Post-Harvest Handling and Transportation Methods that Allow Small-Scale Growers To Deliver Top-Quality Produce

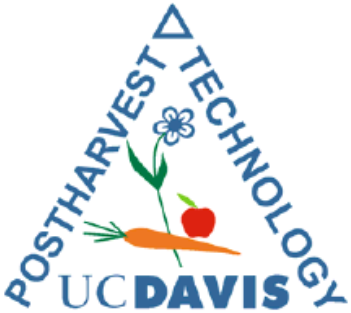
Jeff Kindhart, ***University of Illinois***

Why are good post harvest practices important?

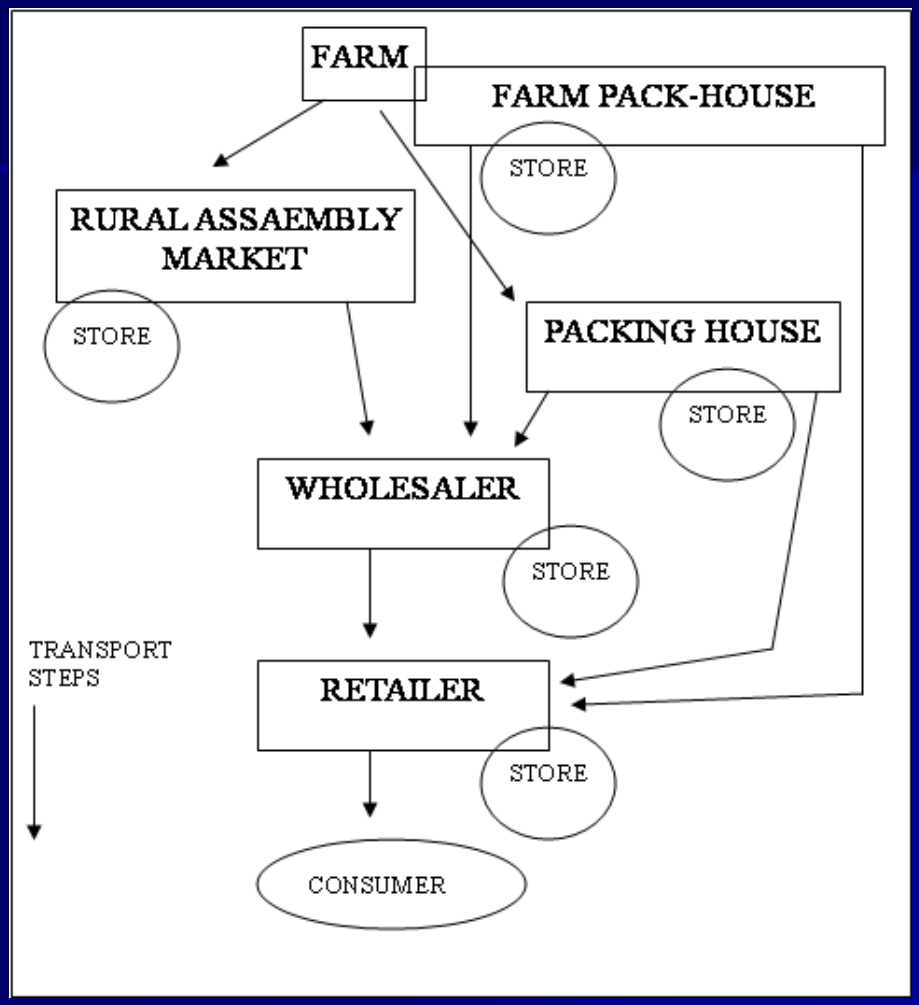
High-quality, disease free produce with a good shelf life is a result of good production practices, proper handling during harvest, and appropriate post harvest handling and storage. ---- ATTRA, Post harvest handling of fruits and vegetables

Small-Scale Postharvest Handling Practices: A Manual for Horticultural Crops (4th Edition)

Lisa Kitinoja and Adel A. Kader



University of California, Davis
Postharvest Technology Research and Information Center


FARM
FARM PACK-HOUSE
STORE
RURAL ASSAEMBLY MARKET
STORE
PACKING HOUSE
STORE
WHOLESALER
STORE
TRANSPORT STEPS
RETAILER
STORE
CONSUMER

Maintain Quality

- Appearance
- Texture
- Flavor
- Nutritive value

Immature-fruit vegetables	Cucumbers Squash Eggplant Peppers Okra Snap beans	Over-maturity at harvest Water loss (shriveling) Bruising and other mechanical injuries Chilling injury Decay
Mature-fruit vegetables and fruits	Tomato Melons Citrus Bananas Mangoes Apples Grapes Stone fruits	Bruising Over-ripeness and excessive softening at harvest Water loss Chilling injury (chilling sensitive fruits) Compositional changes Decay

RELATIVE PERISHABILITY	POTENTIAL STORAGE LIFE (WEEKS)	COMMODITIES
Very high	<2	Apricot, blackberry, blueberry, cherry, fig, raspberry, strawberry; asparagus, bean sprouts, broccoli, cauliflower, green onion, leaf lettuce, mushroom, muskmelon, pea, spinach, sweet corn, tomato (ripe); most cut flowers and foliage; minimally processed fruits and vegetables.

High	2-4	Avocado, banana, grape (without SO_2 treatment), guava, loquat, mandarin, mango, melons (honeydew, crenshaw, Persian), nectarine, papaya, peach, plum; artichoke, green beans, Brussels sprouts, cabbage, celery, eggplant, head lettuce, okra, pepper, summer squash, tomato (partially ripe).

Moderate	4- 8	Apple and pear (some cultivars), grape (SO_2-treated), orange, grapefruit, lime, kiwifruit, persimmon, pomegranate; table beet, carrot, radish, potato (immature).
Low	8-16	Apple and pear (some cultivars), lemon; potato (mature), dry onion, garlic, pumpkin, winter squash, sweet potato, taro, yam; bulbs and other propagules of ornamental plants.

Protect Food Safety

- Maintain good sanitation
- Avoid introduction of pathogens
- Keep from spoilage

Reduce Losses Between Harvest and Consumption

- Improves efficiency
- Improves profitability

Process begins the moment produce is harvested

- Avoid rough handling
  - Train workers – what and how
- Use appropriate harvesting container
- Try to avoid harvest in excessive heat
- Keep product as cool as possible while awaiting transport to the packing shed
  - Shade
  - Get to the shed

Packing Methods

- None ????
- Field packing
- Packing shed

Field packing

- Picking into final package
  - Reduced handling and associated damage
  - Reduces labor cost
  - Strawberries and peaches
- Self propelled field packing systems
  - Peppers and snap beans

Trip from field to packing shed

- Slow down ---- smooth ride
- Keep shaded if long trip or will sit out at shed before being packed

