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Banana Bagging: A Sustainable Solution for Reducing Food Waste and Enhancing Freshness

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Abstract
Banana bagging is a revolutionary method of extending the freshness of bananas and reducing food waste that is gaining favor in the food business and among consumers. This article delves into the notion of banana bagging, its advantages, and the science behind its efficacy. We look at the environmental impact of banana bagging against traditional packing methods and how this practice fits in with sustainable and eco-friendly activities. In addition, we investigate DIY banana bagging methods as well as upcoming technology in the industry. Join us on a journey to learn how banana bagging is affecting both food preservation and environmental protection.

Introduction
Food waste is a worldwide issue that not only wastes precious resources but also contributes to environmental problems. Innovative solutions to this problem are emerging in the hunt for sustainable practices. Banana bagging is one such option that is gaining traction. This technique not only eliminates food waste but also improves the freshness and shelf life of bananas.

The Banana Waste Problem
Bananas are one of the world's most popular and commonly consumed fruits. However, due to their susceptibility to bruising, ripening, and exposure to external stimuli, they have a relatively short shelf life. Bananas frequently go to waste in grocery shops and homes before being consumed, resulting in severe economic and environmental effects. Banana bagging, as a sustainable approach, addresses this issue by forming a protective covering around the fruit, preserving its freshness and reducing waste.

The Banana Bagging Technique
Banana bagging includes enclosing individual bananas in specially designed, biodegradable bags that protect them from physical damage, temperature changes, and exposure to ethylene gas - a natural ripening agent produced by the fruit itself. These bags are typically composed of environmentally friendly materials such as starch-based polymers or paper, resulting in a low environmental effect.

Benefits of Banana Bagging
1. Banana bagging considerably enhances banana shelf life by establishing a barrier that decreases exposure to air and external factors. This gives consumers more time to savor the fruit before it ripens.

2. **Reduced Food Waste:** Banana bagging helps reduce the amount of bananas abandoned due to premature aging by reducing bruising, ripening, and spoiling. This not only saves consumers money, but it also reduces the environmental impact of food waste.
3. **Sustainable Packaging:** Banana bags are frequently made from sustainable and biodegradable materials, reflecting the growing demand for environmentally friendly packaging solutions. This addresses environmental concerns about single-use plastics while also contributing to a more circular economy.
4. **Improved Transportation and Storage:** Banana bags are ideal for transportation and storage due to their protective nature. Banana bagging has the potential to improve supply chain efficiency by reducing the likelihood of damage during transit.
5. **Consumer Convenience:** Banana bags are designed to be simple to use, allowing consumers to transport individual bananas without fear of them becoming squished or damaged. This convenience encourages consumers to make more sustainable choices while decreasing the likelihood of impulse purchases and subsequent waste.

Considerations and Challenges

While there are numerous benefits to banana bagging, it is critical to consider potential challenges and areas for improvement. For example, widespread adoption may necessitate changes in manufacturing processes, and consumer education is critical to ensure proper disposal of the bags in order to maintain their eco-friendliness.

Bagging/sleeving

Recently different methods are being practiced for crop improvement to avert the losses caused by biotic and abiotic factors throughout the world. The tool for the development of techniques to improve the yield, appearance, quality of fruit and to reduce disease and insect infestations is becoming increasingly important. This is to raise awareness towards reducing the use of pesticides to ensure worker safety, consumer health, and environmental protection. The bags are more importantly used for the export markets and processing units by improving production and quality of fruit.

Advantages of Bagging in banana

Bagging may offer direct and almost full protection from mechanical damages (scratches, fruit dropping), birds, physiological disorders caused by the climate (sun scald, cracking, splitting), pests and diseases which are the major cause of heavy losses. which improves their visual quality and also reduces the occurrence of fruit cracking and changes the microenvironment for fruit development. Bagging affects the size and the weight of banana. The increase in temperature inside bagging results in improving fruit size or a result of humidity increase.

Procedure of bagging

1. Pre-Bagging Preparation: Before putting the bags on the bananas, it's important to do a few things:

- Trim the male flower clusters.
- Remove some fruits to space them out and improve their shape.
- Clear away any small or misshapen fruits from the tips.

2. Bagging Selection: Choose specific types of bags for this process:

- Use a kraft paper bag or a two-layer bag with expanded polyethylene foam inside and a film covering outside. These bags come in different sizes, depending on the banana bunch's size.

3. Bagging Process: Here's how to put the bags on the bananas:

- Put the expanded polyethylene foam bag inside the film bag.
- Open the bag and carefully slide it over the banana bunch, starting from the bottom and moving upwards.
- Secure the top of the bag tightly with a rope to keep rainwater.

Methods of bagging

1. Polyethylene Bags: These are transparent plastic bags that are commonly used for bagging bananas. They protect the fruit from insects, birds, and environmental damage while allowing sunlight to reach the fruit for proper ripening. The bags are placed over individual banana hands or clusters and tied securely around the stem.

2. Wax-Coated Paper Bags: These bags are also used to cover banana bunches. The wax coating provides some protection from pests and environmental factors while allowing the fruit to breathe. They're tied around the bunch similar to polyethylene bags.

