Quality and Logistics of Horticultural Products

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Time in transport cut flowers

The diagram shows the time in transport for cut flowers in various countries. The x-axis represents the countries, and the y-axis represents the time in days. The countries listed are HOL (Holanda), D (Germany), FR (France), UK (United Kingdom), IT (Italy), SW (Sweden), USA (United States), and JAP (Japan). The time in transport varies from around 2 to 10 days across these countries.
## Quality loss cut flowers

4 day shipment, vase life determination under optimal conditions

<table>
<thead>
<tr>
<th>Product</th>
<th>Vase life reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gerbera</td>
<td>33%</td>
</tr>
<tr>
<td>Rose</td>
<td>29%</td>
</tr>
<tr>
<td>Carnation</td>
<td>15%</td>
</tr>
<tr>
<td>Tulip</td>
<td>47%</td>
</tr>
<tr>
<td>Chrysanthemum</td>
<td>25%</td>
</tr>
<tr>
<td>Lily</td>
<td>33%</td>
</tr>
<tr>
<td>Iris</td>
<td>46%</td>
</tr>
<tr>
<td>Freesia</td>
<td>27%</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>32%</strong></td>
</tr>
</tbody>
</table>
Contents

• **Changing transport modalities for cut flowers**
• **Factors affecting quality loss pre-harvest**
  – Genetics
  – Cultivation conditions
• **Factors affecting quality loss post-harvest**
  – Water loss
  – Temperature
  – Ethylene
  – Bacteria
  – Botrytis
• **Conclusions**
Transport modality shift

• Standard transport modality: air freight
  – Fast transport times
  – Relatively expensive; fuel surcharges
  – Flexible volumes

• Alternative marine (Reefer) transport
Transportation energy costs

Product km per energy quotient

- Car 1
- Air 43
- Truck 740
- Railroad 2400
- Container Ship 3800

100 x less energy/kg product
50 x less CO2 emission/kg product

- Half the value of a perishable product may be transportation costs
Air freight: poor temperature control

Cargo temperature 4.5 days

Data:
- Dates: 02-12-04 to 07-12-04
- Times: 14:24 and 02:24

Graph:
- Temperature (°C) vs. Date
- Humidity (%) vs. Date

- Temperature chart shows fluctuations over 4.5 days.
- Humidity chart indicates periods of higher humidity.
Attractiveness of container transport for flowers

Pro’s
• Relatively cheap
• Lots of capacity
• Excellent climate control (T, RH, atmosphere)
  – Also in the case of delays !!
  – Closed cold chain from farm to end user
• More sustainable
• Experience with many tropical fruits and, increasingly with flowers/potted plants

Con’s
• Takes long time
• Quality of end product often disappointing!
Consequences of container transport

- Due to the change from air transport to container transport, quality is increasingly becoming an item.
- Flowers have to be resistant to long term storage at relatively low temperatures.
- Needs superior control of water loss (desiccation) and botrytis infection (temperature control is excellent).
Quality aspects in cut flowers

- Vase life
- Desiccation (water loss)
- Lack of flower opening
- Leaf yellowing/blackening or wilting
- Premature senescence
- Fungal attack
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  – Bacteria
  – Botrytis
• Conclusions
There is lots of genetic variation

- Vase life
- Botrytis sensitivity
- Flower opening
- Vascular blockage
- Ethylene sensitivity

- Best way to improve quality is selection!!

Alstroemeria vase life
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• Conclusions
Effect of cultivation conditions on post harvest quality

- Fertilizer (Nitrogen) levels (vase life)
- Humidity (botrytis)
- Day/night temperatures
- Water management
- Shading regime

Conditions aimed at maximum production may interfere with the goal of maximum postharvest quality
Effect of K fertilizer on postharvest leaf quality
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  – Botrytis
• Conclusions
Water loss: Phlox bare-root perennials storage

- Most flowers can lose up to 8-10% of water without quality loss
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• Conclusions
Temperature: less respiration and more vase life

Respiration sunflower

Respiration and vase life
Low temperature effects

• Rapid and continuous cooling is important:
  – Slows down respiration
  – slows down ageing/senescence
  – Slows down botrytis growth
  – Slows down bacterial growth
  – Suppresses ethylene production and sensitivity

