# فناوری پس از برداشت ۸

**Postharvest handling for fruits and vegetables:**

1-Waxing
2- Packaging
3- Irradiation
4- Transportation

# Waxing

# Artificial waxing:

Artificial wax is applied to produce to replace the natural wax lost during washing of fruits or vegetables. This adds a bright sheen to the product. The function of artificial waxing of produce is summarized below:

- Provides a protective coating over entire surface.
- Seals small cracks and dents in the rind or skin.
- Seals off stem scars or base of petiole.
- Reduces water (moisture) loss.
- Permits natural respiration.
- Extends shelf life.
- Enhances sales appeal.

**Brand name application:**

Some distributors use ink or stickers to stamp a brand name or logo on each individual fruit. Ink is not permissible in some countries (e.g., Japan), but stickers are acceptable. Automatic machines for dispensing and applying pressure sensitive paper stickers are readily available. The advantage of stickers is that they can be easily peeled off.

Wax-coated apples in a retail display.

Oranges being waxed.

# Packaging of Fruits and Vegetables

According to Wills et al. (1989), modern packaging must comply with the following requirements:

a) The package must have sufficient mechanical strength to protect the contents during handling, transport, and stacking.

b) The packaging material must be free of chemical substances that could transfer to the produce and become toxic to man.

c) The package must meet handling and marketing requirements in terms of weight, size, and shape.

d) The package should allow rapid cooling of the contents. Furthermore, the permeability of plastic films to respiratory gases could also be important.

e) Mechanical strength of the package should be largely unaffected by moisture content (when wet) or high humidity conditions.

f) The security of the package or ease of opening and closing might be important in some marketing situations.

g) The package must either exclude light or be transparent.

h) The package should be appropriate for retail presentations.

i) The package should be designed for ease of disposal, re-use, or recycling.

j) Cost of the package in relation to value and the extent of contents protection required should be as low as possible.

# Classification of packaging:

Packages can be classified as follows:

- Flexible sacks; made of plastic jute, such as bags (small sacks) and nets (made of open mesh)
- Plastic bags
- Baskets made of woven strips of leaves, bamboo, plastic, etc.
- Wooden crates
- Cartons (fibreboard boxes)
- Plastic crates
- Pallet boxes and shipping containers

**Uses for above packages:**

**Nets** are only suitable for hard produce such as coconuts and root crops (potatoes, onions, yams).

# Flexible sacks; made of plastic jute, such as bags (small sacks) and nets


FIG. 11.10 Washbasin and jute or plastic bags are used in Guinea Conakry for harvesting and transporting potatoes.


FIG. 11.14 Plastic net bags as consumer package of citrus and tomatoes.

Figure 46: **Pallet stabilization with mesh plastic tension netting.**

# Plastic bags

Figure 43: Plastic Bag Containing Apples (Page No. 96)

# Baskets made of woven strips of leaves

FIG. 11.7 Containers made of bamboo and date palm leaves.

**Figure 33: Bamboo Baskets with Mangoes (Page No. 88)**

FIG. 11.15 Baskets used for transport and marketing fresh produce in Guinee Conakry local market.

# Wooden crates

Wooden crates are typically wire bound crates used for citrus fruits and potatoes, or wooden field crates used for softer produce like tomatoes. Wooden crates are resistant to weather and more efficient for large fruits, such as watermelons and other melons, and generally have good ventilation. Disadvantages are that rough surfaces and splinters can cause damage to the produce, they can retain undesirable odors when painted, and raw wood can easily become contaminated with moulds.

