

AGRICULTURE FORUM FOR TECHNICAL EDUCATION OF FARMING SOCIETY

Kota, Rajasthan



A Brief Insight on Packaging Technology of Fresh Horticultural Crops

Authors

**Dr. Mahesha K. N.¹, Dr. Apoorva Guddaraddi²,
Dr. Kalyani Deshmukh³, R. D. Baghele⁴, Dr. V. S. Khandare⁵,
Dr. V. N. Shinde⁶ and Dr. A. M. Bhosale⁷**

¹Assistant Professor (Adhoc.) Department, College of Agriculture, VNMKV, Parbhani, Maharashtra

²Assistant Professor (Adhoc.) Department, College of Agriculture, VNMKV, Parbhani, Maharashtra

³Assistant Professor (Adhoc.) Department, College of Agriculture, VNMKV, Parbhani, Maharashtra

⁴Jr. Breeder (AICRP) on Vegetable crops, HRS (Vegetable), VNMKV, Parbhani, Maharashtra

⁵Head of the Department (Horticulture), College of Agriculture, VNMKV, Parbhani, Maharashtra

⁶Associate Professor, Department of Horticulture, College of Agriculture, VNMKV, Parbhani, Maharashtra

⁷Assistant Professor, Department of Horticulture, College of Agriculture, VNMKV, Parbhani, Maharashtra

INTRODUCTION

Fresh horticultural crops, including fruits, vegetables, flowers, and ornamental plants, are living tissues that continue metabolic activities after harvest. These commodities are highly susceptible to deterioration due to respiration, transpiration, ethylene production, and microbial invasion. Without proper post-harvest handling, significant quantitative and qualitative losses occur, adversely affecting farmers' income and food security. Packaging serves as a vital link between harvest and consumption by protecting produce from mechanical damage, environmental stress, and contamination. In India, where horticulture plays a significant role in agricultural GDP, the adoption of scientific packaging techniques is essential to reduce post-harvest losses and enhance export potential.



1

FUNCTIONS AND IMPORTANCE OF PACKAGING

Packaging of fresh horticultural produce is not merely a containment system but a multifunctional tool that ensures preservation and distribution efficiency. It protects produce from mechanical injuries such as bruising, compression, and vibration during handling and transportation. Proper packaging also minimizes moisture loss, thereby maintaining freshness, weight, and visual appeal.

Another critical function of packaging is to act as a barrier against dust, pathogens, and environmental contaminants. It facilitates ease of handling, stacking, and transportation, which is particularly important in long-distance trade and export markets. Moreover, packaging enhances product presentation and consumer acceptance by improving aesthetic appeal and enabling labelling and branding. Importantly, packaging contributes to shelf life extension by regulating the internal atmosphere and maintaining optimal temperature and humidity conditions, especially when integrated with cold chain systems.

PACKAGING MATERIALS FOR FRESH HORTICULTURAL CROPS

Packaging materials used for fresh produce can be broadly categorized into traditional and modern materials, each with distinct advantages and limitations. Traditional materials such as bamboo baskets, wooden crates, and jute (gunny) bags are widely used in rural and semi-urban areas due to their low cost and availability. However, these materials offer limited protection, poor hygiene, and

2

inadequate ventilation control, leading to higher post-harvest losses.

Modern packaging materials include corrugated fiber-board boxes, plastic crates, and polymeric films such as polyethylene and polypropylene. Corrugated boxes are lightweight, recyclable, and customizable, making them highly suitable for export-oriented packaging. Plastic crates are durable, reusable, and provide better ventilation, thereby reducing mechanical damage. Recent advancements have led to the development of biodegradable and eco-friendly packaging materials derived from starch, cellulose, and chitosan. These materials address environmental concerns associated with plastic waste while maintaining functional efficiency.

PRINCIPLES OF PACKAGING OF FRESH PRODUCE

The design and selection of packaging systems for horticultural crops are governed by the physiological behaviour of the produce. Since fresh produce continues to respire after harvest, packaging must allow for adequate gas exchange to prevent anaerobic respiration and off-flavour development.

Temperature and relative humidity are critical factors influencing the effectiveness of packaging. High humidity helps reduce moisture loss but may increase the risk of microbial growth if not properly managed. Therefore, packaging materials must strike a balance between moisture retention and ventilation. Ethylene sensitivity of produce is another important consideration. Climacteric fruits such as bananas, mangoes, and tomatoes produce

ethylene, which accelerates ripening. Packaging systems should either allow ethylene escape or incorporate ethylene absorbers to delay senescence. Mechanical strength and stacking ability are also essential to ensure that packaging can withstand transportation stresses without damaging the produce.

