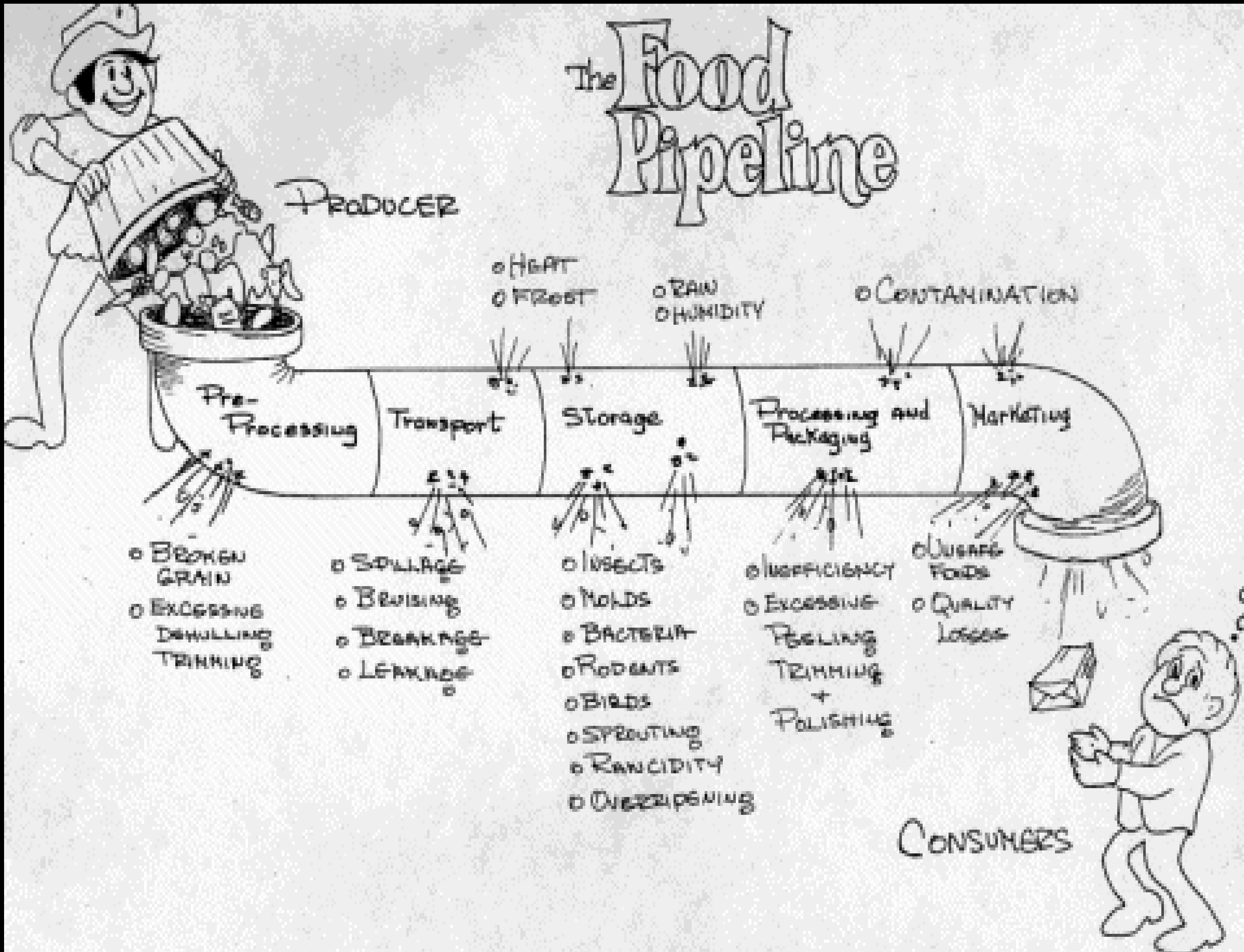
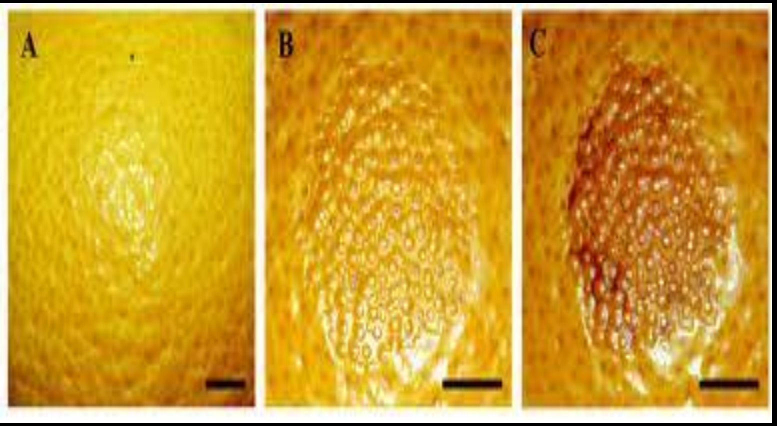
Post Harvest Handling


The Food Pipeline
PRODUCER
Pre-Processing
Transport
Storage
Processing and Packaging
Marketing
HEAT
FROST
RAIN
HUMIDITY
CONTAMINATION
BROKEN GRAIN
EXCESSIVE DEHULLING TRIMMING
SPILLAGE
BRUISING
BREAKAGE
LEAKAGE
INSECTS
MOLDS
BACTERIA
RODENTS
BIRDS
SPROUTING
RANCIDITY
OVERRIPENING
INEFFICIENCY
EXCESSIVE PEELING TRIMMING + POLISHING
UNSAFE FOODS
QUALITY LOSSES
CONSUMERS

HARVESTING

Harvest Methods

Fresh vegetables, fruits, and flowers are still harvested *by hand*. Only humans have the unique combination of eyes, brain, and hands that permits the rapid harvest of delicate and perishable crops with minimal loss and bruising. Harvesters can also be trained to select only those fruits or vegetables of the correct maturity, thus greatly reducing the amount of material that must be removed on the grading line in the packing shed. In fact, some crops can be harvested directly into shipping containers without further sizing or grading.


