of bagging materials on growth, quality and disease-insect damages in pummelo fruit in tropical humid conditions. *Acta Horticulturae*. 2018;1208:319-324.
 34. Jia D, Fan L, Liu G, Shen J, Liu C, Yuan Y. Effects of bagging on β -carotene in apple. *Journal of Agricultural Science*. 2011;3:196-202.
 35. Joshi KK, Singh VP, Saxena D, Dharmi V. Effect of fruit bagging on mango quality. *Progressive Research*. 2016;11(3):416-419.
 36. Joshi KK, Singh VP, Saxena D, Mishra DS. Effect of bagging on litchi fruit quality. *Annals of Horticulture*. 2016;9(1):41-44.
 37. Joyce DC, Beasley DR, Shorter AJ. Effect of pre-harvest bagging on mango ripening. *Australian Journal of Experimental Agriculture*. 1997;37:383-389.
 38. Ju Z. Fruit bagging and anthocyanin synthesis in apples. *Scientia Horticulturae*. 1998;77:155-164.
 39. Kassem HA, Omar AKH, Ahmed MA. Response of Zaghoul date palm productivity, ripening and quality to different polyethylene bagging treatments. *American-Eurasian Journal of Agricultural & Environmental Sciences*. 2011;11:616-621.
 40. Kim H, Lee S, Park J. Adoption of fruit bagging in Korean orchards. *Asian Journal of Horticulture*. 2019;14(2):89-97.
 41. Kim YH, Kim HH, Youn CK, Kweon SJ, Jung HJ, Lee CH. Effects of bagging material on fruit coloration and quality of Janghowon Hwangdo'peach. *Acta Horticulturae*. 2008;772(9):81-86.
 42. Kitagawa H, Manabe K, Esguerra EB. Bagging of fruit to control disease. *Acta Horticulturae*. 1992;321:871-875.
 43. Kolb CA, Käser MA, Kopecký J, Zotz G, Riederer M, Pfündel EE. Effects of UV radiation on grape leaves. *Plant Physiology*. 2001;127:863-875.
 44. Lima JD, Engelking EW, Rozane DE, Gomes EN, Gorla da Silva SHM, Kluge RA. Effect of bunch protection material and bagging time on the yield of Nánica'banana and chilling control. *Australian Journal of Crop Science*. 2020;14(4):574-580.
 45. Lin J, Chang Y, Yan Z, Li X. Effects of bagging on pear fruit quality. *Acta Horticulturae*. 2008;772:315-318.
 46. Ma B, Chen J, Zheng H, Fang T, Ogutu C, Li S, *et al*. Sugar and malic acid composition in apples. *Food Chemistry*. 2021;362:130131-130131.
 47. Martins MC, Lourenço SA, Gutierrez AS, Watanabe HS. Post-harvest damage in guava and bagging relation. *Revista Brasileira de Fruticultura*. 2007;29:245-248.
 48. Mathooko FM, Kahangi EM, Runkwab JM, Onyango CA, Owino WO. Mango fruit bagging improves quality. *Acta Horticulturae*. 2011;906:55-62.
 49. Matsumoto K, Fujita T, Sato S. Bagging and storability of apple. *Horticultural Journal*. 2018;87:443-451.
 50. Meena KR, Maji S, Kumar S, Parihar D, Meena D. Effect of bagging on guava quality. *International Journal of Bio-Resource and Stress Management*. 2016;7:330-333.

51. Mitra SK, Pathak PK. Litchi production in Asia-Pacific region. *Acta Horticulturae*. 2010;863:29-36.
52. Morandi B, Manfrini L, Losciale P, Zibordi M, Corelli-Grappadelli L. The positive effect of skin transpiration in peach fruit growth. *Journal of Plant Physiology*. 2010;167(13):1033-1037.
53. Morera-Montoya R, Blanco-Metzler H, Luis-Loria C. Evaluation of different bagging materials for the control of the fruit fly *Anastrepha* sp. (Diptera: Tephritidae) and fruit pathogens in Taiwanese guava fruits (*Psidium guajava* L.). In: II International Symposium on Guava and other Myrtaceae. 2008;849:283-292.
54. Ni Z, Zhang Z, Gao Z, Gu L, Huang L. Effects of bagging on sugar metabolism in loquat. *African Journal of Biotechnology*. 2010;10:4212-4216.
55. Rahman H, Akter A, Rahman J, Riad MI, Rahman MM. Fruit thinning and bagging in guava. *Journal of Agricultural Science and Technology*. 2017;6:2349-3682.