Packing Shed

Packing Shed

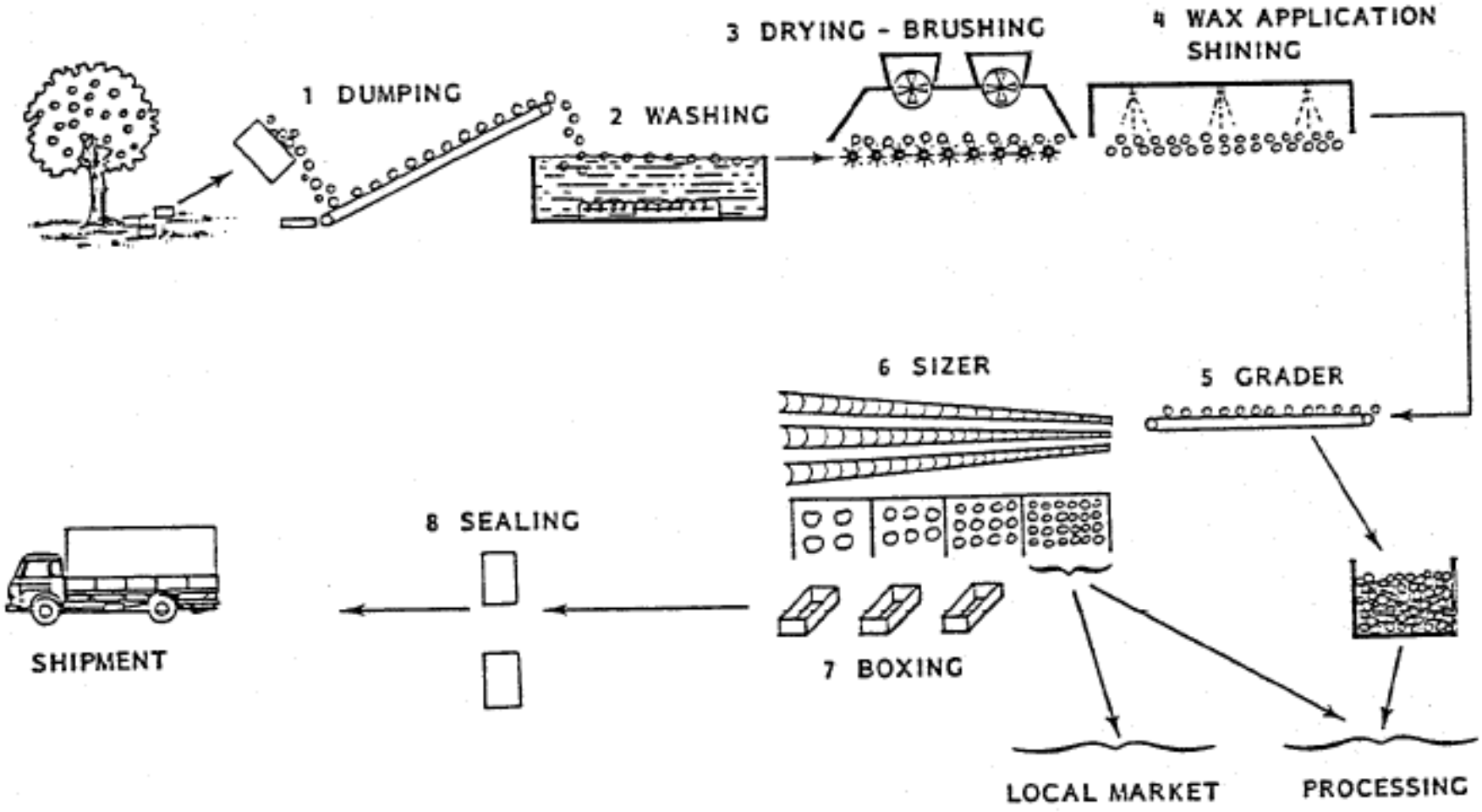
- Roof with or without sides
- Packing line
- Cold storage area
- Loading dock

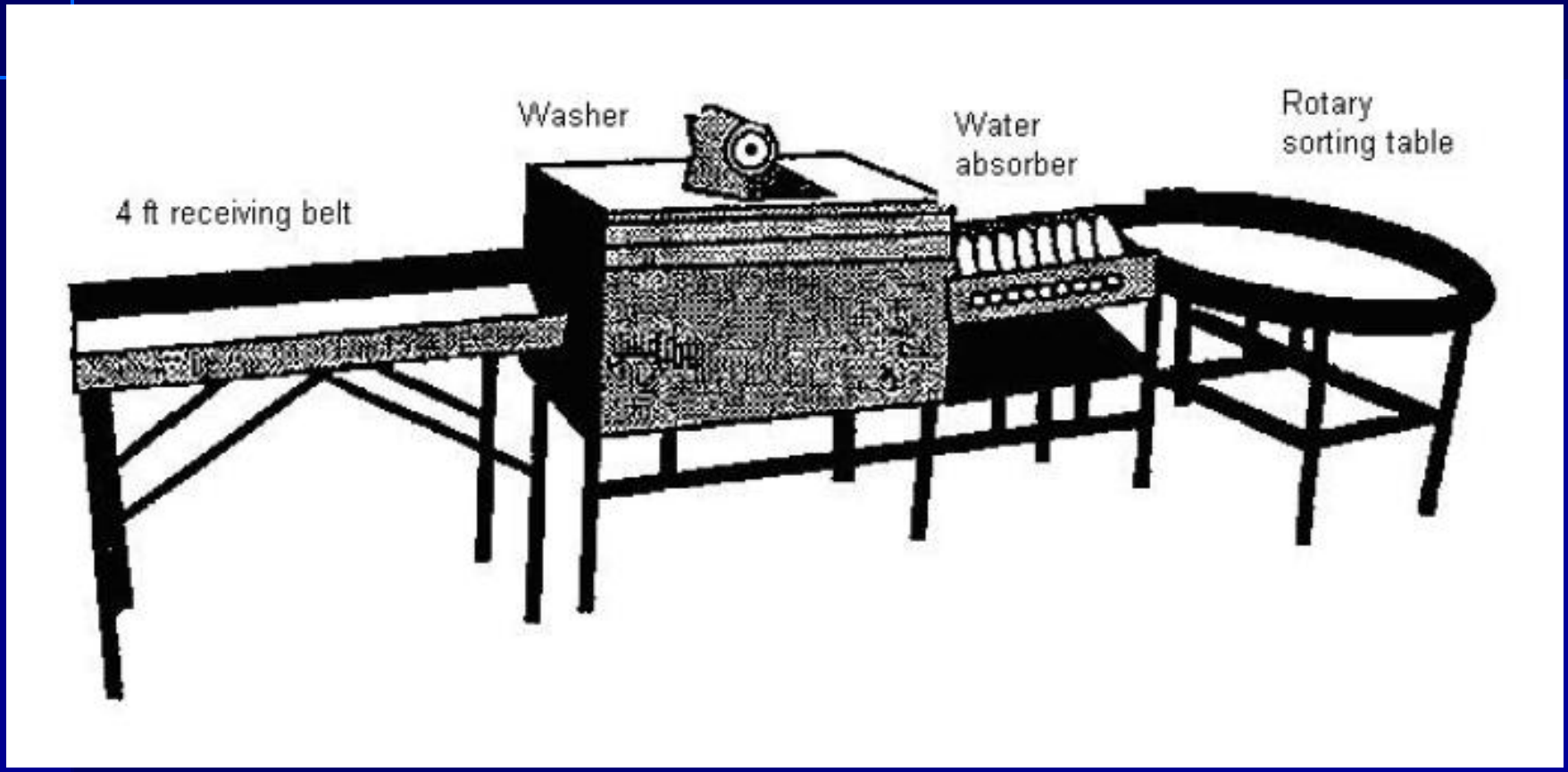
Packing line

- Should be appropriate for size of your operation
- Should be designed to work with commodity you grow
- Vary widely by producer

Components

- Dump
- Receiving line
- Washer (waxer)
- Inspection table
- Sizer (label applicator)
- Sorting tables
- Boxing
- Conveyors


1 DUMPING
2 WASHING
3 DRYING - BRUSHING
4 WAX APPLICATION
SHINING
5 GRADER
6 SIZER
7 BOXING
8 SEALING
SHIPMENT
LOCAL MARKET
PROCESSING


Washer
Water absorber
Rotary sorting table
4 ft receiving belt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Magna View Sorting Systems

Cold Storage

- Most important factor for maintaining quality
  - Removes field heat
  - Lowers respiration
  - Reduces water loss
  - Decreases sensitivity to ethylene

Even after picking, strawberries remain alive and produce heat as a natural consequence of respiration. The amount of heat they produce depends on the storage temperature. At 32 F a ton of strawberries will produce approximately 3,300 Btu per day, whereas at 80 F, a ton will produce 41,800 Btu!

