

*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



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## Careful packing

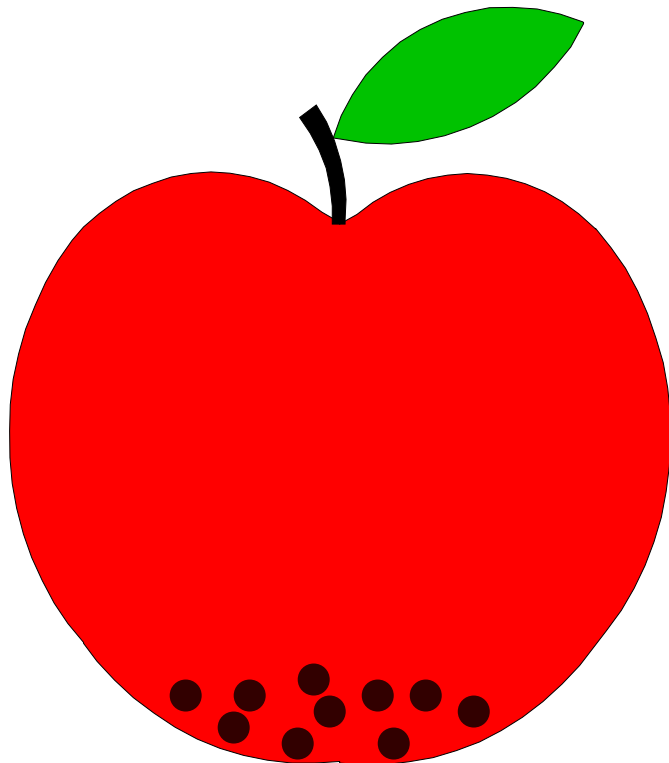


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## Careful packing



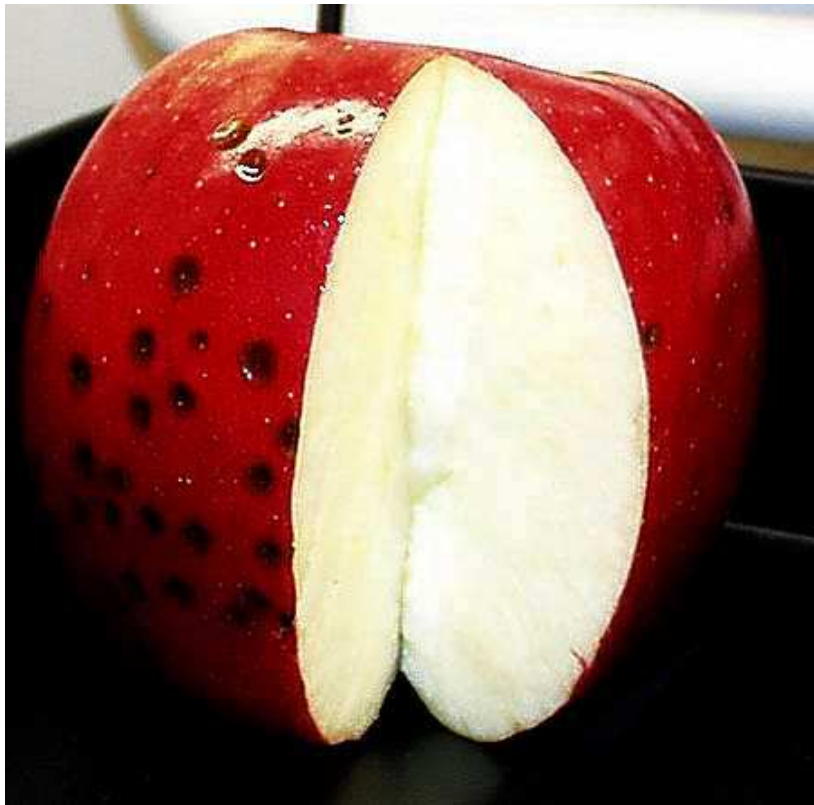
# Bitter pit in apples



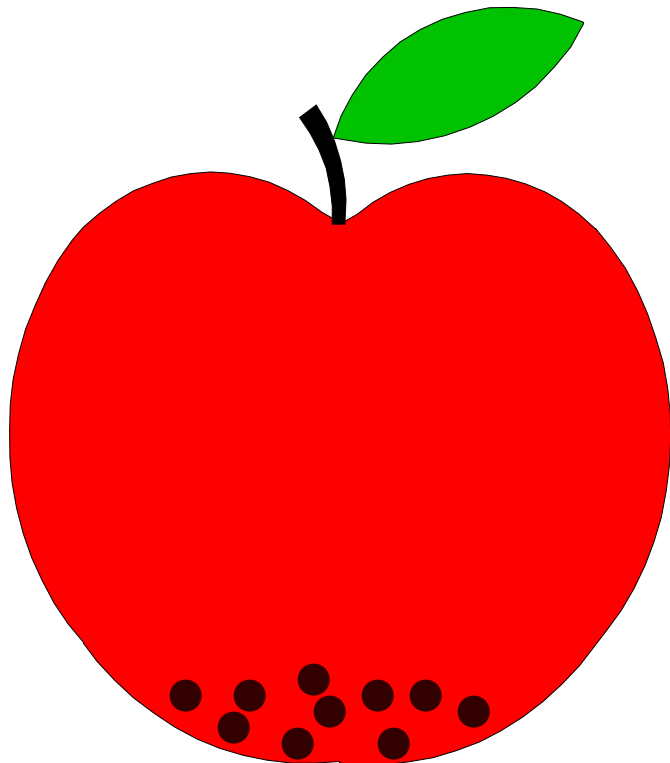
Groups of cells with low calcium levels and therefore rapid senescence