56. Rahman MM, Hossain MM, Rahim M, Rube MHK, Islam MZ. Bagging on post-harvest quality of guava. *Fundamental and Applied Agriculture*. 2018;3:363-371.
57. Rodrigues MGV, Souto RF, Meneguacci JL. Influence of polyethylene banana bunch cover for irrigated banana tree in the North of Minas Gerais state. *Revista Brasileira de Fruticultura*. 2001;23:559-562.
58. Sakuraba Y, Yanagisawa S. Light signalling-induced regulation of nutrient acquisition and utilisation in plants. *Seminars in Cell & Developmental Biology*. 2018;83:123-132.
59. Sarker D, Rahman MM, Barman JC. Efficacy of different bagging materials for the control of mango fruit fly. *Bangladesh Journal of Agricultural Research*. 2009;34(1):165-168.
60. Semple AJ, Frio AS. Bagging of banana bunches improves fruit quality. *Tropical Agriculture*. 1992;69:335-340.
61. Senghor A, Liang WJ, Ho WC. Integrated control of *Colletotrichum gloeosporioides* on mango fruit in Taiwan by the combination of *Bacillus subtilis* and fruit bagging. *Biocontrol Science and Technology*. 2007;17(8):865-870.
62. Sharma RR. Fruit Production: Problems and Solutions. Lucknow, India: International Book Distributing Company; 2009. 649 p.
63. Sharma RR, Pal RK, Asrey R, Sagar VR, Dhiman M. Pre-harvest fruit bagging influences fruit color and quality of apple cv. Delicious. *Agricultural Sciences*. 2013;4(09):443-448.
64. Signes AJ, Burló F, Martínez-Sánchez F, Carbonell-Barrachina AA. Effects of preharvest bagging on quality of black table grapes. *World Journal of Agricultural Sciences*. 2007;3(1):32-38.
65. Singh SK, Reddy YTN, Dey P, Chattopadhyay TK. Fruit bagging improves guava quality. *Indian Journal of Horticulture*. 2012;69:547-552.
66. Teixeira R, Boff MIC, Amarante CVT, Steffens CA, Boff P. Effects of fruit bagging on pests and diseases control and on quality and maturity of Fuji Suprema Apple. *Bragantia*. 2011;70:688-695.
67. Usenik V, Kastelec D, Veberic R, Štampar F. Quality changes during plum ripening. *Food Chemistry*. 2010;111:830-836.
68. Vignati E, Lipska M, Dunwell JM, Caccamo M, Simkin AJ. Fruit development in sweet cherry. *Plants*. 2022;11(12):1531-1531.
69. Wang Y, Yang C, Liu C, Xu M, Li S, Yang L, *et al*. Effects of bagging on volatiles and polyphenols in “Wanmi” peaches during endocarp hardening and final fruit rapid growth stages. *Journal of Food Science*. 2010;75(9):S455-S460.
70. Watanawan A, Watanawan C, Jarunate J. Bagging effects on mango fruit quality. *Acta Horticulturae*. 2008;787:325-328.
71. Wu BH, Cao SY, Ma BH, Zhang GY. Effects of fruit bagging on pesticide residue and fruit quality in grapes. *Journal of Fruit Science*. 2012;29(3):409-414.
72. Xu CX, Chen HB, Huang RY, He YJ. Effects of bagging on fruit growth and quality of carambola. *Acta Horticulturae*. 2008;773:195-200.
73. Xu HX, Chen JW, Xie M. Effect of different light transmittance paper bags on fruit quality and antioxidant capacity in loquat. *Journal of the Science of Food and Agriculture*. 2010;90(11):1783-1788.
74. Yang WH, Zhu XC, Bu JH, Hu GB, Wang HC, Huang XM. Effects of bagging on fruit development and quality in cross-winter off-season longan. *Scientia Horticulturae*. 2009;120(2):194-200.
75. Zhang R, Li H, Wu T, Chen J. Evolution of fruit cultivation in East Asia. *Horticultural Science Journal*. 2018;55(2):112-125.
76. Zhou JH, Zhong GF, Lin ZZ, Xu HL. The effects of bagging on fresh fruit quality of *Canarium album*. *Journal of Food, Agriculture and Environment*. 2012;10:505-508.
77. Zhou XB, Guo XW. Bagging effects on grape sugar metabolism. *Journal of Fruit Science*. 2005;26:30-33.