UCDAVIS
POSTHARVEST TECHNOLOGY

Fresh-cut Fruit & Vegetables

- Examples of products
- Physiology of fresh-cut products
- Preparation and handling
- Raw material and quality

Marita Cantwell
micantwell@ucdavis.edu
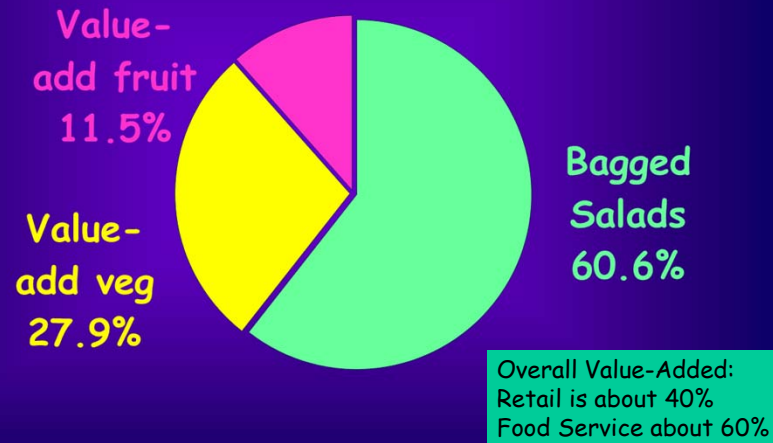**Postharvest Short Course June 2014**

FRESH-CUT PRODUCTS

DEFINITION
"Fresh-cut produce" is defined as any fresh fruit or vegetable that has been physically altered from its original form, but remains in a **fresh state**. It has been trimmed, peeled, washed and/or cut into 100% usable product that is subsequently packaged to offer consumers high nutrition, convenience and value while still maintaining freshness.

- Not all products in this category are cut into pieces: Leafy salad greens, peeled garlic, individual grapes

- However, all products in this category are alive and respire

- Minimally processed, lightly processed, partially processed, pre-cut, value-added

Estimated Value-added Produce Sales in Select US Supermarkets*,$4.7 Billion, 2012

*Excludes club stores, supercenters, part of conventional grocery and other alternative formats.

Value-add fruit 11.5%

Value-add veg 27.9%

Bagged Salads 60.6%

Overall Value-Added:
Retail is about 40%
Food Service about 60%

Sources: Estimated by Roberta Cook from various sources.

Fresh-cut Vegetables

- Lettuces: cleaned, chopped, shredded
- Spinach, leafy greens, washed & trimmed
- Broccoli & cauliflower florets
- Cabbage, shredded
- Carrots, baby, sticks, shredded
- Celery sticks
- Onions, whole peeled, slices, diced
- Potatoes & other roots: peeled, sliced, diced
- Mushrooms sliced
- Jicama, Squash, cucumber slices, dices
- Garlic, fresh peeled, slices
- Tomato and pepper slices

In 2012 Bolthouse bought by Campbells

Simple lettuce to meal salad

Pear Gongonzola Kit

Single
To 3
component

Romaine lettuces, green leaf lettuce and red leaf lettuce, lolla rosa, green tango lettuce, green oak leaf lettuce and red oak leaf lettuce, arugula, mizuna, tatsoi, baby spinach, radicchio, dried pears, frosted almonds, and pear gorgonzola vinaigrette. Ingredients may vary.

