9th lecture: Physiology

Waxing and packaging

Waxing (coating)

1. Improving external appearance (shine)
2. Reducing the rate of water loss
3. Delay ripening the fruit
4. Allows gases to pass
5. Carrier for the application of pesticides, growth hormones, etc.

Wax contain solids from:

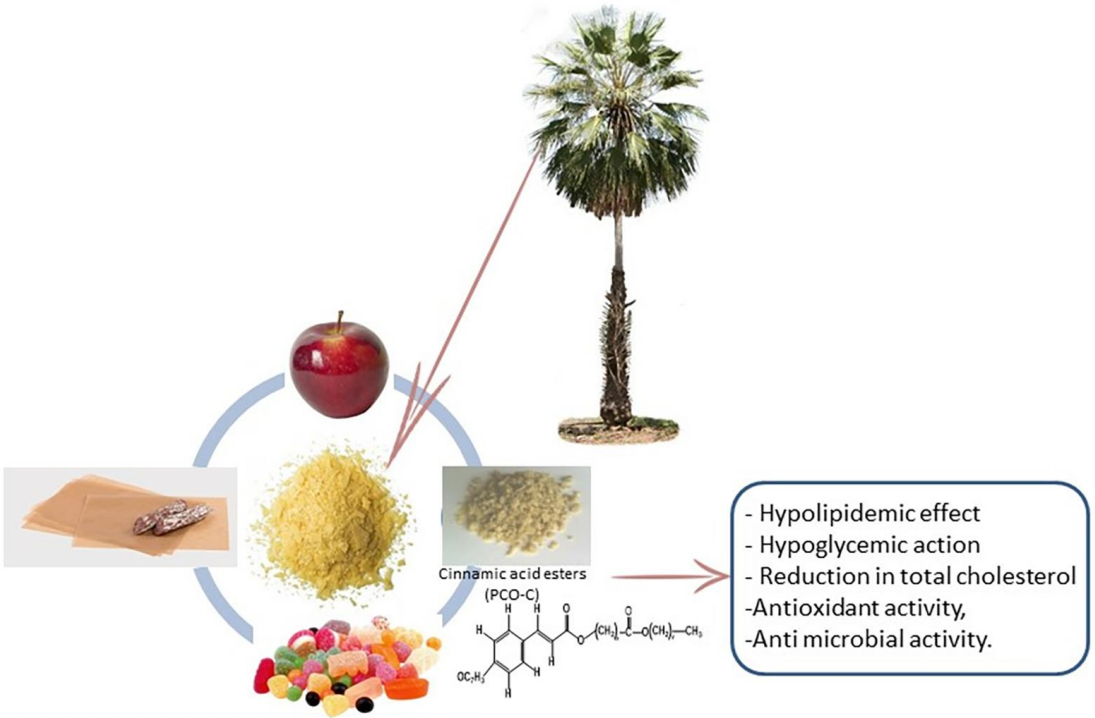
1. plant ingredients (carnauba, candelilla, tree resins),
2. insect secretions (shellac, wax bees),
3. petroleum products (paraffin, polyethylene, mineral oils)

Tree resins

Tree Douglas

Candelilla

Wax extracted from leaves of Carnauba, Brazil



- Hypolipidemic effect
- Hypoglycemic action
- Reduction in total cholesterol
-Antioxidant activity,
-Anti microbial activity.

Codex *Alimentarius* - food additive (**INS 903**):
- Glazing agent;
- Acidity regulator;
- Anticaking and carrier.

Edible shiny coatings of carnauba

Insect secretions - Shellac is a resin secreted by the female *Kerria lacca* on trees in the forests of India and Thailand

300.000 Insects secrete about 1 kg of shellac

Bee Wax products

Waxes are classified according to:

- **The solid soluble components**
  Shellac wax, polyethylene wax and carnauba wax

Or according

- **The solubility basis**
  as petroleum soluble or water soluble.

Petroleum wax (paraffin, polyethylene, mineral oil) are applied to fruits consumed without peel (avocado, banana, citrus, mango, melon, papaya, pumpkin, pineapple).

Shellac wax-based-water, or carnauba/candelilla wax based water-based are applied to fruits and vegetables consumed with their peel (apple, pear, or organic fruit).

Bee wax is applied to organic fruits or fruits and vegetables that are eaten with the peel.

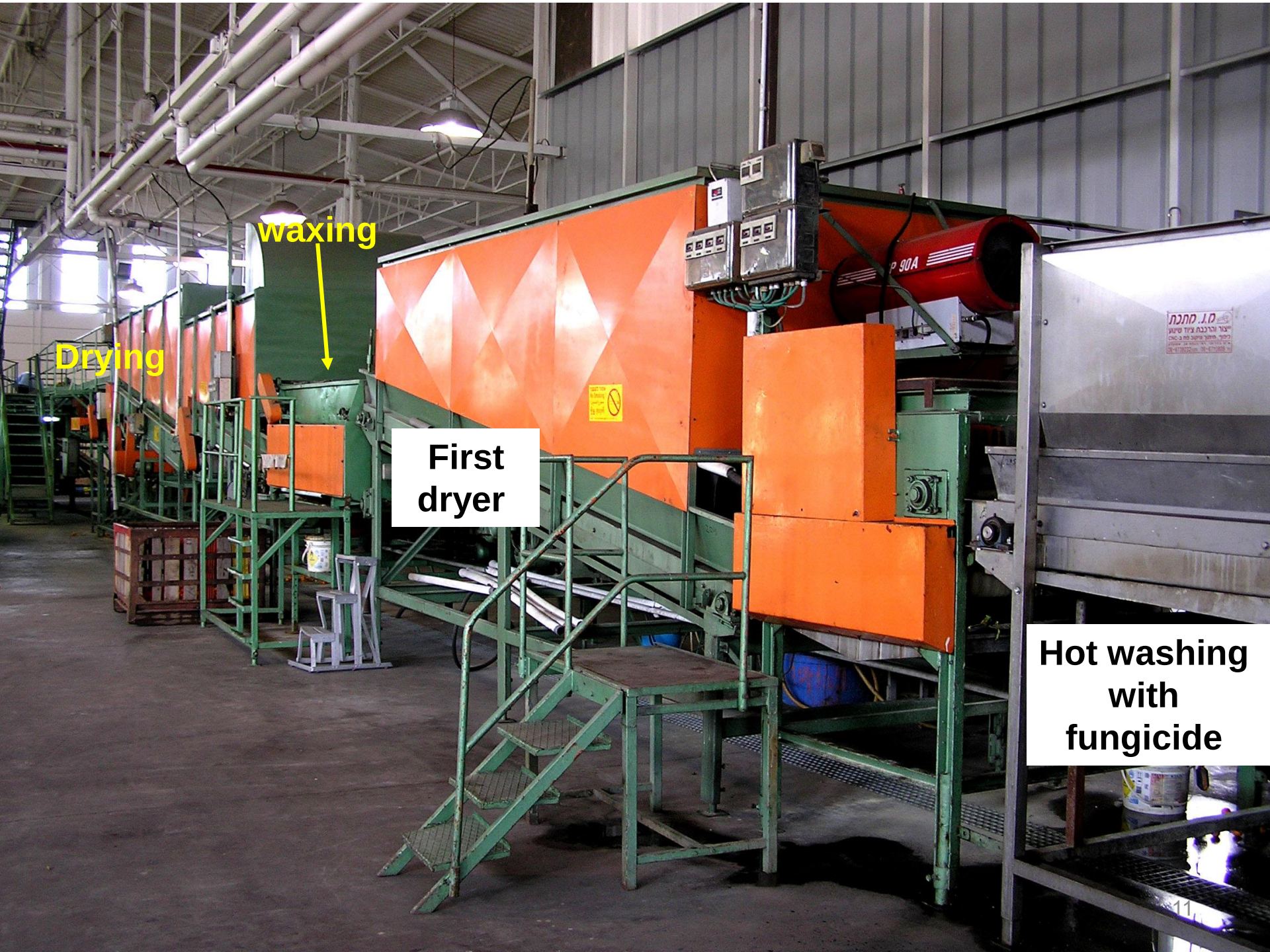
The petroleum-based materials (paraffin, polyethylene, mineral oils) are generally restricted to use in coatings for fruits and nuts where their peel or shell is not normally ingested, including avocado, banana, citrus, coconut, mango, melon, papaya, pineapple, pumpkin, and different nuts.

Water soluble shellac waxes are commonly used in coatings of apple fruit.

