Controlled Atmosphere

Controlling air composition to increase storage life

Sunshine Seminar August 23rd, Eelke Westra

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Postharvest Quality

Fresh produce has to bridge distance and time from where it is produced to where it is consumed while **maintaining its properties**. The resources for doing so are limited and under pressure. With our understanding of the product, technology and value chain and our unique facilities we offer services, find solutions and accelerate R&D.

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85+ Years of Postharvest Research: #1 Worldwide

1936

Foundation IBVT
by prof. A.M. Sprenger

1966

Renamed Sprenger Institute

1990

Renamed ATO-DLO

2017

WFBR – Renewed facilities (PHENOMEA)

DCS™

QUEST™

Sea freight
Cut-flowers

Utilisation of postharvest data — Data & AI

Application of postharvest sensors — Sensing technology

Development postharvest physiology — Ethylene and CA technology

Packaging technology — *Development postharvest handling*

Refrigeration technology — *Development basic postharvest systems*

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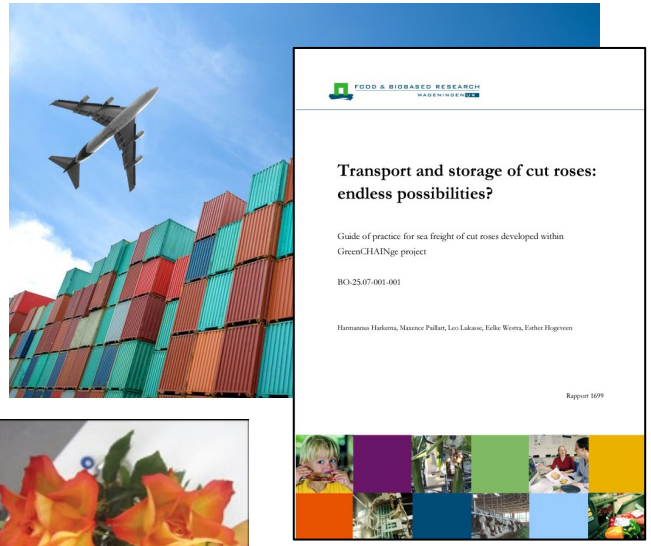
Wageningen Research Services

Contract Wageningen experts for:

- Co-development of Solutions
- Technical Validation
- Consultancy
- Training & Capacity building

Track record flowers

- Protocols for handling cut flowers for seafreight
  - https://edepot.wur.nl/401918
- Ethylene
- Botrytis
  - Storage conditions
  - Treatments
- Water balance in flowers



Typical STAR shaped flowers due to ethylene

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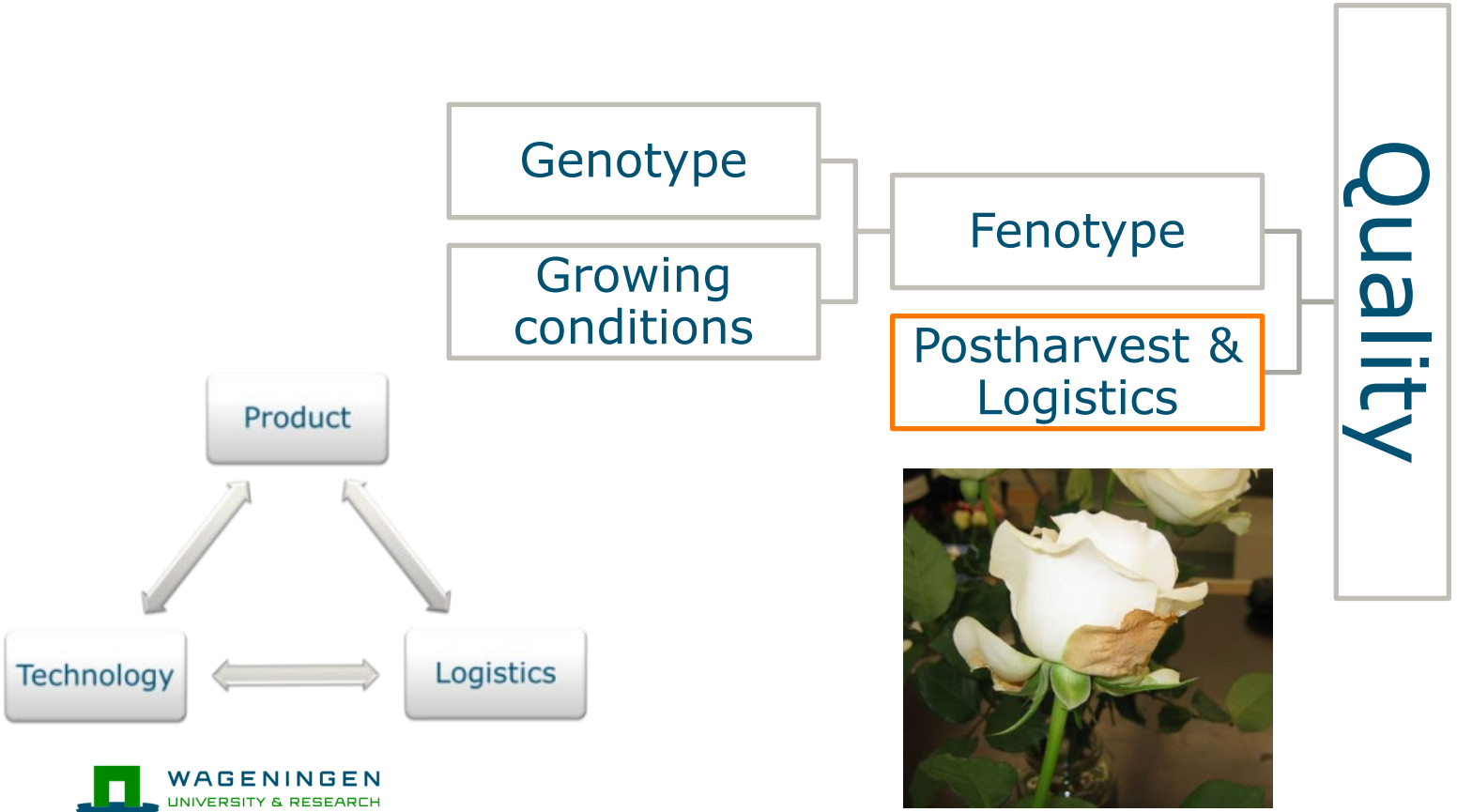
Outline