Typical wooden crate holding fresh tomatoes

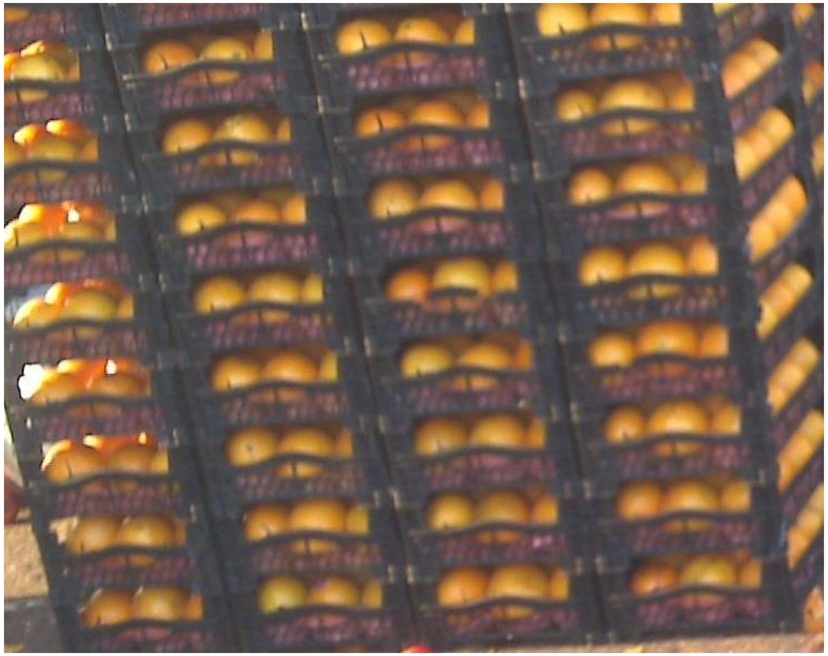
# Plastic crates

Plastic crates are expensive but last longer than wooden or carton crates.

They are easy to clean due to their smooth surface and are hard in strength, giving protection to products. Plastic crates (Figure 2.8) can be used many times, reducing the cost of transport. They are available in different sizes and colours and are resistant to adverse weather conditions. However, plastic crates can damage some soft produce due to their hard surfaces, thus liners are recommended when using such crates.

Figure 2.8 Typical plastic crate holding fresh oranges.

Figure 40: Plastic Crates with Potatoes (Page No. 93)

# Plastic Boxes

## سبد 18 کیلویی

تزریق پلاستیک و سبد میوه و صندوق میوه و سبد 18 کیلوی

سبد 18 کیلویی با استقامت بالا و قیمت پایین مناسب برای حمل گوجه ، ملون ، کدو ، انواع و اقسام میوه جات و فرنگی جات

# Plastic Boxes

## سبد 14 کیلویی

تزریق پلاستیک و سبد میوه و صندوق میوه و سبد 14 کیلویی

سبد 14 کیلویی

# Plastic Boxes

# Pallet boxes

- Pallet boxes are very efficient for transporting produce from the field to the packinghouse or for handling produce in the packinghouse. Pallet boxes have a standard floor size (1200 × 1000 mm) and depending on the commodity have standard heights. Advantages of the pallet box are that it reduces the labour and cost of loading, filling, and unloading; reduces space for storage; and increases speed of mechanical harvest. The major disadvantage is that the return volume of most pallet boxes is the same as the full load. Higher investment is also required for the forklift truck, trailer, and handling systems to empty the boxes. They are not affordable to small producers because of high, initial capital investment.

FIG. 12.16 Bulk bin used for potato and carrot storage.

Figure 14: **Harvested fruits ready to be transported to the packinghouse.**

# Carton crates (Fibreboard boxes)

Fibreboard boxes are used for tomato, cucumber, and ginger transport. They are easy to handle, light weight, come in different sizes, and come in a variety of colours that can make produce more attractive to consumers. They have some disadvantages, such as the effect of high humidity, which can weaken the box; neither are they waterproof, so wet products would need to be dried before packaging. These boxes are often of lower strength compared to wooden or plastic crates, although multiple thickness trays are very widely used. They can come flat packed with ventilation holes and grab handles, making a cheap attractive alternative that is very popular. Care should be taken that holes on the surface (top and sides) of the box allow adequate ventilation for the produce and prevent heat generation, which can cause rapid product deterioration.


PRODUCE OF I.R.IRAN
Marhaba
PACKED FOR
MARHABA MTA GENERAL TRADING L.L.C.
Tel.: +9714 - 333 9696
Fax: +9714 - 333 9699
E-mail: info@marhabafruits.com
Website: www.marhabafruits.com
GOLDEN
GOLDEN
GOLDEN
GOLDEN
Sun East
GOLDEN
APPLE

**Table 1** Types of Paper Commonly Used as Packaging Material

| Product | Characteristics | Example |
|---|---|---|
| Kraft paper | Brown, unbleached paper. Good strength and resistant to bursting when dry | Heavy duty bags and sacks |
| Bleached Kraft paper | White paper, may be glossy. Less strength than unbleached paper | White bags, wrapping paper |
| Parchment paper | Translucent paper treated with $H_2SO_4$ to gelatinize surface layers | Butter and margarine wrap |
| Greaseproof paper | High-density paper, very smooth surface | Wrapping paper requiring high resistance to grease |
| Glassine | High-density greaseproof paper. Transparent, brittle | Overwraps on candy |
| Tissue | Lightweight paper produced from most pulps | Lightweight and used to protect soft products from dust and bruising |
| Paperboard/cardboard | Compacted paper pulp | Cartons, boxes, trays, separators |
| Corrugated cardboard | Paperboard sheets interspersed with paper corrugations | Secondary boxes of many kinds |

*Source*: Adapted from Jelen (1985) and Brown (1992).