Natural edible coatings, mainly based on polysaccharides, are developed for use in fruit and vegetables that are digested with their peel,

Features required of Wax

- The wax must be in liquid aggregation mode
- The wax must cover well the whole surface of the fruit
- The wax must dry quickly
- The wax should not seal the fruit peel (allows gas pass)
- The wax must be resistant to re-wetting
- The wax must remain stable throughout the prolonged storage period
- The wax improve shines' of the fruit


waxing
Drying
First dryer
Hot washing with fungicide

Commercial waxing

Waxing

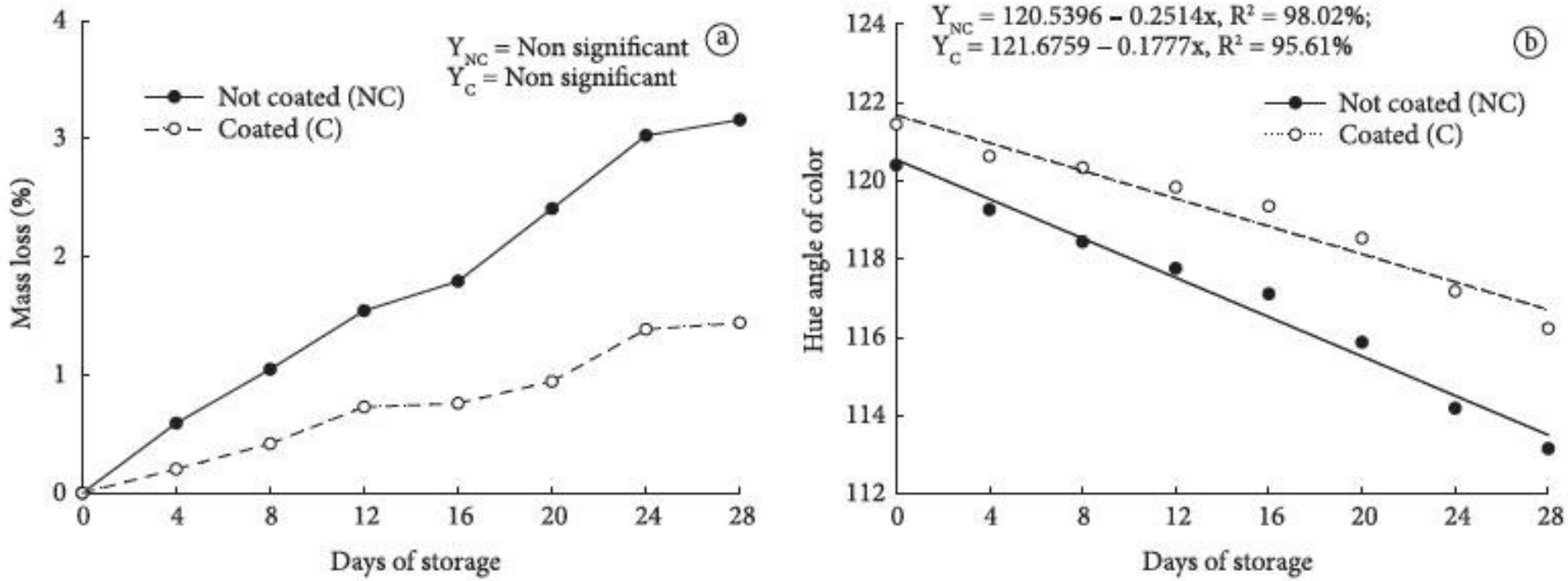
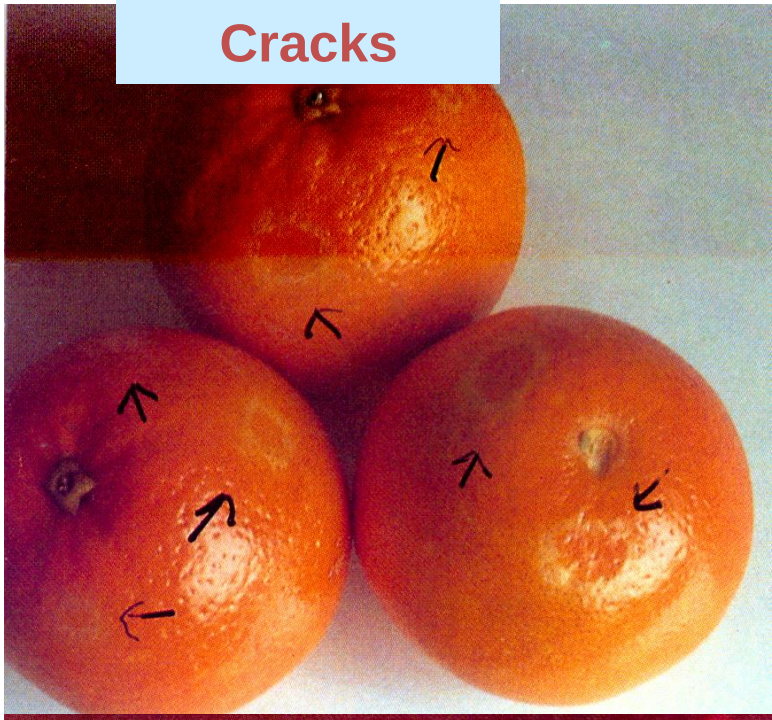


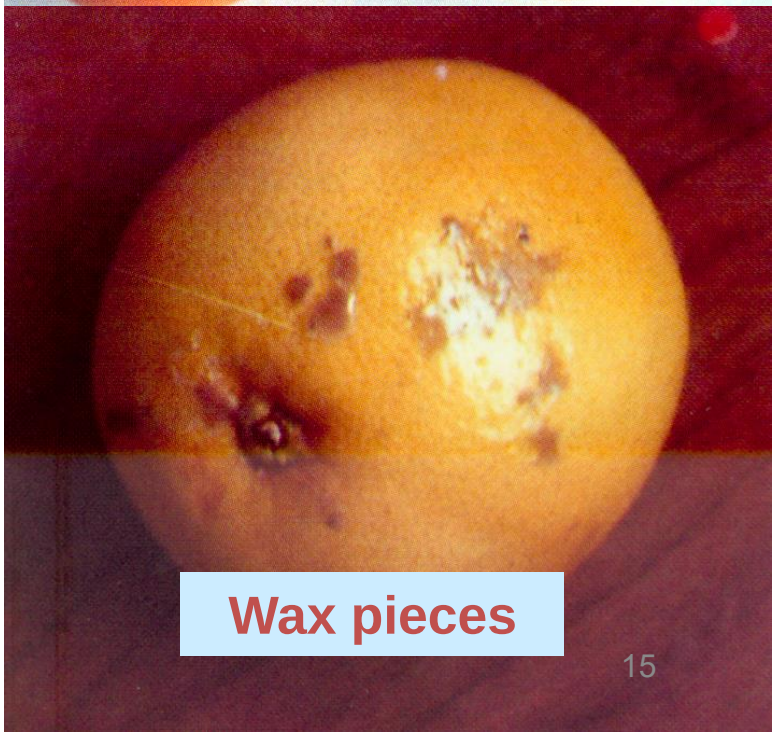
Figure 1. Trends in mass loss (a) and trends in hue angle (b) during storage in 'Delta Valência' oranges wax coated and cold stored.

Powder type of symptoms

lack of crystallization

Wax imperfections





Effects of waxes on gas exchange and water vapor loss

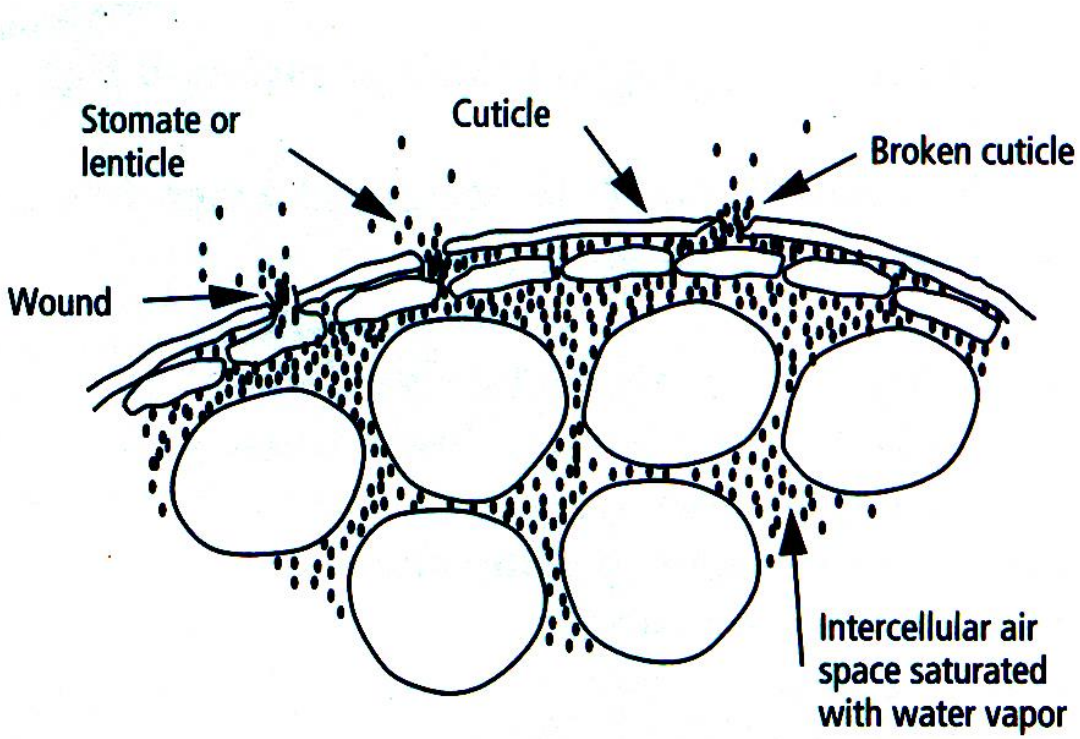
Gas and water vapor movement through the peel may occur:

1) **Through holes, such as stomata pores, the stem scar and wounds.**
2) **Through the cuticle layer.**

Gas exchange through holes is rapid, but is very slow through the cuticle.