- Mechanical refrigeration
- Controlled Atmosphere (CA)
- Components
- CA in transport equipment
- CA and cut roses

Quality controlled logistics is KEY



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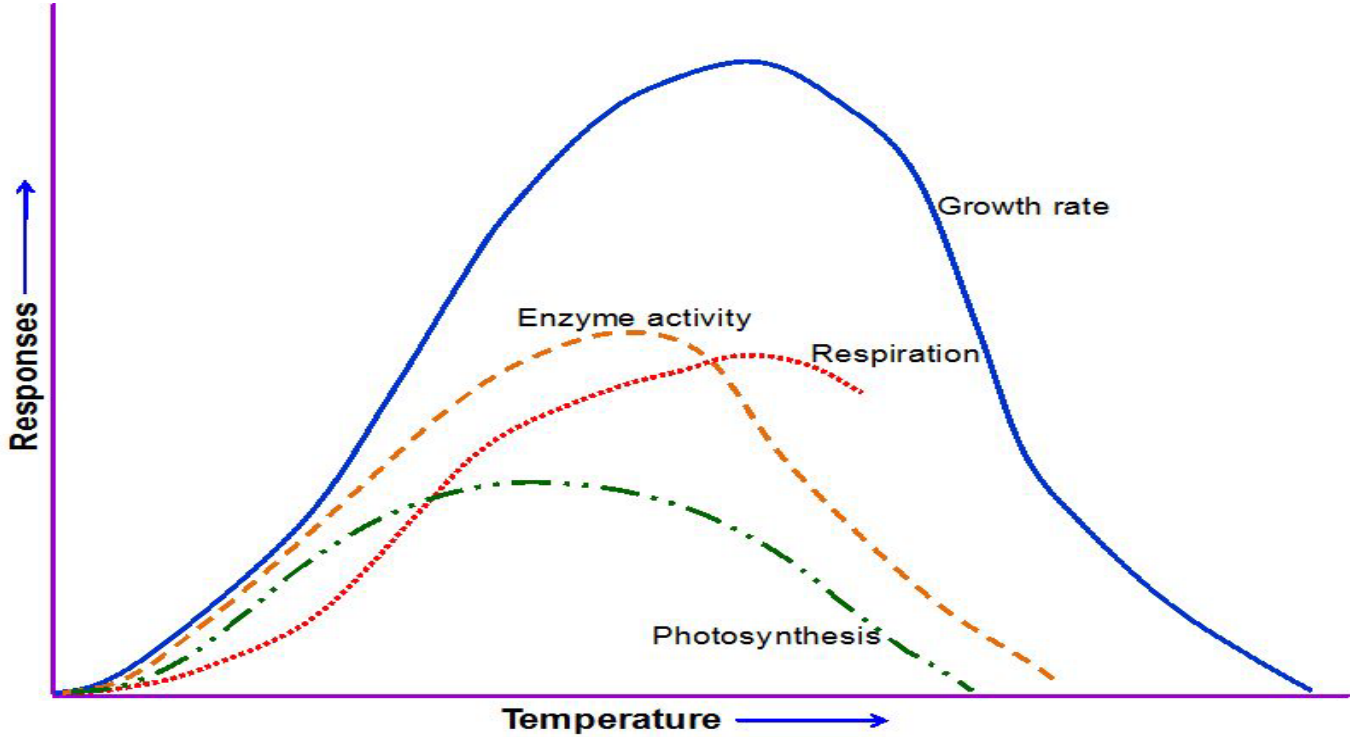
Temperature response of fresh produce



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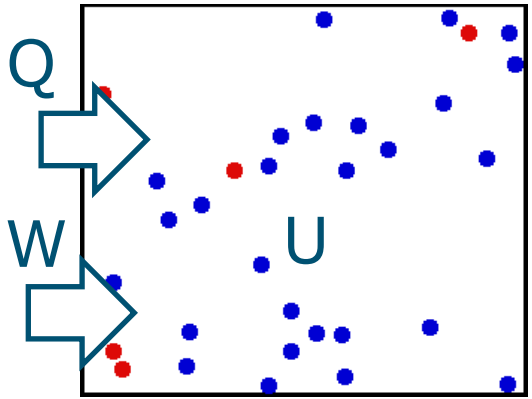
Mirza Hasanuzzaman, Kamrun Nahar and Masayuki Fujita (2013)