A
B
C

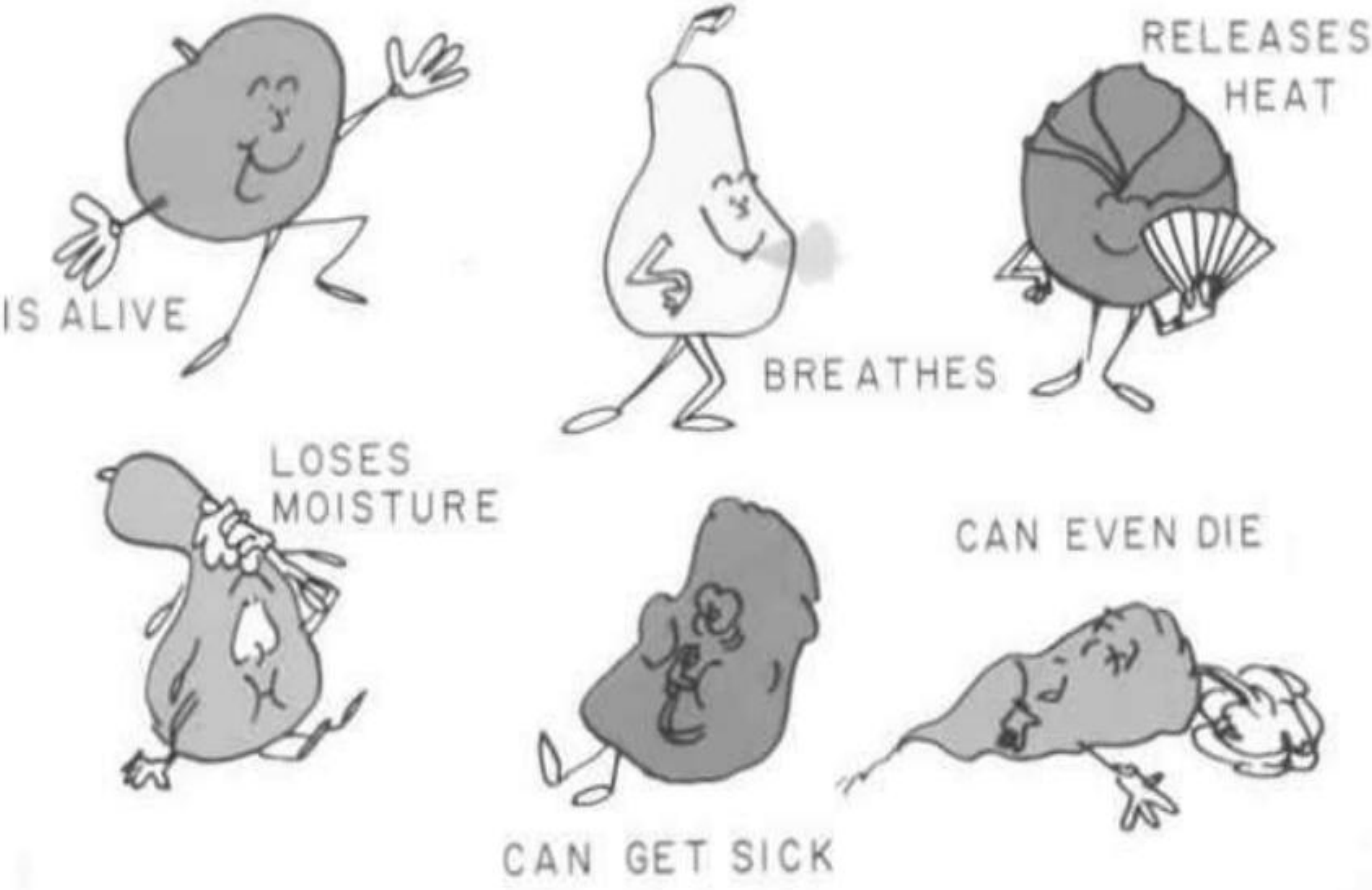
Mechanical harvesters are usually sophisticated and have a very high unit cost. They may require a smaller but more skilled labor force. Savings may be realized because the harvest can be accomplished in less time.

Crops are often damaged, or poorer grade, and more susceptible to decay when mechanically harvested. Mechanically harvested commodities often are fit only for processing.

POSTHARVEST HANDLING

Losses in *quantity* and *quality* affect horticultural crops between harvest and consumption. The magnitude of postharvest losses in fresh fruits and vegetables is an estimated 5 to 25 percent in developed countries and 20 to 50 percent in developing countries, depending upon the commodity. To reduce these losses, producers and handlers must understand the biological and environmental factors involved in deterioration and use postharvest techniques that delay senescence and maintain the best possible quality.