http://www.freshexpress.com

Sweetpotato for Food service

Many garlic products

- Reduced prep time- cleaned and trimmed
- Open bag and add seasonings
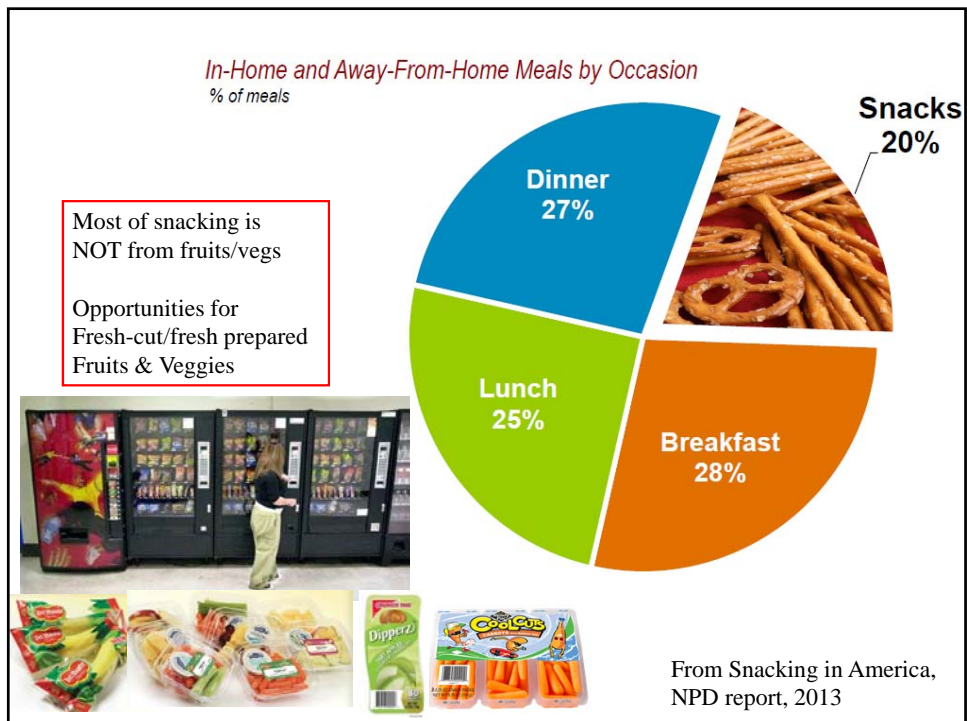- Reseal (zip-lock) and microwave
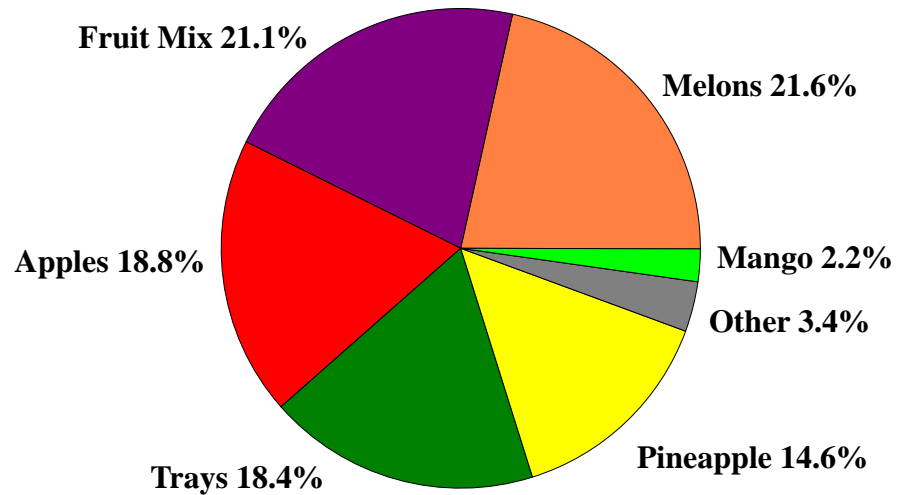
2011 PMA Product Innovation Award

Strips taro, celeriac, sweetpotato

Steam in pouch Brussel sprouts and asparagus

Prepared Vegetables for Home Cooking/Grilling

United Fresh Produce
Dallas, May 2012

In-Home and Away-From-Home Meals by Occasion
% of meals

Most of snacking is NOT from fruits/vegs

Opportunities for Fresh-cut/fresh prepared Fruits & Veggies

Snacks 20%

Dinner 27%

Lunch 25%

Breakfast 28%

From Snacking in America, NPD report, 2013

U.S. Supermarket Fresh-cut Fruit Category Shares (% of sales)

Fruit Mix 21.1%

Melons 21.6%

Apples 18.8%

Mango 2.2%

Other 3.4%

Trays 18.4%

Pineapple 14.6%

2009. Source: Roberta Cook; Perishables Group

Examples fresh-cut fruit products

Lettuce Salad Preparation

- ❖ Harvest
- ❖ Trim, core, defect removal
- ❖ Cool and/or MA
- ❖ Dump, mechanical cut
- ❖ Cooling, disinfection
- ❖ Drying, centrifugation
- ❖ Component blending
- ❖ Weigh and package
- ❖ Metal detector, pack, palletize
- ❖ Temporary cold storage

Trend to automated lines
Minimize personnel at low temperatures
Lower temperature for products
3 separate areas of cleanliness

**Many large volume (lettuces) products
are mechanically cut, but manual preparation
generally results in superior quality**

- ♣ **cutting romaine by hand; eliminate defects**
- ♣ **manually peeled garlic vs compressed air peeled**
- ♣ **broccoli and cauliflower florets manually trimmed**
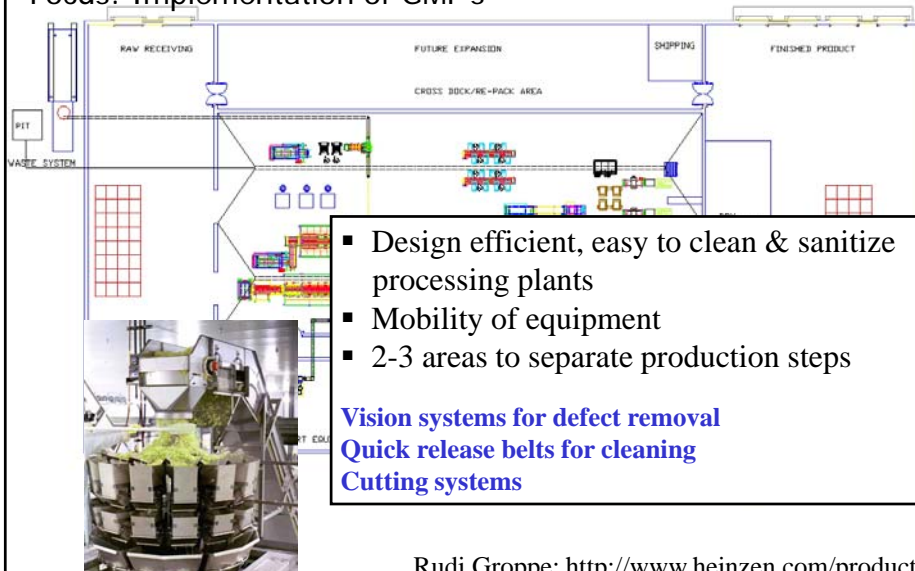- ♣ **manually trimmed and cut melons, pineapples**
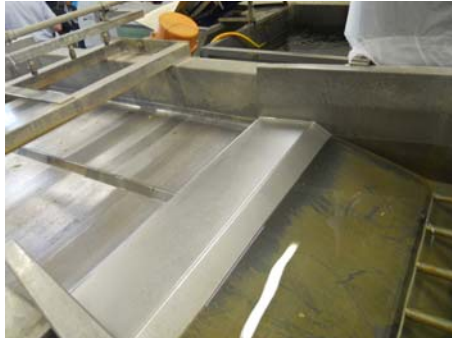
Fresh-cut Products
Food Safety Requirements