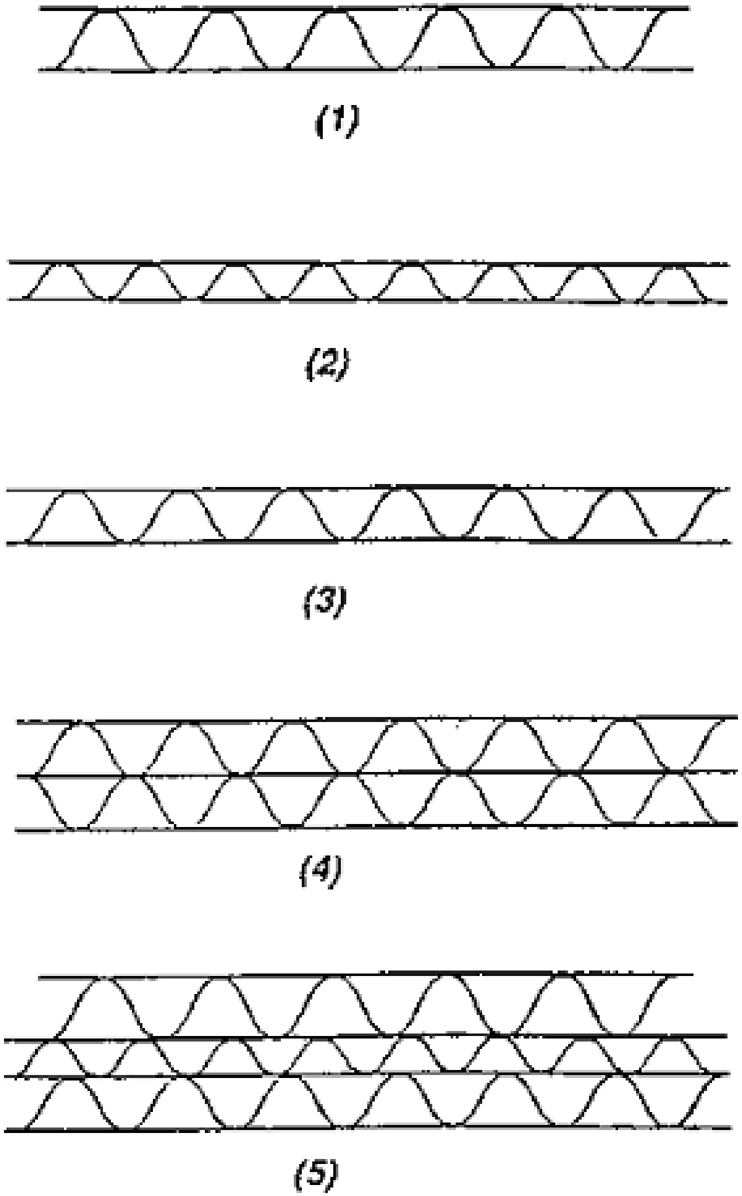



**Fig. 1** Various types of corrugated board construction: (1) "A" flute–single wall, (2) "B" flute–single wall, (3) "C" flute–single wall, (4) "C" and "C"–double wall, and (5) "A," "B," and "C"–triple wall. (Courtesy of Smurfit-MBI, Montreal, Quebec, Canada.)

**Table 2** Examples of Plastics Used as Packaging Materials

| Materials | Structural unit | Important properties |
|---|---|---|
| Cellulose | Glucose | Good strength, poor $H_2O$ and gas barrier, good printability, no heat sealability |
| Polyethylene (PE) | Ethylene | Good strength, flexibility, extensibility, high $H_2O$ barrier, poor gas barrier, low melting point, good heat sealability |
| Polyester (PET) | Ethylene glycol + terephthalic acid | Stiff, strong, inert, excellent mechanical properties, poor heat sealability, moderate $H_2O$ and gas barrier |
| Polyamide (PA) | Diamine + various acids | Stiff, strong, inert, clear, excellent machinability, heat sealability, poor $H_2O$ barrier, high gas barrier when dry |
| Polypropylene (PP) | Propylene | Tough, inert, clear, low melting point, high $H_2O$ barrier, poor gas barrier |