Maintaining the Cold Chain for Perishables

Harvest

- Protect the product from the sun
- Transport quickly to the packinghouse

Cooling

- Minimize delays before cooling
- Cool the product thoroughly as soon as possible

Temporary Storage

- Store the product at optimum temperature
- Practice first in first out rotation
- Ship to market as soon as possible

Transport to Market

- Use refrigerated loading area
- Cool truck before loading
- Load pallets towards the center of the truck
- Put insulating plastic strips inside door of reefer if truck makes multiple stops
- Avoid delays during transport
- Monitor product temperature during transport

Handling at destination

- Use a refrigerated unloading area
- Measure product temperature
- Move product quickly to the proper storage area
- Transport to retail markets or foodservice operations in refrigerated trucks
- Display at proper temperature range

Handling at home or foodservice outlet

- Store product at proper temperature
- Use the product as soon as possible

Why cool?

- Suppress enzymatic degradation and respiratory activity (softening)
- Slow or inhibit water loss (wilting)
- Slow or inhibit the growth of decay-producing microorganisms (molds and bacteria)
- Reduce production of ethylene (a ripening agent) or minimize the product's reaction to ethylene.

Lowest safe temperature

Commodity	Approximate lowest safe temperature		Character of injury when stored between 0°C and safe temperature[1]
	°C	°F	
Apples (Jonathan, McIntosh, Yellow Newton)	2-3	36-38	Internal browning, brown core, soggy breakdown, soft scald
Asparagus	0-2	32-36	Dull, gray-green, and limp tips
Avocados	4.5-13	40-55	Grayish-brown discoloration of flesh
Bananas, green or ripe	11.5-13	53-56	Dull color when ripened
Beans (lima)	1-4.5	34-40	Rusty brown specks, spots, or areas
Beans (snap)	7	45	Pitting and russeting
Cranberries	2	36	Rubbery texture, red flesh
Cucumbers	7	45	Pitting, water-soaked spots, decay
Eggplants	7	45	Surface scald, alternaria rot, blackening of seeds

Melons			
Cantaloupe	2-5	36-41	Pitting, surface decay
Honey Dew	7-10	45-50	Reddish-tan discoloration, pitting, surface decay, failure to ripen
Casaba	7-10	45-50	Same as above but no discoloration
Crenshaw and Persian	7-10	45-50	Same as above but no discoloration
Watermelons	4.5	40	Pitting, objectionable flavor
Okra	7	45	Discoloration, water-soaked areas, pitting, decay
Olives, fresh	7	45	Internal browning
Oranges, California and Arizona	3	38	Pitting, brown stain
Papayas	7	45	Pitting, failure to ripen, off flavor, decay
Peppers, sweet	7	45	Sheet pitting, alternaria rot on pods and calyxes, darkening of seed
Pineapples	7-10	45-50	Dull green when ripened
Pomegranates	4.5	40	Pitting, external and internal browning
Potatoes	3	38	Mahogany browning (Chippewa and Sebago), sweetening[2]
Pumpkins and hard-shell squashes	10	50	Decay, especially alternaria rot
Sweetpotatoes	13	55	Decay, pitting, internal discoloration; hardcore when cooked
Tamarillos	3-4	37-40	Surface pitting, discoloration
Tomatoes			
Ripe	7-10	45-50	Water-soaking and softening, decay
Mature-green	13	55	Poor color when ripe, alternaria rot

Product	Temperature		Relative Humidity (percent)	Approximate storage life
	°C	°F		
Amaranth	0-2	32-36	95-100	10-14 days
Anise	0-2	32-36	90-95	2-3 weeks
Apples	-1-4	30-40	90-95	1-12 months
Apricots	-0.5-0	31-32	90-95	1-3 weeks
Artichokes, globe	0	32	95-100	2-3 weeks
Asian pear	1	34	90-95	5-6 months
Asparagus	0-2	32-35	95-100	2-3 weeks
Atemoya	13	55	85-90	4-6 weeks
Avocados, Fuerte, Hass	7	45	85-90	2 weeks
Avocados, Lula, Booth-1	4	40	90-95	4-8 weeks
Avocados, Fuchs, Pollock	13	55	85-90	2 weeks
Babaco	7	45	85-90	1-3 weeks
Bananas, green	13-14	56-58	90-95	14 weeks
Barbados cherry	0	32	85-90	7-8 weeks
Bean sprouts	0	32	95-100	7-9 days
Beans, dry	4-10	40-50	40-50	6-10 months
Beans, green or snap	4-7	40-45	95	7-10 days
Beans, lima, in pods	5-6	41-43	95	5 days
Beets, bunched	0	32	98-100	10-14 days
Beets, topped	0	32	98-100	4-6 months
Belgian endive	2-3	36-38	95-98	24 weeks
Bitter melon	12-13	53-55	85-90	2-3 weeks
Black sapote	13-15	55-60	85-90	2-3 weeks
Blackberries	-0.5-0	31-32	90-95	2-3 days
Blood orange	4-7	40-44	90-95	3-8 weeks
Blueberries	-0.5-0	31-32	90-95	2 weeks
Bok choy	0	32	95-100	3 weeks
Boniato	13-15	55-60	85-90	4-5 months
Breadfruit	13-15	55-60	85-90	2-6 weeks
Broccoli	0	32	95-100	10-14 days
Brussels sprouts	0	32	95-100	3-5 weeks
Cabbage, early	0	32	98-100	3-6 weeks

Cantaloupes (3/4-slip)	2-5	36-41	95	15 days
Cantaloupes (full-slip)	0-2	32-36	95	5-14 days
Carambola	9-10	48-50	85-90	3-4 weeks
Carrots, bunched	0	32	95-100	2 weeks
Carrots, mature	0	32	98-100	7-9 months
Carrots, immature	0	32	98-100	4-6 weeks
Cashew apple	0-2	32-36	85-90	5 weeks
Cauliflower	0	32	95-98	34 weeks
Celeriac	0	32	97-99	6-8 months
Celery	0	32	98-100	2-3 months
Chard	0	32	95-100	10-14 days
Chayote squash	7	45	85-90	4-6 weeks
Cherimoya	13	55	90-95	2-4 weeks
Cherries, sour	0	32	90-95	3-7 days
Cherries, sweet	-1 to -0.5	30-31	90-95	2-3 weeks
Chinese broccoli	0	32	95-100	10-14 days
Chinese cabbage	0	32	95-100	2-3 months
Chinese long bean	4-7	40-45	90-95	7-10 days
Clementine	4	40	90-95	24 weeks
Coconuts	0-1.5	32-35	80-85	1-2 months
Collards	0	32	95-100	10-14 days
Corn, sweet	0	32	95-98	5-8 days
Cranberries	2-4	36-40	90-95	24 months
Cucumbers	10-13	50-55	95	10-14 days