- Meticulous cleanliness of equipment, employees and product
- Constant monitoring of sanitizer activity
- Rigid maintenance of refrigerated temperatures
- Complete integrity of packages
- Strict adherence to product use by dates & handling instructions

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SANITARY PLANT DESIGN: Product, People, Maintenance

Focus: Implementation of GMP's

- Design efficient, easy to clean & sanitize processing plants
- Mobility of equipment
- 2-3 areas to separate production steps

Vision systems for defect removal
Quick release belts for cleaning
Cutting systems

Rudi Groppe; http://www.heinzen.com/products/

BABY LEAF LINE
Sanitation vs Production
What is CLEARLY wrong here?

Maintain Quality & Safety of Fresh-cut Vegetable Products
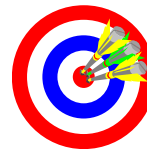
1 Use highest quality raw material

2 Minimize mechanical damage; sharp knives

3 Rinse cut surfaces; remove excess water

4 Maintain strict sanitation; chlorinated water

5 Use appropriate package and atmosphere

6 Maintain product temperature at 1-2°C

Effects of Fresh-cut Processing

Knife/Cutting Blade Sharpness
- Cut cleanly not crush
- Better shelf-life
- Less browning of cut edges

- Physical
  – Mechanical shock, remove protective layers
  – Cell fluids on cut surface, gas diffusion
  – Exposure to microbial and chemical contamination

- Physiological
  – Increased respiration, ethylene rates
  – Increases in other biochemical reactions
    - Discoloration and Color
    - Texture
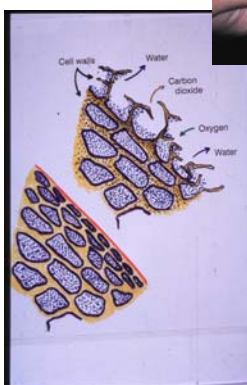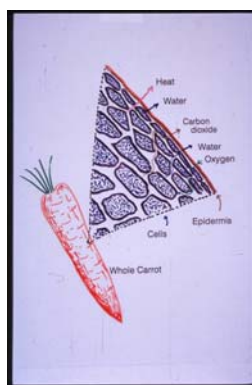   - Aroma and Flavor
    - Nutritional quality