**Table 2** Examples of Plastics Used as Packaging Materials

| Materials | Structural unit | Important properties |
|---|---|---|
| Polystyrene (PS) | Styrene | Stiff, strong, brittle, low $H_2O$ and gas barriers |
| Polyvinyl chloride (PVC) | Vinyl chloride | Soft, inert, clear, extensibility, good $H_2O$ barrier, moderate moisture barrier |
| Polyvinylidene chloride (PVDC, Saran®) | Vinyl alcohol + vinylidene chloride | Inert, clear, not very strong, high melting point, heat sealability at high temperature, excellent $H_2O$ and gas barriers |
| Ethlyene vinyl acetate (EVA) | Vinyl acetate + ethylene | Tough, clear, inert, high extensibility, low melting point, heat sealability, intermediate $H_2O$ barrier, poor gas barrier |
| Ethylene vinyl alcohol (EVOH) | Vinyl alcohol + ethylene | Strong, stiff, inert, heat sealability at low temperature, low $H_2O$ barrier, high gas barrier |
| Ionomer (Surlyn) | Ethylene + methacrylic acid | Tough, inert, clear, heat sealability at low temperature, intermediate $H_2O$ barrier, low gas barrier |

*Source*: Adapted from Jelen (1985) and Brown (1992).

FIG. 11.2 Bad packing and transport stacking of lettuce boxes versus nice protection of bananas in suitable cardboard boxes.


Peaches being packed into trays with different size pockets.

Figure 44: **Individual protection of large fruits.**

FIG. 9.11 A general view of the packaging area in a modern tomato packing house.


Manual packing of grapefruit.