Most gas and water vapor movement occurs through pores in the cuticle layer!!!

Primary routes of water loss in fresh produce



Air injected in pear travels through gas pathways to the fruit surface

Gas and water vapor movement through polymers depend on:

1) The difference in the concentration of the gas or water vapor inside and outside the peel
2) The diffusivity of the barrier
3) The thickness of the barrier

For most polymer barriers, the permeability of CO_2 is several times higher than that of O_2!

Waxes may influence internal gas levels in several ways:

1) **Waxing reduces peel permeability by adding a barrier to gas exchange.**
2) **Waxing reduces perforations (holes) on the peel surface by blocking them.**
3) **Waxing may indirectly affect fruit respiration rates (waxes usually reduce internal O_2 levels and, therefore, reduce respiration by 20-45%).**

Storage temperatures greatly affect respiration and gas exchange rates.

However, since respiration (O_2 uptake and CO_2 production) are influenced much more than the exchange of these gases through the peel, the O_2 levels decrease and CO_2 levels increase with increasing storage temperature.

Development of active edible coatings based on natural polymers

After 3 weeks at 7 C+ 4 days at 20 C

Polysaccharides- natural polymers, they are metabolized naturally, not expensive and easy to use.

Conclusions

1) Waxing greatly affects internal gas levels.

2) Shellac-based waxes restricts gas exchange much more then polyethylene-based waxes, and may lead to anaerobic respiration and development of off-flavors.

Effects of waxes on fruit ripening

Ripening processes, especially in climacteric fruit, involve increases in respiration and ethylene production rates, and requires oxygen.

Modification of the fruits internal atmosphere by application of waxes, decreases oxygen levels and thus retards ripening.

Tommy-Atkins mango after 3 weeks in 12C + 10 days in 20C

Organic treatment **No treatment**

Bananas after 2 weeks at 12C + 1 week at 17 C

WAX 538Z

WAX PA

Control

Grapefruit 'Oroblanco' after 6 weeks at 12 C

Carnauba **Control**

WAX effect on the outer appearance of the fruit and water loss

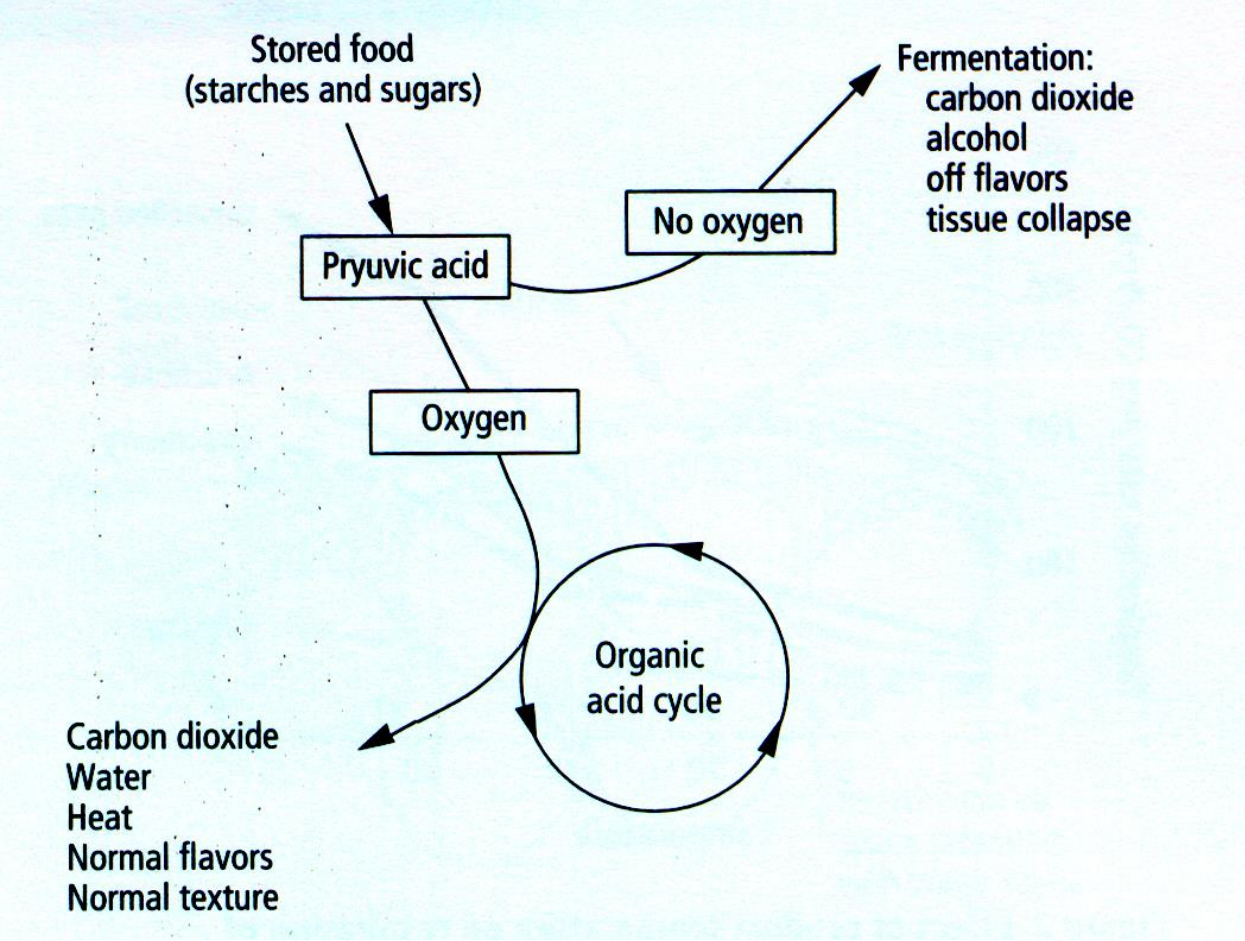
Control **Polyethylene wax**

Use a natural coating to preserve a cut apple

Anaerobic respiration

Application of waxes may block gas exchange and cause O_2 concentrations to fall to a value below the so-called extinction point, where aerobic respiration is replaced at least by part by anaerobic fermentation, resulting in the production of ethanol and off-flavors.