FRESH PRODUCE

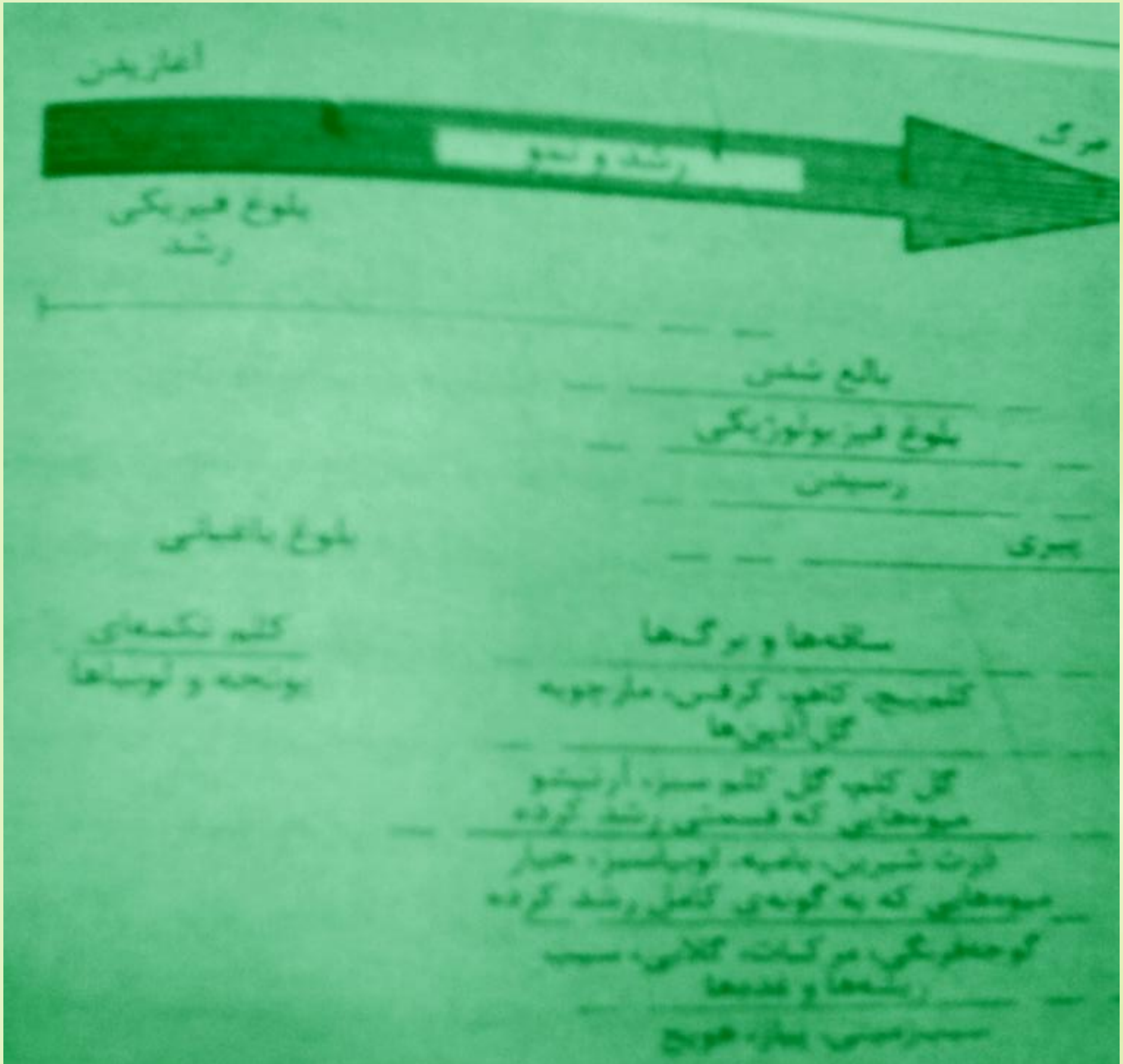


QUALITY AND MATURITY

Maturity in Relation to Quality

Although numerous objective indices for maturity are available, only a few are actually used in practice because they are in most cases destructive and difficult to do in the field or orchard.

For many vegetables, the optimum eating quality is reached before full maturity (true for leafy vegetables and immature fruits including cucumbers, sweet corn, green beans, and peas). With these crops delayed harvest results in lower quality at harvest and faster deterioration after harvest.



نگاره‌ی ۳—۱۰ بلوغ تجارتی در رابطه با مراحل نمو گیاه

Maturity at harvest is the most important factor that determines storage life and final fruit quality. Immature fruits are more subject to shriveling and mechanical damage and are of inferior quality when ripe. Overripe fruits are likely to become soft and mealy with insipid flavor soon after harvest. Fruits picked either too early or too late in the season are more susceptible to physiological disorders and have a shorter storage life than those picked at the proper maturity.

Maturity indices for selected fruits and vegetables (1)

INDEX	EXAMPLES
Elapsed days from full bloom to harvest	Apples, pears
Mean heat units during fruit development	Peas, sweet corn
Development of abscission layer	Muskmelon
Surface morphology and structure	Cuticle formation on grapes and tomatoes Gloss of some fruits (development of wax)
Size	All fruits and many vegetables
Specific gravity	Cherries, watermelons, potatoes
Shape	Angularity of banana fingers Compactness of broccoli and cauliflower

Maturity indices for selected fruits and vegetables (2)

INDEX	EXAMPLES
Solidity	Lettuce, cabbage, Brussels sprouts
Textural properties	
Firmness	Apples, pears, stone fruits
Tenderness	Peas
Toughness	Asparagus
Color, external	All fruits and most vegetables
Internal color and structure	Formation of jelly-like material in tomato fruits
	Flesh color of some fruits
Compositional factors	
Total solids	Avocado, kiwifruit
Starch content	Apples, pears
Sugar content, acid content, and/or sugar/acid ratio	Apples, pears, stone fruits, grapes, pomegranates, citrus, papaya, melons
Juice content	Lemons, limes
Oil content	Avocados
Astringency (tannin content)	Persimmons, dates
Internal ethylene concentration	Apples

Components of quality of fresh horticultural crops (1)