Refrigeration

Refrigeration = heat removal

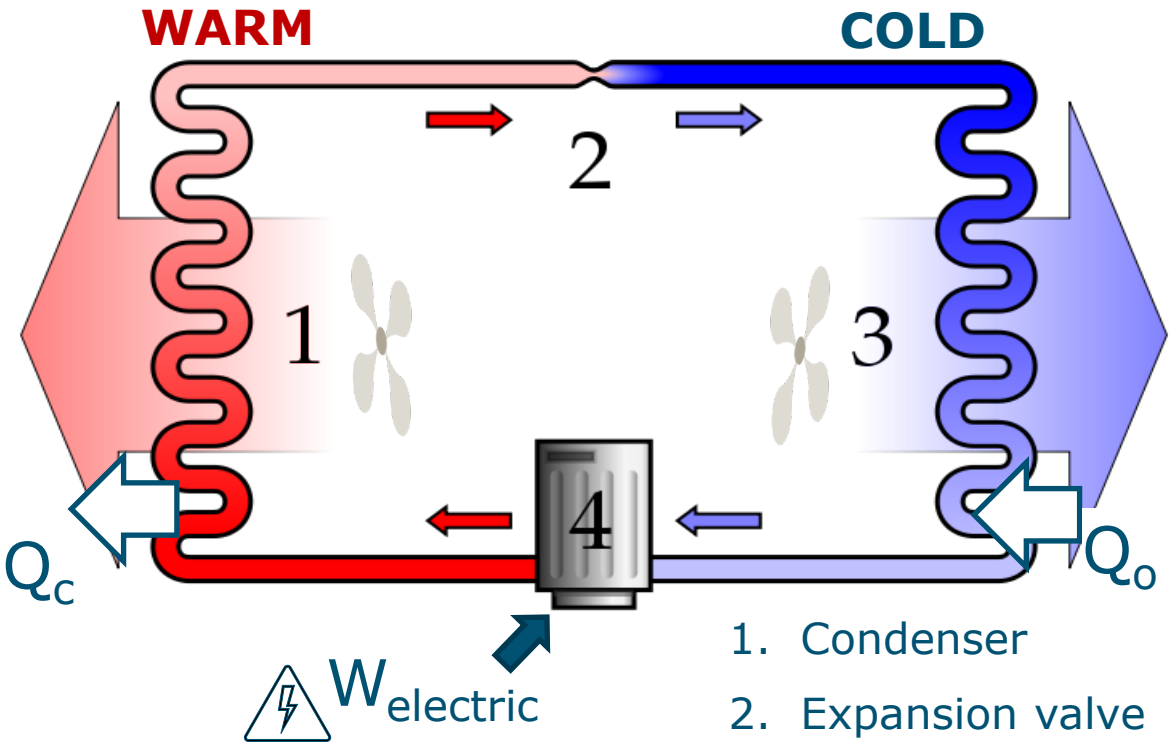


Internal energy U [Joule] = potential + kinetic energy of molecules

First law of thermodynamics (conservation of energy): $\Delta Q = \Delta U + \Delta W$

Physics: **Heat flows from warm to cold**, so **refrigeration** (moving heat from cold to warm) **requires (electrical) energy**

Refrigeration system



1. Condenser
2. Expansion valve
3. Evaporator
4. Compressor

1

3

4

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Controlled Atmosphere (CA) storage

- Stretching marketing period by “hibernating” products
- Mainly applied for climacteric products with annual harvest
  - Apples, pears, kiwi,……but many more
- NL 2022: ~600M kg apples and pears harvested
  - >75% is stored in CA

