

# Unlocking the Market Potential of Assam Lemon with Innovative Postharvest Treatments

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Assam lemon fruits (*Citrus limon* Burm. f.) is one of the most important citrus fruits cultivated extensively in the Northeastern region of India, particularly in Assam, Meghalaya, Tripura, Nagaland, Arunachal Pradesh and adjoining states. It belongs to the family Rutaceae and is highly valued for its characteristic aroma, superior flavour, acidity, juice content, medicinal properties and year-round market demand. The fruit is characterized by high juice content (40-50%), attractive yellow peel at maturity, distinctive aroma, high citric acid content, rich vitamin C concentration and excellent processing suitability. Assam lemon occupies a significant place in the livelihood of small and marginal farmers because of its adaptability to humid tropical conditions and its economic profitability. Economically, Assam lemon contributes substantially to rural income generation and local market trade in Northeast India, however, postharvest losses ranging from 20-35% are common because of inadequate storage and transportation infrastructure.

## Importance of postharvest treatment in Assam lemon

Postharvest treatments aim to reduce physiological loss, maintain freshness, minimize decay, extend shelf life, enhance marketability and improve economic returns of the harvested fruits. However, freshly harvested lemon fruits remain biologically active and continue physiological processes after harvest. Even a small percentage of moisture loss can negatively influence consumer acceptance, Assam lemon fruits suffers considerable postharvest losses due to its highly perishable nature and under tropical ambient conditions, and these problems become more severe due to high temperature and humidity. Postharvest deterioration in Assam lemon results mainly from physiological, biochemical and microbial changes occurring after harvest viz. physiological loss in weight (PLW), respiration and senescence, rind shrinkage and wrinkling, decay and fungal infection, loss of juice quality and chilling injury. Increasing demand for Assam lemon fruits provides opportunities for domestic

premium markets, organic produce markets, export-oriented trade and processed products. However, realizing these opportunities requires significant reduction of postharvest losses and maintenance of fruit quality during transport and storage, modern postharvest approaches increasingly emphasize environmentally safe and consumer friendly technologies that minimize chemical residues. Innovative postharvest technologies including edible coatings, GRAS (Generally Recognized As Safe) dips, plant-derived biopolymers, modified atmosphere packaging and integrated storage strategies offer promising opportunities for enhancing fruit quality, extending shelf life, and improving marketability.

## Use of edible coating

Edible coatings have emerged as one of the most effective technologies for extending citrus shelf life. These coatings form a thin semi-permeable layer on the fruit surface that regulates moisture transfer, oxygen diffusion and carbon dioxide exchange while improving microbial resistance. Consequently, respiration and transpiration rates are reduced. Commonly used coatings in citrus fruits are chitosan coating (studies have reported significant reductions in decay incidence in citrus fruits treated with chitosan coating), aloe vera gel coating (a natural bio-preservative, the gel forms a protective coating that preserves fruit freshness and appearance), guar gum coating (an economical plant-derived polysaccharide, maintenance of peel integrity and delayed softening) and carboxy methyl cellulose (CMC) wherein combination treatments involving CMC and natural antimicrobials show promising results.

## GRAS dips

Generally recommended as safe (GRAS) compounds are food-grade substances recognized as safe for human consumption. These compounds are increasingly used as alternatives to synthetic fungicides which are calcium chloride (Calcium treatments strengthen cell walls by forming calcium pectate complexes), potassium sorbate (acts as an antimicrobial agent), sodium bicarbonate (widely recognized for its antifungal properties), salicylic acid (functions as a signalling

molecule involved in plant defence), natural plant extracts and essential oils (plant derived compounds are increasingly explored for residue free preservation), neem extract (provides anti-microbial activity), lemongrass oil (effective against several fungal pathogens) and cinnamon oil (contains bioactive compounds capable of suppressing fungal growth and extending storage life).

### Modified atmosphere packaging (MAP)

Modified atmosphere packaging alters the gaseous composition around fruits, typically oxygen concentration decreases and carbon dioxide concentration increases. The benefits includes reduced respiration rate thereby delayed senescence, reduced moisture loss and better retention of quality. For Assam lemon, MAP can significantly improve transportability to distant markets.

### Cold storage and integrated management

Temperature management remains one of the most effective approaches for extending citrus shelf life. Benefits of cold storage include reduced metabolic activity, delayed ripening, lower microbial growth and better retention of nutritional quality. However, cold storage alone may not be sufficient. Integrated approaches combining edible coatings, GRAS dips, proper packaging and cold storage, often provide superior results compared with individual treatments.

Commercial importance of eco-friendly postharvest technologies

The adoption of edible coatings and GRAS substances offers several commercial advantages reduced postharvest losses. These technologies are particularly suitable for organic and residue-free citrus production systems. Further research and extension activities are needed for commercial adoption. Future prospects include nano-edible coating, bioactive packaging, smart storage systems, cold chain integration and sustainable citrus supply chains.

### Shrink film wrapping

Shrink film wrapping involves enclosing individual fruits or fruit trays in a thermoplastic polymer film followed by the application of controlled heat. The film shrinks tightly around the fruit surface, forming a protective barrier. The wrapped fruit develops a semi-modified atmosphere characterized by lower oxygen concentration, elevated carbon dioxide concentration and higher relative humidity. These conditions slow physiological and biochemical processes responsible for fruit deterioration. Types of shrink films used are polyolefin (POF), polyvinyl chloride (PVC), polyethylene (PE) and biodegradable shrink films viz. polylactic acid (PLA), starch based polymers and cellulose derivatives.

### Opportunities for value addition

Postharvest interventions can facilitate development of value-added products such as ready-to-serve lemon juice, lemon concentrate, citrus beverages, pickle, candied peel, essential oil and nutraceutical formulations.

### Impact on marketability

Improved postharvest management directly enhances marketability through extended shelf life, reduced losses, better fruit appearance, improved consumer satisfaction and increased farmer income.

### Conclusion

Assam lemon possesses enormous potential for domestic and international markets owing to its superior quality, nutritional richness and diverse utilization opportunities. Innovative postharvest technologies including edible coatings, GRAS dips, natural plant extracts, modified atmosphere packaging and integrated storage systems provide sustainable solutions for extending shelf life and preserving quality. Strengthening postharvest infrastructure and promoting scientific handling practices will be critical for unlocking the full market potential of Assam lemon and ensuring sustainable growth of the citrus sector in Northeast India.

### References

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