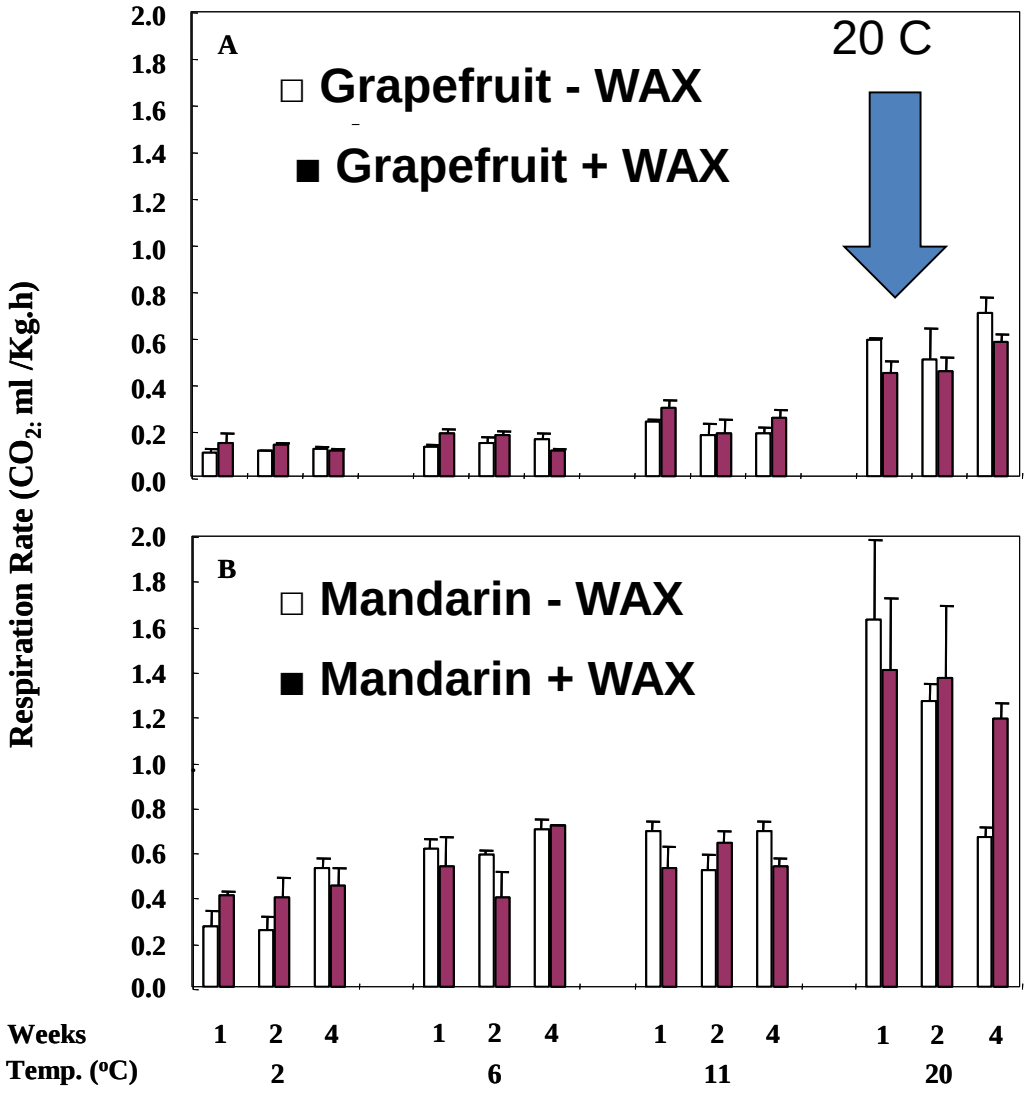
A simplified description of plant aerobic and anaerobic respiration pathways



Effects of polyethylene and shellac-based waxes on internal O_2, CO_2 and ethanol levels in grapefruit

Variety	Coating[z]	O_2 (%)	CO_2 (%)	$\Delta O_2/\Delta CO_2$[y]	Ethanol (ppm)
Marsh white grapefruit	Shellac	2.7	11.6	1.6	1679
	Polyethylene	7.9	6.1	2.1	826
	None	11.5	6.7	1.4	690

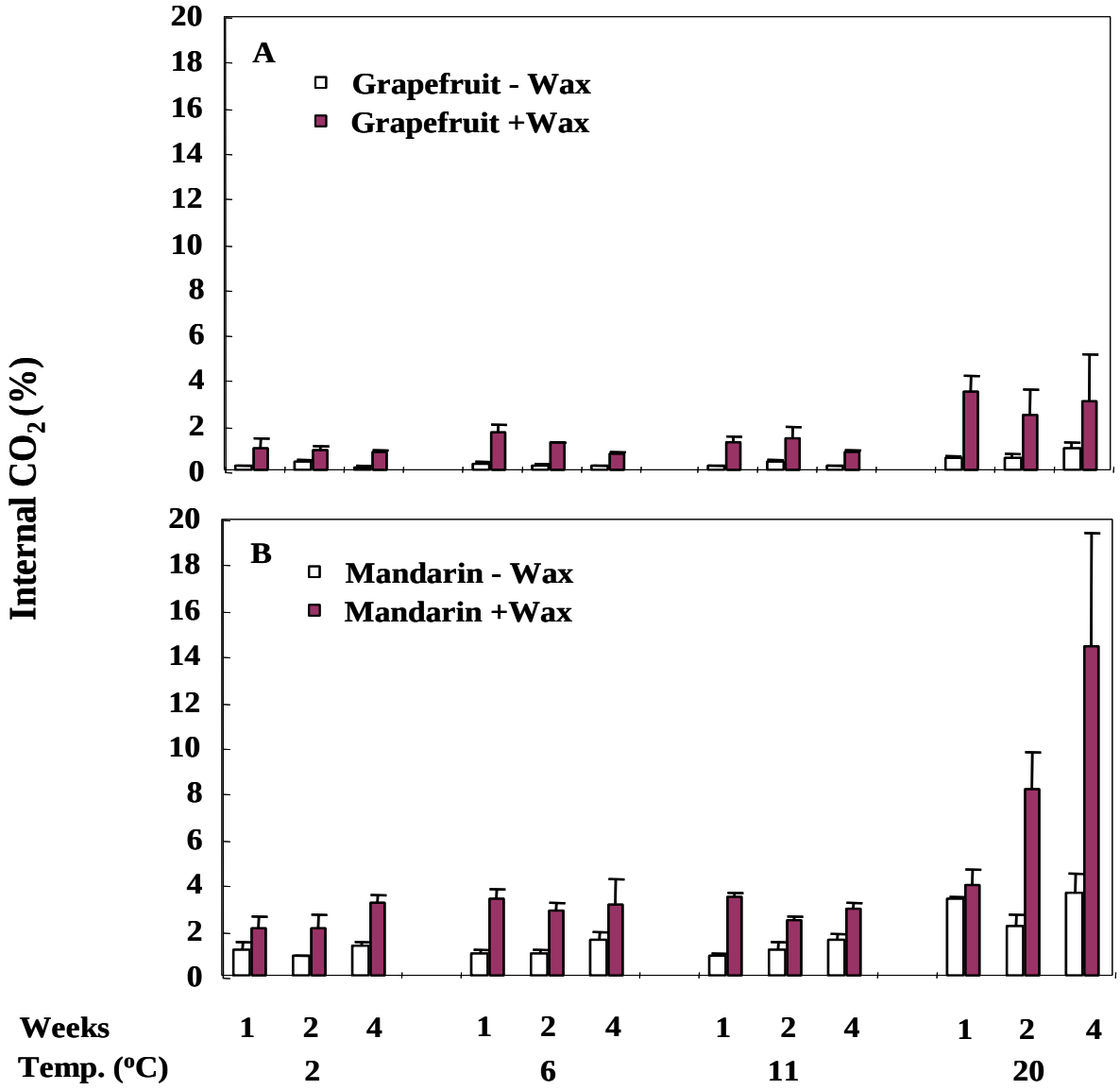
Effects of storage temperature on respiration rates



Grapefruit

Mandarin

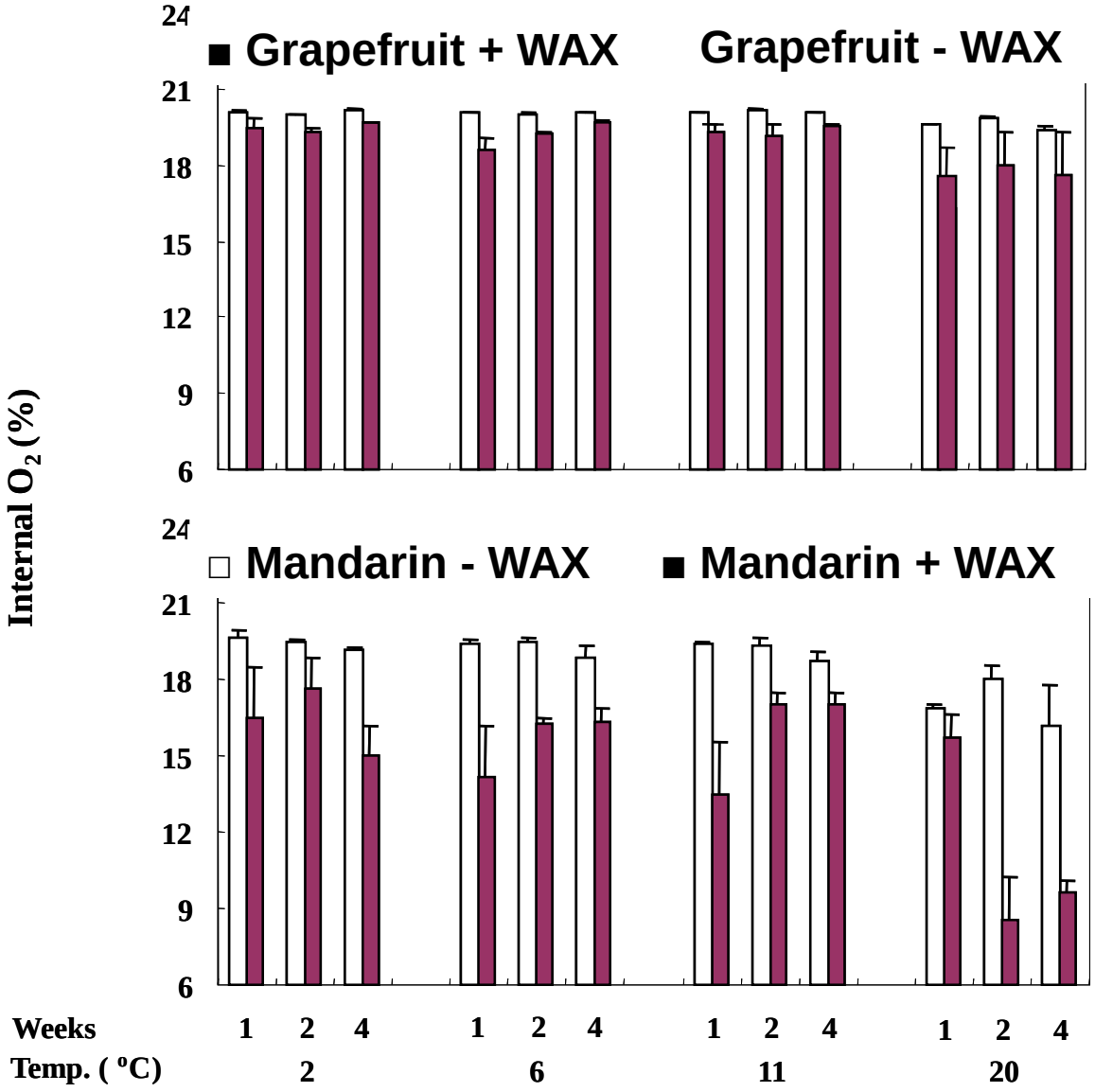
Effects of storage temperature on internal CO_2 levels