Main strategy to minimize changes is to use low temperature
- Product cooled before cutting
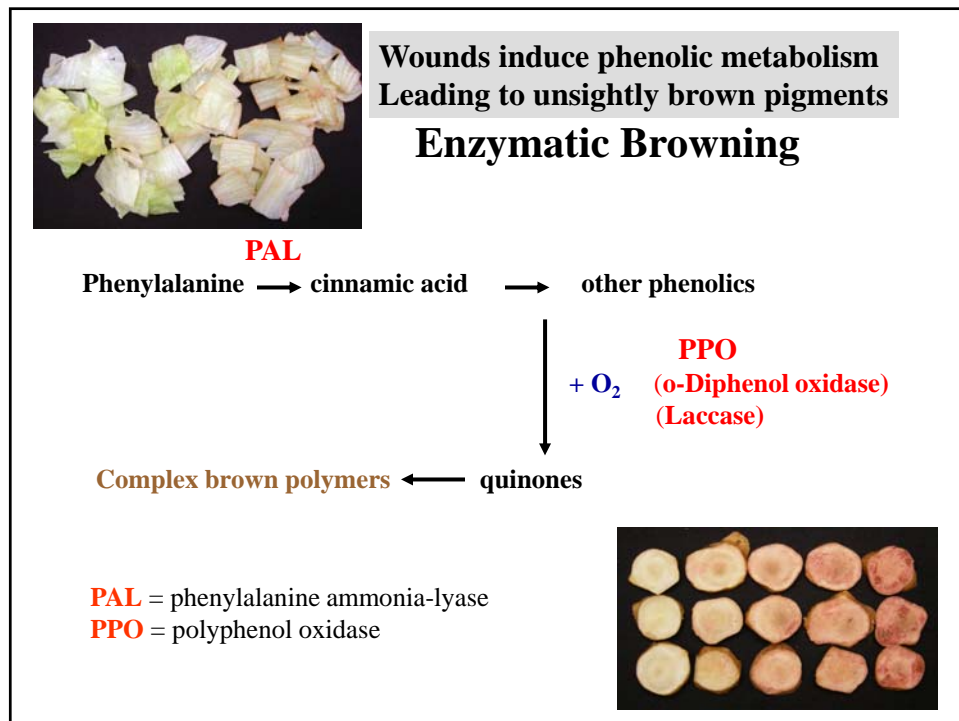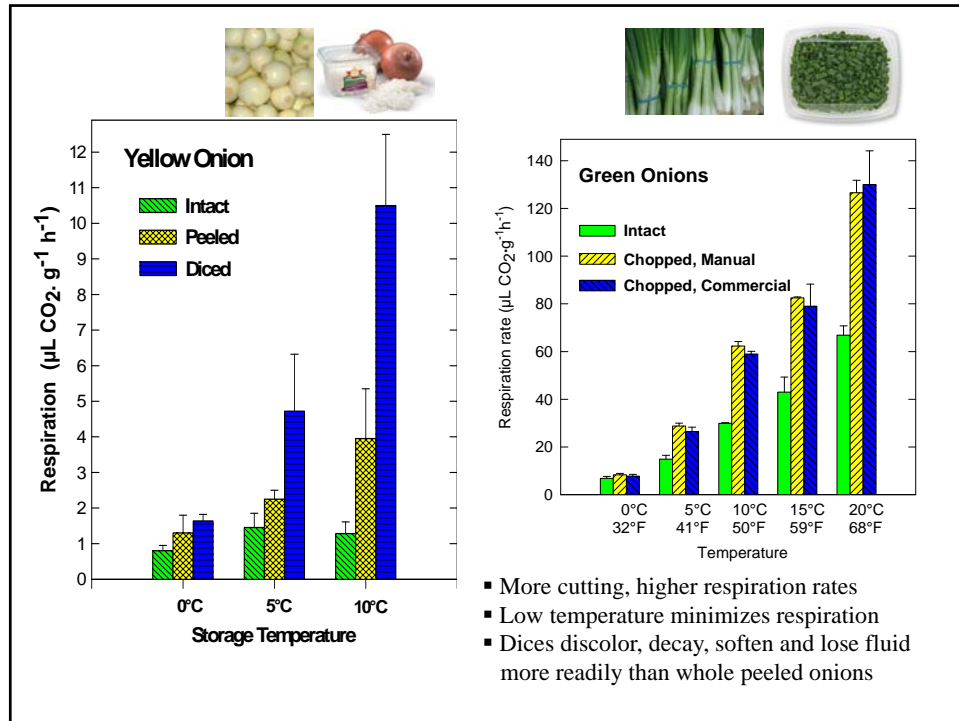- Product prepared in cold room

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Abrasion peeling of carrots leads to fragmented cell walls that dry out and result in "white blush"; can rehydrate carrots.

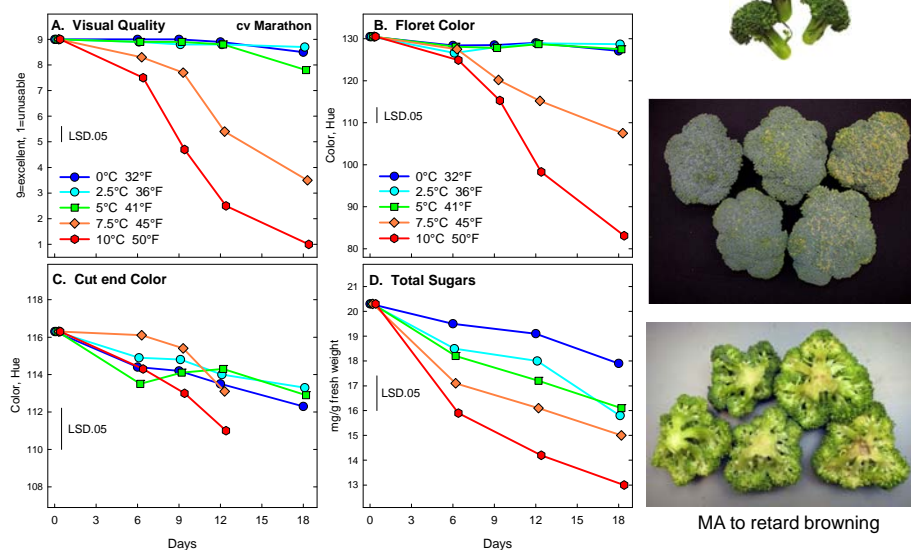**New equipment peels and then cuts the carrots; have less problem with "white blush"**

Diagrams from Saltveit, UC Davis

Yellow Onion
- Intact
- Peeled
- Diced

Respiration (μL $CO_2 \cdot g^{-1} h^{-1}$)

Storage Temperature: 0°C, 5°C, 10°C

Green Onions
- Intact
- Chopped, Manual
- Chopped, Commercial

Respiration rate (μL $CO_2 \cdot g^{-1} h^{-1}$)

Temperature: 0°C 32°F, 5°C 41°F, 10°C 50°F, 15°C 59°F, 20°C 68°F

- More cutting, higher respiration rates
- Low temperature minimizes respiration
- Dices discolor, decay, soften and lose fluid more readily than whole peeled onions

