Quality and Safety of Fresh-cut Products

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

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DEFINITION
Fresh-cut Produce

“Fresh-cut produce” is defined as any fresh fruit or vegetable or any combination thereof that has been physically altered from its original form, but remains in a fresh state. Regardless of commodity, it has been trimmed, peeled, washed and cut into 100% usable product that is subsequently bagged or prepackaged to offer consumers high nutrition, convenience and value while still maintaining freshness.

- Minimally Processed
- Lightly Processed
- Partially Processed
- Preprepared
- Fresh Processed
- Pre-cut
- Value-added

Fresh-Cut Produce Sales in US Supermarkets, $4.4 Billion and Shares by Type, 2011, * (excludes supercenters and club stores and represents about 62% of supermarket sales)

<table>
<thead>
<tr>
<th>Category</th>
<th>Market Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit</td>
<td>8.4%</td>
</tr>
<tr>
<td>Vegetables</td>
<td>28.3%</td>
</tr>
<tr>
<td>Packaged salads</td>
<td>63.3%</td>
</tr>
</tbody>
</table>

Source: Nielsen *52 weeks ending July 16, 2011
From Roberta Cook, UC Davis

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

CARROT CHIPS™
CARROT DIPPERS™
CARROT SNACKSTM for Horses!

http://www.grimmway.com

Food Service Presentations

http://www.postharvest.ucdavis.edu
Examples fresh-cut fruit products

U.S. Supermarket Fresh-cut Fruit Category Shares (% of sales)
- Fruit Mix 21.1%
- Melons 21.6%
- Apples 18.8%
- Trays 18.4%
- Pineapple 14.6%
- Mango 2.2%
- Other 3.4%

2009. Source: Roberta Cook; Perishables Group

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
Fresh-cut Potato Products
Abrasion Peeling
Size reduction: slices, strips, dices

- Fresh-cut potatoes
  - Color change can occur rapidly
  - Preformed phenolics and available PPO activity

- Many large volume (lettuce) 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

Processing Baby Peeled Carrots

- Washing
- Disinfecting
- Rapid cooling
- Cut to 2 inch sections
- Mechanical Peeling
- Mechanical shaping
- Disinfection
- Cooling
- Computerized quality and color sorting
- Packaging (form, fill, seal)

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
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/

Objective of Wash Water Disinfection
- Prevent Cross Contamination
- May reduce Microbial Load
- Will NOT Sterilize the Product
- Constant monitoring is required

Types of Disinfection Methods
- Chemical
  - Oxidizer, Oxidizer and Acid, Non-Oxidizer
  - Most chlorine based, but continued search for alternatives
- Non Chemical
  - Irradiation (produce), heat, UV, filtration

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

- 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
Low temperature minimizes wound response. Diced onions discolor, decay, soften and lose fluid more readily than whole peeled onions.

Storage Temperature:

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Respiration rate (µL CO₂. g⁻¹ h⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0°C</td>
<td>Intact: 0, Peeled: 0, Diced: 0</td>
</tr>
<tr>
<td>3°C</td>
<td>Intact: 1, Peeled: 1, Diced: 1</td>
</tr>
<tr>
<td>6°C</td>
<td>Intact: 2, Peeled: 2, Diced: 2</td>
</tr>
</tbody>
</table>

Yellow Onion

Intact

Peeled

Diced

Green Onions

Intact

Peeled, Manual

Peeled, Commercial

Temperature

Respiration rate (µL CO₂. g⁻¹ h⁻¹)

0

1

2

3

4

5

6

7

8

9

10

11

12

More cutting, higher respiration rates.

Low temperature minimizes respiration.

Dices discolor, decay, soften and lose fluid more readily than whole peeled onions.

Enzymatic Browning:

- PAL = phenylalanine ammonia-lyase
- PPO = polyphenol oxidase

Wounds induce phenolic metabolism leading to unsightly brown pigments.

Phenylalanine → cinnamic acid → other phenolics

PPO (o-Diphenol oxidase) (Laccase)

Complex brown polymers → quinones

Prevention of enzymatic/oxidative browning:

- Refrigeration (slows enzymatic reactions)
- Exclusion of oxygen (CA, MAP, edible films)
- Inhibition of PAL (lettuces & veggies)
- 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%O₂ + 8%CO₂)

6 days at 5°C

Control

Control

MA

MA

Control

Control

MA

MA

Control

Control

MA

MA

Control

Control

MA

MA

Control

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Resealable bags

Single serve

Snack packs

Rigid containers and bowls

Biobased packaging PLA resin

Packaging is a key enabling technology.

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Packaging is a key enabling technology.
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

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

Temperature Effects on Retail Packaged Salads

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
Temperature Management

- Insures best product quality
- Longest shelf life
- Reduces microbial growth
- Required for MA packaging

Modified Atmospheres

- Can be an important supplement to temperature
- Can retard deterioration
- Can retard discoloration in fresh-cuts products
- Can retard microbial growth

Modified atmospheres are a supplement to but not a substitute for good temperature management

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

Temporarily Storage, Transport and Distribution

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

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

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Air</th>
<th>1% O2</th>
<th>Air + 10% CO2</th>
<th>1% O2 + 10% CO2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notice the quality at 0°C
### Quality of Fresh-Cut Fruits and Vegetables

**Standardization and Inspection**

- The following booklet provides guidelines and definitions for inspection:
  

Best if used by dates

### 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

### 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)

### Nutrition messages on salads

Darker green lettuces have more nutrition

Vitamin C can be reduced in MAP

### 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.
**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

**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)**

<table>
<thead>
<tr>
<th>Defect level</th>
<th>Category</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>None or slight</td>
<td>1 and 2</td>
<td>54.8</td>
</tr>
<tr>
<td>Moderate damage</td>
<td>3</td>
<td>49.2</td>
</tr>
<tr>
<td>Severe damage</td>
<td>4</td>
<td>13.7</td>
</tr>
<tr>
<td>Leaf Presence</td>
<td>5</td>
<td>0.8</td>
</tr>
</tbody>
</table>

**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

**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

**Importance of Variety**

“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