Grapefruit

Mandarin

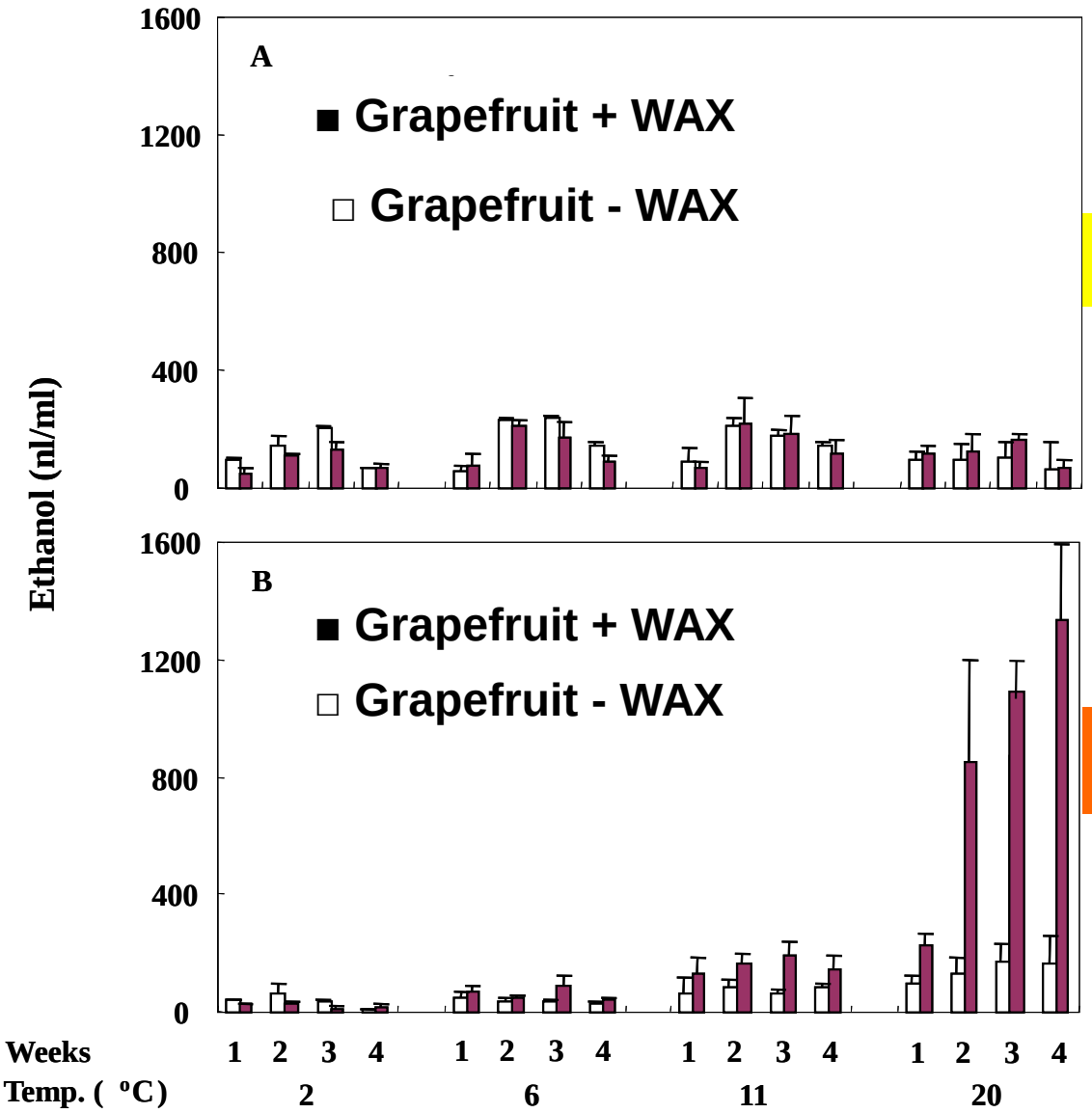
Effects of storage temperature on internal O_2 levels



Grapefruit

Mandarin

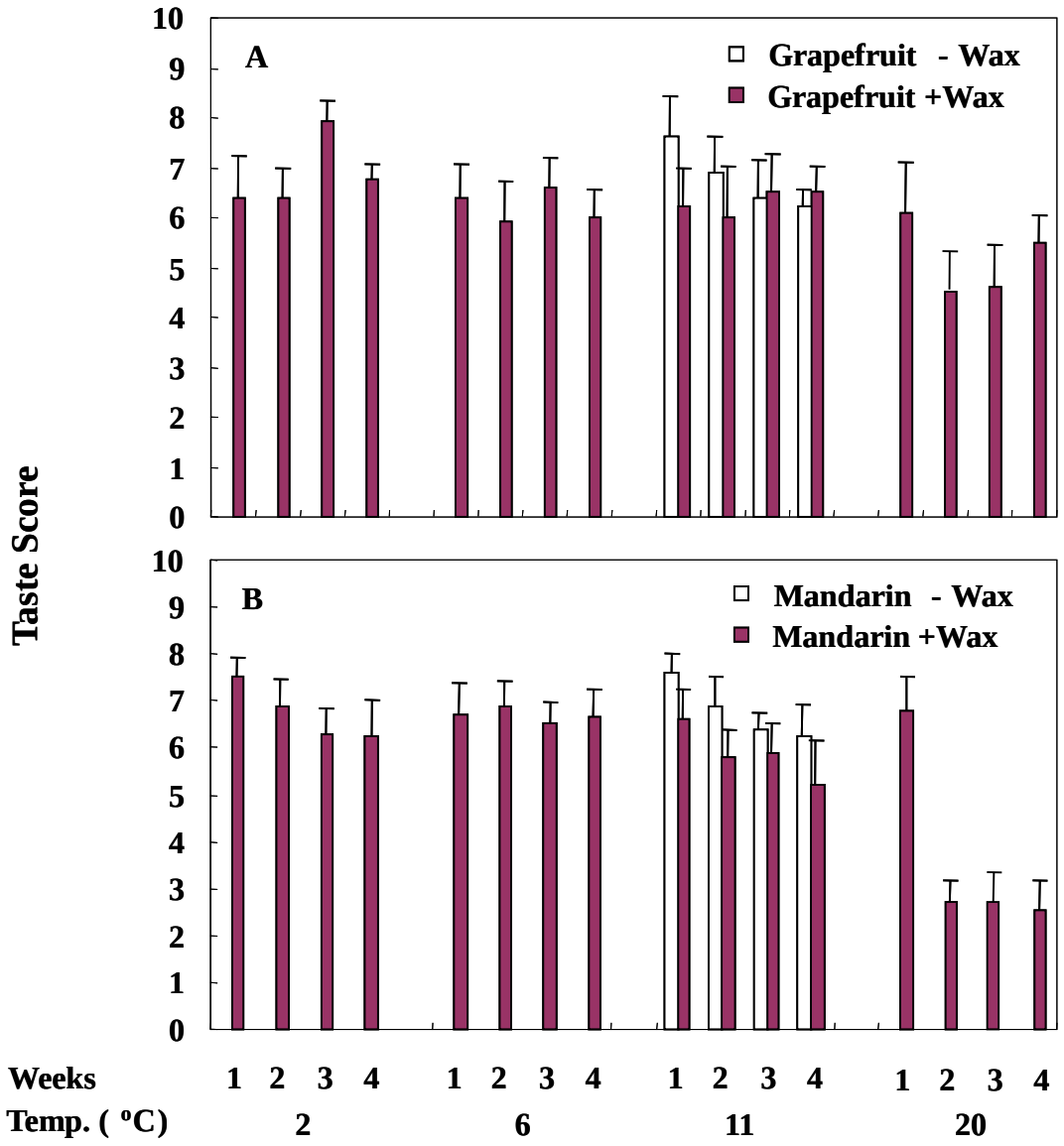
Effects of storage temperature on ethanol levels



Grapefruit

Mandarin

Effects of storage temperature on fruit taste



Grapefruit

Mandarin

Conclusions

1) Waxing greatly affects internal gas levels

2) Shellac-based waxes restricts gas exchange much more then polyethylene-based waxes, and may lead to anaerobic respiration and development of off-flavors

Packages are convenient units for marketing and distribution of horticultural products.