MAIN FACTORS	COMPONENTS
Appearance (visual)	Size: dimensions, weight, volume
	Shape and form: diameter/depth ratio, smoothness, compactness
	Color: uniformity, intensity
	Gloss: wax
	Defects: external, internal Morphological (such as sprouting, rooting, and floret opening) Physical and mechanical (such as shriveling and bruising) Physiological (such as blossom end rot of tomatoes) Pathological (caused by fungi, bacteria, or viruses) Entomological (caused by insects)
Texture	Firmness, hardness, softness
	Crispness
	Succulence, juiciness
	Mealiness, grittiness
	Toughness, fibrousness

Components of quality of fresh horticultural crops (2)

Flavor (taste and smell)	Sweetness
	Sourness (acidity)
	Astringency
	Bitterness
	Aroma (volatile compounds)
	Off-flavors and off-odors
Nutritive value	Carbohydrates (including dietary fiber)
	Proteins
	Lipids
	Vitamins
	Minerals
Safety	Naturally occurring toxicants
	Contaminants (chemical residues, heavy metals, etc.)
	Mycotoxins
	Microbial contamination

Numerous defects can influence ***appearance*** quality of horticultural crops. Morphological defects include sprouting of potatoes, onions, and garlic, rooting of onions, and seed germination inside fruits. Physical defects include shriveling (aszalódás) and wilting of all commodities; internal drying of some fruits; and mechanical damage such as punctures, cuts and deep scratches. Temperature-related disorders (freezing, chilling, sunburn, sun-scald), puffiness of tomatoes, blossom-end rot of tomatoes, tipburn of lettuce, internal breakdown of stone fruits, water core of apples, and black heart of potatoes are examples of physiological defects.

A Burger grape cluster exhibits (A) slight browning due to sunburn and (B) more severe sunburn and cracking. (C) *Left*, A healthy Barbera cluster and, *right*, a sunburned cluster with poor coloration and raisining.

Textural quality of horticultural crops is not only important for their eating and cooking quality but also for their *shipping ability*. Soft fruits cannot be shipped long distances without extensive losses owing to physical injuries. This has necessitated harvesting fruits at less than ideal maturity from the flavor quality standpoint in many cases.

Flavor quality involves perception of the tastes and aromas of many compounds. *Objective* analytical determination of critical components must be coupled with *subjective* evaluations by a taste panel to yield useful and meaningful information about flavor quality of fresh fruits and vegetables. This approach can be used to define a minimum level of acceptability. To find out consumer preferences for flavor of a given commodity, large-scale testing by a representative sample of consumers is required.

Fresh fruits and vegetables play a very significant role in human ***nutrition*,** especially as sources of vitamins (vitamin C, vitamin A, vitamin B6, thiamin, niacin), minerals, and dietary fiber. They also contain many phytochemicals (such as antioxidant phenolic compounds and carotenoids) that have been associated with reduced risk of some forms of cancer, heart disease, stroke, and other chronic diseases. Postharvest losses in nutritional quality, particularly vitamin C content, can be substantial and are enhanced by physical damage, extended storage, higher temperature, low relative humidity, and chilling injury of chilling-sensitive commodities.

Safety factors include levels of naturally occurring toxicants in certain crops (such as glycoalkaloids in potatoes) that vary according to genotypes and are routinely monitored by plant breeders to ensure that they do not exceed their safe levels in new cultivars. Contaminants, such as chemical residues and heavy metals, on fresh fruits and vegetables are also monitored by various agencies to ensure compliance with established maximum tolerance levels. Sanitation procedures throughout the harvesting and postharvest handling operations are essential to minimizing microbial contamination. Proper preharvest and postharvest handling procedures must be enforced to reduce the potential for growth and development of mycotoxin-producing fungi.

Quality factors for selected fresh fruits and vegetables in the U.S. standards for grades

Commodity	QUALITY FACTORS
Apple	Maturity, color (color charts), firmness, shape, size; freedom from decay, internal browning, internal breakdown, scald, scab, bitter pit, Jonathan spot, freezing injury, water core, bruises, russeting, scars, insect damage, and other defects.
Grape	Maturity (as determined by % soluble solids), color, uniformity, firmness,berry size; freedom from shriveling, shattering, sunburn, waterberry, shot berries, dried berries, other defects, and decay. Bunches: fairly well filled but not excessively tight. Stems: not dry and brittle, at least yellowish-green in color.
Lettuce	Turgidity, color, maturity (firmness), trimming (number of wrapper leaves); freedom from tip burn and other physiological disorders; freedom from mechanical damage, seedstems, other defects, and decay.
Tomato	Maturity and ripeness stage (color chart), firmness, shape, size; freedom from defects (puffiness, freezing injury, sunscald, scars, catfaces, growth cracks, insect injury, and other defects) and decay.


Biological Factors Involved in Deterioration

- Respiration
- Ethylene Production
- Compositional Changes
- Growth and Development
- Transpiration or Water Loss
- Physiological Breakdown
- Physical Damage
- Pathological Breakdown

Respiration

Respiration is the process by which stored organic materials (carbohydrates, proteins, fats) are broken down into simple end products with *a release of energy*. Oxygen (O_2) is used in this process, and carbon dioxide (CO_2) is produced. The loss of stored food reserves in the commodity during respiration hastens senescence as the reserves that provide energy to maintain the commodity's living status are exhausted; reduces food value (energy value) for the consumer; causes loss of flavor quality, especially sweetness; and causes loss of salable dry weight (especially important for commodities destined for dehydration). *The energy released as heat,* known as vital heat, affects postharvest technology considerations such as estimations of refrigeration and ventilation requirement.

Respiration rate is related to deterioration rate of horticultural perishables; the higher the respiration rate, the faster the deterioration rate and shorter the postharvest-life of a given commodity. *Respiration rate increases with temperature, exposure to ethylene, and physical and physiological stresses.*

Ethylene Production

Ethylene, the simplest of the organic compounds affecting the physiological processes of plants, is a natural product of plant metabolism and is produced by all tissues of higher plants and by some microorganisms. As a *plant hormone*, ethylene regulates many aspects of growth, development, and senescence and is physiologically active in trace amounts (less than 0.1 ppm). It also plays a major role in the abscission of plant organs.