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Wounds induce phenolic metabolism Leading to unsightly brown pigments

Enzymatic Browning

$$\text{Phenylalanine} \xrightarrow{\text{PAL}} \text{cinnamic acid} \longrightarrow \text{other phenolics}$$

$+ O_2$ $\quad$ **PPO (o-Diphenol oxidase) (Laccase)**

Complex brown polymers $\longleftarrow$ **quinones**

PAL = phenylalanine ammonia-lyase
PPO = polyphenol oxidase

Discoloration Rating Scale for Romaine

1=none

2=slight

3=moderate

4=mod. severe

5=severe

Impact of Temperature on Broccoli Floret Quality

MA to retard browning

Cantwell, UC Davis

Prevention of enzymatic/oxidative browning

- Refrigeration (slows enzymatic reactions)
- Exclusion of oxygen (CA, MAP, edible films)
- Inhibition of PAL (lettuces & vegs)
- Inhibition of PPO (fruits)
- Use of reducing agents (ascorbic acid, etc.)
- Other chemical agents

Examples of benefit of MA and chemical treatments

Romaine 1   Romaine 2   Fresh-cut potato

AIR

MA
$(0.7\%O_2 + 8\%CO_2)$

6 days at 5°C

Control Air | Bisulfite Air | C.A.+A.A. Air | Control MA | Bisulfite MA | C.A.+A.A. MA

8days 5°C; MA =3%O2 +12%CO2

C.A.+A.A. =citric acid + ascorbic acid

Blade and waterjet cutting
Minimize damage at cutting and minimize discoloration

Discoloration chart:
- 1=none, 2=slight, 3=moderate (y-axis)
- Days at 2.5C (x-axis)
- Used and resharpened knives
- New knives
- Foodgrade nozzle, fast, 35k psi
- Foodgrade nozzle, slow, 55k psi
- LSD.05
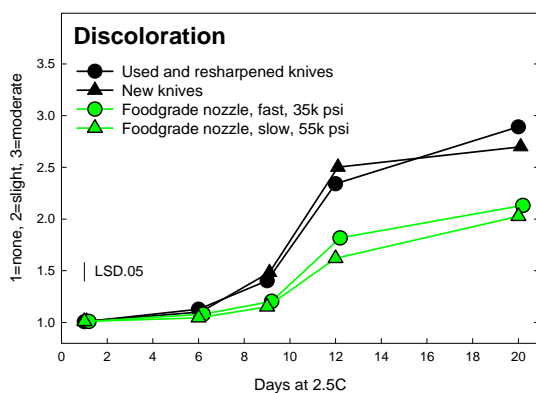
Cantwell et al., 2012

Package, no MA; 8 days at 2.5C in air

Packaging is a key enabling technology

Resealable bags

Single serve Snack packs

Steam in Bag

Active packaging
- Oxygen scavengers
- Gas exchange control
- Anti-microbials
- Moisture control
- Odor absorbers
- Self-venting films
- Preservative releasers

Intelligent/Smart Packaging
- Time-temperature indicators
- RFID tags, labels
- Thermochromic inks
- Moisture indicators
- Doneness indicators
- Microorganism indicators
- Freshness indicators

Rigid containers and bowls

Biobased packaging PLA resin

Fresh-cut Packaging

- Bags (LDPE) with holes
  - No modified atmosphere
- Bags with microperforations
  - Often PP
  - Permeability of O2:CO2 =1:1
- Differentially permeable films
  - Layered plastics
  - Co-extruded plastics
  - Gas permeability ratios vary
  - Permeable patches

Effect of **O2** on Respiration
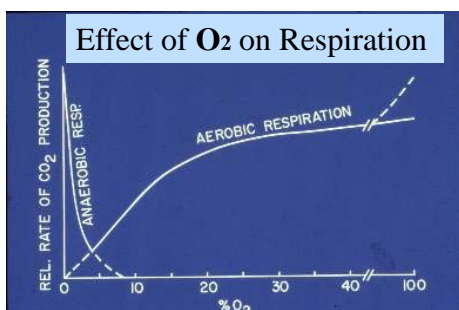
✓ Often lower O2 and increase CO2
✓ A too extreme atmosphere will lead to fermentation
✓ Temperature abuse leads to undesirable change in atmosphere
✓ An inappropriate atmosphere is worse than no modified atmosphere