There are many different materials, sizes and shapes for packaging (more than 500 different kinds of packages are used in the US)

Packages at 'Rangies' wholesale market, Paris

Packaging of fresh produce

Packaging materials are convenient units for the marketing and distribution of fresh products and aim to protect the produce during these operations. There are hundreds of packaging types made of different materials, shapes and sizes.

International marketing can not be run by this type baskets

tomatos

International marketing can not be run by this type baskets

Durian

Ranbutan

Banana leaves for packaging

General properties of packages

√ Packages should protect the products from mechanical damage.

√ Packages should maintain their strength and shape during long periods of storage at high RH.

√ Packages should allow rapid cooling.

√ Packages must be adaptable to high volume packaging operations (build up of pallets).

√ Packages should display information about the produce.

√ Packages should be attractive to the consumers.

√ Packages should be inexpensive

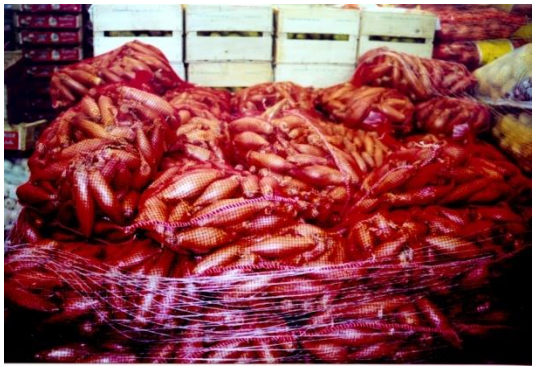
Most packages are made from: fiberboard
plastic
wood
fabric nets

Fiberboard box

Plastic box

Wood box

Fabric sacks



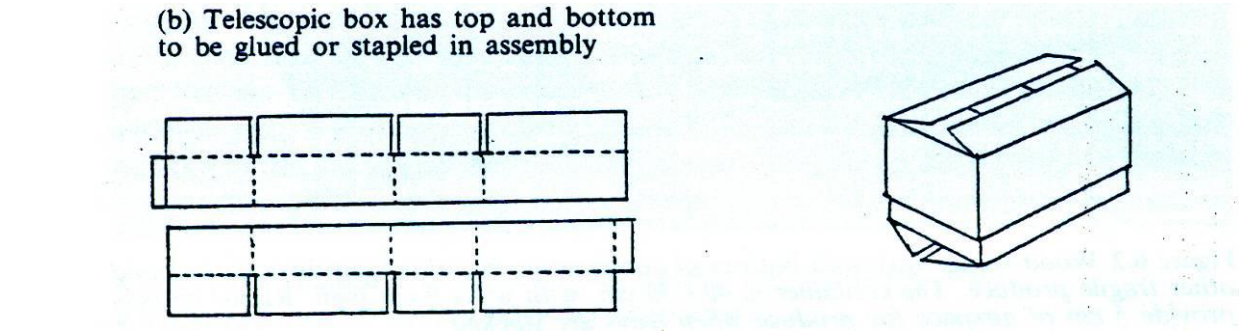
Bamboo baskets

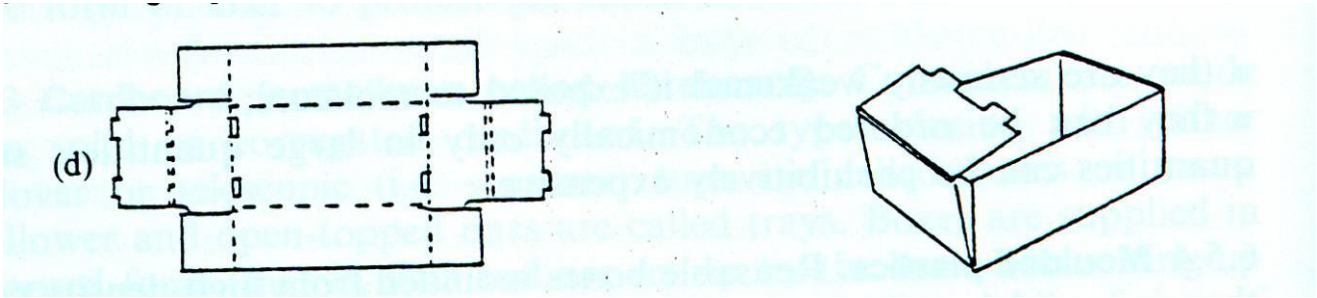
Fiberboard (cardboard) boxes

Made from solid or corrugated fiberboard.

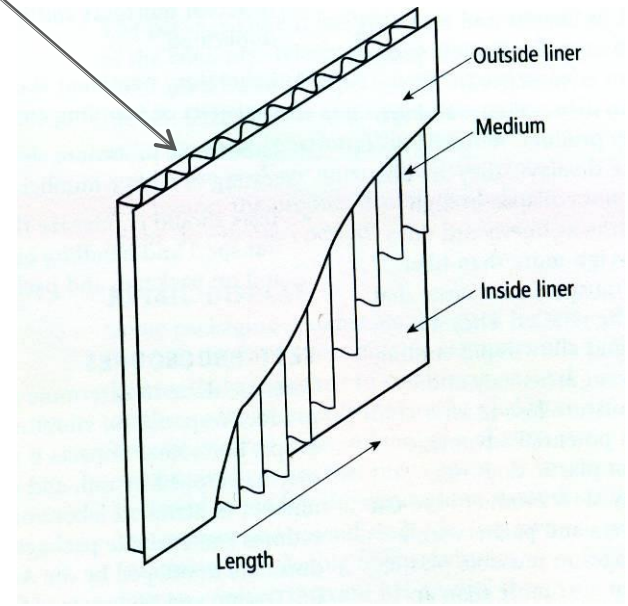
Include either fold over (telescopic) topped boxes or open topped trays.

The boxes can be supplied flat and set up by the users.





Corrugated fiberboard boxes can absorb some shocks by permanently compressing



Fiberboard boxes

Advantages

Light weight

Clean

Easily printed

Various sizes

Disadvantages

Expensive, if used only once

Easily damaged by careless handling

Seriously weakened if exposed to moisture

Need to be disposed

Plastic boxes

Made from high-density polyethylene.

Advantages

Very strong

Smooth

Easily cleaned

Resistance to moisture

Reusable

Disadvantages

Expensive

Require tight organization and control

Deteriorate when exposed to sunlight

Take a lot of space

Wood boxes

Made from thin covered wood (veneers) of various thicknesses.

Advantages

Rigid

Reusable

Stack well on trucks

Disadvantages

Difficult to clean

Expensive

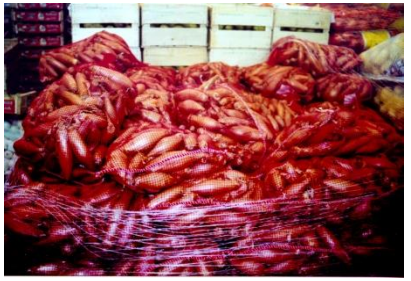
Heavy

Often have sharp edges or splinters

Fabric sacks

Made from polypropylene or polyethylene fibers.

Usually used with less easily damaged produce such as potatoes and onion.



Advantages

Inexpensive

Various capacities

Disadvantages

Lack rigidity, and handling, especially dropping, can damage the produce

Often too large for careful handling

Difficult to stack on pallets

Package requirements

- √ **Protection from injuries.**
- √ **Temperature management.**
- √ **Protection from water loss.**
- √ **Facilitating special treatments.**
- √ **Compatibility with handling systems.**
- √ **Economic considerations.**
- √ **Display information about the product**

Package requirements

Protection from injuries.

Temperature management.

Protection from water loss.

Compatibility with handling systems.

Economic considerations.

