



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

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**WAGENINGEN UR**  
For quality of life



## What to expect

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- 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

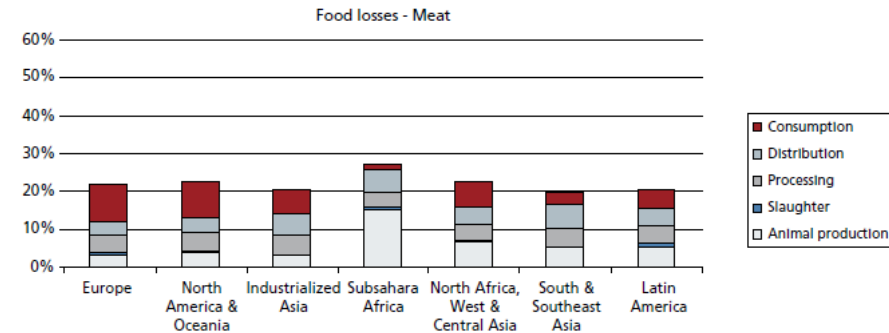




# Literature/background

- 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

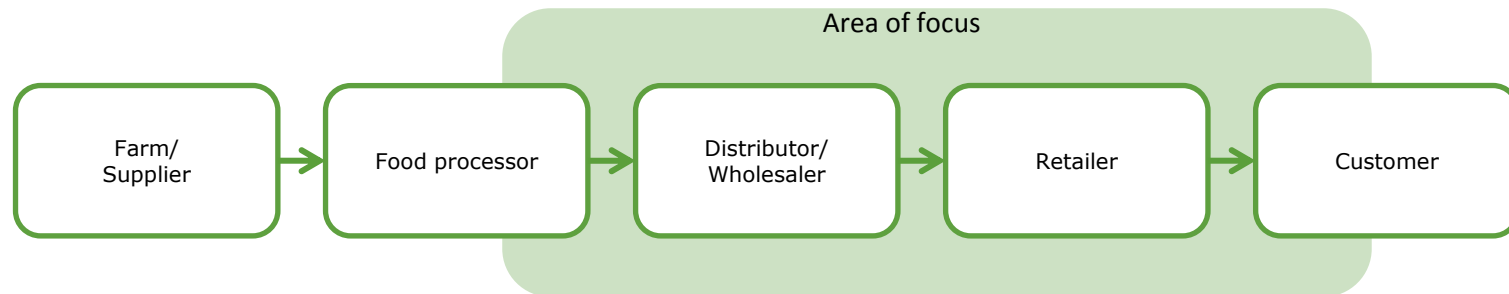
## Research question

- 🥦 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

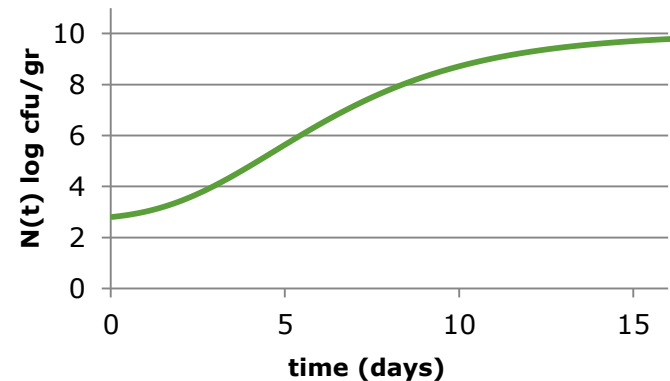




## Method

- Fixed shelf life: 6 days after production
- Dynamic shelf life: based on actual quality
  - Gompertz model for microbiological growth