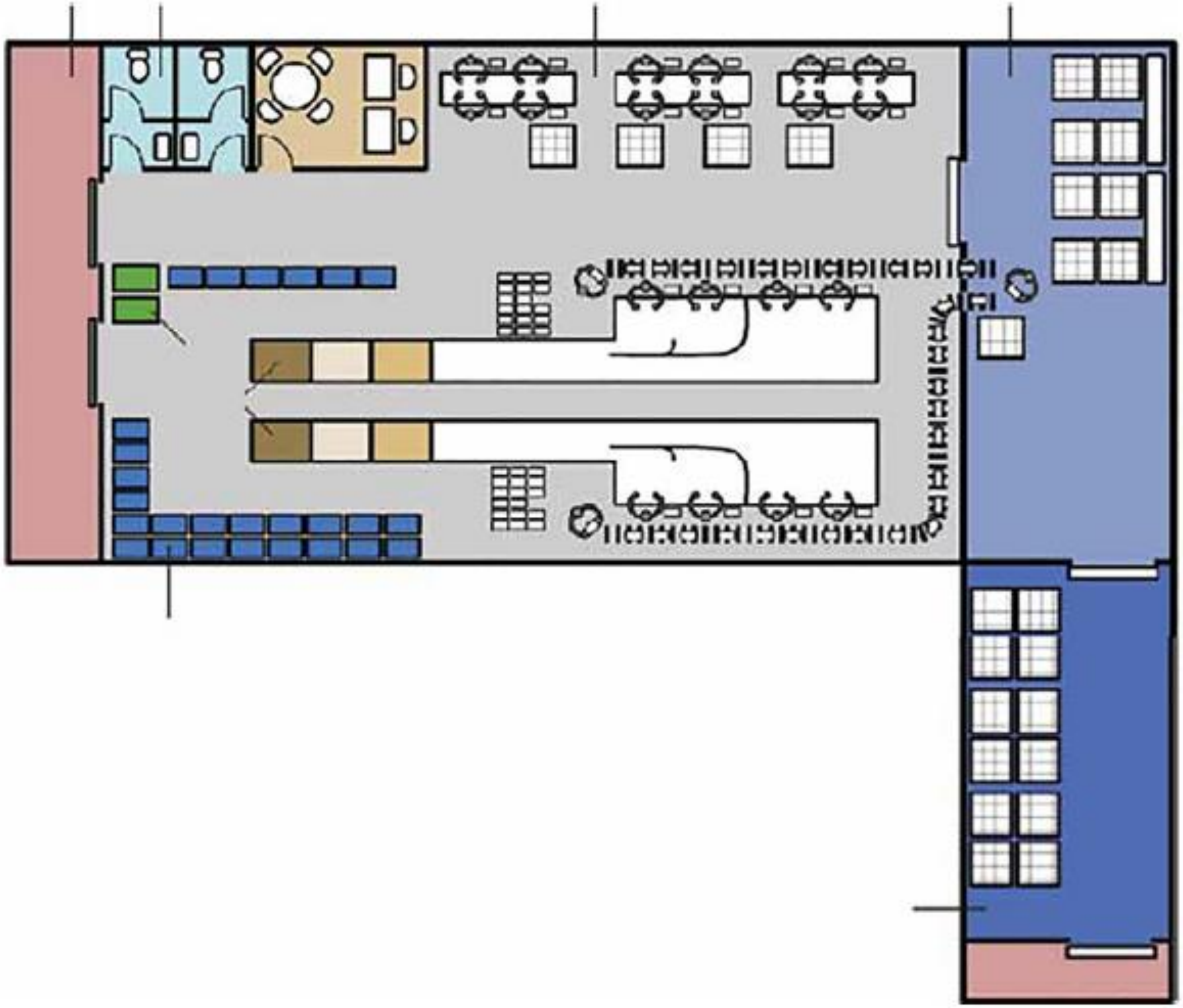


FIG. 9.13 Layout of a packing house facility in an L-shaped configuration. Areas include a receiving dock (1), restrooms (2), office space (3), packing area for small volumes of produce (4), precooling area (5), temporary holding of incoming produce in crates (6), assembly area for cartons (7), cold storage (8), and a refrigerated loading dock (9). Equipment includes weighing scales (a), sorting and grading tables (b), a mechanized packing-line for large volumes of produce (c), and conveyors (d). *From Yaptenco, K.; Esguerra, E., 2012. Good Practice in the Design, Management and Operation of a Fresh Produce Packing-House, Food and Agriculture Organization of the United Nations/FAO Regional Office for Asia and the Pacific, Bangkok.*

FIG. 9.14 Assembling area of wooden crates in the packing house.

Full product coverage on a tomato packingline brush bed.

# Consumer Packaging

Figure 40: **Consumer packaging or prepackaging.**


FIG. 11.12 Types of consumer packages for citrus and tomato.

FIG. 11.13 Trays and clamshell boxes are commonly used for very perishable fruits.

# Modified Atmosphere Packaging (MAP)


FIG. 11.16 Examples of fruits kept in plastic trays with modified atmosphere packaging. In general the plastic film used on the top is perforated.

# Active Packaging

TABLE 11.1 Active packaging systems applied for some fresh horticultural products

| System of active packaging | Types | Material | Function |
|---|---|---|---|
| Absorbers/ scavengers | Oxygen scavengers | Sulfites, zinc and alkali metal salts, copper powder | Delay nonenzymatic browning in some fruits and vegetables |
| | Moisture absorbers | Silica gel, propylene glycol, sugar, inorganic salt | Remove excess water of fresh-cut produce or reduce the level of moisture |
| | Carbon dioxide scavengers | Calcium hydroxide, sodium hydroxide, calcium oxide or silica gel | Absorb carbon dioxide |
| | Ethylene absorbers | Potassium permanganate, silicon oxide, zeolite, active carbon | Absorb ethylene and delay ripening process of fresh produce |
| | Carbon dioxide absorbers | Zeolite, silica gel | Remove excess $CO_2$ in the package |
| | Other absorbers | Immobilized enzymes | Absorb flavor and odor |
| | Carbon dioxide emitters | Ascorbic acid, ferrous carbonate, sodium carbonate | Reduce respiration rate of fresh produce and prevent pack collapse |
| Releasers/ emitters | Ethanol emitter | Encapsulated ethanol | As antifungal and antibacterial agents |
| | Antioxidant releasers | Antioxidants (BHA, BHT), natural antioxidants from plants or essential oils | Reduce oxidative spoilage |
| | Antimicrobial releasers | Antimicrobials, natural antimicrobials | Release antimicrobial agent to package space or to the surface of fresh produce |
| | Other releasers | Flavors | Release of desirable flavor |

TABLE 11.2 Active packaging systems commercially available

| Trade name | Manufacturer | Principle | Type |
|---|---|---|---|
| Ageless | Mitsubishi Gas Chemical Co. Ltd., Japan | Iron-based | Oxygen scavenger |
| Freshilizer | Toppan Printing Co. Ltd., Japan | Iron-based | Oxygen scavenger |
| Freshmax, Freshpax, Fresh Pack | Multisorb Technologies, USA | Iron-based | Oxygen scavenger |
| Oxyguard | Toyo Seikan Kaisha Ltd., Japan | Iron-based | Oxygen scavenger |
| Zero$_2$ | Food Science Australia, Australia | Photosensitive dye | Oxygen scavenger |
| Bioka | Bioka Ltd., Finland | Enzyme-based | Oxygen scavenger |
| Dri-Loc | Sealed Air Corporation, USA | Absorbent pad | Moisture absorber |
| Tenderpac | SEALPAC, Germany | Dual compartment system | Moisture absorber |
| Biomaster | Addmaster Limited, USA | Silver-based | Antimicrobial packing |
| Agion | Life Materials Technology Limited, USA | Silver-based | Antimicrobial packing |
| SANICO | Laboratories STANDA | Antifungal coating | Interleavers |
| Neupalon | Sekisui Jushi Ltd., Japan | Activated carbon | Ethylene scavenger |
| Peakfresh | Peakfresh Products Ltd., Australia | Activated clay | Ethylene scavenger |
| Evert-Fresh | Evert-Fresh Corporation, USA | Activated zeolites | Ethylene scavenger |