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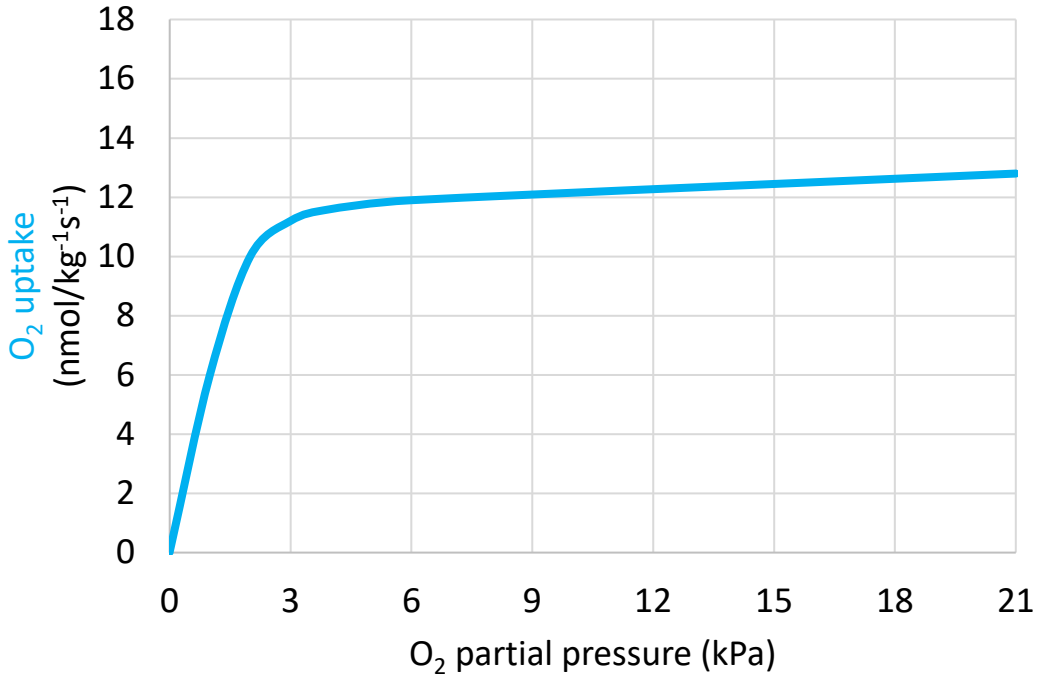
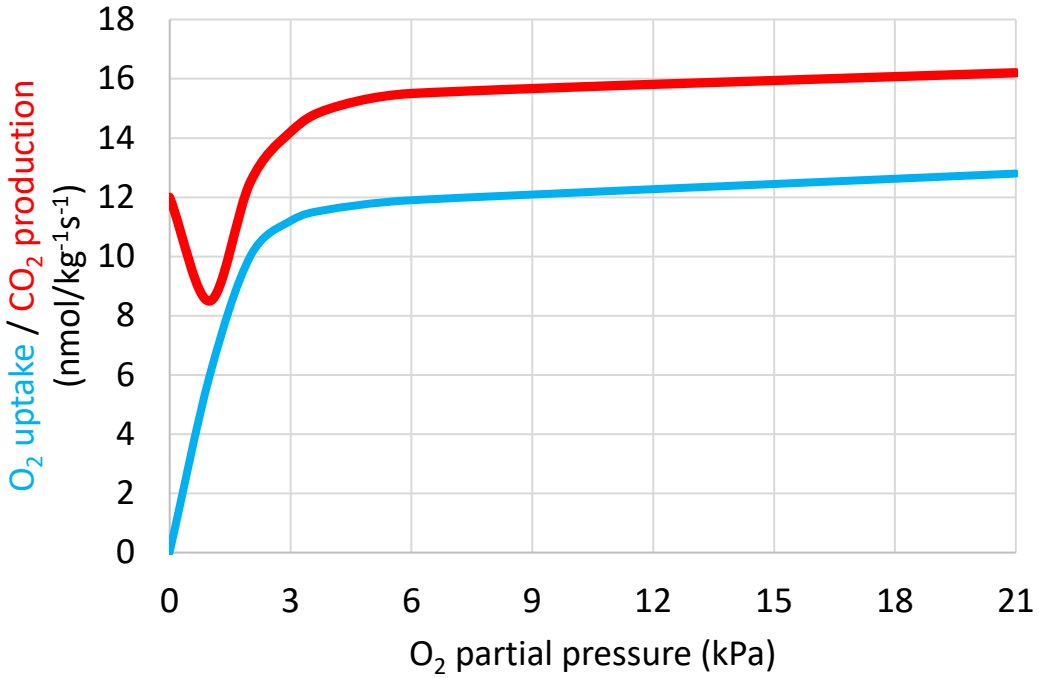
Principle (1) – lowering oxygen