3. Mesh or Net Bags: These bags are made of a mesh or net-like material that allows air circulation while providing some protection from pests. They are placed around banana hands or clusters and tied securely.

4. Organic Fabric Bags: Some farmers use biodegradable or organic fabric bags made of materials like jute or cotton. These bags provide protection similar to plastic bags but are more environmentally friendly.

5. Double Bagging: In areas with high pest infestation, some farmers use a double-bagging method. They first cover the banana bunch with a paper or fabric bag and then use a polyethylene bag outside for additional protection.

Types of Bagging based on physical structure

(i) Nets: Nets can be placed directly on the plants or over individual tree branches. Using a sturdy frame secure nets at ground levels with the use of stakes or pegs to prevent fruit fly from getting inside the net. Also, prune trees to a smaller size so that nets can more easily be placed or planting dwarfed varieties of fruit trees. Sometimes, it is also possible to use insecticide-treated nets on plants for protecting crop as well to kill fruit flies. Covering of individual fruits (for peaches and other larger fruits), fruiting clusters or entire fruiting plants (for berries) netting, nylon stocking or paint strainer bag are promising options.

Nets placed on individual bunches

Nets placed over plants

(ii) Bags and Sleeves: Try to place bags and sleeves over the fruit desired to keep inside and secure bags and sleeves to the plant with tie wire, clothes, pegs or string. Covering the fruit with paper during bagging is an important technique. It affects many of properties that enhance the quality of the paper bag. It is found best because it creates a microclimate in which temperature rise but not so simultaneously it ensures the temperature raising slowly which affect the fruit in a beneficial way by improving the aroma and total sugar this can be justified in grapes and mango respectively.

	
Bags or sleeves placed over fruit	**Covering fruits with paper during bagging**

Banana fruit protection bags also are known as banana ripening bags, banana bunch covers and banana sleeves are used during the commercial banana growing areas of the world to get rid of blemishes and freeness from pests some of the farmers were using pesticides over bunches. Commercial producers use expensive plastic banana bunch bags that often are soaked with insecticides to protect banana bunches.

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Bunch covers provide protection against pathogens, wind damage, leaf, petiole scarring, dust, light hail, sunburn, bird feeding, and handling damage during harvest and transport. Bunch covers can also be used in temperate country to protect bunches from low temperatures. Export quality like appealing skin colour, reduced sunburn, reduced fruit splitting, and increased finger length and bunch weight among others. The net effect of bunch cover use is better fruit quality and increased marketable yield. Market returns for bananas in international markets are economic for large fruit that are blemish-free.

Types of Bagging (Based On Time)

In banana cultivation, bagging methods can be categorized based on the timing of when the bags are applied or removed. Here are the types of bagging based on time:

1.Preventive Bagging: Bags are placed on banana clusters or hands early in the fruit development stage or we can say hands are not visible yet, usually right after flowering or when the fruits are small. This method is aimed at preventing damage from pests, insects like thrips, birds, and environmental factors right from the beginning of fruit growth.

2. Regular bagging -The cover is placed at the last horizontal hand stage, at which time the bracts are about to fall. Which is divided into further baggings.

I. **Seasonal Bagging:** Bags are used during specific seasons or periods when the risk of pest infestation or environmental damage is higher. For instance, during the fruiting season or in regions where certain pests are more active, farmers might opt for bagging to protect the bananas during these vulnerable periods.

II. **Continuous Bagging:** This method involves continuously keeping the bananas covered with bags throughout the growth cycle until harvesting. Bags are replaced or adjusted as the fruit grows to accommodate its size while ensuring constant protection.

III. **Selective Bagging:** Farmers monitor the banana crop and selectively bag certain clusters or hands that show signs of pest infestation, damage, or vulnerability. This method involves a more targeted approach, focusing on specific fruits rather than covering the entire bunch.

IV. **Post-Harvest Bagging:** After harvesting, some farmers might still bag the bananas for transportation and market purposes. This protects the fruits from physical damage during handling, transportation, and storage.

The timing of bagging can vary based on factors like the variety of banana, local climate, pest prevalence, and the farmer's preferences or specific challenges faced in cultivation. Each timing has its advantages in protecting the bananas and maintaining their quality until harvest.

Advantages of banana bunch covers

1. Microclimate: The sleeves create a microclimate that maintains a high temperature and prevents winter damage. The study suggests that the temperature over a 24-hour period increases on average by 0.5°C inside the cover and can increase by 7°C in the warmest hours. This microclimate reduces the days from flowering to harvesting to 14 days depending on the type of cover and the environmental conditions and increase bunch weight. During winter bunch cover temperatures were 1-2°C above ambient. The bunch cover humidity remaining above 95%, carbon dioxide concentrations were 8% inside covers when bunches were harvested. To prevent building up of high relative humidity inside the banana bags can however be reduced with the use of perforated bags, ultimately preventing multiplication of fungi and rotting at the higher temperature.