Product	Temperature		Relative Humidity (percent)	Approximate storage life
	°C	°F		
Potatoes, early crop	10-16	50-60	90-95	10-14 days
Potatoes, late crop	4.5-13	40-55	90-95	5-10 months
Pummelo	7-9	45-48	85-90	12 weeks
Pumpkins	10-13	50-55	50-70	2-3 months
Quinces	-0.5-0	31-32	90	2-3 months
Raddichio	0-1	32-34	95-100	2-3 weeks
Radishes, spring	0	32	95-100	34 weeks
Radishes, winter	0	32	95-100	24 months
Rambutan	12	54	90-95	1-3 weeks
Raspberries	-0.5-0	31-32	90-95	2-3 days
Rhubarb	0	32	95-100	24 weeks
Rutabagas	0	32	98-100	+6 months
Salsify	0	32	95-98	2-4 months
Santol	7-9	45-48	85-90	3 weeks
Sapodilla	16-20	60-68	85-90	2-3 weeks
Scorzonera	0-1	32-34	95-98	6 months
Seedless cucumbers	10-13	50-55	85-90	10-14 days
Snow peas	0-1	32-34	90-95	1-2 weeks
Soursop	13	55	85-90	1-2 weeks
Spinach	0	32	95-100	10-14 days
Squashes, summer	5-10	41-50	95	1-2 weeks
Squashes, winter	10	50	50-70	2-3 months
Strawberries	0	32	90-95	5-7 days
Sugar apples	7	45	85-90	4 weeks
Sweetpotatoes	13-15	55-60	85-90	4-7 months
Tamarillos	3-4	37-40	85-95	10 weeks
Tamarinds	7	45	90-95	3-4 weeks
Tangerines, mandarins, and related citrus fruits	4	40	90-95	24 weeks
Taro root	7-10	45-50	85-90	4-5 months
Tomatillos	13-15	55-60	85-90	3 weeks
Tomatoes, mature-green	18-22	65-72	90-95	1-3 weeks
Tomatoes, firm-ripe	13-15	55-60	90-95	4-7 days
Turnips	0	32	95	4-5 months
Turnip greens	0	32	95-100	10-14 days

Cold storage compatibility

- Ethylene
  - Producer
  - Sensative
- Similar temperature
- Similar relative humidity

Group 1: Fruits and vegetables, 0 to 2°C (32 to 36°F), 90-95% relative humidity. Many products in this group produce ethylene.

apples	grapes (without sulfur dioxide)	parsnips
apricots	horseradish	peaches
Asian pears	kohlrabi	pears
Barbados cherry	leeks	persimmons
beets, topped	longan	plums
berries (except cranberries)	loquat	pomegranates
cashew apple	lychee	prunes
cherries	mushrooms	quinces
coconuts	nectarines	radishes
figs (not with apples)	oranges* (Florida and Texas)	rutabagas
		turnips

*Citrus treated with biphenyl may give odors to other products

Group 2: Fruits and vegetables, 0 to 2°C (32 to 36°F), 95-100% relative humidity. Many products in this group are sensitive to ethylene.

Amaranth*	cherries	parsley*
anise	daikon*	parsnips*
artichokes*	endive*	peas*
asparagus	escarole*	pomegranate
bean sprouts	grapes (without sulfur dioxide)	raddichio
beets*	horseradish	radishes*
Belgian endive	Jerusalem artichoke	rhubarb
berries (except cranberries)	kiwifruit	rutabagas*
bok choy	kohlrabi*	salsify
broccoli*	leafy greens	scorzonera
brussels sprouts*	leeks' (not with figs or grapes)	snow peas
cabbage*	lettuce	spinach*
carrots*	lo bok	Sweet corn*
cauliflower	mushrooms	turnips*
celeriac*	onions, green* (not with figs, grapes, mushrooms, rhubarb, or corn)	water chestnut
celery*		watercress*

*these products can be top-iced

Group 5: Fruits and vegetables, 10°C (50°F), 85-90% relative humidity. Many of these products are sensitive to ethylene. These products also are sensitive to chilling injury.

beans	kiwano	pummelo
calamondin	malanga	squash, summer (soft shell)
chayote	okra	tamarind
cucumber	olive	taro root
eggplant	peppers	
haricot vert (fine beans)	potatoes, storage	

Group 6: Fruits and vegetables, 13 to 15°C (55 to 60°F), 85-90% relative humidity. Many of these products produce ethylene. These products also are sensitive to chilling injury.

atemoya	granadilla	papayas
avocados	grapefruit	passionfruit
babaco	guava	pineapple
bananas	jaboticaba	plantain
bitter melon	jackfruit	potatoes, new
black sapote	langsat	pumpkin
boniato	lemons*	rambutan
breadfruit	limes*	santol
canister	mamey	soursop
carambola	mangoes	sugar apple
cherimoya	mangosteen	squash, winter (hard shell)
coconuts	melons (except cantaloupes)	tomatillos
feijoa		tomatoes, ripe
ginger root		

*citrus treated with biphenyl may give odors to other products

Cold storage methods

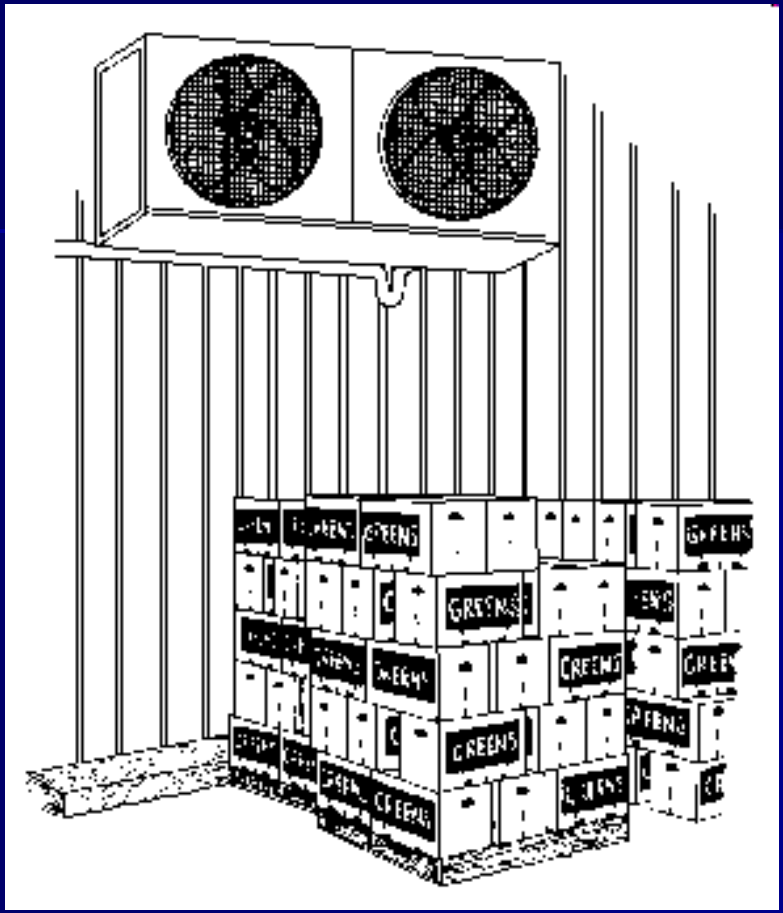
- Mechanical Refrigeration
- Evaporative
- Ice
- Underground
- High altitude

