

# Enhancing Dragon Fruit Marketability Using Edible Coatings, Sprays and Generally Recognized as Safe (GRAS) Dips

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Dragon fruit, also known as pitaya or pitahaya, is an exotic tropical fruit belonging to the genera *Hylocereus* and *Selenicereus* under the family Cactaceae. The crop is native to Central and South America but is now cultivated commercially in many tropical and subtropical regions of the world. India have emerged as important producers of dragon fruit because of its increasing consumer demand and export potential. In India, dragon fruit cultivation has gained momentum during the last decade due to its adaptability to arid and semi-arid climates, low water requirement, high economic returns and increasing health awareness among consumers. Commercial cultivation is expanding rapidly in Gujarat, Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, West Bengal, Odisha and Northeastern states. Dragon fruit is increasingly recognized as a high-value horticultural crop capable of improving farmer income and promoting diversification in fruit production systems. The fruit is characterized by its bright red or yellow peel with green scales and attractive white or red pulp containing numerous edible black seeds. Besides its visual appeal, dragon fruit possesses high nutritional and nutraceutical value, rich in vitamin C, betalains, carotenoids, polyphenols, flavonoids, minerals, dietary fiber and antioxidants.

## Importance

Despite its high commercial value, dragon fruit is highly perishable after harvest as the fruit undergoes rapid physiological and biochemical deterioration during storage and transportation. Moisture loss, shrivelling, softening, microbial decay, peel browning and chilling injury are major postharvest problems affecting quality and shelf life. Such deterioration leads to significant economic losses during marketing and export. Conventional postharvest preservation techniques often involve synthetic fungicides and chemical preservatives. However, increasing consumer concern regarding food safety, environmental sustainability and chemical residues has stimulated the development of eco-friendly postharvest technologies. Among these, edible

coatings, natural sprays and generally recognized as safe (GRAS) dips have emerged as promising approaches for enhancing storage life while maintaining fruit quality and safety. Dragon fruit has wide commercial applications because of its attractive appearance, refreshing taste and health benefits, primarily consumed fresh because of its pleasant flavour and appealing texture however fruit is also processed into varied products viz. juice, jam, jelly, wine, ice cream, yogurt, candy, dried fruit and nutraceutical products.

## Postharvest physiology of Dragon fruit

Dragon fruit is a non-climacteric fruit, meaning it does not continue significant ripening after harvest. Therefore, harvesting at proper maturity is critical for optimum quality. After harvest, the fruit undergoes various physiological and biochemical changes viz. respiration, transpiration, enzymatic softening, pigment degradation, oxidative reactions and membrane deterioration. The rate of these processes are influenced by the storage temperature, humidity, packaging and postharvest treatments.

## Major postharvest problems in Dragon fruit

### 1. Physiological loss in weight (PLW)

Rapid transpiration causes moisture loss and shrinkage. Excessive water loss reduces freshness and marketability.

### 2. Fruit softening

Enzymes such as polygalacturonase, cellulase and pectin methylesterase degrade cell wall components, leading to softening.

### 3. Peel browning

Oxidative enzymes, such as polyphenol oxidase, cause browning and discoloration of the peel.

### 4. Microbial decay

Fungal pathogens such as *Colletotrichum*, *Alternaria*, *Fusarium* and *Aspergillus* can infect fruits during storage.

### 5. Chilling injury

Storage below optimum temperature can induce peel pitting, surface browning, water soaked lesions and uneven ripening.

### 6. Loss of nutritional quality

Vitamin C, antioxidants and pigments decline during prolonged storage.

## Mechanism of action of edible coating

Edible coatings are thin layers of edible substances applied to fruit surfaces to create a protective barrier. Edible coatings, sprays and GRAS dips are increasingly used because they are biodegradable, residue-free and environmentally safe. Edible coatings extend shelf life through several mechanisms such as -

### 1. Reduction of respiration rate

Coatings limit oxygen entry and carbon dioxide escape, thereby slowing metabolic activity.

### 2. Reduction of transpiration

Semi-permeable films reduce water loss and prevent shrivelling. These coatings modify internal gas composition and reduce moisture transfer between the fruit and environment

### 3. Delay of ripening

Lower respiration rate delays biochemical changes associated with ripening and senescence.

### 4. Antimicrobial protection

Certain coatings possess antimicrobial compounds that inhibit pathogens.

### 5. Maintenance of texture

Coatings reduce cell wall degradation and preserve firmness.

### 6. Preservation of nutritional quality

Antioxidants and pigments are retained for longer periods.

## Types of edible coatings used in Dragon fruit

### 1. Chitosan Coating

Chitosan is a natural polysaccharide derived from chitin obtained from crustacean shells. Studies indicate that chitosan coated fruits can maintain acceptable quality for several weeks under refrigerated conditions by reduced PLW, delayed peel browning, lower microbial decay, enhanced firmness and improved antioxidant retention. Chitosan coatings reduce oxygen permeability and inhibit fungal growth.

### 2. Aloe vera gel coating

Aloe vera gel is increasingly used as a natural edible coating because of its antimicrobial and moisture-retaining properties. Aloe vera gel coatings also enhance gloss and external appearance. Benefits of its usage include reduced respiration, lower moisture loss, delayed senescence, better retention of vitamin C and improved sensory quality.

### 3. Gum based coating

Natural gums are polysaccharides obtained from plant sources viz. guar gum, xanthan gum, gum Arabic and tragacanth (gond katira) gum. Gum based coatings are increasingly preferred because of their low cost and biodegradability. It gives fruits excellent film forming ability, moisture barrier properties and texture preservation.