• Most flowers can be stored at near ZERO temperatures
  – Some exceptions (orchids, lilies, anthurium, ..)
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Ethylene

- In sensitive flowers/plants affects:
  - flower senescence/abscission
  - leaf yellowing/abscission
  - flower malformation
Fresh produce Innovations
Ethylene sensitivity of flowers (petal senescence)

- **Sensitive**
  - Carnation
  - Campanula
  - Trachelium
  - Gypsophila
  - Orchids
  - Physostegia
  - Scabiosa

- **Insensitive (low sensitivity)**
  - Iris
  - Chrysanthemum
  - Euphorbia
  - Gladiolus
  - Liatris

- **Intermediate**
  - Rose, snapdragon, aconitum, scabiosa, alstroemeria, ..
Sources of ethylene

- Industrial PE plants
- Industrial pollution
- Cars and trucks

- Still concentration in outside air is generally LOW
- Some soil bacteria use ethylene as a carbon source

- Plants are also sources of ethylene
### Ethylene concentration at different locations

<table>
<thead>
<tr>
<th>Location</th>
<th>Concentration (ppb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside air</td>
<td>2 - 10</td>
</tr>
<tr>
<td>Flower packaging station</td>
<td></td>
</tr>
<tr>
<td>• minimal activity</td>
<td>10</td>
</tr>
<tr>
<td>• maximal activity</td>
<td>100 - 300</td>
</tr>
<tr>
<td>Fire</td>
<td>4,000</td>
</tr>
<tr>
<td><strong>Car exhaust gases</strong></td>
<td><strong>400,000</strong></td>
</tr>
<tr>
<td>Fruit storage room</td>
<td>1,000,000</td>
</tr>
</tbody>
</table>

Levels that may damage flowers/plants
## Ethylene concentrations during distribution (2500 samples)

<table>
<thead>
<tr>
<th>Location</th>
<th>Ethylene concentrations (ppb)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 50</td>
<td>50-100</td>
<td>&gt; 100</td>
<td></td>
</tr>
<tr>
<td>Grower</td>
<td>80%</td>
<td>17%</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>Auction</td>
<td>68%</td>
<td>27%</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Wholesaler</td>
<td>81%</td>
<td>18%</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>Retail trade</td>
<td>79%</td>
<td>18%</td>
<td>3%</td>
<td></td>
</tr>
</tbody>
</table>
## Sources of ethylene in the chain

<table>
<thead>
<tr>
<th>Location</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grower</td>
<td>CO$_2$-supplementation</td>
</tr>
<tr>
<td>Auction</td>
<td>exhaust gases, ripening fruits</td>
</tr>
<tr>
<td>Wholesaler</td>
<td>exhaust gases, ripening fruit</td>
</tr>
<tr>
<td>Retail trade</td>
<td>heating equipment, ripening fruit</td>
</tr>
<tr>
<td>Trucks</td>
<td>exhaust gases, flowers</td>
</tr>
</tbody>
</table>
Plants produce ethylene: ageing hormone

Ethylene biosynthesis

- Ethylene
  - Receptor
    - Signal transduction
      - Gene expression
        - Effects
          - Ripening
          - Senescence
          - Autocatalysis
            - Ethylene from other source

Fresh produce Innovations
CARNATION FLOWERS
Temperature and ethylene

- At low temperature plants produce less ethylene
- Less effect of ethylene at low temperatures

In addition:
- Less effect of ethylene at low concentrations
- Less effect of ethylene at short exposure times
Effect temperature

- **Ethylene production (nl/g.h)**
  - Roses: (chart showing increasing production with temperature)

- **Sensitivity (%)**
  - Carnation: (bar chart showing sensitivity at different temperatures)

**Temperature (C)**
- 0, 5, 10, 15, 20, 25, 30

**Temperature (degC)**
- 3, 6, 12, 18, 24

**Fresh produce Innovations**
Chemical inhibitors of ethylene biosynthesis and action

ACC synthase

ACC oxidase

Ethylene

Receptor and signal transduction

Effects

AVG
AOA
AIBA, Cobalt
KMnO₄
zeolites
Ventilation
STS (silver thiosulphate)
1-MCP (methyl cyclopropene)
SmartFresh quality Crop Overview