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 is 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


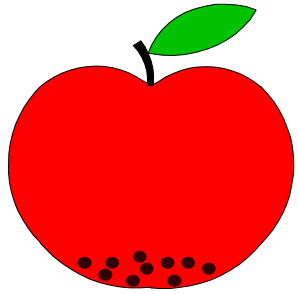
Less sensitive



Belle de Boskoop  
Cox Orange  
Golden delicious  
Granny Smith  
Marigold  
Jonathan  
Gravenstein

Macintosh  
Spartan  
Lobo  
Gala  
Fuji'

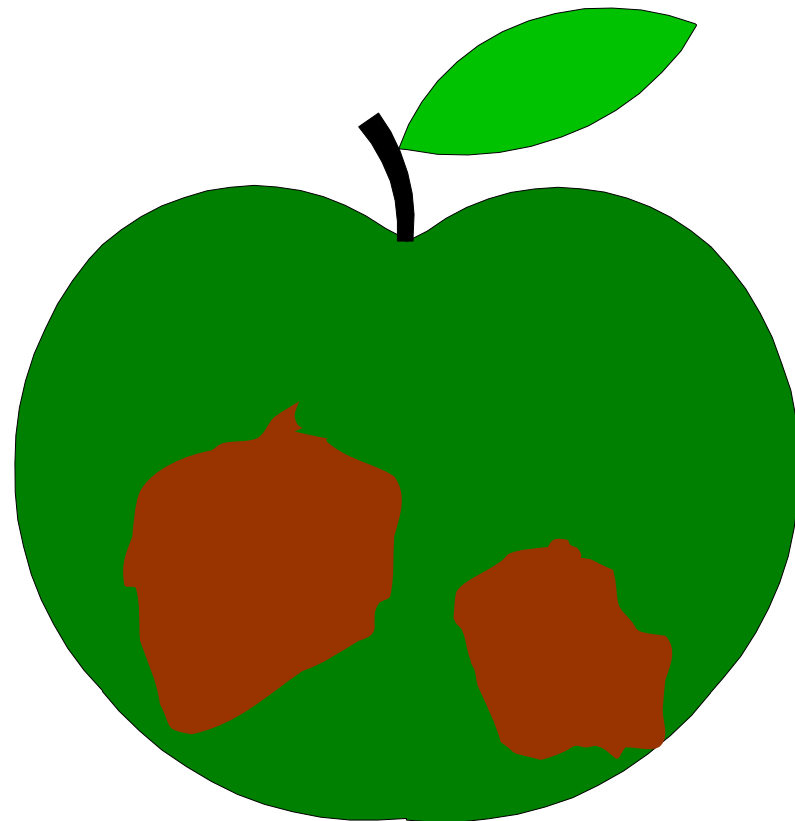




As low calcium levels are central in the development of bitter pit, factors that affect fruit Calcium levels have to be paid attention to.