Respiration rate

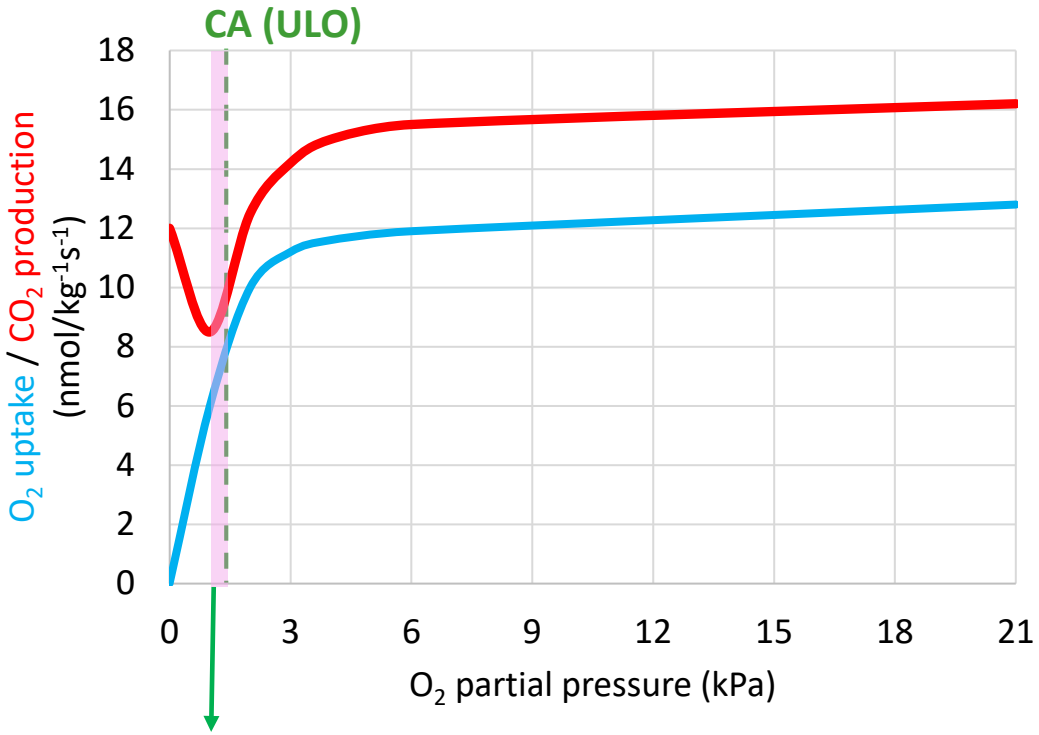


~approx. % O_2 at ambient pressure

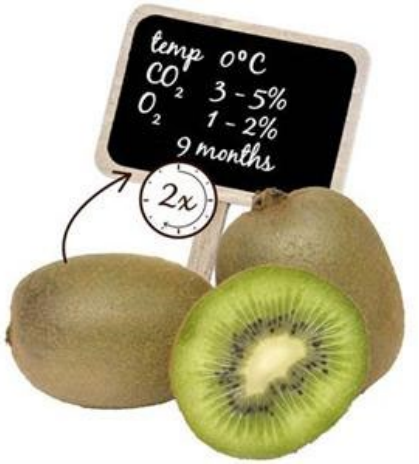
Principle (2) – product response



Principle (3) – fixed safe oxygen level



Controlled Atmosphere



- Lowest possible temperature
- A fixed safe O_2 level is maintained during storage
- A fixed safe CO_2 level is maintained during storage
- Ultra Low Oxygen (ULO) possible since cold rooms are more air tight
- Example CA kiwi = 0°C; 1-2% O_2; 3-5% CO_2

- CA brings down respiration, moisture loss and ripening

Basics of fresh product storage Summary

- Storage is NOT a hospital → quality is not increasing
- Storage at the lowest safe temperature is the most effective method to reduce respiration and to ensure storability, transportability, shelf life and it exceeds any other post-harvest method
- Respiration can be slowed down further by lowering the oxygen concentration and increasing the CO_2 concentration
- Optimal storage conditions are always a compromise
- Order in conditioning: 1)Temperature 2)oxygen 3)CO_2 ,%RH, ethylene
- Limit biological variation

Outline

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CA components

- Insulated refrigerated room
- Air tight
    - Lungs
- Main CA components
    - N_2 generator
    - CO_2 scrubber
    - Control and registration unit