*From Biji, K.B., Ravishankar, C.N., Mohan, C.O., Srinivasa Gopal, T.K. 2015. Smart packaging systems for food applications: a review. J. Food Sci. Technol. 52(10), 6125–6135.*

Thermochromic inks are materials that are sensitive to heat and change color according to the temperature. The inks can be printed or labeled, allowing the information to be delivered to the consumers. Applying these inks allow the customers to be aware of the end of the product's shelf life, which coincides with the color of the reference. Samples of the TTIs systems are presented in Fig. 11.17.


FIG. 11.17 Samples of time–temperature indicators used for monitoring temperature breaks and indicate the endpoint of shelf life of the packaged product.

# Mango Packaging


Mango cartons showing the traceback code number.


**Figure 7.1** Mango packing styles for the retail markets in selected countries.

**Figure 7.2** Clamshell containers (top) and plastic liner cups (bottom) used for mango packaging.


Air-freight Box


Sea-freight Box

Shipment Ready Pelletized Boxes
in Cold Room

Export Pack with Mesh
(qurantine requirement)

**Figure 7.3** Mango boxes used for air/sea freight, shipment ready palletized mango, and a display ready fancy export pack.


(a) Mango Slices

(b) Mango Chunks

**Figure 7.4** Fresh-cut mango slices and chunks/dices packaged in plastic trays with snap-on lids.


(a) Layers of Brick Pack

(b) Juice in Brick Pack

(c) Nectar in Brick Pack

(d) Juice in Plastic Bottle

(e) Juice in Glass Bottle

(f) Beverage in Can

**Figure 7.5** Composite layers of brick-type package (a), with juice/nectar (b,c), juice in plastic and glass bottles (d,e), and beverage in aluminum can (f).


**Figure 7.6** Metal cans used for mango products – diced mangoes, mango slices in pull-tab lid can, and mango pulp.


**Figure 7.7** Mango products in glass jars.


(a) Frozen, 1-lb (b) Frozen, 5-lb (c) Dried, 3.5 oz

**Figure 7.8** Frozen mango chunks (a,b) and dried mango slices (c) in flexible pouches.


(a) 4lb (b) 7-oz (c) 4-oz

**Figure 7.9** Ready to eat mango chunks in extra light syrup packaged in plastic jar (a) and cups (b,c).

# Irradiation

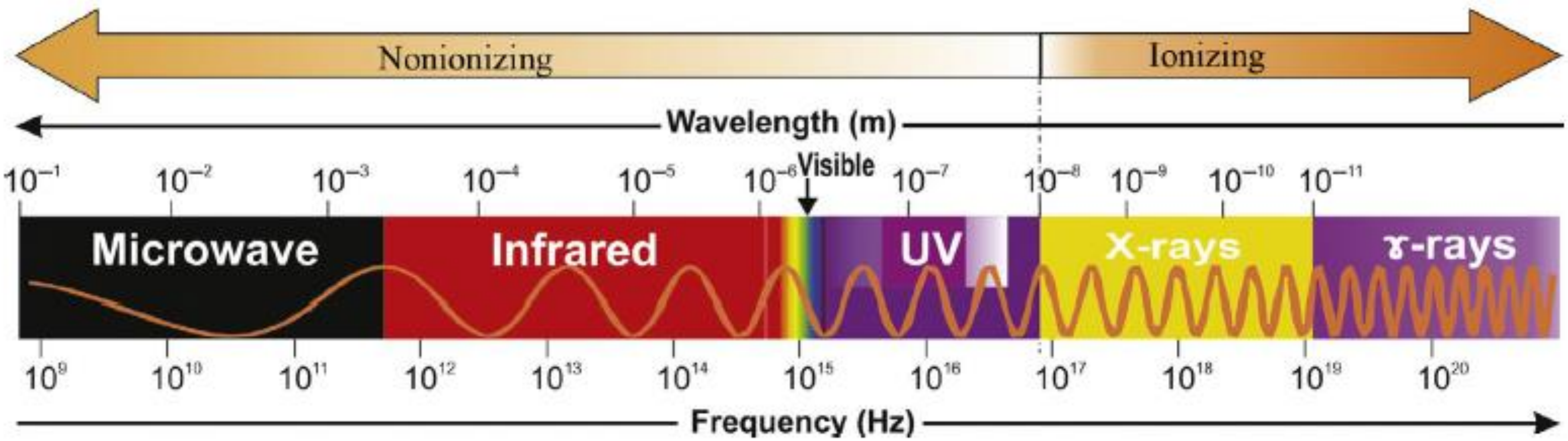



FIG. 17.1 The types of electromagnetic radiation composing the electromagnetic spectrum.