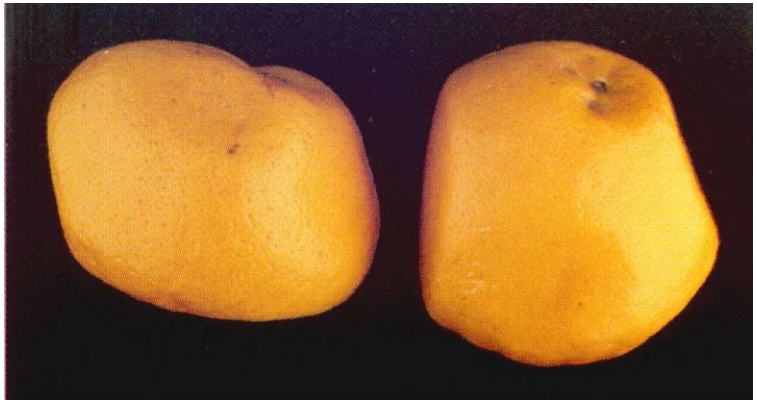
Display information about the product.

Protection from injuries

Impact (shock) bruises – are caused by dropping the product onto a hard surface.
Bruises could occur either during dropping the product into the box or by rough handling by hand or machinery.

Compression (squeezing) bruises – are caused by overfilling boxes or by allowing too much product depth.

Overfilled fiberboard boxes become week, and deform, and the weight of the packages above may cause compression bruises.



Soft commodities require shallow packing depths to prevent compression of the produce.

One layer packages of tomatoes

Vibration (shaking) damage – some products are damaged when they move inside the box during transit.

There are various techniques to pack the product so that it is immobilized in the box to prevent vibration damage:

1. **Packing in plastic bags.**
2. **Adding supplemental materials: trays, cups, pads, etc.**
3. **Tight-fill packing: padding that fills the free volume of the box.**

Using a plastic bag to prevent vibration damage in pears

A single-layer box of mangoes with dividers

Pads to prevent vibration damage in mango

Cupped trays for packing nectarines

Cupped trays for packing tomatoes

Cupped trays and paper wrapping for packing pears

Using paper pads for packing melons

Using filling materials to prevent vibration damage in melons

Package requirements

Protection from injuries.

Temperature management.

Protection from water loss.

Compatibility with handling systems.

Economic considerations.

Display information about the product.

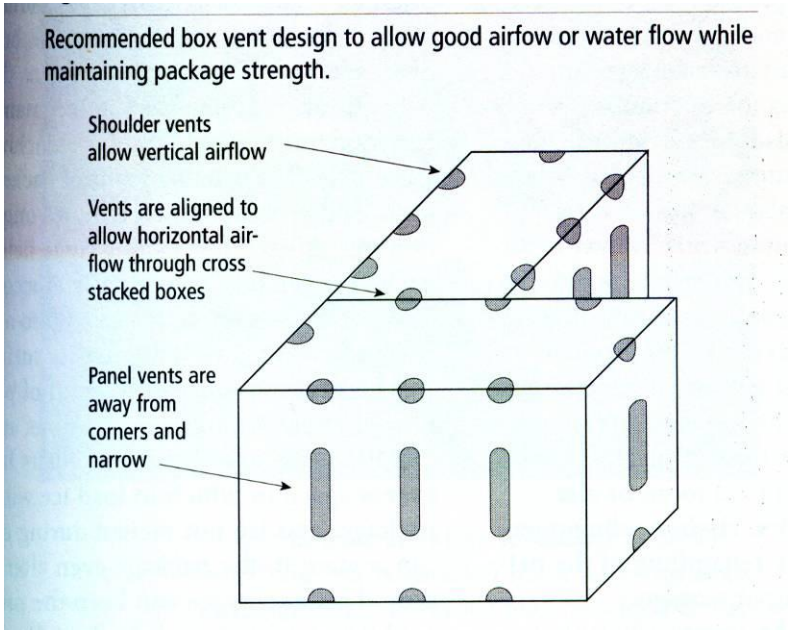
Temperature management

Packages must accommodate the temperatures requirements of the product!

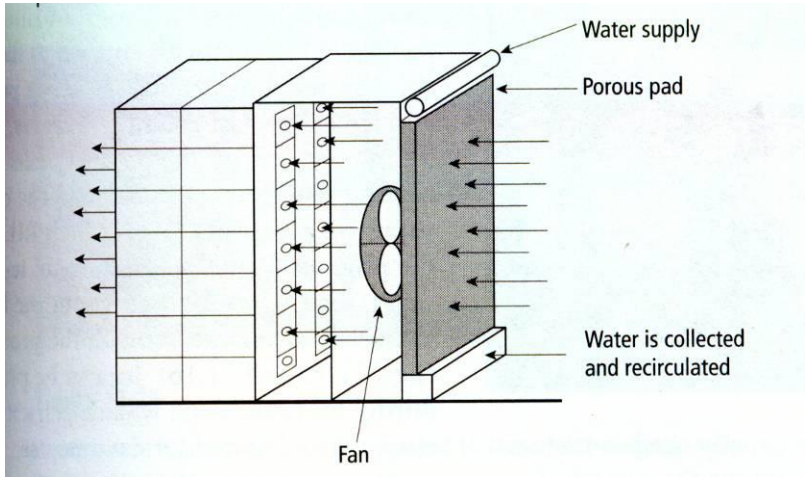
Good temperature management depends on good contact between the product in the package and the environment:

1. There should be sufficient air flow near package surface.

2. Ventilation is needed for forced-air cooling (increasing the ventilation area speeds heat exchange).



Corrugated fiberboard boxes with vertical ventilation slots



Forced-air cooling and movement of air through the ventilation areas

For corrugated fiberboard boxes: 5% venting area of side panels allows rapid cooling without overly weakening the package.

Most of the strength in corrugated fiberboard boxes is built near the corners. Therefore, it is recommended that the ventilation slots should be located at least 5 cm away from the edges and oriented vertically to minimize strength loss.

Ventilated packages used for forced-air cooling are also suitable for “in-box” room ripening with ethylene!

Maintaining low temperatures during air craft using insulation materials

Protection from water loss

Water loss occurs because of a water vapor pressure difference between the product (which is usually near saturation, 100% RH) and the environment.

Wood and fiberboard absorb water whereas plastic boxes do not!

Therefore, plastic boxes allow to maintain a saturated atmosphere within the package and reduce water loss.

The inside surface of corrugated fiberboard boxes may be coated with polyethylene wax emulsions to restrict moisture loss.

Package requirements

Protection from injuries.

Temperature management.

Protection from water loss.

Compatibility with handling systems.

Economic considerations.

Display information about the product.

Compatibility with handling systems

Most packages are hand lifted at some points of the marketing chain, so package weight must be limited.

A few commodities, like watermelons, are picked and marketed in pallet bins designed only for mechanical lifts.

Bulk bins designed for mechanical lifting

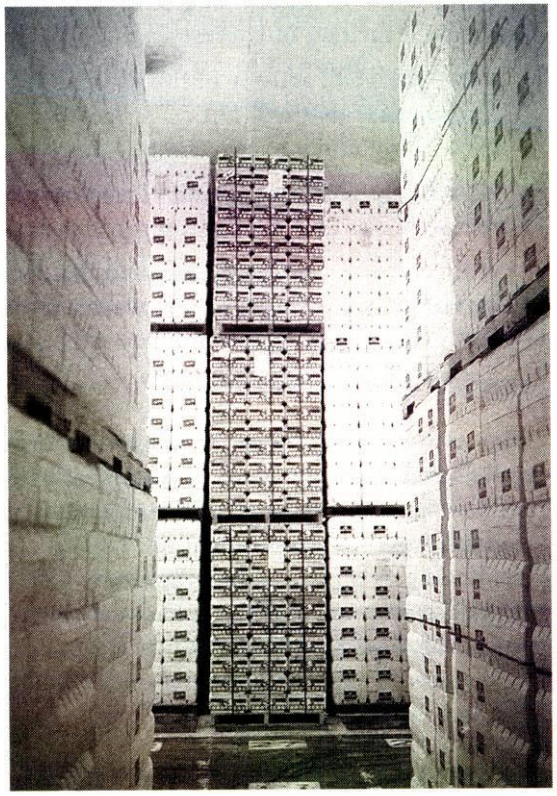
The packages should be sized to fill a pallet, that is usually 1.2 m x 1 m.

Table 10.1. Horizontal box dimensions for standard-sized pallets

Boxes per layer	Nominal outside box dimensions for 48" × 40" pallet* length × width (in)	Nominal outside box dimensions for 1,000 × 1,200 mm pallet length × width (mm)
4	24 × 12	500 × 300
5	24 × 16	600 × 400
6	20 × 16	500 × 400
8	20 × 12	500 × 300
9	19 × 13.3	400 × 333

Compression bruises may also occur if a box is not strong enough to support the weight of the boxes on top of it (It's not recommended to stock more then two pallets on top each other).

Interior view of a table grape cold storage.



Pallets in a cold storage room of grapes

Packing facilities

The chosen package must be compatible with other packing equipment (modifying the equipment is expensive).