$$N = A + C * e^{-e^{-B(t-M)}}$$



- Temperature is main influencer of product quality



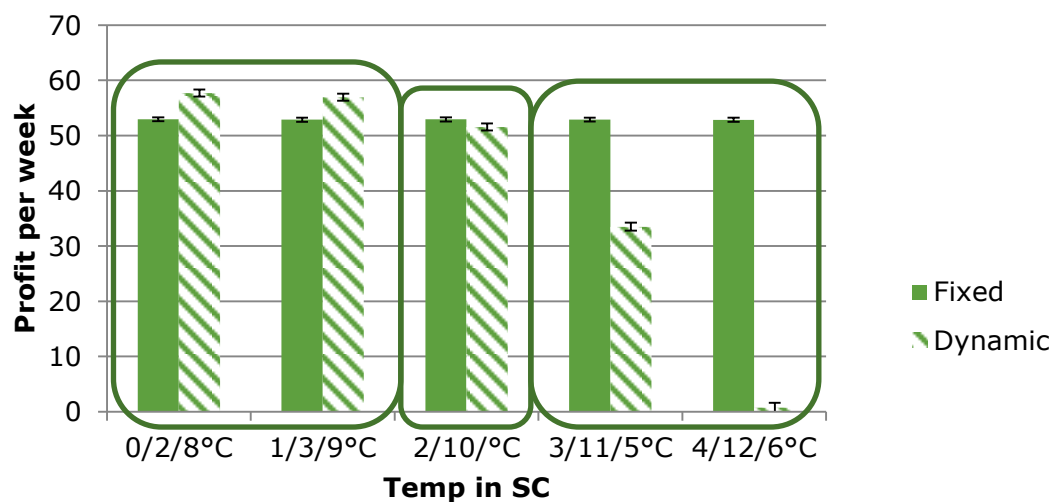
## Scenario's tested

Scenarios	Experiment	Temperatures (DC, transport to retailer, shelf)	Change in parameters of Gompertz curve
1. Base	1	2, 10, 4	$N = A + C * e^{-e^{-B(t-M)}}$
2. Temp	2a	0, 8, 2	
	2b	1, 9, 3	
	2c	3, 11, 5	
	2d	4, 12, 6	
3. Growth model	3a		-10 %
	3b		-5 %
	3c		+5 %
	3d		+10 %

 Fixed and dynamic shelf life

# Results Temperature changes

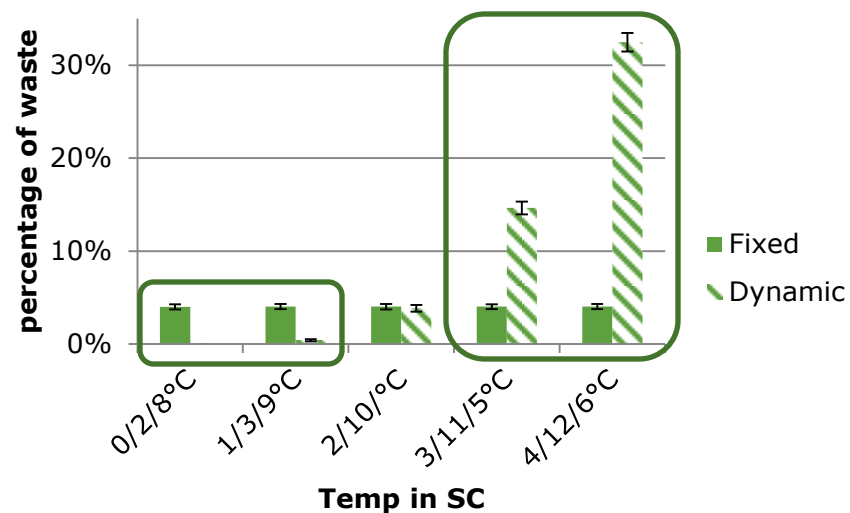
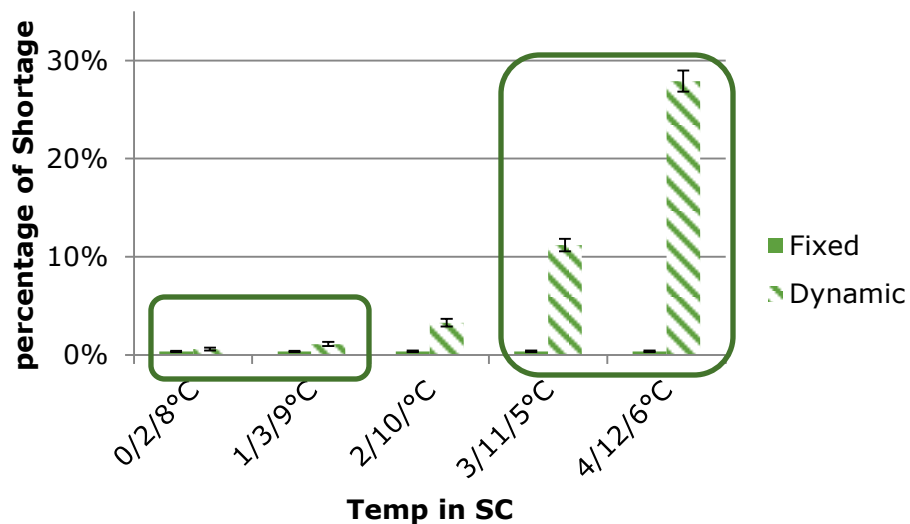
## Profit