Effect of **CO2** on Respiration
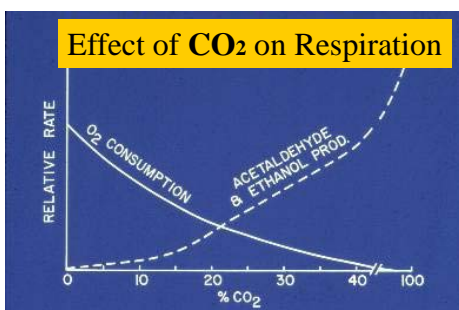
Temperature Effects on Retail Packaged Salads
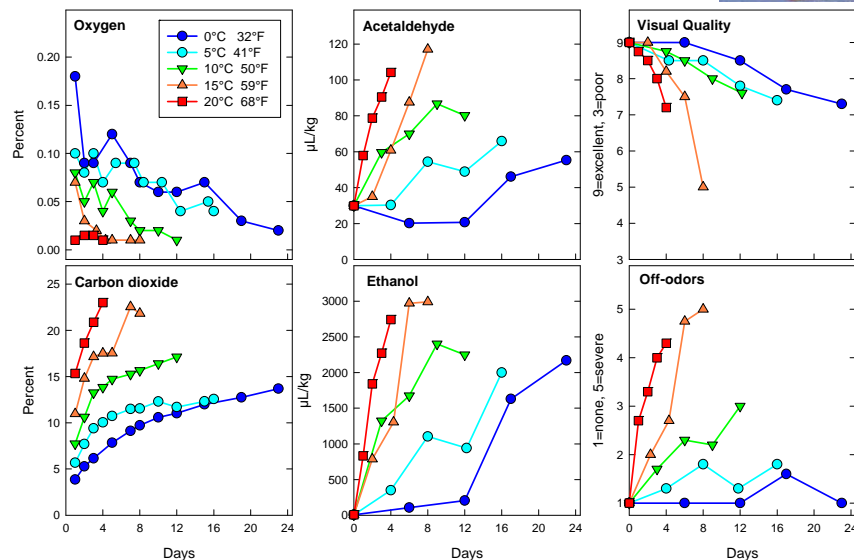
Peiser and Cantwell, UC Davis

Cut Vegetable Quality and Modified Atmospheres

grape tomato
celery sticks
baby carrots
broccoli florets
sugar snap peas

Vegetable trays - want 18 day shelf-life
Products in tray and **compatibility issues**
      - raw material sourcing and handling before prepare
      - shelf-life of individual products in tray varies
      - temperature; 5°C too low for grape tomatoes
      - modified atmospheres—not good for all products in tray

Lettuce Salad Quality Parameters

- **Fresh appearance**
- **No decay**
- **No discoloration**
- **Crisp texture**
- **Good aroma and flavor**
- **Good nutritional value**

✓ To date, these quality components have been undervalued
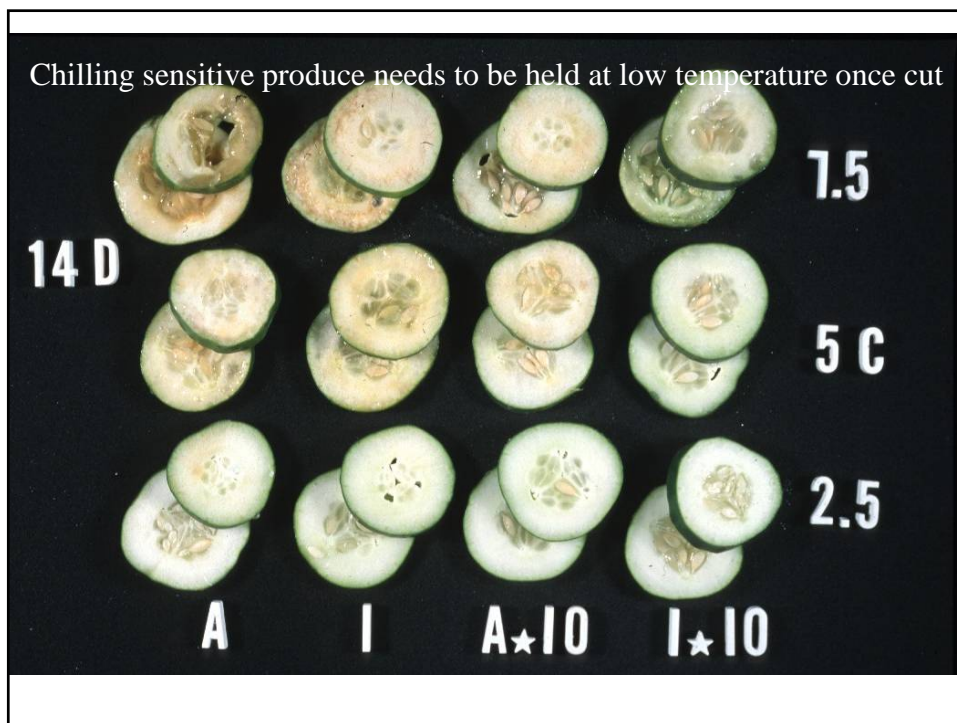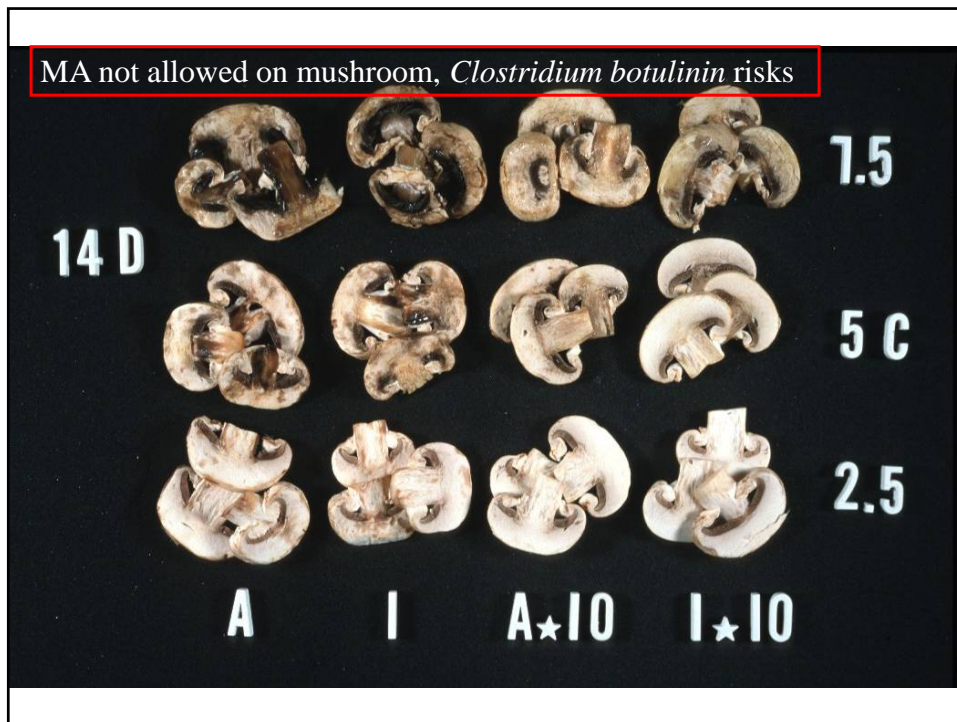✓ Current package atmospheres cause loss in all three