Generally, ethylene production rates increase with maturity at harvest, physical injures, disease incidence, increased temperatures up to 30°C, and water stress. On the other hand, ethylene production rates by fresh horticultural crops are reduced by storage at low temperature, and by reduced O_2 (less than 8 percent) or ethylene is competitively inhibited by elevated CO_2 (above 1 percent) levels around the commodity

Compositional Changes

Many changes in *pigments* take place during development and maturation of the commodity on the plant. Some may continue after harvest and can be desirable or undesirable. Loss of chlorophyll (green color) is desirable in fruits but not in vegetables. Development of carotenoids (yellow and orange colors) is desirable in fruits such as apricots, peaches, and citrus; the desired red color development in tomatoes, watermelons, and pink grapefruit is due to a specific carotenoid (lycopene); beta-carotene is provitamin „A" and is important in nutritional quality. Development of anthocyanins (red and blue colors) is desirable in fruits such as apples (red cultivars), pomegranates, cherries, strawberries, cane berries, and red-flesh oranges; these water-soluble pigments are much less stable than carotenoids. Changes in anthocyanins and other phenolic compounds, however, are undesirable because they may result in tissue browning.

Changes in carbohydrates include starch-to-sugar conversion (undesirable in potatoes but desirable in apple, banana, kiwifruit, mango, and other fruits), sugar-to-starch conversion (undesirable in peas and sweet corn but desirable in potatoes), and conversion of starch and sugars to CO_2 and water through respiration. Breakdown of pectins and other polysaccharides results in softening of fruits and a consequent increase in susceptibility to mechanical injures. Increased lignin content is responsible for toughening of asparagus spears and root vegetables.

Changes in organic acids, proteins, amino acids, and lipids can influence flavor quality of the commodity. Loss in vitamin content, especially ascorbic acid (vitamin „C"), is detrimental to nutritional quality. Production of flavor volatiles associated with ripening of fruits is very important to their eating quality.

Growth and Development

Sprouting of potatoes, onions, garlic, and root crops greatly reduces their utilization value and accelerates deterioration. Rooting of onions and root crops is also undesirable.

Similar geotropic responses occur in cut gladiolus and snapdragon flowers stored horizontally. Seed germination inside fruits such as tomatoes, peppers, and lemons is an undesirable change.

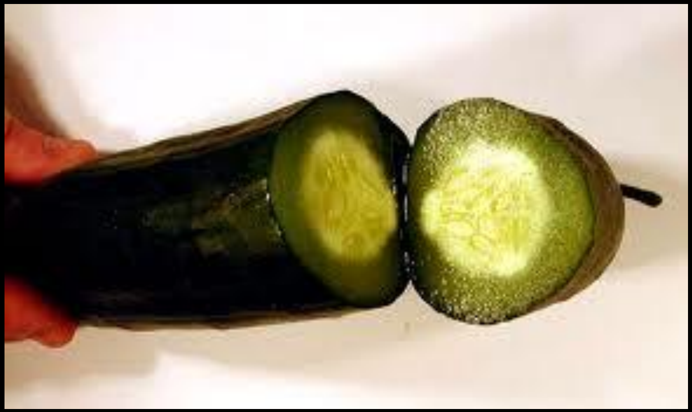
Transpiration or Water Loss

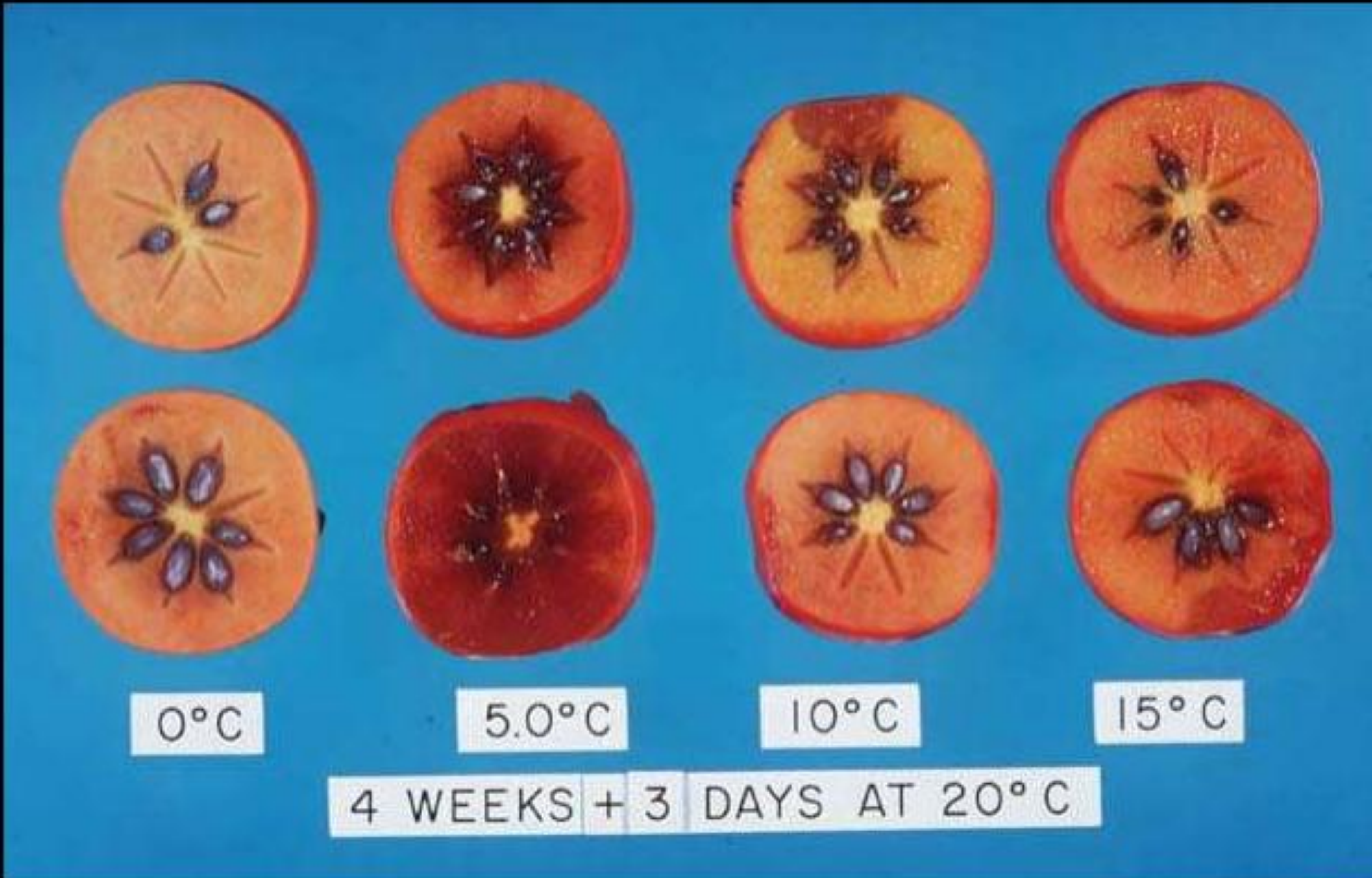
Water loss is a main cause of deterioration because it results not only in direct quantitative losses (loss of salable weight) but also in losses in appearance (wilting and shriveling), textural quality (softening, flaccidity, limpness, loss of crispness and juiciness), and nutritional quality.