Mechanical Refrigeration Cooling

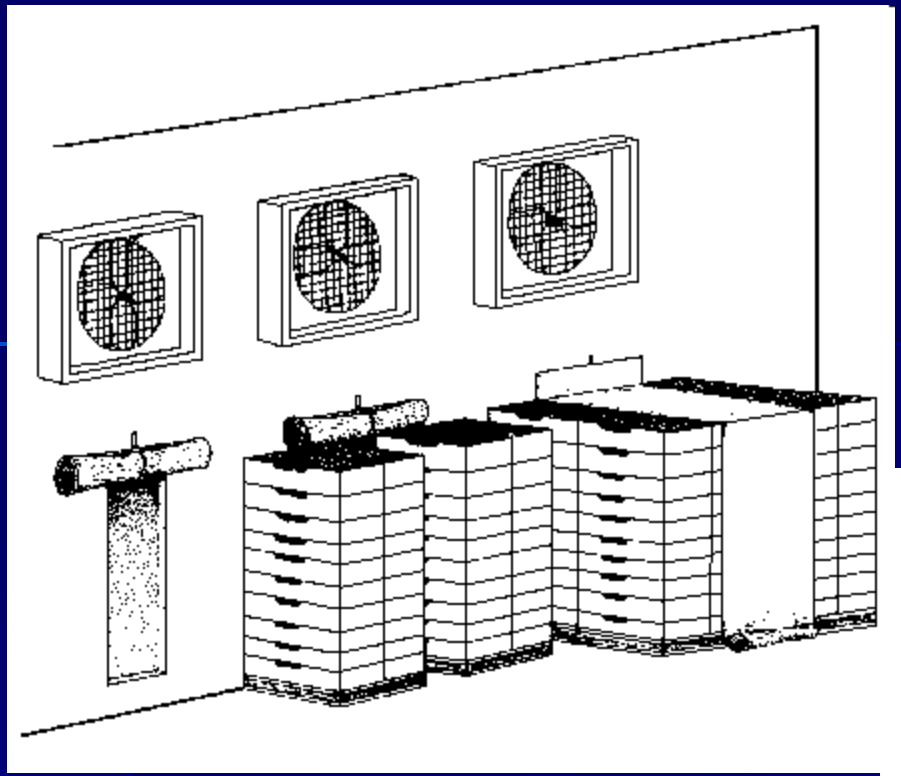
- Forced Air
- Room Cooling

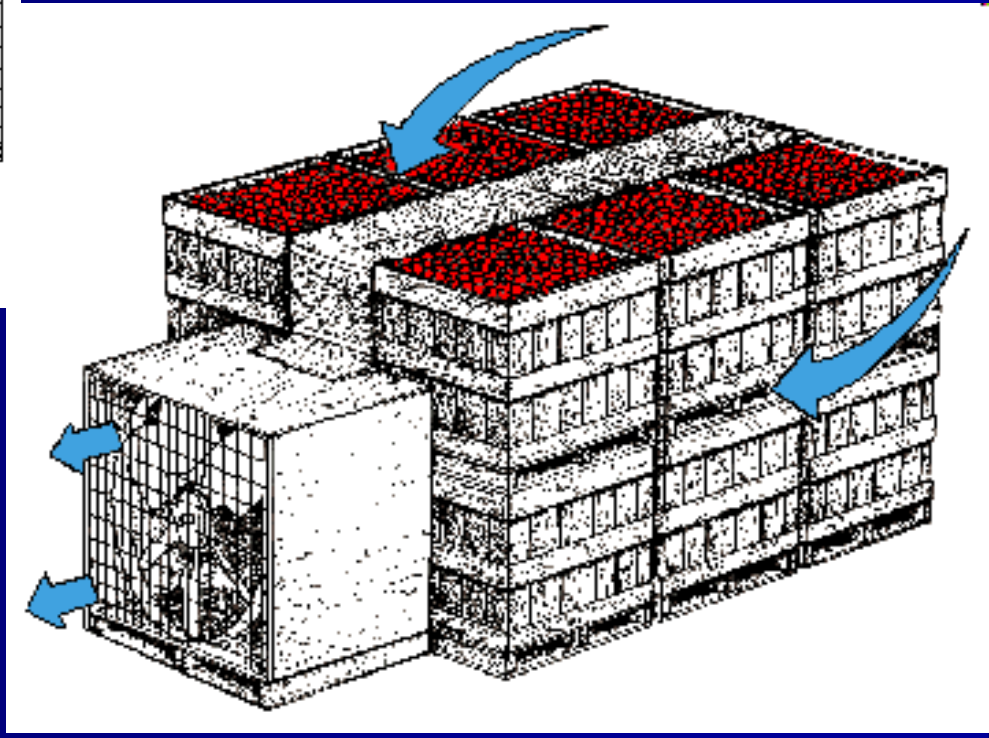
Introduction to
Proper Postharvest Cooling and Handling Methods

Prepared by
M. D. Boyette, Extension Agricultural Engineering Specialist
L. G. Wilson, Extension Horticulture Specialist
E. A. Estes, Extension Marketing Specialist
Sponsored by the Energy Division, North Carolina Department of Commerce, with petroleum violation escrow funds, in cooperation with the Agricultural Extension Service, North Carolina State University. Any opinions, findings, conclusions, or recommendations expressed herein are those of the authors and do not reflect the views of the Energy Division, North Carolina Department of Commerce.



