Fresh-cut Products: Overview and Challenges

- Examples of products
- Physiology of fresh-cut products
- Preparation and handling
- Quality aspects of fresh-cut products

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Postharvest Technology Short Course June 2011
Ch. 36 Postharvest Technology Book

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.

IFPA-UFPF

Estimated Projected National Retail Fresh-Cut Produce Sales:
$5.3 Billion in 2009 vs. $5.4 in 2008

Fruit 9%
Vegetables * 32.8%
Packaged salads 58.2%

Sources: The Perishables Group and estimates by Roberta Cook

Examples of products
- 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

Sweetpotato for Food service
Many garlic products

Steam in pouch B sprouts & asparagus
Immediate Physical Effects

- **Mechanical shock to tissue**
  - Bruises, cracks, fractures in tissue
- **Removal of protective epidermal layer**
  - Alter gas diffusion
  - Provide entry for contaminants
- **Cell fluids on cut surface**
  - Reduced gas diffusion
  - Provides substrate for microbes
- **Exposure to contaminants**
  - Microbial, Chemical

Physiological Effects of Fresh-cut Processing

- Increased respiration rates
- Altered ethylene production rates
- Increases in other biochemical reactions
  - Discoloration and Color
  - Texture
  - Aroma and Flavor
  - Nutritional quality

Main strategy to minimize changes in physiology is low temperature
Low temperature minimizes wound response (µL CO₂/ g/h).

Yellow Onion
- Intact
- Peeled
- Diced

Green Onion
- Intact
- Chopped, Manual
- Chopped, Commercial

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

Intact and Fresh-cut Kale

Respiration rate (mL CO₂/ kg/h)

<table>
<thead>
<tr>
<th>Product</th>
<th>0°C</th>
<th>5°C</th>
<th>10°C</th>
<th>15°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full size leaves</td>
<td>8</td>
<td>12</td>
<td>29</td>
<td>33</td>
</tr>
<tr>
<td>Small leaves</td>
<td>14</td>
<td>21</td>
<td>42</td>
<td>57</td>
</tr>
<tr>
<td>Chopped</td>
<td>15</td>
<td>23</td>
<td>46</td>
<td>53</td>
</tr>
<tr>
<td>Shredded</td>
<td>17</td>
<td>28</td>
<td>59</td>
<td>68</td>
</tr>
</tbody>
</table>

Yellow Onion: Intact, Peeled, Diced

Green Onion: Intact, Chopped, Manual, Chopped, Commercial

Intact and Fresh-cut Kale Respiration

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

Wounds induce phenolic metabolism leading to unsightly brown pigments

PAL
Phenylalanine → cinnamic acid → other phenolics

PPO
(α-Diphenol oxidase) (Laccase)

Complex brown polymers → quinones

Enzymatic Browning

Salad Lettuce:
- Cut edge browning
- Wound induction of PAL and brown pigments
- Lettuce types and varieties differ in PAL and browning

Type 1 Fresh-cut Browning
PAL activity induced, low pre-formed phenolic content (e.g. lettuce)

Type 2 Fresh-cut Browning
Plenty of PPO and pre-formed phenolics present (e.g. apples)

Cut-Edge Discoloration
Key Browning Reactions

PHE → PAL
(Phenylalanine) → Phenolics

PPO
Phenolics → Quinones

Condensation
Rx’s → Colored Pigments

Oxygen
Copper

Type 1 Fresh-cut Browning

Type 2 Fresh-cut Browning

Phenolics highest in outer leaves; browning highest in outer leaves
Sugar highest in heart leaves
Chlorophyll/carotenoids highest in outer leaves
Vitamin C not much affected by leaf age or position

Ermen, Hong, Cantwell, 2006
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

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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

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Knife/Cutting Blade Sharpness

- Cut cleanly not crush
- Better shelf-life
- Less browning of cut edges

Carrot

Sharp Razor        Dull Knife

Quality of Cut Iceberg Lettuce
(Hussell & Bok, 1977)
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)

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

Cantaloupe Melon Tranlucency: Sharp vs Blunt Blades

Same:
- Soluble solids
- Texture
- Microbial growth
- Respiration, ethylene

Different:
- Appearance
- Color values
- Ferm.volatiles
- Electrolyte Leakage
- Off-odors

Portela & Cantwell 2001 JFS 66:1265

SANITARY PLANT DESIGN
Focus: Implementation of GMP's

- Design efficient, easy to clean & sanitize processing plants
- Mobility of equipment
- 2-3 areas to separate production steps
- The sanitation crew is as important as the production crew

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

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

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
**Nutrition Fresh-cut Products**

- Larger piece size retains nutrients better than smaller pieces
- In packaged salads, high CO2 atmospheres can cause significant loss of Vitamin C
- Vitamin A (carotenoids) content correlated with chlorophyll concentrations
- Initial nutrient content is paramount; loss of vitamins is minimized by low temperature

**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

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**Cut Romaine Total Vitamin C**

![Graph showing Vitamin C content over time under different conditions]

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**Cut Romaine Total Vitamin C vs Chl**

![Graph showing correlation between Vitamin C and chlorophyll content]

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**Fresh-cut produce Chill Chain Temperatures During Shipping, Distribution and Retail Display.**

![Graph showing temperature data from a fresh-cut processor]

We can do better!!

Good temperature control throughout handling and distribution is a necessity for fresh-cut products; vertical air flow cabinets.
Impact of temperature and CA (1%O₂ + 10%CO₂) on the quality of yellow fresh-cut onions

Commercial prepared red onion rings and dices stored 9 days.

Increased complexity and compatibility issues

- 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

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

- 7.5°C (45°F)
- 5°C (41°F)
- 2.5°C (36°F)

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

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
“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
Shell-life requirement

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.

Preprocessing Storage
Example: Lettuce heads stored at 5°C (41°F)
Longer heads are stored, greater browning on cut salad pieces

Ripeness stage & storage temperature affect Shelf-life

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

Difference in juice purge of 2 tomato cultivars
Fresh-cut Fruit Challenges

- Labor Intensive Production
- High Cost per pound-yields and price
- Fruit availability
  - Sourcing domestic and offshore
  - Storage history
  - Managing stage of ripeness
- Perishable cut product
  - Softening, browning, microbial
- Flavor quality

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

Products Potential post-cutting storage life at 2-5°C

<table>
<thead>
<tr>
<th>Products</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>VEGETABLES</td>
<td></td>
</tr>
<tr>
<td>Baby carrots, peeled onions, peeled garlic</td>
<td>&gt;21</td>
</tr>
<tr>
<td>Lettuce salads, whole lettuce leaves, mixes small</td>
<td>14-18</td>
</tr>
<tr>
<td>PEPPERS</td>
<td></td>
</tr>
<tr>
<td>Pepper and tomato dices, cucumber slices, squash slices, mushroom slices, jicama sticks</td>
<td>4-9</td>
</tr>
<tr>
<td>FRUITS</td>
<td></td>
</tr>
<tr>
<td>Apple wedges, pineapple chunks, pomegranate arils</td>
<td>10-14</td>
</tr>
<tr>
<td>Strawberry slices, melon chunks, mango cubes, citrus segments, peach &amp; pear slices, grape berries, kiwifruit slices</td>
<td>2-9</td>
</tr>
</tbody>
</table>

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

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:


We want FRESH Fresh-cut Products!

Best if used by dates

THANK YOU!