Transpiration rate is influenced by internal or commodity factors (morphological and anatomical characteristics, surface-to-volume ratio, surface injuries, and maturity stage) and external or environmental factors (temperature, relative humidity, air movement, and atmospheric pressure). Transpiration (evaporation of water from the plant tissues) is a physical process that can be controlled by applying treatments to the commodity (e.g., *waxes* and other surface coatings and *wrapping with plastic films*) or by *manipulating the environment* (e.g., maintenance of high relative humidity and control of air circulation.

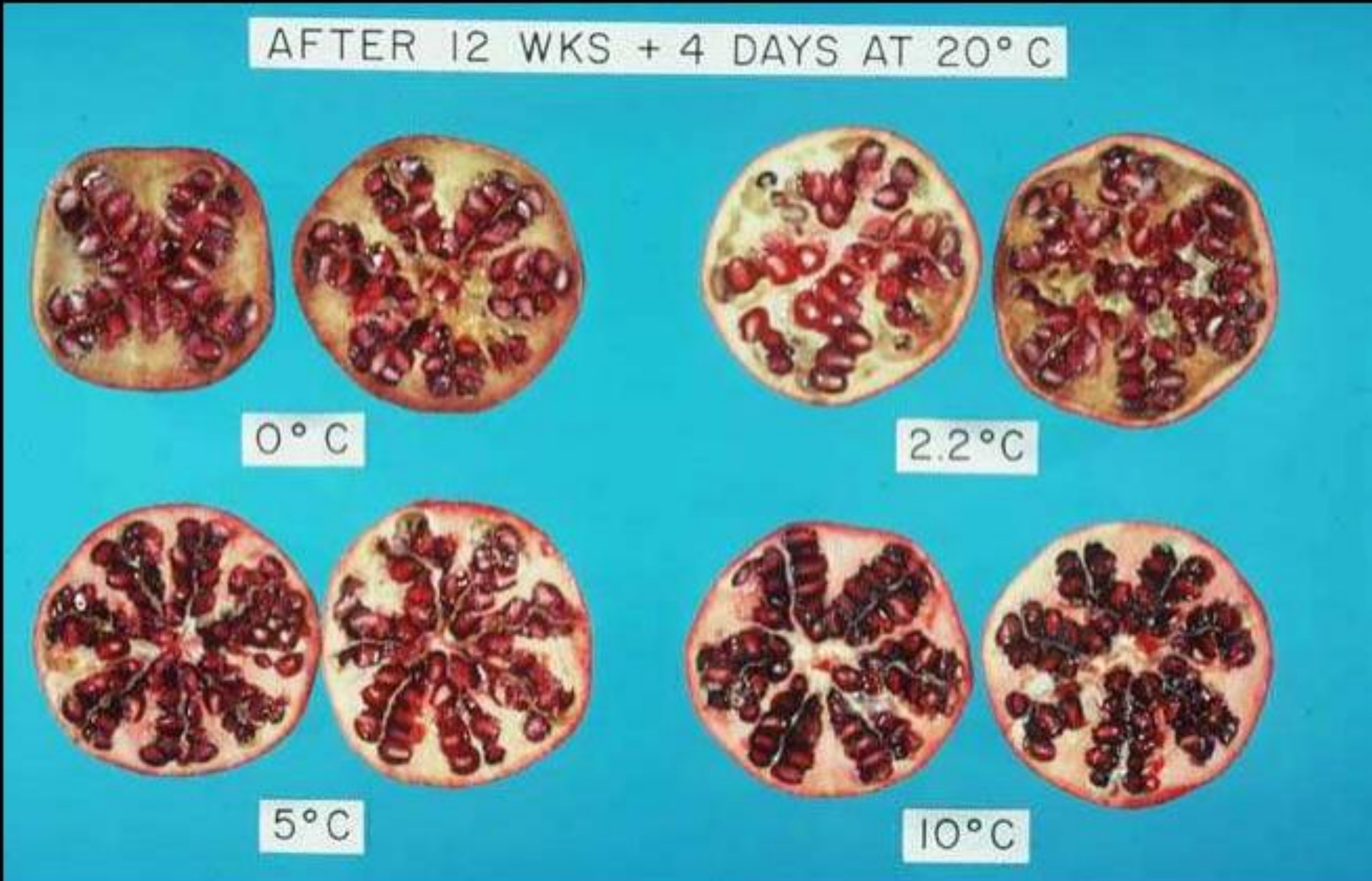
Physiological Breakdown

Exposure of the commodity to undesirable *temperatures* can result in physiological disorders. Freezing injury results when commodities are held below their freezing temperatures. The disruption caused by freezing usually results in immediate collapse of the tissues and total loss. Chilling injury occurs in some commodities (mainly those of tropical and subtropical origin) held at temperatures above their freezing point and below 5° to 15°C (41°-59°F), depending on the commodity. Chilling injury symptoms *become more noticeable* upon transfer to higher (nonchilling) temperatures. The most common symptoms are surface and internal discoloration (browning), pitting, water soaked areas, uneven ripening or failure to ripen, off-flavor development, and accelerated incidence of surface molds and decay (especially organisms not usually found growing on healthy tissue). Heat injury is induced by exposure to direct sunlight or to excessively high temperatures. Its symptoms include bleaching, surface burning or scalding, uneven ripening, excessive softening, and desiccation.





Chilling injury of Persimmons



