PREPARATION AND HANDLING FRESH-CUT ROOT VEGETABLES

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Preparation and handling fresh-cut root vegetables

- Production
- Handling and Storage
- Processing and Packaging
- Distribution and Market
- Consumption

Pre-harvest | Post-harvest | Processing | Post-processing
CONTENT

- Characteristics of root vegetables
- The unit operation
  - Peeling and cutting
  - Washing
  - Pre-packaging treatments
  - Packaging
- Research needs
- Conclusions
Root vegetables are mostly underground storage organs containing soil.

**Roots**
- True taproots

**Tubers**
- Includes a swollen hypocotyl

*Images of various root vegetables.*
Root vegetables are biennial crops

Seed → Growth → Termination of root growth → Dormancy → Sprouting and flowering → Re-growth → Seed

Harvest → Nov → Jan → March → May → Cold storage

Root vegetables are biennial crops.
Chemical constituents vary between cultivars of root vegetables. The total terpene content in carrots is shown in the graph below, adapted from Kreutzmann et al. 2008.
Sensory quality vary between cultivars

Taunus
Rocket
Pablo
Chioggia
Touchstone Golden

Mikkelsen 2012
CHARACTERISTICS OF ROOT VEGETABLES

- Belong to many different plant families
- Are biennial crops
- Continue to grow after harvest
- Can be stored for up to 12 months
- Store mainly sugars
- Vary considerably in quality depending on family, species, cultivar and time of usage
The unit operation for root vegetables

Peeling → Cutting → ± Washing → ±Pre-packaging → Packaging
An example with processing of carrot sticks

- **Household**
  - Hand peeling knife
  - Trimming + rinsing

- **Factory A**
  - Coarse → fine abrasion peeling + rinsing
  - Cutting into 2 x 2 mm sticks
  - Cold air cooling on conveyer belt
  - Centrifugation

- **Factory B**
  - Fine abrasion peeling + rinsing
  - Cool room overnight
  - Washing in tap water

- **Factory C**
  - Trimming
  - Packaging

**Unit operation**

- ‘Bolero’ carrots

**Household box with ventilation**
Effect of processing on visual quality

Unit operation

Trimming
Peeling
Cutting

Factory A
Trimmed
Peeled
Cut

Factory C
Trimmed
Peeled
Cut

Fractures
Effect of processing on microbial load

![Bar chart showing the log CFU/g after 1 day in MAP at 5 °C for Factory A, Factory B, and Factory C for Coliforms, Lactic acid bacteria, and Yeast & Mold.](image-url)
Effect of processing on sensory quality

Sensory scores from low to high

<table>
<thead>
<tr>
<th>Orange colour</th>
<th>Wet surface</th>
<th>Carrot flavour</th>
<th>Sweetness</th>
<th>Juiciness</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Household</strong></td>
<td><strong>Factory A</strong></td>
<td><strong>Factory B</strong></td>
<td><strong>Factory C</strong></td>
<td><strong>Factory C</strong></td>
</tr>
<tr>
<td>a</td>
<td>b</td>
<td>a</td>
<td>b</td>
<td>c</td>
</tr>
<tr>
<td>b</td>
<td>a</td>
<td>ab</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>c</td>
<td>c</td>
<td>a</td>
<td>ab</td>
<td>c</td>
</tr>
</tbody>
</table>

- Orange colour:
  - Household: a
  - Factory A: b
  - Factory B: a
  - Factory C: c

- Wet surface:
  - Household: a
  - Factory A: b
  - Factory B: a
  - Factory C: c

- Carrot flavour:
  - Household: a
  - Factory A: a
  - Factory B: b
  - Factory C: c

- Sweetness:
  - Household: a
  - Factory A: b
  - Factory B: b
  - Factory C: c

- Juiciness:
  - Household: a
  - Factory A: b
  - Factory B: b
  - Factory C: c
Effect of processing on aroma volatiles and sensory quality

Volatile content (ng/g fresh weight)

- Control (cut)
- Cut
- Cut+spin
- Cut+wash+spin

Edelenbos et al. (2010) Acta Hort 876
Washing to reduce total microbial load

![Graph showing microbial load over storage days for different treatments.](image)

- **Control**: 6.3%
- **Pre-wash water**: 5.2%
- **Pre-wash chlorine**: 6.3%
- **Pre-wash ozone**: 6.3%
- **Washed sticks chlorine**: 5.2%