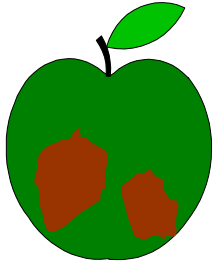
# *Scald*

Irregular patches of brown (damaged cells) on the fruit skin.



# *Scald in apples*

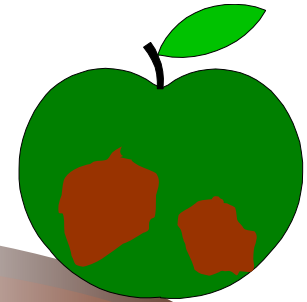




## *Scald*

- 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

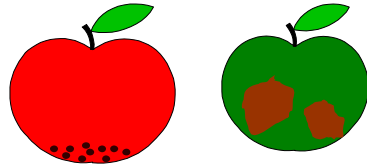
## Moderately

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*

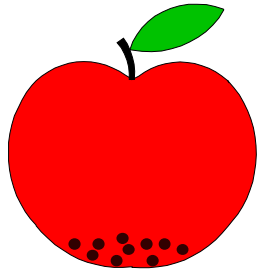


- Late harvest
- High  $CO_2$  in storage
- Delayed cooling after harvest
- Temperatures above  $3^\circ$  in storage
- Bad ventilation in storage

# *Calcium in the maintenance of apple quality*

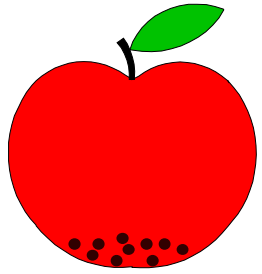


- Storability of apples is related to fruit Calcium levels (and K/Ca ratio)
- Many physiological disorders have been connected with low calcium levels in apples
  - Bitter pit
  - Scald
  - Sunburn
  - Watercore



## *Calcium uptake and water*

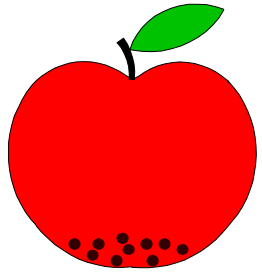
- Calcium from the ground is transported by the water taken up by the tree.
  - So little water means little calcium to the fruit



## *Calcium uptake and soil types*

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

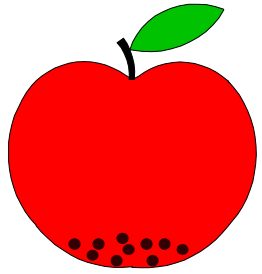
So, in a dry spring, the risk for calcium deficiency is greater on a light sandy soil



## *Calcium uptake in time*

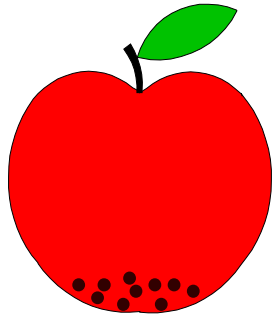
- Most of the calcium in apples is taken up during the first 6 weeks after flowering.
  - So a dry spring means less calcium to the fruit