Chilling injury of Pomegranate

Sunburn of apple

Certain types of physiological disorders originate from preharvest *nutritional imbalances*. For example, blossom-end rot of tomatoes and bitter pit of apples result from *calcium deficiency*. Increasing calcium content via preharvest or postharvest treatments can reduce the susceptibility to physiological disorders. Calcium content also influences the textural quality and senescence rate of fruits and vegetables; increased calcium content has been associated with improved firmness retention, reduced CO_2 and ethylene production rates, and decreased decay incidence.

Very low *oxygen* (less than 1 percent) and high *carbon dioxide* (greater than 20 percent) atmospheres can cause physiological breakdown (fermentative metabolism) of most fresh horticultural commodities. *Ethylene* can induce physiological disorders in certain commodities. The interactions among O_2, CO_2, and ethylene concentrations, temperature, and duration of storage influence the incidence and severity of physiological disorders related to atmospheric composition.

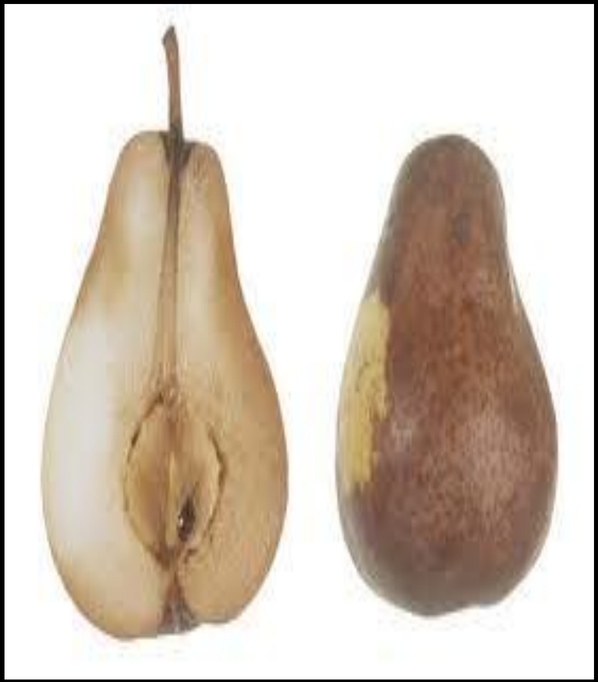
Core breakdown of pear

Bitter pit of apple

Internal browning of apple

Peach Inking


Granny Smith
Water Core



fermentative
metabolism

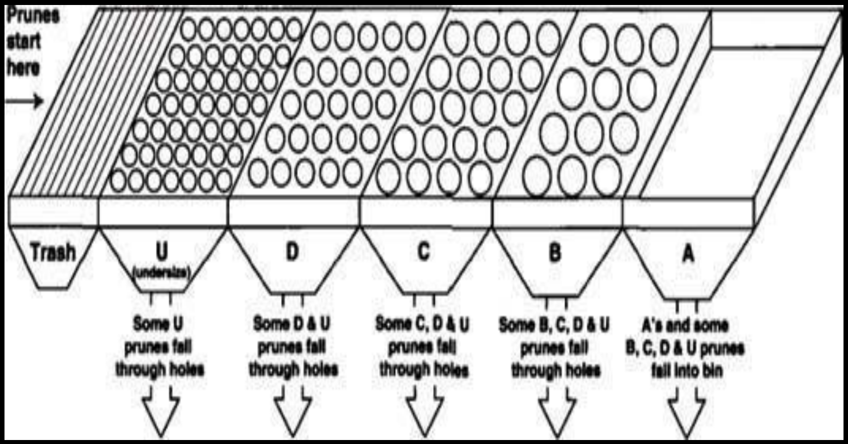
Physical Damage

Various types of physical damage (surface injuries, impact bruising, vibration bruising, and so on) are major contributors to deterioration. Browning of damaged tissues results from membrane disruption, which exposes phenolic compounds to the polyphenol oxidase enzyme. Mechanical injuries not only are unsightly but also accelerate water loss, provide sites for fungal infection, and stimulate CO_2 and ethylene production by the commodity.