**Table 10.4** Effects of UV-C treatment and thermal pasteurization on clarity, total carotenoids, and ascorbic acid content of Chokanan mango juice.

| Treatment | Clarity, transmittance (at 660 nm) | Total carotenoids (μg/100 ml) | Ascorbic acid (mg/100 ml) |
|---|---|---|---|
| Control | 25.50 ± 0.22 | 82.03 ± 1.29 | 8.91 ± 0.51 |
| UV-C, 15 min | 25.40 ± 0.08 | 87.10 ± 1.14 | 7.85 ± 0.24 |
| UV-C, 30 min | 25.17 ± 0.15 | 84.97 ± 1.35 | 7.55 ± 0.30 |
| UV-C, 60 min | 24.25 ± 0.10 | 80.16 ± 1.80 | 6.87 ± 0.12 |
| Pasteurization | 7.30 ± 0.14 | 48.92 ± 1.32 | 3.10 ± 0.62 |

*Source:* Adapted from Santhirasegaram *et al.* (2015).

**TABLE 17.4** Minimum Doses of γ-Irradiation Approved for the Control of Pests of Relevance in the International Trade of Fruits and Vegetables

| Pest | Dose (Gray) |
| --- | --- |
| Apple maggot (*Rhagoletis pomonella*) | 60 |
| Mexican fruit fly (*Anastrepha ludens*) | 70 |
| West Indian fruit fly (*Anastrepha obliqua*) | 70 |
| Caribbean fruit fly (*Anastrepha suspensa*) | 70 |
| Plum curculio (*Conotrachelus nenuphar*) | 92 |
| Sapote fruit fly (*Anastrepha serpentina*) | 100 |
| Javis fruit fly (*Bactrocera jarvis*) | 100 |
| Queensland fruit fly (*Bactrocera tryoni*) | 100 |
| Other fruit flies of the Tephritidae family | 150 |
| Sweetpotato vine borer (*Omphisa anastomosalis*) | 150 |
| Sweet potato weevil (*Cylas formicarius elegantulus*) | 150 |
| West Indian sweet potato weevil (*Euscepes postfasciatus*) | 150 |
| Codling moth (*Cydia pomonella*) | 200 |
| Oriental fruit moth (Grapholita molesta) | 200 |
| Koa seedworm (*Cryptophlebia illepida*) | 250 |
| Litchi fruit moth (*Croptphlebia ombrodelta*) | 250 |
| False red spider mite (*Brevipalpus chilensis*) | 300 |
| Mango seed weevil (*Sternochetus mangiferae* (Fabricus)) | 300 |
| Pests of *insecta* class (excludes pupae/adults of Lepidoptera order) | 400 |

Application of Irradiation for Fruits and Vegetables

| Purpose | Products Subjected To | Dose (kGy) |
|---|---|---|
| Sprout inhibition | Potatoes, onion, garlic, ginger, yam | 0.05–0.15 |
| Insect disinfestations | Fresh and dried fruits | 0.15–0.5 |
| Delaying maturity and senescence | Fresh fruits and vegetables | 0.25–1.0 |
| Extending shelf life | Strawberries, mushrooms | 1.0–3.0 |
| Improving technological properties | Grapes (juice recovery), dehydrated vegetables (reduced cooking time) | 2.0–7.0 |