## *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.

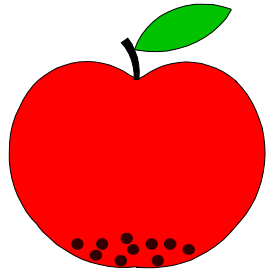


## *Calcium and pips (seeds)*

- 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**



## *Leaf/ fruit ratio and calcium levels in fruit*

- 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**

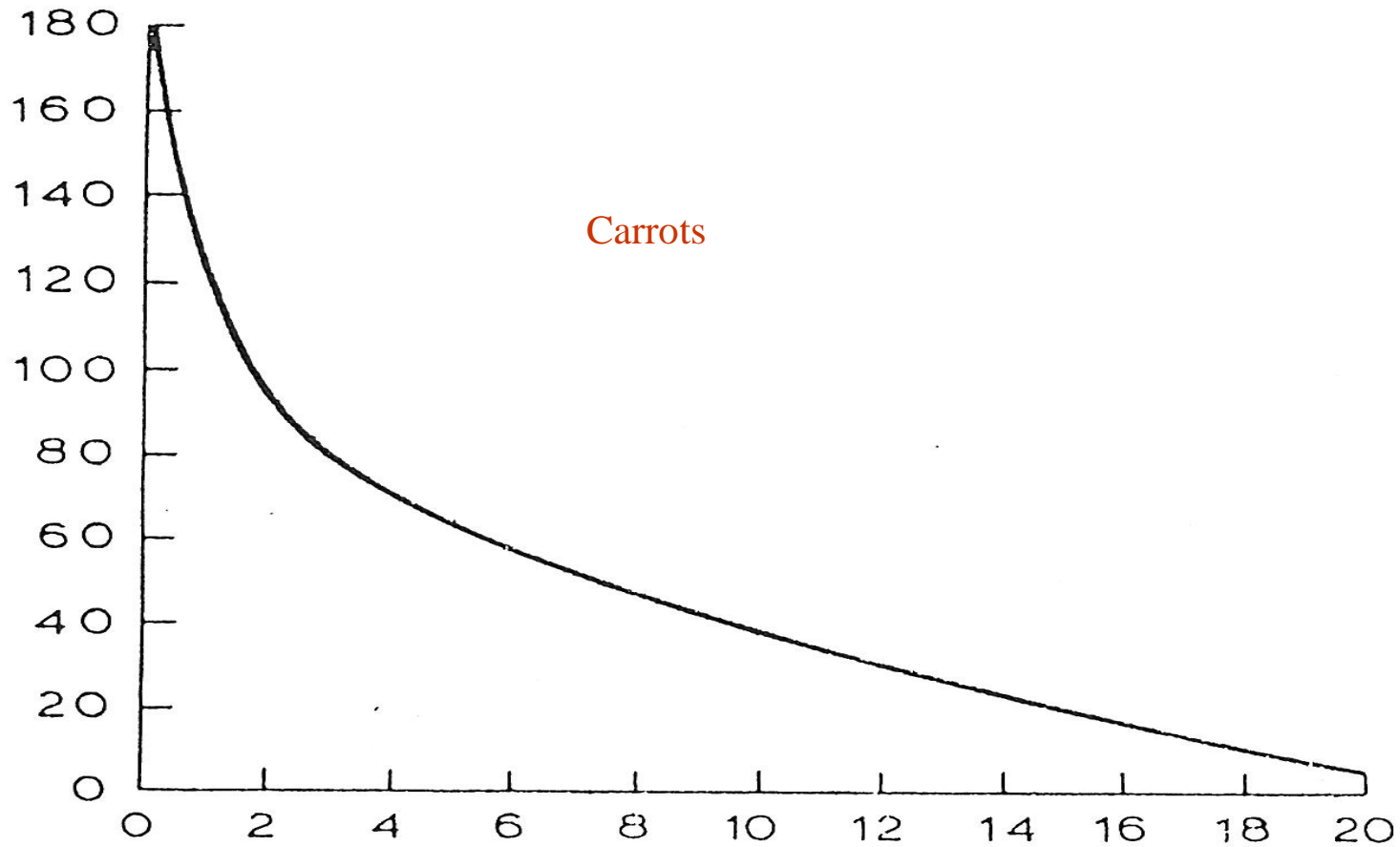
# *Temperature*



- 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*

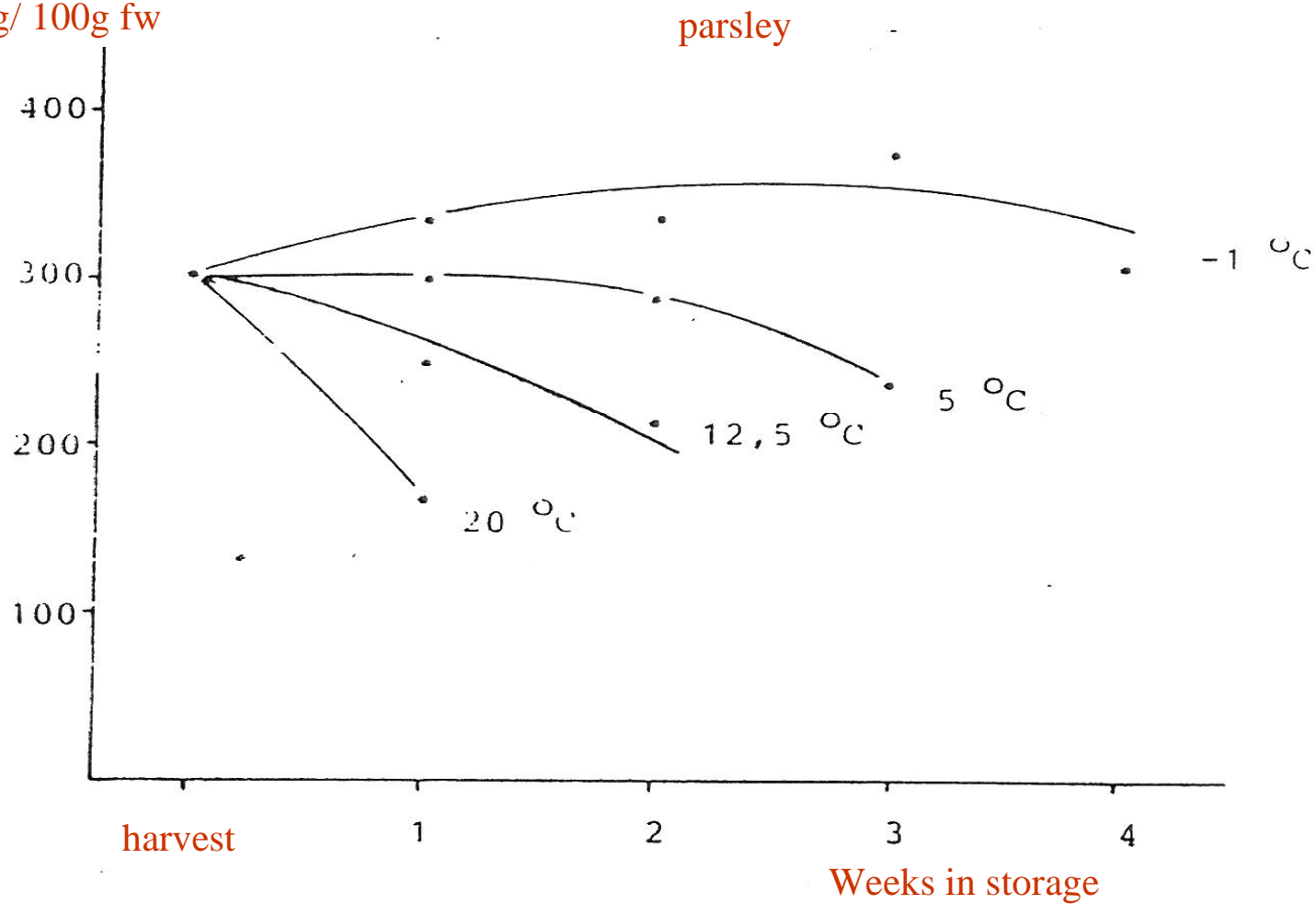
Storage life, days



Temperature in degrees celsius

# Ascorbic acid loss in parsley stored at different temperatures

Ascorbic acid  
mg/ 100g fw





# *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*

<b>Cultivar</b>	<b>Oxygen, %</b>	<b>Carbon dioxide, %</b>	<b>Temp, degrees C</b>	<b>Storage, months</b>
Braeburn	1.8	1.0	0.7	"6-9
Fuji	1.4	1.0	0.3	"7-11
Gala	1.7	1.6	1.3	"2-9
Golden Delicious	1.6	2.3	0.5	"7-11
Granny Smith	1.4	2.0	0.6	"7-11
Idared	2.1	2.5	1.9	"7-10
Jonagold	1.4	2.7	0.9	"5-10
McIntosh	2.1	2.9	2.5	"5-10
Red delicious	1.6	1.8	0.0	"6-11
Royal Gala	1.7	1.8	"-0.0	"5-8

**Source: University of California**

*Low, but non freezing,  
temperatures are essential for  
retaining apple quality*

*Thank you for your attention*