Profit increases when temperature decreases

# Results Temperature changes

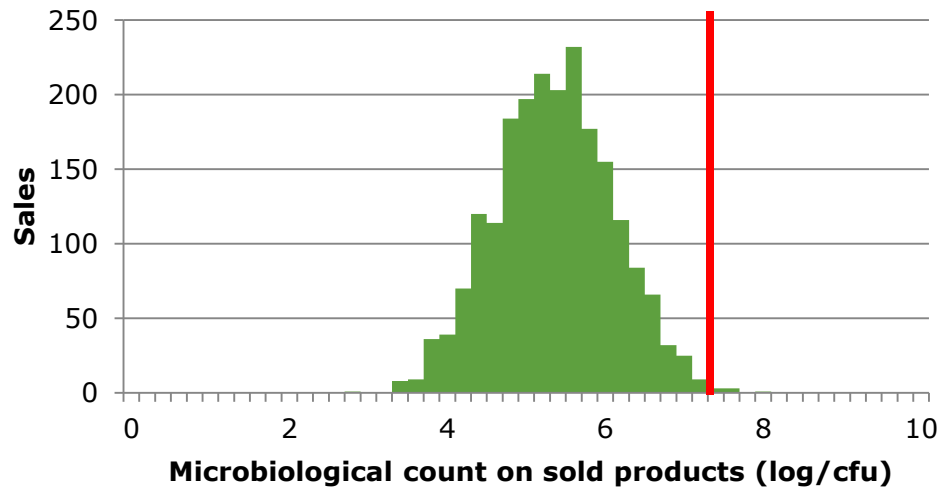
## Shortages and waste



Shortages/waste decreases with lower Temp.

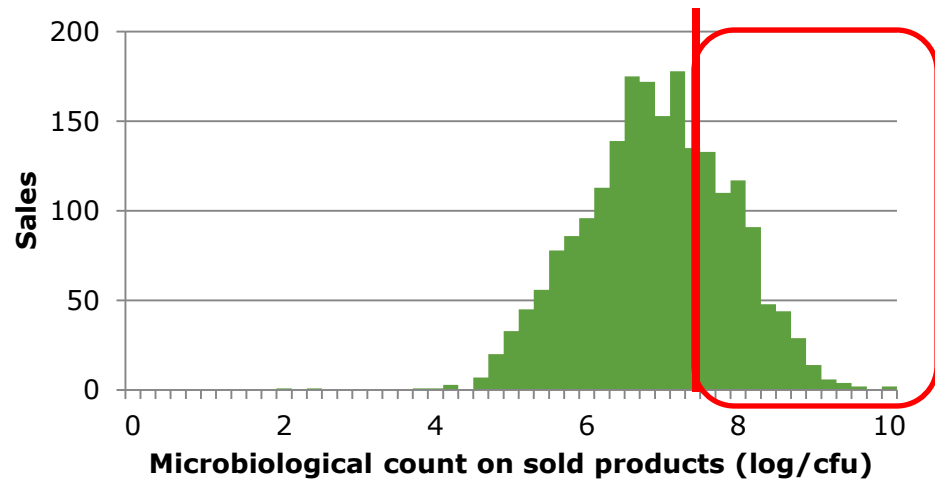


# Results Temperature changes



 Fixed shelf life

 Basic temperature

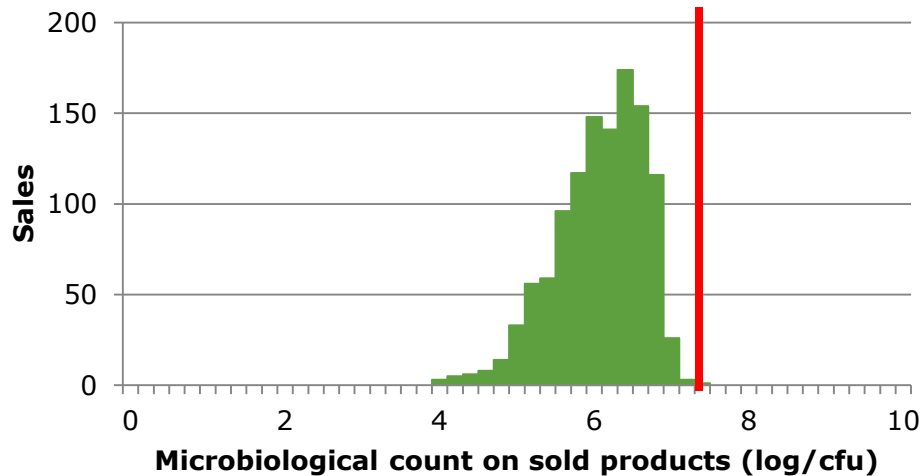
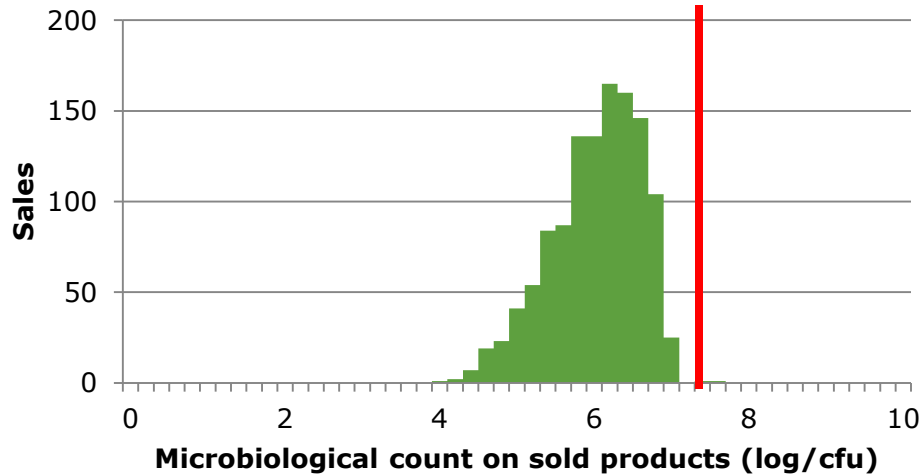