Adapted from Klaiber et al. 2004
Washing to reduce microbial load

- Peeled, topped carrots
- Ctr samples (Industrial practice)
- HS samples
- UV samples
  - Heat Shock (Hot water, 150°C, 45 s)
  - Cooling (0°C, 3 min)
  - Water removal
  - Storage at 0°C (24 h)

Decontamination (500 ppm free chlorine/1 min)

- Rinsing (0°C, 60 s)
- Water removal

Packaging

Storage (5°C, 10 days)

Graph showing Microbiological threshold limit, Initial contamination level (raw material), and TAPC (Log cfu/g) over Storage time (days).
Phytochemicals in carrots

Polyacetylenes

- Falcarnol (FaOH)
- Falcarnidol (FaDOH), R=OH
- Falcarnidol 3-acetate (FaDOAc), R=OAc

Phenolic acids

- \( \rho \)-Coumaric acid, R= H
- Caffeic acid, R= OH
- Ferulic acid, R = OCH\(_3\)

Isocoumarins

- 6-Methoxymellein (6-MM)

Quinic acid
Some phytochemicals are simply removed in the peeling process.
Effect of processing on polyacetylenes

Parsnip discs

Effect of peeling on phenolic acids

Carrot discs

![Graph showing the effect of peeling on phenolic acids over storage time.](image)
‘White blush’ in root vegetables

Rehydration

White blush (score 1-4)

Time after processing

Minutes

A.d.N. Simões et al. / Postharvest Biology and Technology 55 (2010) 45–52
Chitosan-based coating to overcome ‘white blush’

6 mm carrot sticks

![Graph showing the effect of coating on white blush in 6 mm carrot sticks.](image-url)
Packaging to maintain the initial sensory profile

Edelenbos et al. (2010) Acta Hort 876
Packaging to prolong shelf-life

Swede cubes

H.S. Helland et al./Postharvest Biology and Technology 111 (2016) 150–160
Effect of time, temperature and packaging on quality

### Sugars

<table>
<thead>
<tr>
<th>Total sugars (g/100 g FW)</th>
<th>Swede</th>
<th>Turnip</th>
<th>Swede</th>
<th>Turnip</th>
<th>Swede</th>
<th>Turnip</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 d</td>
<td>A</td>
<td>B</td>
<td>a</td>
<td>b</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>10 d</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>A</td>
</tr>
</tbody>
</table>

### Sweetness

<table>
<thead>
<tr>
<th>Score from low to high</th>
<th>Swede</th>
<th>Turnip</th>
<th>Swede</th>
<th>Turnip</th>
<th>Swede</th>
<th>Turnip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days</td>
<td>5 d</td>
<td>10 d</td>
<td>5 °C</td>
<td>10 °C</td>
<td>MA1</td>
<td>MA2-5%</td>
</tr>
</tbody>
</table>

Adapted from: 
H.S. Helland et al./Postharvest Biology and Technology 111 (2016) 150-160
Effect of time, temperature and packaging on quality

Whiteness (the higher the score the less enzymatic browning)
# PROCESSING OF ROOT VEGETABLES

## Variation in the unit operation
- Abrasion peeling
- Knife cutting, slicing, dicing & shredding
- Chemical treatments
- Physical treatments
- Edible coatings
- Gas transmission rates

## Effects on:
- The physical properties
- Wounding & oxidation
- Vapor exchange
- Constituents & microbial load
- Leakage
- Enzymatic browning
- Microbial load
- Moisture retention
- Quality retention
RESEARCH NEEDS

- Appropriateness of cultivars/colored types/tissue age at processing.
- Gentle processing/efficient decontamination to maintain sensory quality and safety.
- Better methods to evaluate the direct effects of processing on quality.
CONCLUSIONS

- Root vegetables contain dietary fibers, sugars and phytochemicals. Are low in vitamin C.
- Peeling removes the protective skin so microorganisms can enter. Specific phytochemicals are removed.
- ‘White blush’ develops in wounded tissue due to loss of moisture from the surface.
- Harsh handling/abiotic stress enhance phenolic metabolism.
CONCLUSIONS

- Fresh-cut root vegetables are prone to:
  - enzymatic browning in white/light-colored tissue
  - white blush in dark-colored tissue
  - loss of aroma and flavor especially in carrots, parsnips, root parsley and celeriac if finely cut and washed
  - loss of sweet taste if finely cut and washed
  - fermentation if oxygen get too low in the package
THANK YOU FOR YOUR ATTENTION!