Pits caused by a drop to a rough surface

Pathological Breakdown

One of the most common and obvious symptoms of deterioration results from the activity of *bacteria and fungi*. Attack by most organisms follows physical injury or physiological breakdown of the commodity. In a few cases, pathogens can infect apparently healthy tissues and become the primary cause of deterioration. In general, fruits and vegetables exhibit considerable resistance to potential pathogens during most of their postharvest life. The onset of ripening in fruits, and senescence in all commodities, renders them susceptible to infection by pathogens. Stresses such as mechanical injuries, chilling, and sunscald lower the resistance to pathogens.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(undersize)
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through holes
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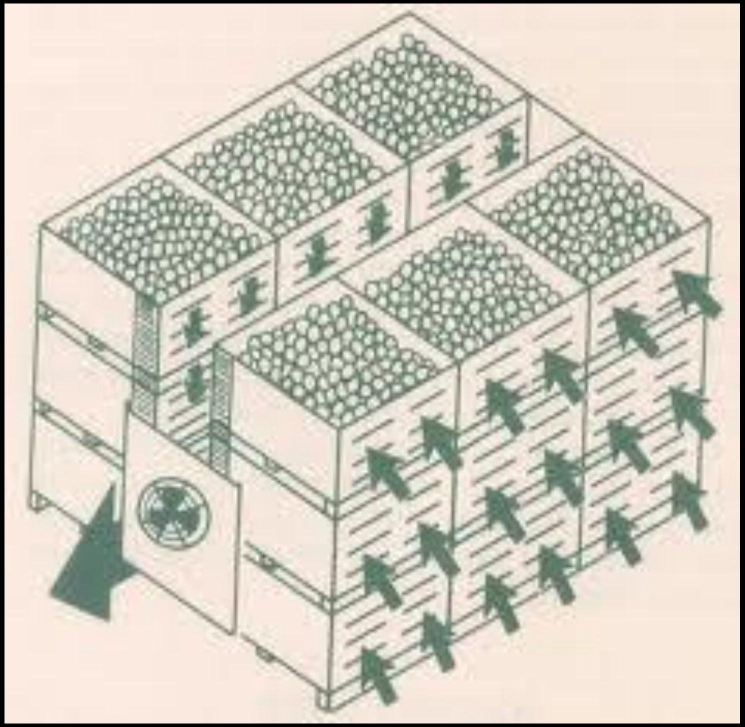
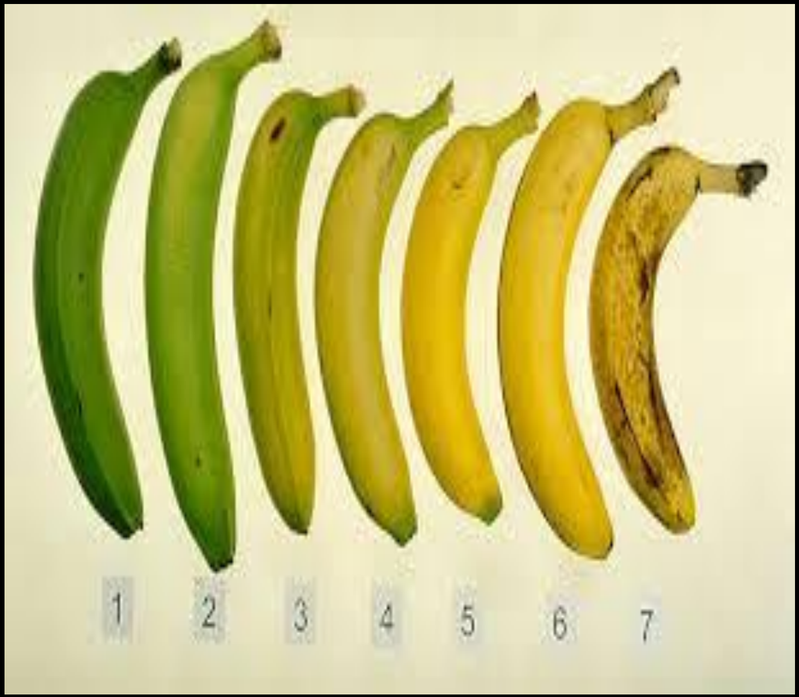
degreening

precooling



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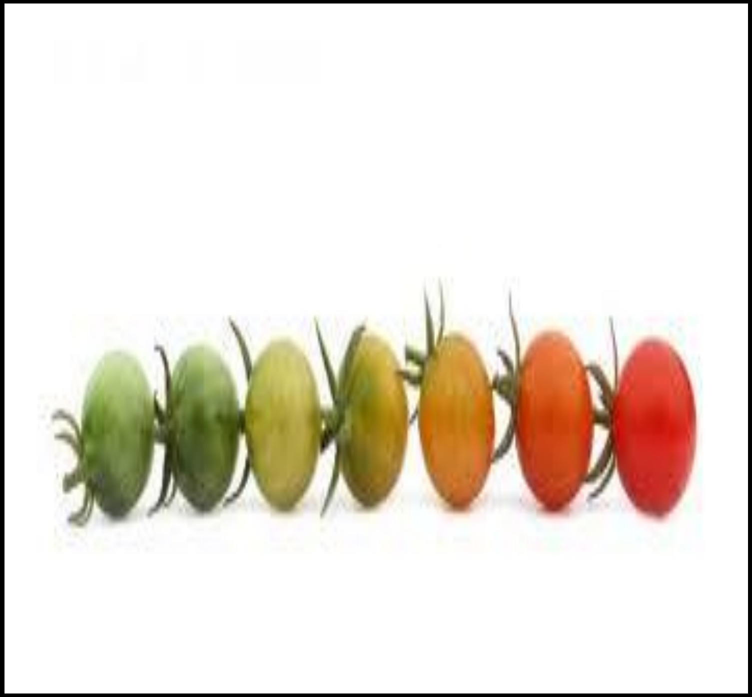


APPLES / POMMES