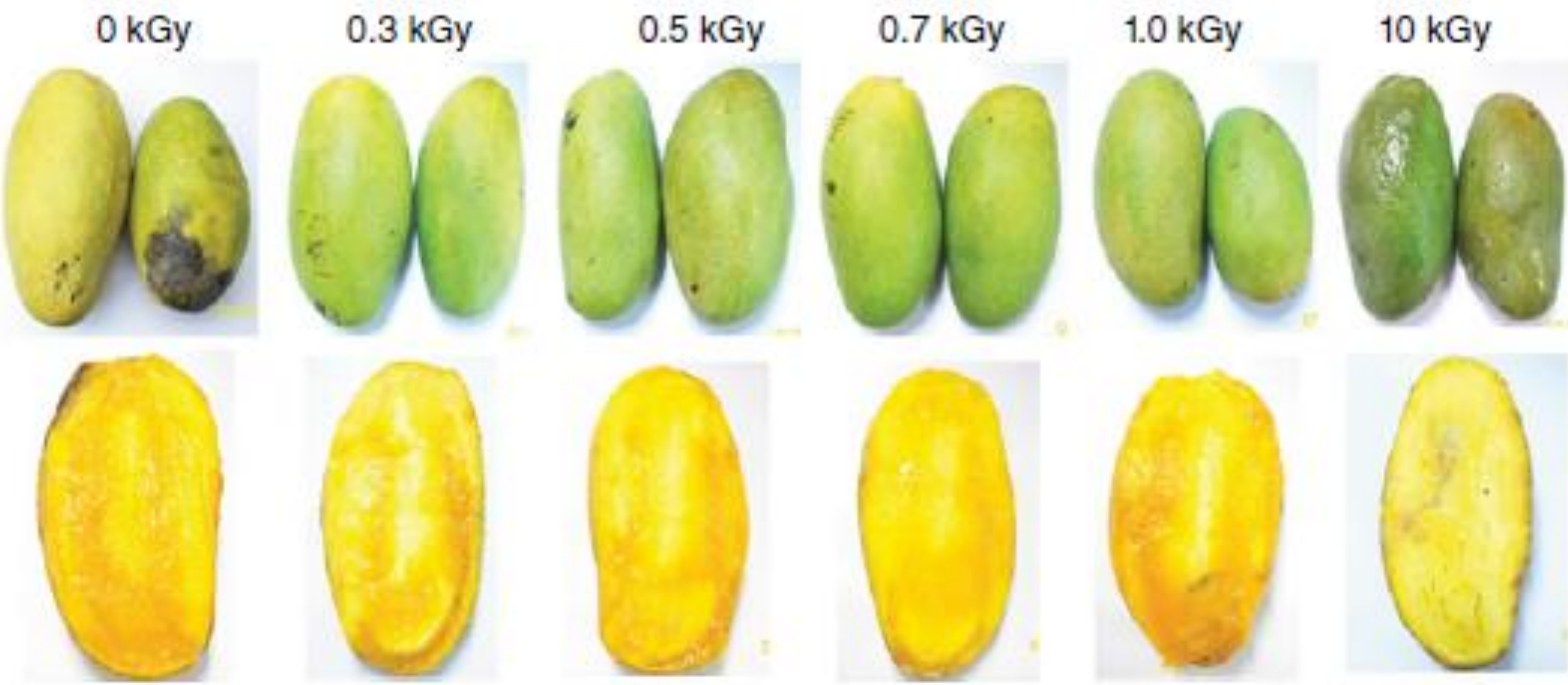



**Figure 9.5** Effect of irradiation on appearance of the Indian "Dushehri" mango after 7 days of storage at 20 °C. *Source:* Mahto and Das (2013).

# Transportation and Handling of Fresh Fruits and Vegetables

# FACTORS AFFECTING PRODUCE QUALITY DURING TRANSPORT

- Initial Quality
- Temperature
- Humidity and Water Loss
- Gas Composition
- Mixed Load

1. Recommended storage temperature
2. Recommended relative humidity
3. Sensitivity to chilling or freezing injury
4. Production and sensitivity to gases and volatiles
5. Production and absorption of odors

- Physical Injury
- Transport Conditions

**Figure 51: Refrigerated Van Carrying Fruits and Vegetables**
**(Page No. 137)**

Figure 52: Air Transport (Page No. 138)

Figure 53: Cargo for Shipment (Page No. 139)


**Fig. 3** Nose-mounted refrigeration system used in a semitrailer.

**Table 1** Heat Absorption Characteristics of Liquid Ice and Various Cryogenic Refrigerants

| Cooling medium | Initial temperature (°C) | Amount of heat absorbed to reach 0°C or 1°C (kJ/kg) |
|---|---|---|
| Liquid ice | 0 | 335 |
| Liquid ice | −13 | 372 |
| Liquid $N_2$ | −196 | 396 |
| Liquid $CO_2$ (at $5.7 \times 10^6$ Pa) | +20 | 215 |
| Liquid $CO_2$ (at $2.1 \times 10^6$ Pa) | −18 | 326 |
| Solid $CO_2$ (dry ice) | −79 | 633 |

*Source*: From International Institute of Refrigeration (1995).