How to get and preserve good quality in apples – a short survey
Factors affecting apple quality

- Bruising/Mechanical damage
- Physiological disorders
  - Bitter Pit
  - Scald
  - Water core
  - Sunburn (sunscald)
  - Internal browning
- Calcium
- Temperature management
- Storage atmosphere
Bruising/ Mechanical damage

- Increased water losses
- Shortened storage life
- Decreased product value
Mechanical damage

- Bruising (skin still intact) which may be caused by f.ex.:
  - Picking in wet weather
  - No padding in wooden boxes
  - Rough transport conditions
  - Rough handling in sorting/packing house
  - Overfilled boxes in pallets
Mechanical damage

- Cuts (healed and not healed) which may be caused by f.ex.:
  - Nails
  - Edges in boxes
  - Sorting/packing equipment
  - Overfilled boxes
Careful picking of dry apples
Careful transfer to padded bins
Careful transfer from bins to sorting equipment
Proper sorting equipment
Careful packing
Careful packing
Bitter pit in apples

Groups of cells with low calcium levels and therefore **rapid senescence**

Necrotic (dead) cells under the skin, first around the blossom end, later developing over the rest of the fruit.
Bitter pit
Development of bitter pit

Bitter pit usually develops after storage, when the fruit it brought out into higher temperatures, maybe after arriving at the destination and when displayed in a shop.

Longer storage increases the risk.

Bitter pit may, in very severe cases develop while the fruit is still sitting on the tree but this is unusual.
Risk factors for bitter pit

- Strong vegetative growth in trees
- Large fruits
- Low calcium levels
- High availability of nitrogen in late season
- Late harvests
Varietal differences - bitter pit

More sensitive:
- Belle de Boskoop
- Cox Orange
- Golden delicious
- Granny Smith
- Marigold
- Jonathan
- Gravenstein

Less sensitive:
- Macintosh
- Spartan
- Lobo
- Gala
- Fuji’
As low calcium levels are central in the development of bitter pit, factors that affect fruit Calcium levels have to be paid attention to.
Irregular patches of brown (damaged cells) on the fruit skin.
Scald in apples
Scald

• Probably a type of chilling injury
• Usually occurs after 3 months of storage
• Develops 3-7 days after warming the fruit
• Connected to low levels of calcium but not as strongly as bitter pit
• Decreases with late harvest
• Decreases in low oxygen storage
Varying susceptibility to Scald

Susceptible varieties
Granny Smith
Golden delicious

Moderately susceptible varieties
Gala
Fuji
A late harvest

- May increase the risk for bitter pit
  - But

- May decrease the risk for scald!!!
Watercore

- Watersoaked regions in the flesh near the core and vascular bundles.
Risk factors for water core

- Large fruit
  - Excessive thinning
  - High leaf to fruit ratio
- Low fruit calcium
- High fruit nitrogen
- High light exposure
- Late harvests
Sunburn (*sunscald*)

White, tan or yellow patches on the sun side of the fruit.

Injured areas can turn brown on the tree.

Injury to the flesh can occur.
Risk factors for sunscald

- Apple production in
  - high temperatures, and
  - Clear skies
- Heavy crops
- Water stress
- Low calcium concentration
- Heavy crops
- Granny Smith
Internal browning

Brown discolouration in the flesh, often in or near the core.

Symptoms are seen early in storage and may increase in severity.

Probably a CO$_2$ injury
Risk factors for internal browning

- Late harvest
- High $CO_2$ in storage
- Delayed cooling after harvest
- Temperatures above 3° in storage
- Bad ventilation in storage
Calcium in the maintenance of apple quality

- Storability of apples is related to fruit Calcium levels (and K/Ca ratio)
- Many physiological disorders have been connected with low calcium levels in apples
  - Bitter pit
  - Scald
  - Sunburn
  - Watercore
Calcium uptake and water

- Calcium from the ground is transported by the water taken up by the tree.
  - So little water means little calcium to the fruit
Calcium uptake and soil types

- A light sandy soil dries out much quicker than a clay soil.

So, in a dry spring, the risk for calcium deficiency is greater on a light sandy soil.
Most of the calcium in apples is taken up during the first 6 weeks after flowering.

- So a dry spring means less calcium to the fruit
**Calcium content and autumn rains**

- **BUT**, a lot of water late in the season, will not bring much more calcium.
- Instead it promotes an increase of fruit size which "dilutes" the calcium in the fruit.

- Thus, when a dry spring is followed by a wet autumn, the risk for low calcium in fruits increases.
Calcium and pips (seeds)

- Pips (i.e. the auxin in the seeds) help attract Calcium to the fruit
  - Hence, a greater number of pips in the fruit means a lower risk for low calcium levels
- Some varieties require crosspollination.
  - The further away the pollinating variety is, the lower the number of seeds.
- As a rule of thumb, a pollinating variety should not be further than 25 meters away.
Proper pollination is essential in some varieties.
A large leaf/fruit ratio will increase the risk for low calcium levels. Measures that increase leaf/fruit ratio will therefore increase the risk for bitter pit.

- Severe pruning
- Young trees
- Lots of available nitrogen
Proper pruning is required to ensure fruit quality.
Temperature

- Temperature has an effect on a number of processes that influence quality and storage life
  - Respiration
  - Water losses
  - Ethylene production
  - Effect of ethylene in the air
  - Rate of enzyme activity
Carrot shelf life in different temperatures

Storage life, days

Temperature in degrees celsius

Carrots
Ascorbic acid loss in parsley stored at different temperatures

Ascorbic acid (mg/100g fw) over weeks in storage at different temperatures.
Temperature management

• Rapid cooling after harvest
• Keeping an unbroken cold chain after harvest
Storage atmosphere

- **CA** – controlled atmosphere
  - Low oxygen
  - Increased carbon dioxide
- **ULO** – Ultra low oxygen
  - A type of CA with oxygen levels under 1% 
- Is a complement to low temperature but cannot replace it
### Average optimum levels in CA-storage of popular apple varieties

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Oxygen, %</th>
<th>Carbon dioxide, %</th>
<th>Temp, degrees C</th>
<th>Storage, months</th>
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<tbody>
<tr>
<td>Braeburn</td>
<td>1.8</td>
<td>1.0</td>
<td>0.7</td>
<td>&quot;6-9&quot;</td>
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<tr>
<td>Fuji</td>
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<td>1.0</td>
<td>0.3</td>
<td>&quot;7-11&quot;</td>
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<tr>
<td>Gala</td>
<td>1.7</td>
<td>1.6</td>
<td>1.3</td>
<td>&quot;2-9&quot;</td>
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<tr>
<td>Golden Delicious</td>
<td>1.6</td>
<td>2.3</td>
<td>0.5</td>
<td>&quot;7-11&quot;</td>
</tr>
<tr>
<td>Granny Smith</td>
<td>1.4</td>
<td>2.0</td>
<td>0.6</td>
<td>&quot;7-11&quot;</td>
</tr>
<tr>
<td>Idared</td>
<td>2.1</td>
<td>2.5</td>
<td>1.9</td>
<td>&quot;7-10&quot;</td>
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<tr>
<td>Jonagold</td>
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<td>0.9</td>
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<tr>
<td>McIntosh</td>
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<td>2.5</td>
<td>&quot;5-10&quot;</td>
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<td>Red delicious</td>
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<td>1.8</td>
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<td>Royal Gala</td>
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<td>1.8</td>
<td>&quot;-0.0&quot;</td>
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</tr>
</tbody>
</table>

**Source:** University of California
Low, but non freezing, temperatures are essential for retaining apple quality

Thank you for your attention