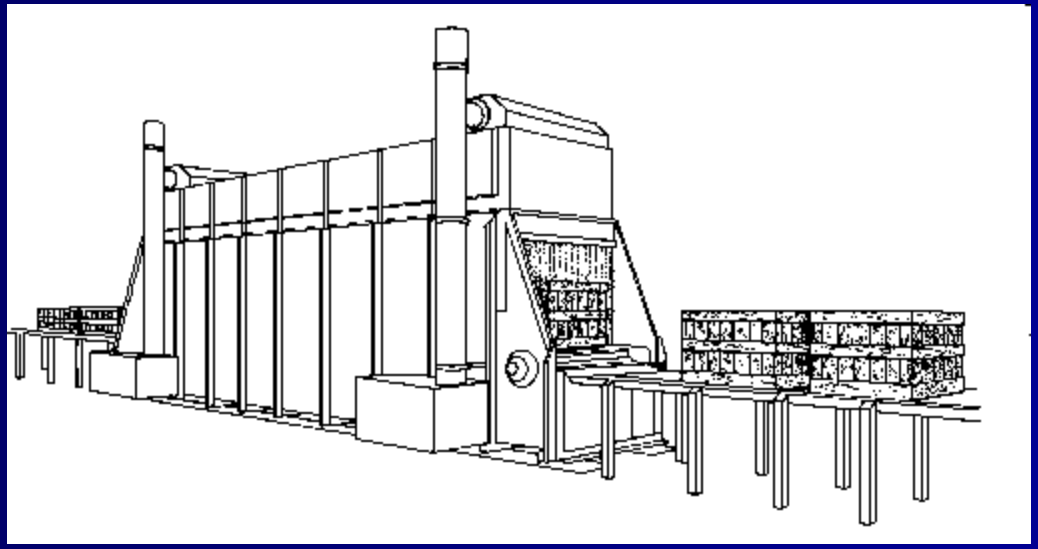
Room Cooling

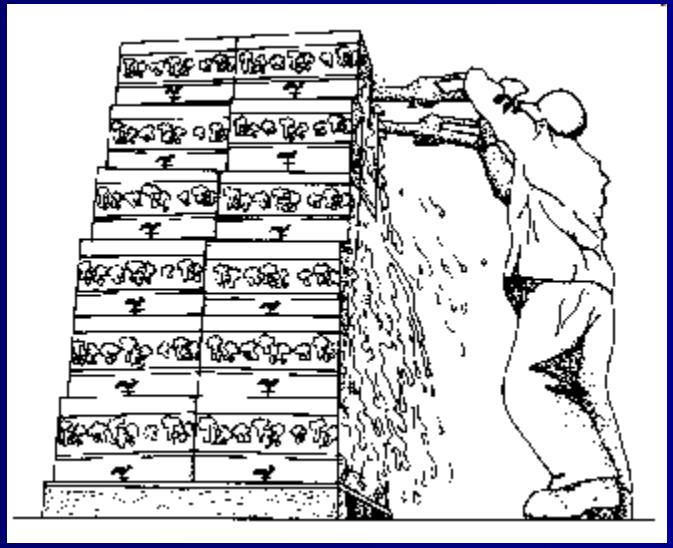




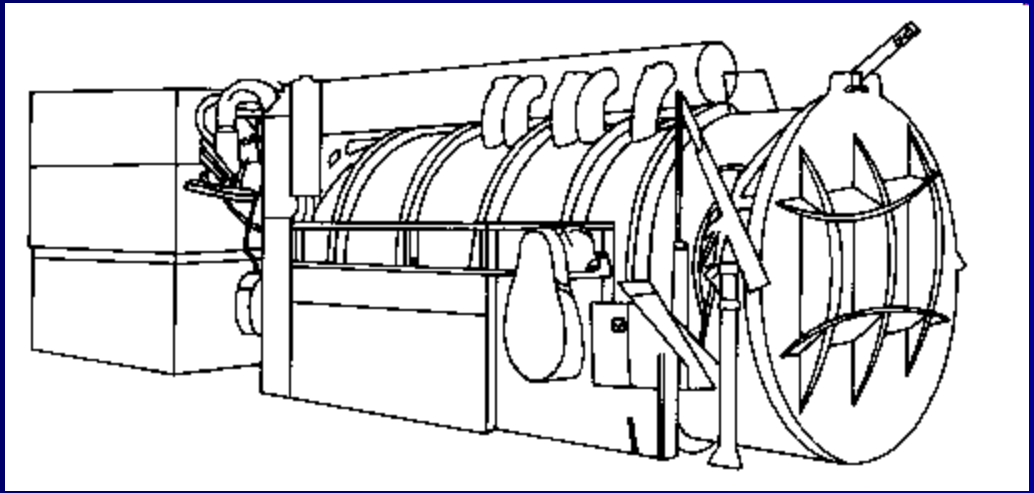
Forced Air Cooling

COOL AND SHIP:
A LOW-COST, PORTABLE FORCED-AIR COOLING UNIT



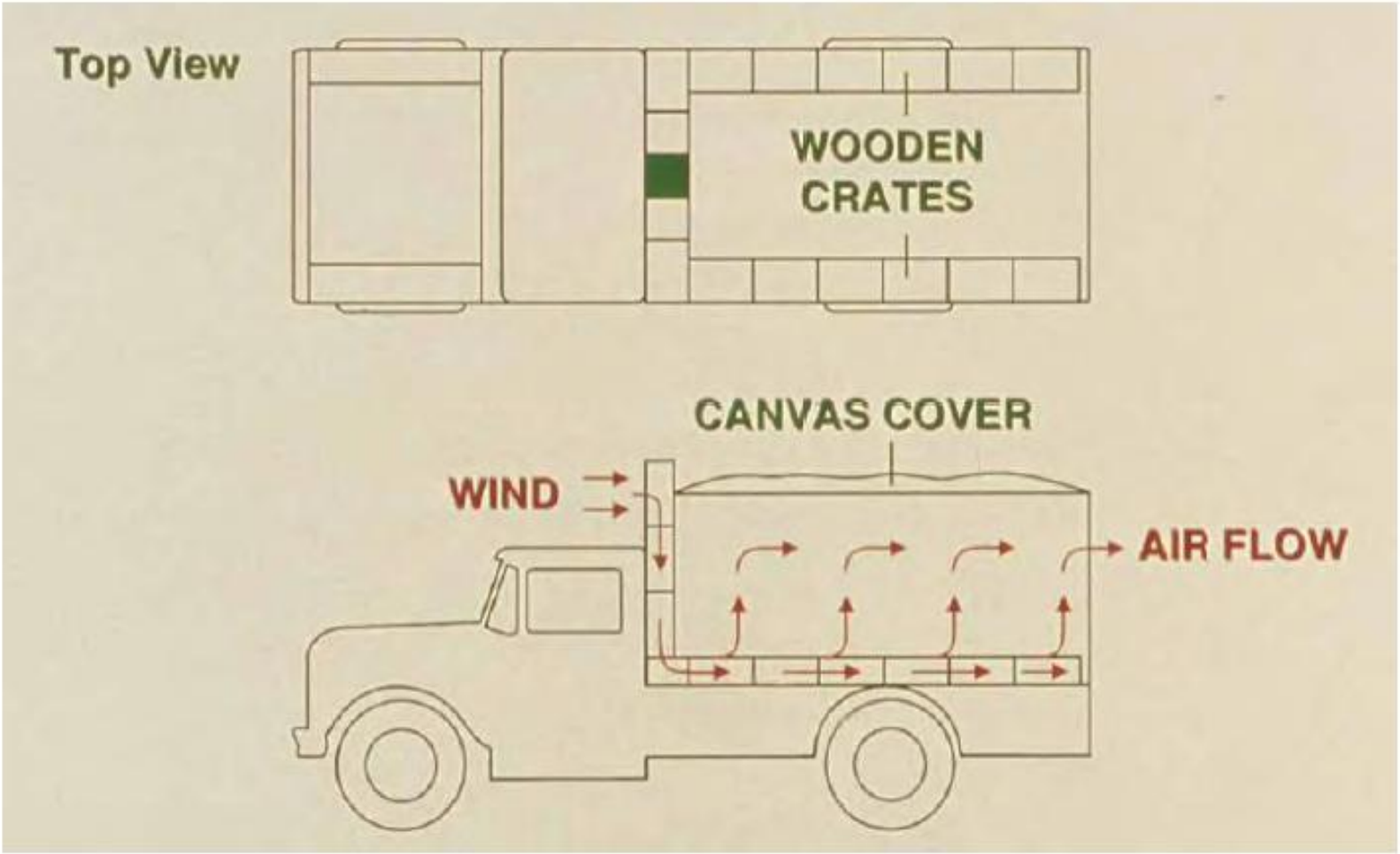


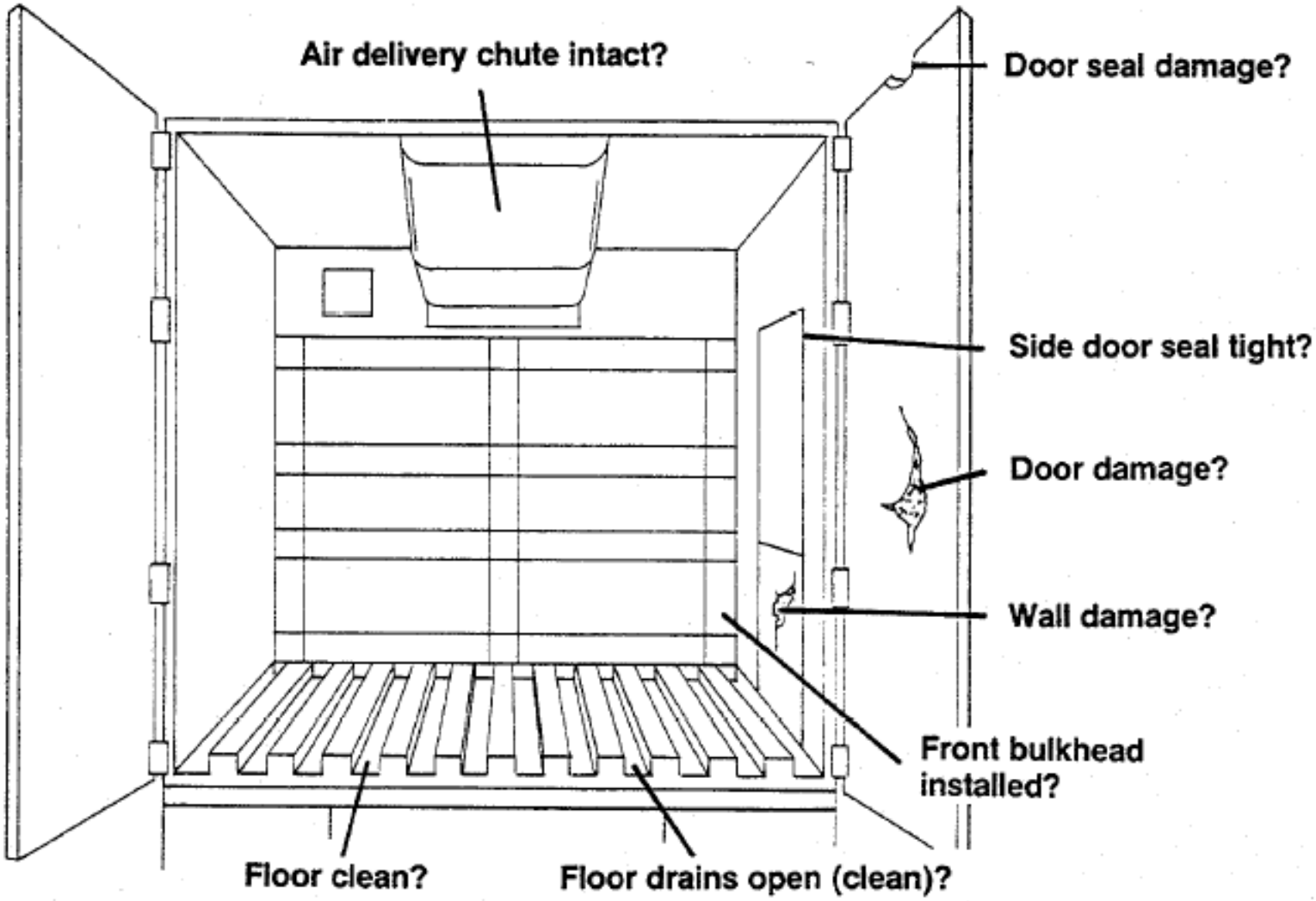
Should be Top-iced:	Can be Top-iced:
beets with tops	artichokes, globe
broccoli	beet greens
carrots with tops	beets topped
corn sweet	brussels sprouts
endive	cantaloupes
escarole	carrots, topped