ADVANCED PACKAGING TECHNOLOGIES

- **Modified Atmosphere Packaging (MAP)**

Modified Atmosphere Packaging is one of the most significant innovations in fresh produce packaging. It involves altering the internal gaseous composition within the package, typically by reducing oxygen levels and increasing carbon dioxide concentration. This modification slows down respiration and delays ripening, thereby extending shelf life. MAP can be achieved through passive means, where the produce itself modifies the atmosphere through respiration, or through active methods involving gas flushing. This technology is widely used for fresh-cut vegetables, leafy greens, and high-value fruits.

- **Controlled Atmosphere Packaging (CAP)**

Controlled Atmosphere Packaging maintains a constant and precisely regulated gas composition throughout storage and transportation. Unlike MAP, which allows dynamic equilibrium, CAP requires continuous monitoring and control systems. It is commonly used in large-scale storage facilities and export chains for commodities such as apples and pears.

- **Active Packaging**

Active packaging systems interact with the internal environment of the package to enhance preservation. These systems may include oxygen scavengers, ethylene absorbers, antimicrobial agents, and moisture regulators. By actively controlling internal conditions, active packaging significantly improves the shelf life and safety of fresh produce.

- **Intelligent and Smart Packaging**

Smart packaging technologies incorporate sensors and indicators that monitor the condition of the produce in real time. These systems can detect changes in temperature, gas composition, and freshness, providing valuable information throughout the supply chain. Integration with digital technologies such as IoT enhances traceability and reduces post-harvest losses.

- **Edible Coatings and Films**

Edible coatings made from natural substances such as wax, chitosan, and alginate form a thin protective layer on the surface of fruits and vegetables. These coatings reduce moisture loss, delay ripening, and enhance shelf life without generating packaging waste. They are increasingly being used as sustainable alternatives to synthetic packaging materials.

ROLE OF PACKAGING IN SHELF LIFE EXTENSION

Packaging significantly influences the shelf life of fresh horticultural crops by regulating physiological and biochemical processes. By reducing oxygen availability, packaging slows respiration and

metabolic activity. High humidity within the package minimizes transpiration, preventing wilting and weight loss. Packaging also plays a role in delaying ripening by controlling ethylene concentration and reducing enzymatic degradation. Furthermore, it limits microbial contamination, thereby enhancing food safety and reducing spoilage. The integration of packaging with cold storage systems further enhances its effectiveness by maintaining optimal temperature conditions throughout the supply chain.

PACKAGING DESIGN CONSIDERATIONS

Effective packaging design requires a thorough understanding of commodity-specific requirements. Different crops have varying respiration rates, sensitivity to temperature, and susceptibility to mechanical damage, necessitating tailored packaging solutions. Ventilation is crucial for high-respiring produce, while moisture retention is important for leafy vegetables. Packaging must also be strong enough to withstand stacking and transportation pressures. Cost-effectiveness is a major consideration, particularly for smallholder farmers in developing countries. Additionally, packaging should comply with food safety standards and environmental regulations, ensuring sustainability and consumer safety.

CHALLENGES IN PACKAGING OF FRESH HORTICULTURAL CROPS

Despite advancements, several challenges hinder the adoption of improved packaging technologies.

High initial costs of advanced packaging materials and systems limit their accessibility for small and marginal farmers. Environmental concerns related to plastic waste have also raised questions about sustainability.

Inadequate infrastructure, lack of awareness, and limited technical knowledge further constrain the adoption of scientific packaging practices in developing regions. Additionally, improper packaging design may lead to issues such as condensation, microbial growth, and off-flavour development.

EMERGING TRENDS AND INNOVATION

Recent advancements in packaging technology focus on sustainability and smart solutions. Biodegradable and compostable packaging materials are gaining popularity as environmentally friendly alternatives to conventional plastics. Nanotechnology-based packaging offers improved barrier properties and antimicrobial activity. Smart packaging systems equipped with sensors and freshness indicators are transforming supply chain management by enabling real-time monitoring. Edible coatings are also emerging as innovative solutions to reduce packaging waste while maintaining product quality. These innovations are expected to play a crucial role in addressing future challenges in horticultural supply chains.

CONCLUSION

Packaging technology is an indispensable component of post-harvest management in fresh

horticultural crops. It not only protects produce from physical damage but also regulates physiological processes, thereby extending shelf life and maintaining quality. Advanced technologies such as modified atmosphere packaging, active packaging, and smart packaging have significantly improved the efficiency of horticultural supply chains. However, the widespread adoption of these technologies requires addressing challenges related to cost, environmental sustainability, and infrastructure development. Future research should focus on developing affordable, eco-friendly, and efficient packaging solutions tailored to the needs of developing countries like India.