- The SmartFreshSM Quality System ensures that packers and shippers of fresh produce and their retail customers can offer consistently high-quality produce to consumers with total confidence. Consumers enjoy the benefits of these best-quality fruits and vegetables for longer.
**Ethylene and 1-MCP**

1-Methylcyclopropene (1-MCP) prevents ethylene from occupying the receptor.
Ethylene receptor

Fresh produce Innovations
Ethylene receptor

No response

Response
STS and 1-MCP

Fresh produce Innovations
Fresh produce Innovations

Score 0  Score 1  Score 2  Score 4

+ ethylene
- ethylene

MCP concentration (ppb)

time to coloration (days)

+ MCP in air

MCP in air

Fresh produce Innovations
Fresh produce Innovations

Score 0
Score 1
Score 2
Score 4

+ ethylene
- ethylene

MCP concentration (ppb)

MCP in air

MCP in ethylene

Time to coloration (days)

0 4 8 12 16 20

0.001 0.01 0.1 1 10

MCP concentration (ppb)
How to tackle ethylene

- Low temperature !!
- No mixed loads (fruits, flowers, ..)
- Chemical blockers (MCP, STS, ..)
- Ventilation
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Vascular blockage

- Blockage of the water conducting vessels
  - Bacteria in water and in stem restrict water uptake
  - Air embolism
  - Physiological processes due to wounding

- >>>>>> Water uptake is impaired!!
Effect of bactericide
Vascular blockage
Sensitivity to vascular blockage

- **Very sensitive:**
  - Rose
  - Gerbera
  - Astilbe
  - Syringa

- **Intermediate sensitive:**
  - Lily
  - Chrysanthemum

- **Low sensitivity:**
  - Carnation
  - Freesia
  - Iris
  - Tulip
### Bacterial counts in water (3200 samples)

<table>
<thead>
<tr>
<th>Location</th>
<th>low</th>
<th>intermediate</th>
<th>high</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grower</td>
<td>56%</td>
<td>24%</td>
<td>21%</td>
</tr>
<tr>
<td>Auction</td>
<td>40%</td>
<td>42%</td>
<td>18%</td>
</tr>
<tr>
<td>Wholesaler</td>
<td>27%</td>
<td>36%</td>
<td>37%</td>
</tr>
<tr>
<td>Retail trade</td>
<td>21%</td>
<td>39%</td>
<td>40%</td>
</tr>
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</table>
Keep water clean

• Bactericides can be added to the water
  – Aluminum sulphate
  – Quaternary Amonium
  – Chloramine-T
  – Hydroxyquinoline sulphate
Solution to vascular blockage

- For sensitive flowers, use proper bactericides for pre-treatment, during transport and in the vase
- Recut flower stems to remove air/bacteria filled vessels
- Use detergents (surfactants) to facilitate water uptake
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Botrytis - spores are everywhere!

Unfavourable conditions stimulate infection

- Frequent temperature changes >> condensation
- High relative humidity
4 stages of botrytis development

1. Spores on surface
2. Spores “attached” ??
3. Spores germinated (needs high humidity)
4. Tissue invasion
Germ tube

attached
Petal epidermis

Botrytis hyphe
At low humidity spores do not germinate

- Rose sprayed with 1000 botrytis spores/ml (contaminated)
- Put in vase at 60% and 100% RH, Photo day 8
Packaging

- 2 layers in bunch:
  - Lower layer more Botrytis

![Diagram of two layers in a bunch with Botrytis index labels](image-url)
Solutions to botrytis

- Humidity < 90% prevents spore germination
- More problems when flowers are more mature (open)
- Low temperature slows down fungal growth
- Fungicides pre- and postharvest >> but creates resistance!
- Loose packaging
- Sufficient air movement (lowers humidity around the flower)
- Cultivar differences!
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Conclusions

How to transport flowers successfully by sea?

- Select suitable species/cultivars
- Pay attention to harvest stage
- Use proper pre-treatments (and rehydration treatments)
- Use lowest temperature possible !!!
- Adapt packaging/stacking to allow sufficient air movement
- Built up a database to establish relations between species, cultivation and climate factors and final outcome of shipments
Thanks for your attention