green onions	celeriac
parsley	chard
radishes with tops	kohlrabi
radish greens	leeks
spinach	mustard greens
turnips	parsnips
turnips with tops	radishes
turnip greens	rutabagas
watercress	



Transportation Methods

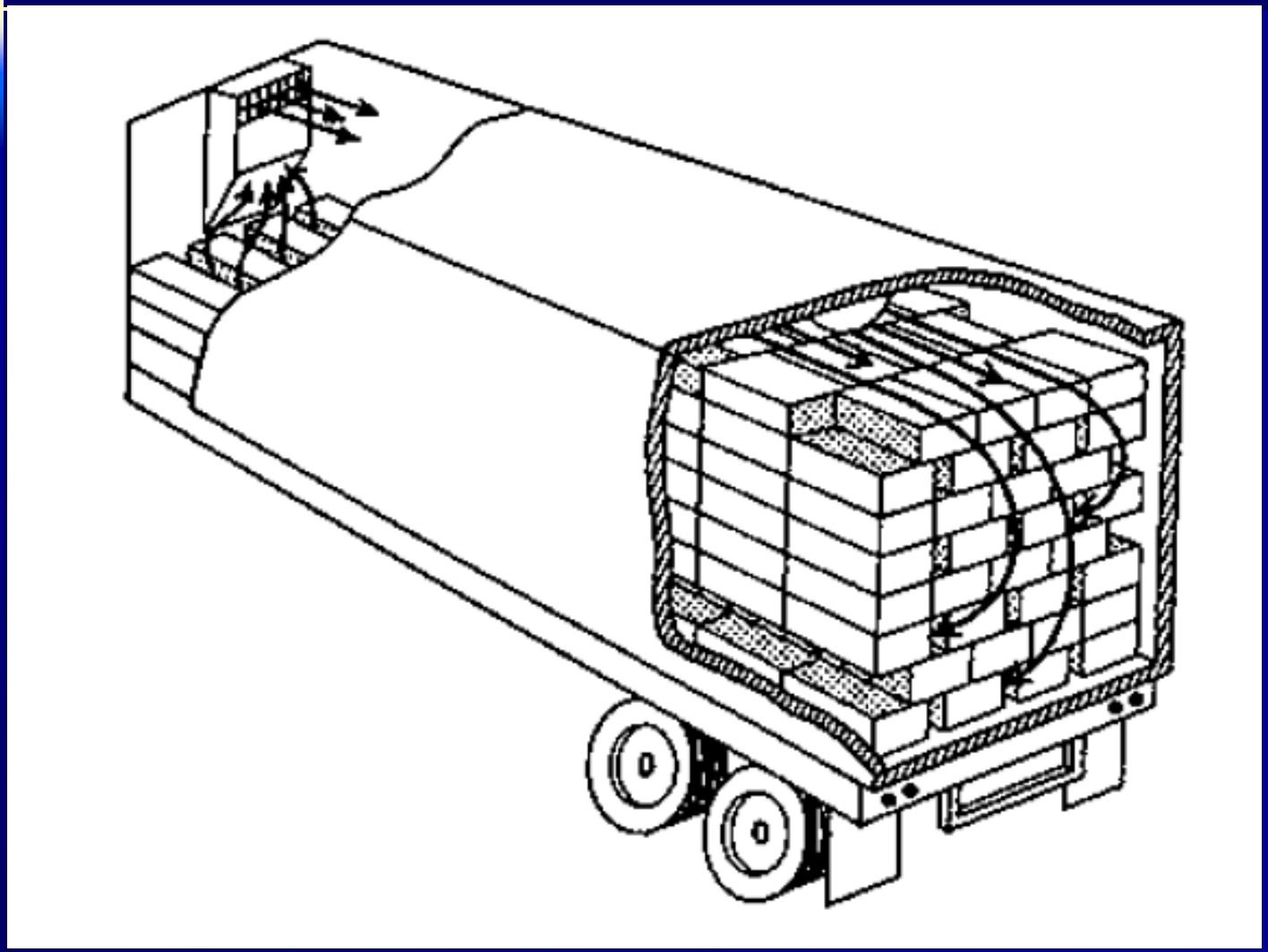
- Open Vehicle
- Refrigerated Vehicle
  - Box Truck
  - Tractor Trailer


Top View
WOODEN
CRATES
CANVAS COVER
WIND
AIR FLOW



Inside width adequate for load?
Inside height adequate for load?
Door height adequate for load?