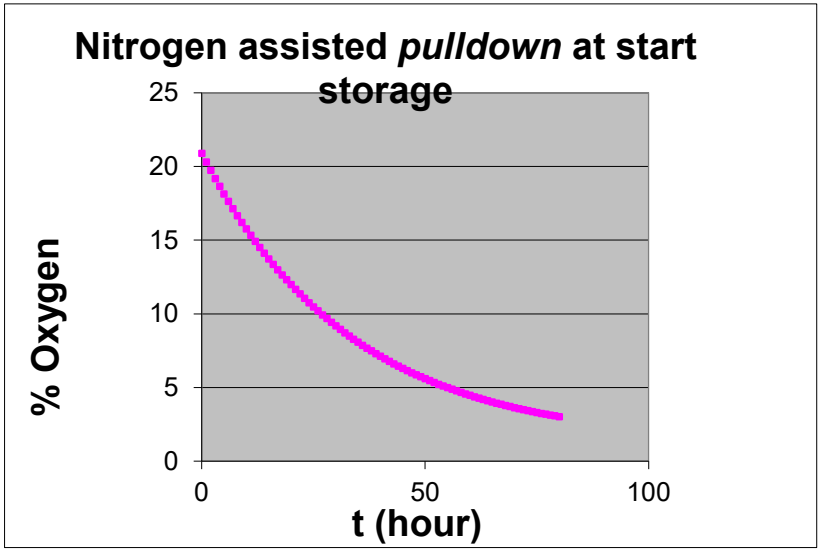
Lungs

Nitrogen generator for oxygen control

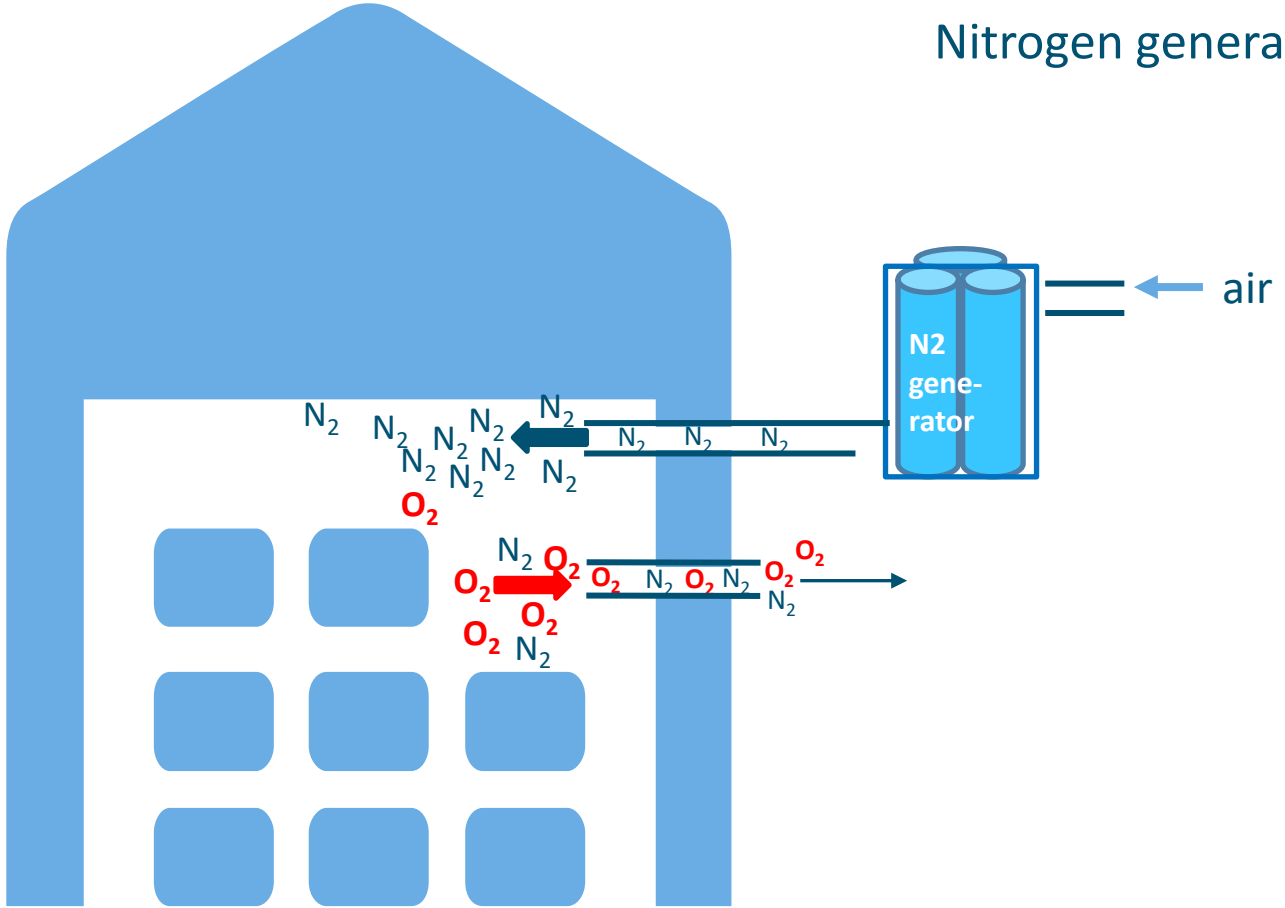
O_2 Removal

- **Nitrogen injection**
  - Activated carbon (VPSA, PSA)
  - Pressurised N_2
  - Membrane adsorber
- Fruit respiration

O_2 level increase: fresh air exchange



Nitrogen generator



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Carbon scrubber for CO_2-control

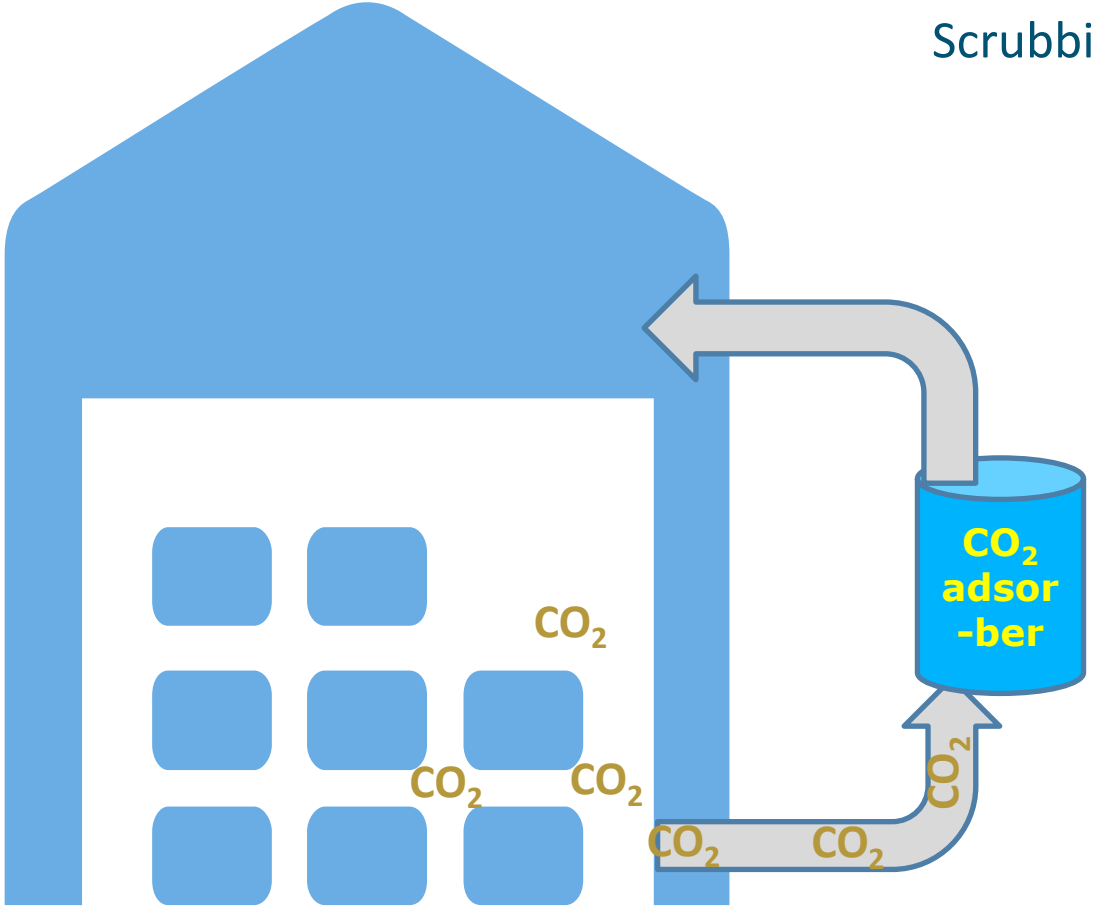
CO_2 level increase

- **Fruit respiration**
- CO_2 injection (gas cylinders, for high levels only, e.g. berries)