## 4. Starch based coating

Starch coatings are prepared from corn, cassava, rice and/or potato starch. Starch coatings are often combined with essential oils or antimicrobial agents for enhanced performance. The advantages are its low cost and easy availability giving better shelf stability.

## 5. Cellulose based coating

Cellulose derivatives such as carboxymethyl cellulose (CMC) and methyl cellulose are widely used. These coatings improve texture and reduce physiological deterioration providing good mechanical strength, transparent film formation and moisture barrier properties.

## 6. Lipid and wax based coating

This includes viz. carnauba wax, bees wax, paraffin wax. Wax coatings are commercially important in fruit preservation by reduced transpiration, improved gloss and enhanced visual appeal. Wax coated dragon fruits exhibit reduced shriveling during storage.

## Pre-harvest and postharvest sprays

These sprays are applied before harvest or after harvest of fruits to improve storage performance and disease resistance. They are -

### Calcium sprays

Calcium chloride sprays strengthen cell wall stability and membrane integrity. Calcium also reduces membrane leakage and enhances tolerance to physiological disorders.

### Salicylic acid sprays

Salicylic acid is a plant signalling molecule involved in stress response. Its benefits in dragon fruit include better firmness retention, reduced peel browning, lower decay incidence and physiologically by activation of antioxidant enzymes, reduction of oxidative stress, delayed senescence and improved disease resistance

### Essential oil sprays

Plant-derived essential oils viz. cinnamon oil, clove oil, thyme oil, lemongrass oil, oregano oil, possess natural antimicrobial properties. Essential oils disrupt microbial membranes and inhibit fungal growth by reduced postharvest decay, enhanced storage life and reduced dependence on fungicides.

### Jasmonic acid and methyl jasmonate sprays

These compounds enhance the plant defence mechanisms by delayed senescence and enhanced disease resistance.

## GRAS postharvest dips and their importance

GRAS substances are food safe compounds approved for direct use in food systems. GRAS dips are increasingly preferred because they leave minimal residues, are environmentally safe and acceptable to consumers, and reduce microbial spoilage. Commonly used GRAS dips in Dragon Fruit are -

### 1. Calcium chloride ( $\text{CaCl}_2$ ) dip

Calcium strengthens cell walls and delays degradation and its effect is on better firmness retention, lower PLW, reduced spoilage and improved storage life.

### 2. Ascorbic acid dip

Ascorbic acid acts as an antioxidant and anti-browning agent and its benefits are retention of vitamin C, reduced oxidative stress, better peel colour and improved sensory quality.

### 3. Citric acid dip

Citric acid reduces surface pH and inhibits microbial growth by delayed spoilage, reduced enzymatic browning and better microbial safety.

### 4. Sodium bi-carbonate dip

Sodium bi-carbonate exhibits antifungal activity by suppression of pathogens, reduced decay incidence and enhanced shelf stability.

### 5. Hydrogen peroxide ( $\text{H}_2\text{O}_2$ ) treatment

$\text{H}_2\text{O}_2$  is used as a sanitizer for reducing microbial contamination. It lowers microbial load, improve hygiene and better postharvest disease management.

### Combined treatments and hurdle technology

Recent studies indicate that combining multiple postharvest treatments produces synergistic effects by improving preservation efficiency viz. chitosan + calcium chloride, aloe vera + salicylic acid, gum coating + essential oils, calcium dip + wax coating. Advantages of these treatments on quality parameters are -

#### 1. Firmness

Coatings and calcium treatments reduce enzymatic degradation of cell walls.

#### 2. Weight loss

Moisture barrier properties reduce transpiration.

#### 3. Total soluble solids (TSS)

Treatments help maintain sugar balance and flavor.

#### 4. Titratable acidity

Reduced respiration slows acid degradation.

#### 5. Vitamin C retention

Antioxidant treatments preserve ascorbic acid.

#### 6. Antioxidant activity

Coatings help maintain phenolic compounds and pigments.

#### 7. Sensory Quality

Improved appearance, texture, flavor, and freshness enhance consumer acceptance.

### Commercial applications and industrial importance

Eco-friendly postharvest technologies are increasingly adopted in commercial fruit handling systems because of the mentioned multiple benefits. These technologies support modern residue-free horticultural production systems. However, despite promising results, several challenges remain such as, produce specific

standardization of formulations, cost of commercial application, variability in effectiveness, sensory changes at high concentrations and thus the need for large-scale validation.

Future prospects and emerging technologies worth mentioning are nano-edible coatings (improve antimicrobial and barrier properties), bioactive packaging (incorporation of natural antimicrobials), smart packaging systems (sensors and intelligent packaging), integration with cold chain (combining coatings with refrigerated transport) and sustainable export systems.

### Conclusion

Dragon fruit is a nutritionally valuable and economically important tropical fruit with growing global demand. However, rapid postharvest deterioration significantly limits storage life and marketability. Moisture loss, softening, microbial spoilage, peel browning and chilling injury (in cold storage) are major factors responsible for quality deterioration. Edible coatings, natural sprays and GRAS dips offer safe, sustainable and eco-friendly approaches for extending shelf life and preserving quality. Chitosan, aloe vera gel, gum-based coatings, starch coatings and wax formulations reduce respiration and transpiration while improving microbial protection. Calcium sprays, salicylic acid, jasmonates and essential oils enhance physiological stability and disease resistance. GRAS dips such as calcium chloride, citric acid, sodium bicarbonate and ascorbic acid further improve storage quality and food safety.

The integration of these technologies can substantially reduce postharvest losses, improve export potential, enhance consumer acceptance and support sustainable horticultural production systems. Continued research on nano-coatings, bioactive packaging and integrated preservation strategies will further strengthen dragon fruit postharvest management in the future.

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