Load bars used to secure load?
Trailer precooled before loading?
Refrigeration unit operates satisfactorily?



Resources

Grades and Standards, Phyto-Sanitary Regulations

http://www.ams.usda.gov
http://www.ams.usda.gov/fv (Fruit & Vegetable Programs)
http://www.ams.usda.gov/tmd (Transportation & Marketing Programs)
Agricultural Marketing Service at the U.S. Department of Agriculture
The Agricultural Marketing Service includes six commodity programs--Cotton, Dairy, Fruit and Vegetable, Livestock and Seed, Poultry, and Tobacco. The programs employ specialists who provide standardization, grading and market news services for those commodities. They enforce such Federal Laws as the Perishable Agricultural Commodities Act and the Federal Seed Act. AMS commodity programs also oversee marketing agreements and orders, administer research and promotion programs, and purchase commodities for Federal food programs.

http://www.ams.usda.gov/nop/ (The National Organic Program)
This site includes the national standards on organic agricultural production and handling.

http://www.aphis.usda.gov/ (Animal and Plant Health Inspection Service)
The mission of the Animal and Plant Health Inspection Service (APHIS) is to protect America's animal and plant resources by:

- Safeguarding resources from exotic invasive pests and diseases,
- Monitoring and managing agricultural pests and diseases existing in the United States,
- Resolving and managing trade issues related to animal or plant health, and
- Ensuring the humane care and treatment of animals.

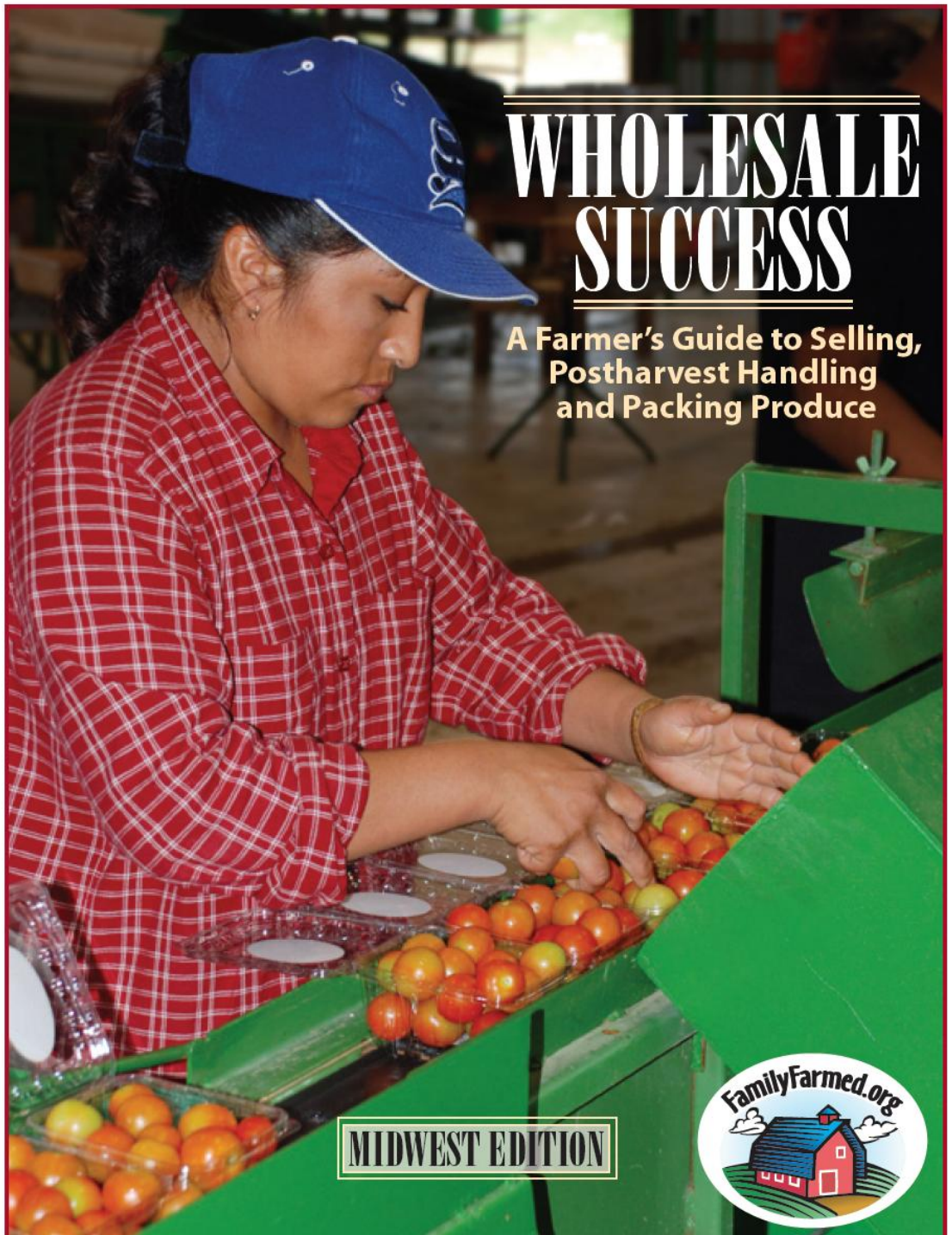
http://postharvest.ucdavis.edu
At this University of California (UC) website you will find a wide range of fact sheets on individual fruits and vegetables, temperature recommendations for storage, links to suppliers of postharvest equipment and many reference articles on the postharvest handling of perishables.

http://www.uckac.edu/postharv/
This University of California, Kearney Agricultural Center Internet site includes information about postharvest handling of apricot, Asian pear, fig, kiwifruit, nectarine, olive, peach, persimmon, plum and fresh prune, and table grape.

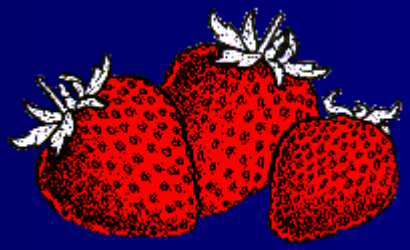
www.fao.org/inpho/
This United Nations website includes a variety of FAO and other publications that users can browse on-line or download for their personal use. The UCDavis training publication. Small-Scale Postharvest Handling Practices: A Manual for Horticultural Crops (3rd edition) provides cost-effective recommendations on improved handling of fruits and vegetables from the farm to the market. Other publications focus on packaging, storage, marketing or training and extension.

www.bae.ncsu.edu/programs/extension/publicat/postharv/
This website sponsored by North Carolina State University offers information on postharvest cooling and storage options for many commodities.

http://www.postharvest.tfrec.wsu.edu
This Washington State University Internet site includes information about postharvest handling of apple, pear, cherry, and stone fruits.


WHOLESALE SUCCESS
A Farmer's Guide to Selling, Postharvest Handling and Packing Produce
MIDWEST EDITION
FamilyFarmed.org

Postharvest Cooling and Handling of Strawberries



http://www.bae.ncsu.edu/programs/extension/publicat/postharv/ag-413-2/index.html