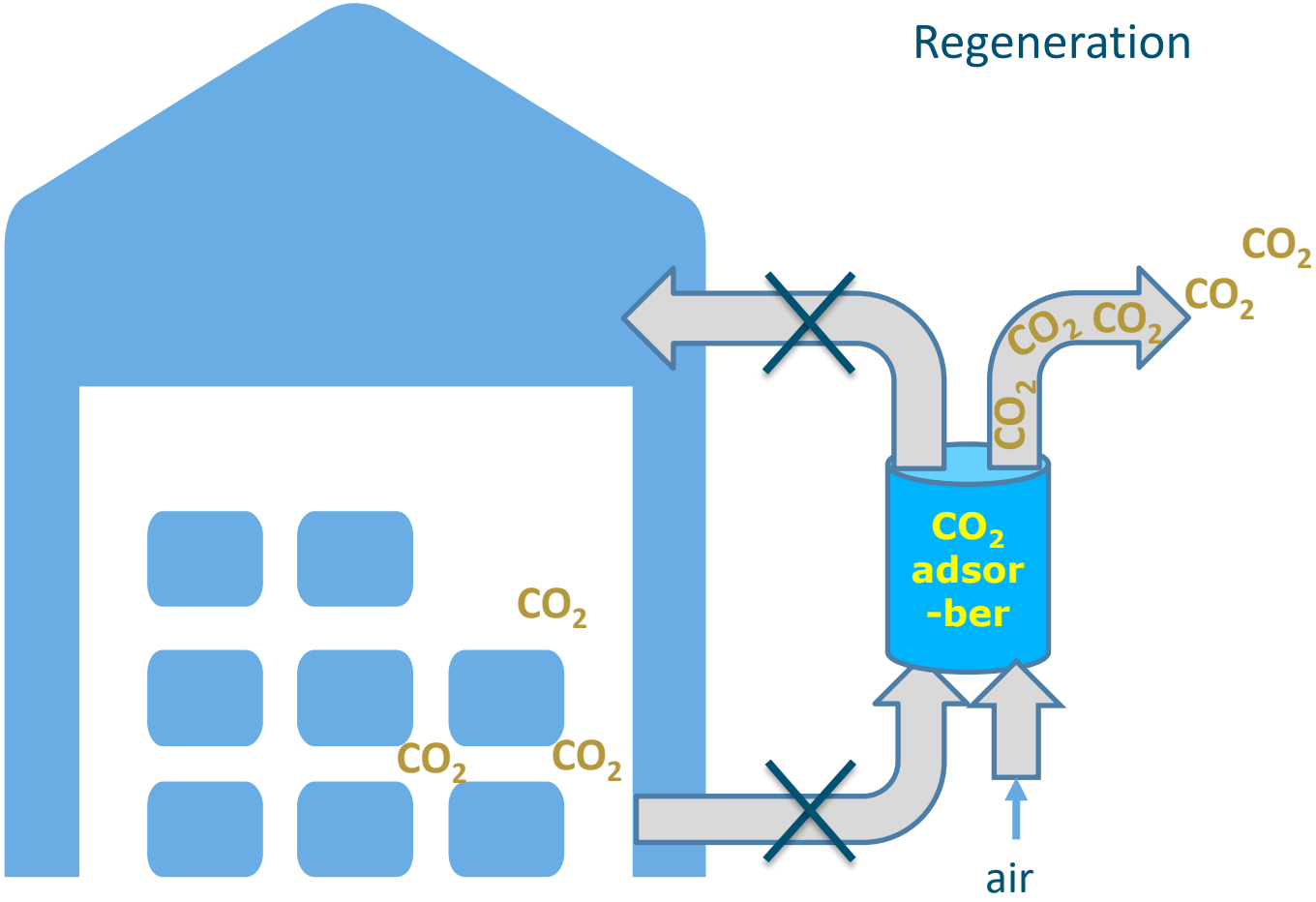
CO_2 Removal

- Scrubbers:
  - **Activated carbon scrubber**
  - $Ca(OH)_2$ (lime)
  - Membrane technology (Reefer, Everfresh)
- (Fresh air exchange)

Scrubbing (CO_2 adsorbtion)



Regeneration



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Safety → low oxygen is very DANGEROUS

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Active and passive CA-systems

Different types of CA-systems:

- Active:

  Active means to generate a gas flow with low O_2 to the container

- Passive:

  No active means to generate a gas flow with low O_2 to the container

  Fruit respiration is used to lower O_2 concentration

- However different active/passive systems on CO_2

Different brands and/or systems

Containers

- Starcool (AV+) & Starcare
- Carrier Everfresh & Extendfresh
- Thermo King AFAM (+)
- Daikin Active CA
- ....

Add-ons

- PURfresh
- Liventus
- Maxtend
- ....

Pallets

- Transfresh
- ....

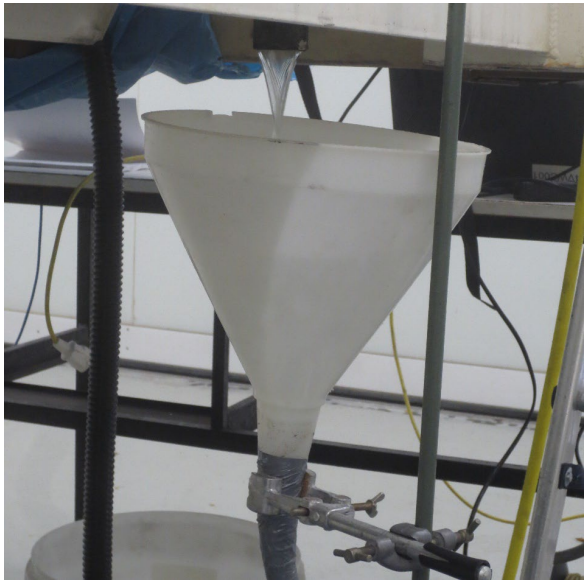
Components reefer CA-system

- Refrigeration
- Air tight container
- CA components (depending on type of CA-container)
    - CO_2 scrubber
    - N_2 generator
    - Control and registration unit

Air tight container

CA-curtain

Drain hole
needs to be closed!