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Cut Lettuce Alternatives
Intact Baby size
Clean Whole leaves
Hearts of romaine
Small mixed lettuces
Organic Spring Mix

Rely on temperature Control; No MA used

4 and 6 count clamshell

MA not allowed on mushroom, *Clostridium botulinin* risks

Chilling sensitive produce needs to be held at low temperature once cut

Relative Importance of Temperature and Modified Atmospheres for Fresh-cut melon

10 days

7.5°C (45°F)

5°C (41°F)

2.5°C (36°F)

Air   1% O2   Air + 10% CO2   1% O2 + 10% CO2

IMPORTANCE OF TEMPERATURE
Commercial prepared red onion rings and dices stored 9 days.

Notice the quality at 0°C

0°C   5°C   10°C

I*10
2WK
AIR
0   5   10 C

	0°C (32°F)	5°C (41°F)	10°C (50°F)
8d			
12d			
16d			
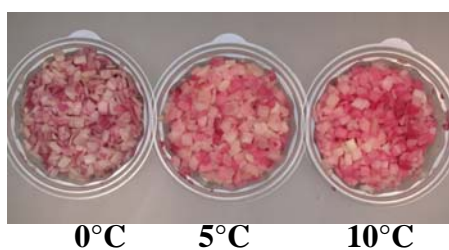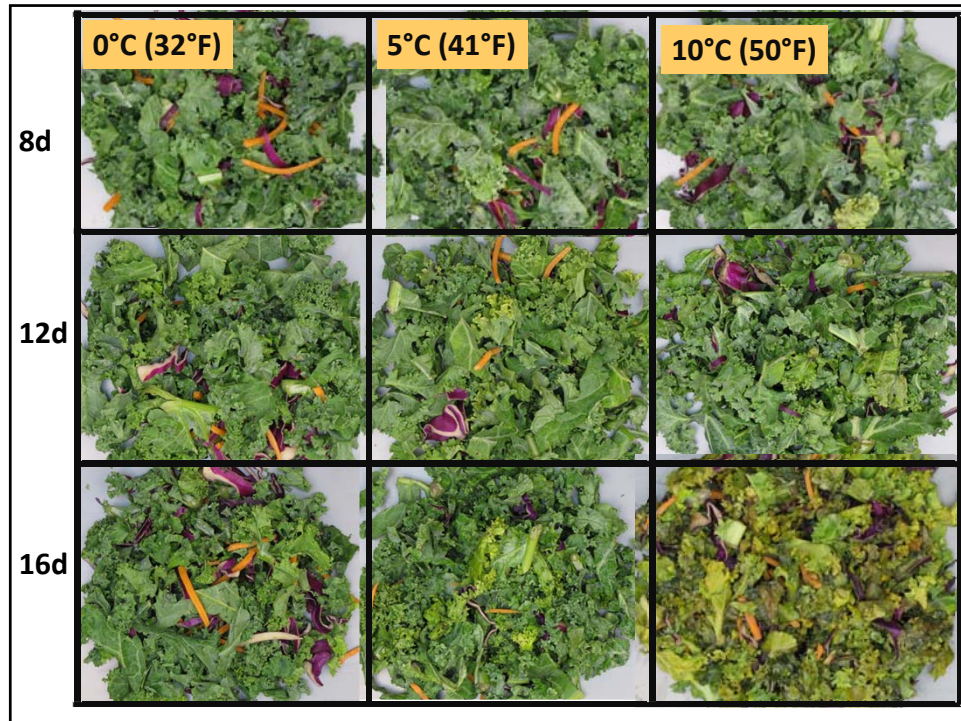
Temporary Storage, Transport and Distribution

TEMPERATURE
TEMPERATURE
TEMPERATURE

Good temperature control throughout distribution
Temperatures increase during distribution
Vertical air flow; ice is a problem

What is the temperature of this product?