A package used for field packing must be compatible with field conditions:

If the package might be exposed to rain – it's better to use plastic moisture-resistant boxes.

If packages are placed on the ground they may collect soil and contaminate neighboring boxes. In this case, it's better to use closed-top packages.

Handling

Each time a package is handled, the box and it's content are subject to damage.

Manual handling and palletizing is particularly damaging, since the workers usually drop heavy boxes into their position to prevent back pains. Therefore, filled boxes should not weigh more than 15-20 kg.

Retail display

Some packages are designed for use in retail display. For example, berries packed in small baskets, carrots in consumer size bags, mandarins in fabric nets, etc.

Attached booklets with peeling instructions

Package requirements

Protection from injuries.

Temperature management.

Protection from water loss.

Facilitating special treatments.

Compatibility with handling systems.

Economic considerations.

Display information about the product.

Economic considerations

Economic considerations of choosing a package type for a given commodity are complicated and may depend on various circumstances, including:

- **Direct cost of the package**
- **Effects of the package on reducing loss**
- **Disposal costs**

Overall, marketable experience shows that good produce well packed has an advantage over produce poorly packed, and the profits from it can cover the investment.

Package requirements

Protection from injuries.

Temperature management.

Protection from water loss.

Facilitating special treatments.

Compatibility with handling systems.

Economic considerations.

Display information about the product.

The package must display all relevant information for the costumer:

- **Place (country, farm) of production**
- **Date of packaging**
- **Name of variety**
- **Weight, size and quantity of the produce**
- **Postharvest applications of chemicals and waxes**


Sweet Clementines
OR
Jaffa
9371372
Jaffa
CITRUS / AGRUMES / ZITRUSFRÜCHTE
COATED WITH
AGENT D'ENROBAGE
UBERZUGSMITTEL
(E-904)
(E-914)
TREATED WITH
CONSERVATEUR
KONSERVIERUNGSMITTEL
(THIABENDAZOLE)
AND / OR
(O.P.P.)
(IMAZALIL)


I
Class/
Categorie/
Klasse
5 Kg.
WEIGHT/POIDS/GEWICHT
CAPSICUM
Grower/Producteur/
Produzent
Carmel
AGREXCO
121 HA'HASHIMONAIM ST.
TEL-AVIV 67133, ISRAEL
FAX: 972-3-5630918
PRODUCE OF ISRAEL
PAYS D'ORIGINE ISRAEL
RED
YELLOW
ORANGE
GREEN
Size
Calibre
Grösse
Diameter/Weight
Diametre/Poids
Durchmesser/Gewicht
S 60-80 mm
M 70-90 mm
M2 135-155 gr.
M 150-180 gr.
L 180-220 gr.
L 80-100mm
EL 90-110mm

Recent advances

Vacuum packages

Eco Pack™ - recyclable and re-usable plastic trays

Compostable (bio-degradable) packages

Oxo-biodegradable plastics

Totally Degradable Plastic Additives (*TDPA*)

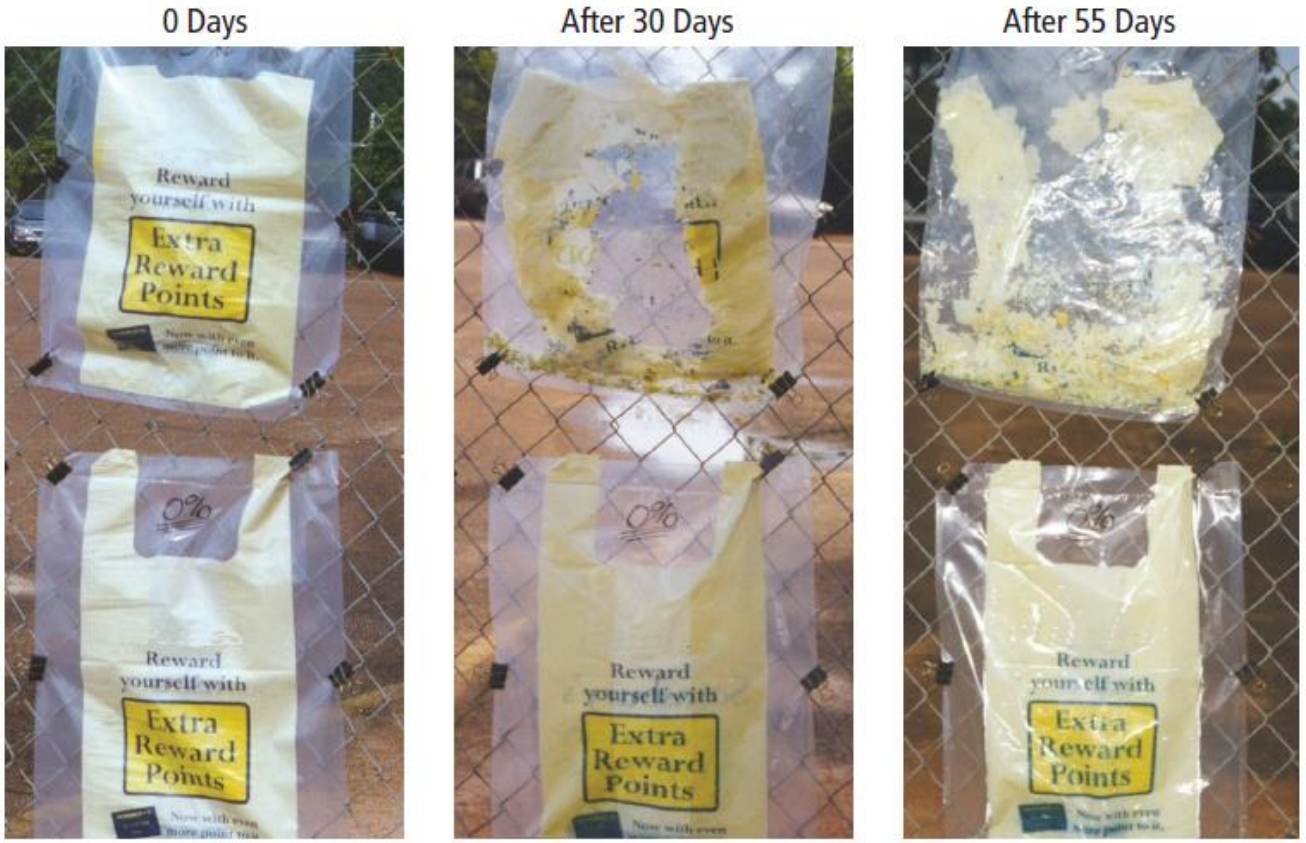


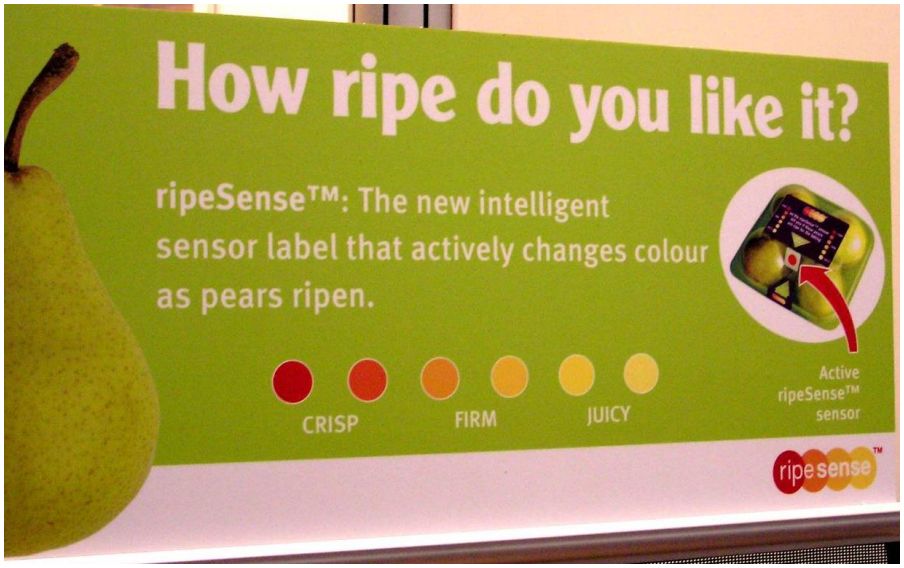
Photo illustration of the thermal degradation of a carrier bag incorporating EPI's TDPA® additive (top row) vs. a bag without EPI's TDPA® additive (bottom row). Test procedures follow ASTM D5272 "Outdoor Exposure Testing of Photo Degradable Plastics" Guidelines.

Active bags

Bags with ethylene absorbers

What's the secret?
Bio Fresh® Modified Atmosphere Packaging system (MAP) **absorbs gases such as Ethylene**, Ammonia and Hydrogen Sulfide which are the main catalyst gases in the ripening process of fruits and vegetables.

Smart packages - RipeSence™




That's all Folks!
kalilak