Open drain hole

Air tightness (1)

- Air tightness is decisive, esp. in passive CA systems
- Factors:
  - Close fresh air exchange
  - Close 4 (!) drain holes
  - Curtain at door-end
  - Pre-trip air tightness test

Open air exchange

Drian holes

Open

Open

Closed

Air tightness (2)

- Factors:
  - Close fresh air exchange
  - Close 4 (!) drain holes
  - Curtain at door-end: air-tight and lung-function
  - Pre-trip air tightness test

Equal pressure

Lower pressure in cargo hold

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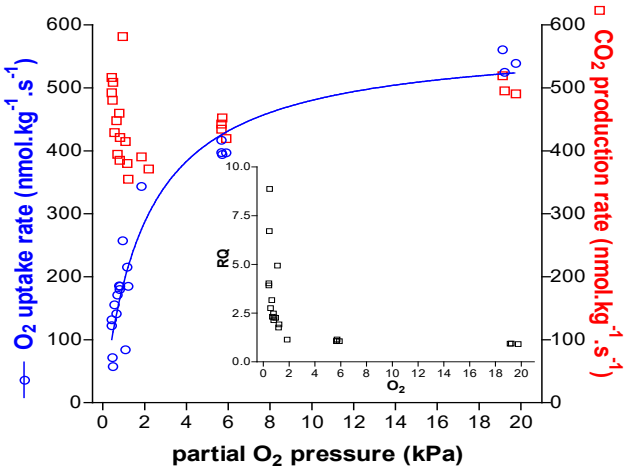
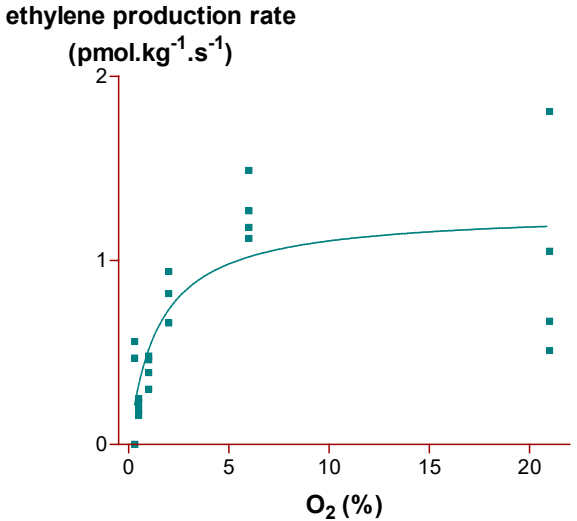
Controlled atmosphere and rose flowers (1)

Low oxygen storage of roses ($<2\%0_2$)

- Lower respiration
- Increased CO_2 production
  - harmful



- Lower ethylene production



Controlled atmosphere and rose flowers (2)

- Inhibition of flower opening

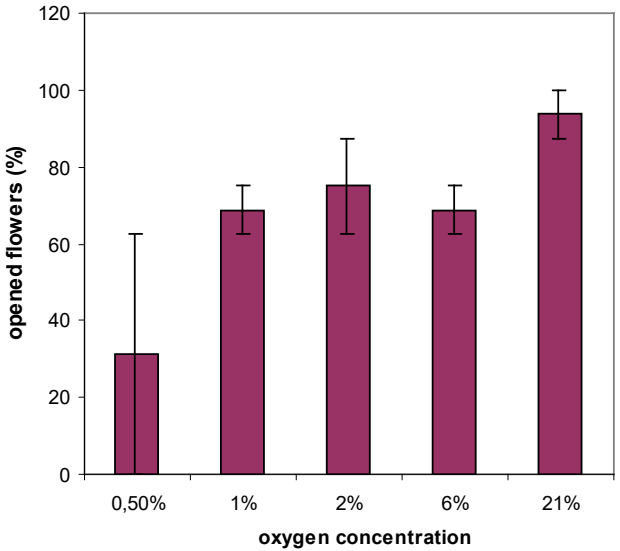


Fig.5. Two representative flowers.

Effect on roses

- Low O_2 inhibits respiration rate & ethylene production of cut rose flowers
- O_2 0.5 – 6 kPa no real positive effect on length of vase life.
- O_2<2% → increased CO_2-production → ethanol, acetaldehyde?
- After low O_2 flower opening is inhibited and growth of petals seems to be disturbed
- Low O_2 during storage has no advantage for rose flowers

- Higher CO_2 inhibits fungal growth, however >10% phytotoxic
    - More effect from dip treatments

Recap

- CA is an **additional technique** to increase storage life of fresh produce
    - Temperature management is key
- Requires control over initial product quality and strict handling protocols
- CA is an available option during transport in containers

- CA has no large effect on extending storage life of roses
    - Consequential effects (ethylene, RH) might have an effect!

Thank you for your attention!

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Postharvest Quality

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