Products	Potential post-cutting storage life at 2 to 5ºC
VEGETABLES	Days
Baby carrots, peeled onions, peeled garlic	>21
Lettuce salads, whole lettuce leaves, mixes small leaves (spring mix, mesclun),spinach leaves, peeled potatoes; sliced root mixtures	14-18
Broccoli & cauliflower florets, shredded cabbage, shredded lettuce, shredded broccoli stem, celery & carrot sticks	10-14
Pepper and tomato dices, cucumber slices, squash slices, mushroom slices, jicama sticks	4-9
FRUITS	
Apple wedges, pineapple chunks, pomegranate arils	10-14
Strawberry slices, melon chunks, mango cubes, citrus segments, kiwi, peach & pear slices, grape berries	2-9

For quality and shelf-life: <u>All</u> cut products benefit from low temperature, <u>some</u> benefit from modified atmospheres, and a <u>few</u> benefit from additional treatments

Flavor and nutritional life is about 2/3 shelf-life (appearance)

- Applies to whole products
- Applies to fresh-cut products

Problem: processors and handlers of fresh-cut products focus too much on shelf-life, not enough on flavor quality

But we need more critical data!

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Quality of Fresh-Cut Fruits and Vegetables

Standardization and Inspection

➤ **There are no U.S. grade standards for fresh-cut products; raw product standards apply; http://www.ams.usda.gov**

➤ **The following booklet provides guidelines and definitions for inspection:**

USDA. 1998. Fresh-cut produce: shipping point and market inspection instructions.
Fresh products branch, Fruit & Vegetable Division, Agricultural Marketing Service, U.S. Department of Agriculture, Washington, D.C.

This publication is currently being updated

Best if used by dates

Factors affecting the nutritional quality of fresh-cut products

1. Genotypic variation

2. Preharvest factors

3. Maturity and ripeness stage

4. Fresh-cut operations

5. Storage conditions

Generally, post-cutting life based on visual quality ends before significant losses of nutritional content occur (Gil and Kader)

High Quality Raw Material is Necessary for High Quality Fresh-cut Product

Brassicas have higher respiration rates than lettuces.
Freshness of color and flavor ingredients extremely important.

Raw material quality

Some important factors-not always known or controlled

- Cultivar selection
- Nitrogen, fertilization
- Water, irrigation
- Climate and season
- Maturity

Damage on commercial washed and packaged spinach (cv Space)

Defect level	Category	%
None or slight	1 and 2	34.2
Moderate damage	3	49.2
Severe damage	4	13.7
Leaf Pieces	5	2.8

It is hard to underestimate the importance of varieties

Baby Carrots and Variety Selection

- Uniform, bright orange color
- Small or no core
- High sugars with no harshness/bitterness
- Smooth exterior to minimize peeling loss
- No green should or green core problems
- Strong tops for mechanical harvest
- Balance between juicy texture and resistance to shatter

Immature

Romaine 1   Romaine 2

Mature

Romaine 1   Romaine 2

Overmature

4D 5°C Air

IMPORTANCE OF VARIETY

Fresh-cut Peach & Nectarine

"Next Level Fresh Fruit Cuts, a division of Fruit Dynamics, Inc., Fresno, CA, has announced that after 5 years of product development, they have identified the **proper cultivars, processes and packaging** necessary to commercialize fresh cut peaches and nectarines, in many cases with a shelf life exceeding 15 days."

400 varieties evaluated
Flavor profile
Resistance to discoloration
Shelf-life requirement

http://www.californiafarmer.com/story.aspx/
fresh/cut/peaches/go/commercial/9/41540; Aug 2010

Fresh-cut Fruit Challenges

- Labor Intensive Production
- High Cost per pound-yields and price
- Fruit availability
  - Sourcing domestic and offshore
  - Storage history
  - **Stage of ripeness ideal for cutting**
    - **Maturity at harvest**
    - **Stage of ripeness; texture**
- Perishable cut product
  - Flavor
  - softening, browning
  - microbial
- Flavor quality

Fresh-cut tomato for food service
Shelf-life vs quality
Importance of initial ripeness
Importance of ripening conditions

Color
Texture
Composition-flavor

Difference in juice purge of 2 tomato cultivars

High Quality Fresh-cut Products
Maintain Quality and Safety

- Highest quality raw material
- Minimal cutting damage
- Meticulous sanitation
- Low temperature always and MA if needed
- Less shelf-life for better flavor

19th Annual

Fresh-Cut Products: Maintaining Quality & Safety

Tuesday-Thursday September 23-25, 2014

At the Buehler Alumni & Visitors Center

A three-day workshop for food professionals including lectures, demonstrations, discussions and updates on fresh-cut fruit and vegetable research.

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Maintaining Produce Quality & Safety

http://postharvest.ucdavis.edu

freshCUT

The Magazine for Value-Added Produce
http://www.freshcut.com/
Annual guide to suppliers equipment, etc.

3rd International Conference on Fresh Cut Produce

September 13-17, 2015
UC Davis

ISHS

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http://postharvest.ucdavis.edu