Innovative storage concepts in private home refrigeration

Cold Chain Management Workshop
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Product Area Refrigeration
- **home food storage: food handling & storage**
  - consumer demands
  - food safety and food loss

- **food preservation in home refrigeration**
  - temperature control concepts
    - storage zones
    - vitaFresh concept
  - storage atmosphere and hygiene control
    - air filtration
    - ethylene control
home food storage: consumer demands

patterns & trends in food consumption
- health & wellness
- convenience & simplicity

consumption
- serving
- preparation
- storage
- transport
- purchase

consumer demands in storage concepts
- functionality ("smart technologies")
- shelf life extension and quality maintenance
home food storage: food safety & handling

deviation in real handling practice and claimed knowledge, especially in:
- shelf life estimation
- food hygiene
- food storage
  - temperature regime
  - storage systematics
  - packaging

contributing factors in foodborne outbreaks in private homes
[WHO, 2002]
home food storage: storage losses / food discard

storage losses
→ major reasons:
- loss in product quality
  - desiccation
  - texture loss
  - discolorations
  - over ripeness
- microbial deterioration
- leftovers

food storage losses in private homes
van Garde, S.: Food discard practices of householders, 1987]
refrigerator layout and design

- temperature
- humidity
- gas atmosphere
- air circulation
- illumination

- humidity control
- ethylene control
- oxygen control
- control of dehumidification parameters & storage atmosphere cleaning
- maintenance of postharvest photosynthetic activity

- air circulation
- control of dehumidification parameters & storage atmosphere cleaning

- illumination
- maintenance of postharvest photosynthetic activity
### Temperature Control

#### Temperature Ranges in Home Refrigeration

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<th>Temperature Range</th>
<th>Storage Applications</th>
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<td>Refrigerator</td>
<td>0 to 14°C</td>
<td>- Fresh food storage compromising one or more storage compartments</td>
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<td>- Storage of fresh, unfrozen foods</td>
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<td>Fresh food compartments</td>
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<td>- Storage of highly perishable goods</td>
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<td>- 0°C storage compartments: fruits and vegetables, meat and fish products</td>
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<td>- Frozen food storage and home freezing</td>
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<td>Fridge-freezers</td>
<td>-18 to +14°C</td>
<td>- Combination of fresh food and frozen food storage within one appliance</td>
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<td>- Fridge freezers (2 temperature zones)</td>
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<td>- Multi zone refrigerators (&gt;2 zones)</td>
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## Temperature Control: Technical Solutions

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<td>→ temperature distribution</td>
<td>→ adjustable settings</td>
<td>→ meat &amp; fish storage</td>
<td>→ -2…+3°C storage</td>
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temperature control: vitaFresh concept

- fresh food compartment: 2°C to 8°C
- chill compartment: vitaFresh zone, near 0°C
- freezer: -16 to -26°C
- temperature & humidity control
- temperature control
temperature control: vitaFresh concept

freshness retention in chicken breast
vitaFresh storage - conventional refrigerator storage

microbial analysis (total viable count)

sensory analysis

CNTA (Centro National de Tecnología y Seguridad Alimentaria) on behalf of BSH, 2007
temperature control: vitaFresh concept

freshness retention in fish fillet
vitaFresh storage - conventional refrigerator storage

microbial analysis (total viable count)

sensory analysis

CNTA (Centro National de Tecnologia y Seguridad Alimentaria) on behalf of BSH, 2007
temperature control: vitaFresh concept

- humid zone
  - temperature and humidity control
  - weight loss & wilting ↓
  - nutritive value ↑
  - improved resistance to microbial deterioration ↑

conventional refrigerator
5°C, 60%rH
humidity levels:
~ 50% rH
humidity control layer
humidity levels:
up to 90% rH
excess humidity
humidity controlled crisper

vitaFresh storage
0°C, 90%rH

after 15 days in storage
storage atmosphere and hygiene control

- **hygiene control**
  - overall storage hygiene for
    - stored food products
    - storage atmosphere
    - storage surface areas

- **additional storage support**

**evaluation criteria**

- backup of consumers in storage systematics
- backup of safe food handling practices
- limitation in cross-contamination:
  - microbial contamination
  - carry-over effects
- shelf life extension properties
## Storage Atmosphere and Hygiene Control

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<td>ClO₂ Creation</td>
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<td>Antimicrobial Systems</td>
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- **Activated Carbon Filter**
- **Photocatalytic Filter**
- **Ionization**
- **Ozone Generator**
- **Activated Carbon Pellets**
- **KMnO₄ Pellets**
- **PdCl₂ Pellets**
- **Ionization**
- **Vacuum Box Systems**
- **Vacuum Packaging**
- **Low Pressure Storage**
- **CA Storage**
- **ClO₂ Creation**

**Technical Realization**

**System**

**Passive Atmosphere Control**

**Technical Realization**
storage atmosphere cleaning: AirFreshFilter

- odour reduction by adsorption effects on activated carbon surface
- reduction of carry-over effects
- high efficacy by honeycomb structure and catalytic surface treatment
- placement in refrigerator air duct
activity evaluation

- gas chromatographic analysis of filter activity by simulation of refrigerator atmosphere with typical odorous compounds
- gas chromatography - mass spectrometry analysis of real storage atmosphere with / w/o filter material
- sensory analysis of carry-over effects: triangle test in accordance to DIN ISO 4120

chromatogram of the odorous compounds adsorbed by the filter material in 24h
storage atmosphere cleaning: ethylene scavengers

- **ethylene**
  gaseous plant hormone that induces senescence and ripening in sensitive produce during storage

- **scavenger material**
  based on ethylene absorption by KMnO₄/PdCl₂/activated carbon

- **activity evaluation**
  - evaluation of ethylene oxidation activity by gas chromatographic analysis
  - simulation of vegetable crisper atmosphere for ethylene scavenger activity evaluation

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**gas chromatographic analysis of ethylene scavenger activity**

- blank value
- PdCl₂ pellets
- KMnO₄ pellets
- KMnO₄ and carbon

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**time / hours**

**ethylene / ppm**
storage atmosphere cleaning: ethylene scavengers

- simulation of a mixed crisper load consisting of
  - ethylene sensitive goods
  - ethylene emitting goods

- subsequent storage with and w/o ethylene scavengers

→ reduced respiration activity
→ improved colour retention
→ shelf life extension

sensory quality in lettuce with and w/o ethylene scavenger material

- reduced respiration activity
- improved colour retention
- shelf life extension
Conclusion: refrigerator layout and design

- Food freshness
- Food safety
- Consumer practice

Overall climate control
- Temperature control
- Humidity control
- Storage atmosphere

Storage systematics
Storage advice
for further information:

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temperature control: vitaFresh concept

- integration of temperature controlled drawers in cooling appliances
  - active temperature control
    exact temperature control by separate temperature sensor and magnetic valve
  - passive humidity control
    use of moisture released by product transpiration

- separate storage compartments for perishable goods with defined storage systematics:
  - dairy products & eggs
  - meat & fish
  - fruits & vegetables