On the effectiveness of food waste reducing actions in the meat supply chain

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What to expect

- REFRESH project
- Introduction of study
- Methodology
- Results
- Further research
REFRESH: Resource Efficient Food and dRink for Entire Supply cHain

Reduce food waste:
- At retailers
- At consumers
- Production chains

Project structure
- EU Horizon 2020 project
- 26 Partners from 12 European countries and China
- Duration: July 2015 – June 2019

My role
- Develop simulation and optimization models to test food waste reducing actions
Almost half of the food grown is lost for human consumption (Lundqvist et al., 2008)

20% in the meat supply chain

Need to incorporate food safety in inventory management (Akkerman et al., 2010)

Quality controlled logistics improves supply chains (van der Vorst et al., 2011)
Objective and research questions of study

Need to:
- Reduce food waste
- Include safety in inventory management

Research question
- Effect of dynamic shelf life on food waste?
Method

Simulation model of meat supply chain
From processor to retailer
Method

Simulation modelling in MATLAB

Inventory and microbiological growth model

Inputs
- Consumer demand
- Costs
- Time
- Temperature
- Maximum shelf life

Outputs
- Profit
- Waste
- Microbiological count
- Shortages
Method

- Retailer orders product at DC (R,S policy)
- Products sold to consumers either FIFO or LIFO
- Products are wasted at the end of shelf life
  - Based on date
  - Based on microbiological count
Method

- **Fixed shelf life:** 6 days after production
- **Dynamic shelf life:** based on actual quality
  - Gompertz model for microbiological growth
  
  \[ N = A + C \cdot e^{-e^{-B(t-M)}} \]

- **Temperature is main influencer of product quality**
## Scenario’s tested

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Experiment</th>
<th>Temperatures (DC, transport to retailer, shelf)</th>
<th>Change in parameters of Gompertz curve</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Base</td>
<td>1</td>
<td>2, 10, 4</td>
<td>$N = A + C e^{-e^{-B(t-M)}}$</td>
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<tr>
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<tr>
<td></td>
<td>2b</td>
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<tr>
<td></td>
<td>2c</td>
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<td>2d</td>
<td>4, 12, 6</td>
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<tr>
<td>3. Growth model</td>
<td>3a</td>
<td>-10 %</td>
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</tr>
<tr>
<td></td>
<td>3b</td>
<td>-5 %</td>
<td></td>
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<tr>
<td></td>
<td>3c</td>
<td>+5 %</td>
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<tr>
<td></td>
<td>3d</td>
<td>+10 %</td>
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</tr>
</tbody>
</table>

**Fixed and dynamic shelf life**
Results Temperature changes

Profit

Profit increases when temperature decreases
Results Temperature changes

- Shortages and waste

Shortages/waste decreases with lower Temp.
Results Temperature changes

- Fixed shelf life
- Basic temperature
- Increase of 2°C
Results Temperature changes

- Dynamic shelf life
- Basic temperature
- Increase of 2°C
- Safer products
Parameter changes

![Graph showing microbiological count (log/cfu) over days]

- **Microbiological count (log/cfu)**
- **Days**
- **Basic**
- **Spoilage point**

*Note: The graph shows the increase in microbiological count (log/cfu) over time, with a horizontal line indicating the spoilage point for 'Basic' samples.*
Parameter changes

\[ N = A + C \cdot e^{-e^{-B(t-M)}} \]

- Microbiological count (log/cfu)
- Days

- Spoilage point
- -10%
- -5%
- +5%
- +10%
Influence of alternative growth models

- Microbiological growth modelled with Gompertz
  - Results are affected by parameter setting

- Many more options for predictive modelling of *Pseudomonas* spp. on meat
  - Gamma
  - Ratakowsky
  - Logistic model
  - etc.
Influence of alternative growth models

Bacterial count at 3°C

- Ratakowsky
- Gompertz
- Gamma
- Spoilage point
Influence of alternative growth models

- Growth rate of *Pseudomonas* spp. differs for the tested models

- Differences may occur due to
  - Predictive nature of the models
  - Tested in laboratory
  - Many factors important in growth of micro-organisms on food products
Wrap-up

- **Dynamic shelf life**
  - Reduces food waste if temperatures are lower than expected
  - Ensures safe products

- **Profit levels are maintained with dynamic shelf life**

- **Choice of quality model is important**
Further research

- Other actions such as dynamic pricing
  - Discounting on almost spoiled products
  - Optimizing replenishment

- Consumer behaviour
  - Towards a TTI sensor
  - Towards “old” vs. “fresh” products
Questions and remarks?

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