2. Temperature: For centuries, old banana leaves have been enfolded around maturing bunches. Bunch covers also reduce the rise of temperature across the bunch, and fruit from covered bunches is more uniform than that from uncovered bunches. The use of non-perforated blue or white polyethylene bags with a thickness of 30-35 micron have increased temperatures inside the bag and shorten the development cycle of winter bunches. In summer, the white perforated bags have been used and are ideal for a hot humid climate. The lower temperature inside the bunch reflection of direct solar radiation, which results in, has resulted in better green life. Transparent and perforated polythylene sheets with 2% (during the cool season) and 4% (during summer season) aeration may be used to cover bunches. It helps the bunch in early maturity by increasing the temperature inside the developing bunch. Sunburn can be avoided if a protective covering such as paper is placed between the fruit and the cover, or covers with a reflective coating on one side are used. To reduce sunburn for overseas export production perforated covers are commonly used.

3. Pest and diseases: Most banana bunch pests cause superficial peel damage which does not affect the quality of the fruit but degrade the market value. Banana thrips (Chaetanaphothrips orchidii) can be controlled with bunch covers in 2-3 weeks after the formation of fruits Also, bunches were protected against the pests and diseases such as thrips, beetles, pitting, anthracnose, tip end rot, cigar end rot, brown spot and diamond spot Bunches enclosed in these bags have been found free of attack by the banana rust thrips up to 85%. The bags retain their potency for at least a year in storage. Early bunch covering protects the fruit from scarring caused by nectar-feeding birds and bats during the flowering phase. Applying considerable gauge bunch covers (150 mm) before any bracts lift on the bunch can overcome this problem. In addition, insect pressure can be reduced by covering the developing banana bunches with chlorpyrifos 20 EC impregnated bunch cover.

4. Recycling: All type of bunch covers can be recycled and hence proved not harmful to the environment.

Disadvantages of bunch covers

There are some undesirable effects of bunch cover application. The use of non-perforated bunch covers in hot, humid climates may damage the bunch physiologically due to overheating, rotting, and premature ripening. In addition, insect pests may proliferate inside non-insecticide treated bunch covers. Another negative consequence of ineffective bunch covers is the economic loss due to the extra cost of the material and the labour needed for the application. In sub-tropical countries, the negative consequences are avoided by using perforated bunch covers for aeration and cooling, and insecticide-impregnated covers for pest control. If water gets trapped while using plastic bag may damage the fruits or promote the growth of fungi or bacteria. Opening the bags at the bottom

or having some perforations will allow water to drain out. The method can only be used on fruits that don't need sunlight for their development. This method requires more labour is one of the disadvantage.

Advantages of Bagging in banana

- Protect the fruits from direct sunshine and birds harm.
- Bag material can withstand impact by wind and rain
- Bag materials are Ecofriendly and biodegradable after several usage compared to plastics
- Effectively reduce the growing time and increase the bunch weight.
- Reduce application of pesticides

Characteristics of Bagging Material

- The cover is generally made of **0.08 mm** thick polyethylene. A banana sleeves thickness in micron plays an important role in influencing temperatures inside the bag within the bunch.
- That is perforated every **76 mm** and hole is **12.7 mm** in diameter.
- The cover is **90 cm** in diameter and **155 cm** long.
- **Biodegradable** covers were also developed and tested in various countries.
- Price of **122 cm × 72 cm** covering bags: **690 Rs.** (IFFCOBAZAR)

Types of bagging material according to their colour

A. Transparent bags: Transparent covers treated to block ultraviolet and infrared rays. These transparent bunch bags have specific UV and IR permeability properties were found to allow better light and temperature conditions for banana growth. Transparent polyethylene can be used only under high density planting systems if sunscald is not a problem while blue bags have been very effective in protecting bunches from sunscald.

B. Blue polyethylene bags: Banana production regions mostly use blue covers as they let in the heat without causing sunscald, because it blocks UV rays. Blue Polyethylene bags used to improve banana's quality, appearance and protect from birds and pests. These bags allow faster & uniform harvest with adequate ripening of the banana.

C. Half blue and half-silver plastic bags: These bags are half-blue plastic and half silver to reflect heat and are used with the silver colour facing the sun and the blue side closest to the "trunk". During cool months face the blue coloured sleeves face towards north to increase heat and during warmer months face the silver side north to reduce heat inside helping to maintain a constant temperature. These bags also protect the fruit from bird, wind and sun damage, improve their quality and increase the yield.

Perforations

The presence of holes is important to prevent the multiplication of fungi. In the absence of perforations, the relative humidity inside the cover is too high. The size of the holes varies 12.7 mm every 76 mm, 6 mm every 10 cm, 3 mm or micro-perforations. Sizes of the holes should also vary with climatic conditions within production areas. Indeed bagging has been shown to reduce winter stress under optimal condition, which resulted in early fruit maturation. This is due to enhanced physiological and metabolic activities provided by the microclimate created by bagging.

Conclusion

Banana bagging emerges as a promising and long-term solution to the persistent problem of banana waste. This simple yet effective technique contributes to a more sustainable and environmentally friendly food system by extending the shelf life of bananas and reducing food waste. Banana bagging represents a step forward in promoting responsible consumption and reducing the environmental impact of food waste as consumers become more conscious of their ecological footprint.