 Increase of 2°C

!!



# Results Temperature changes



 Dynamic shelf life

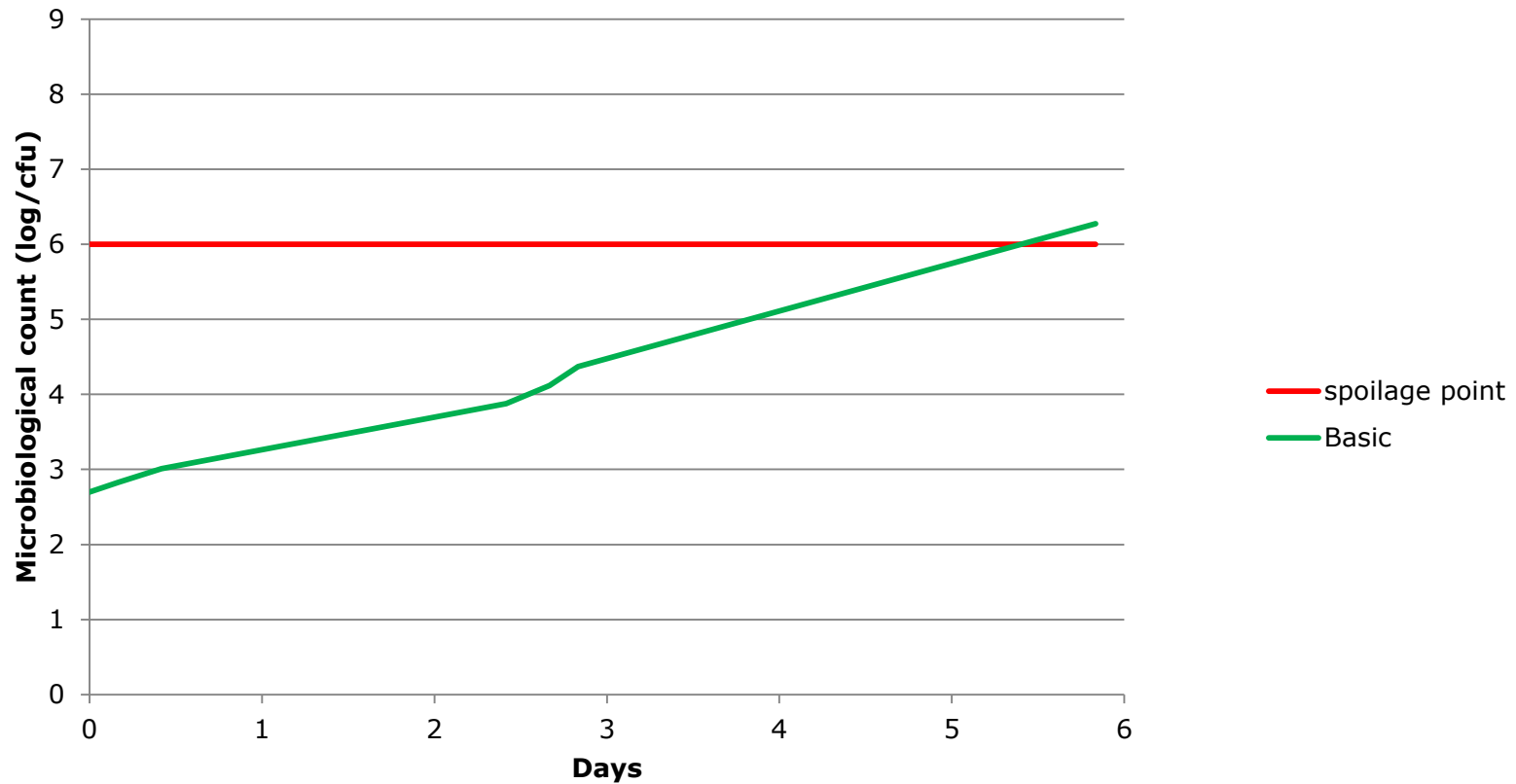
 Basic temperature

 Increase of 2°C

 **Safer products**



# Parameter changes

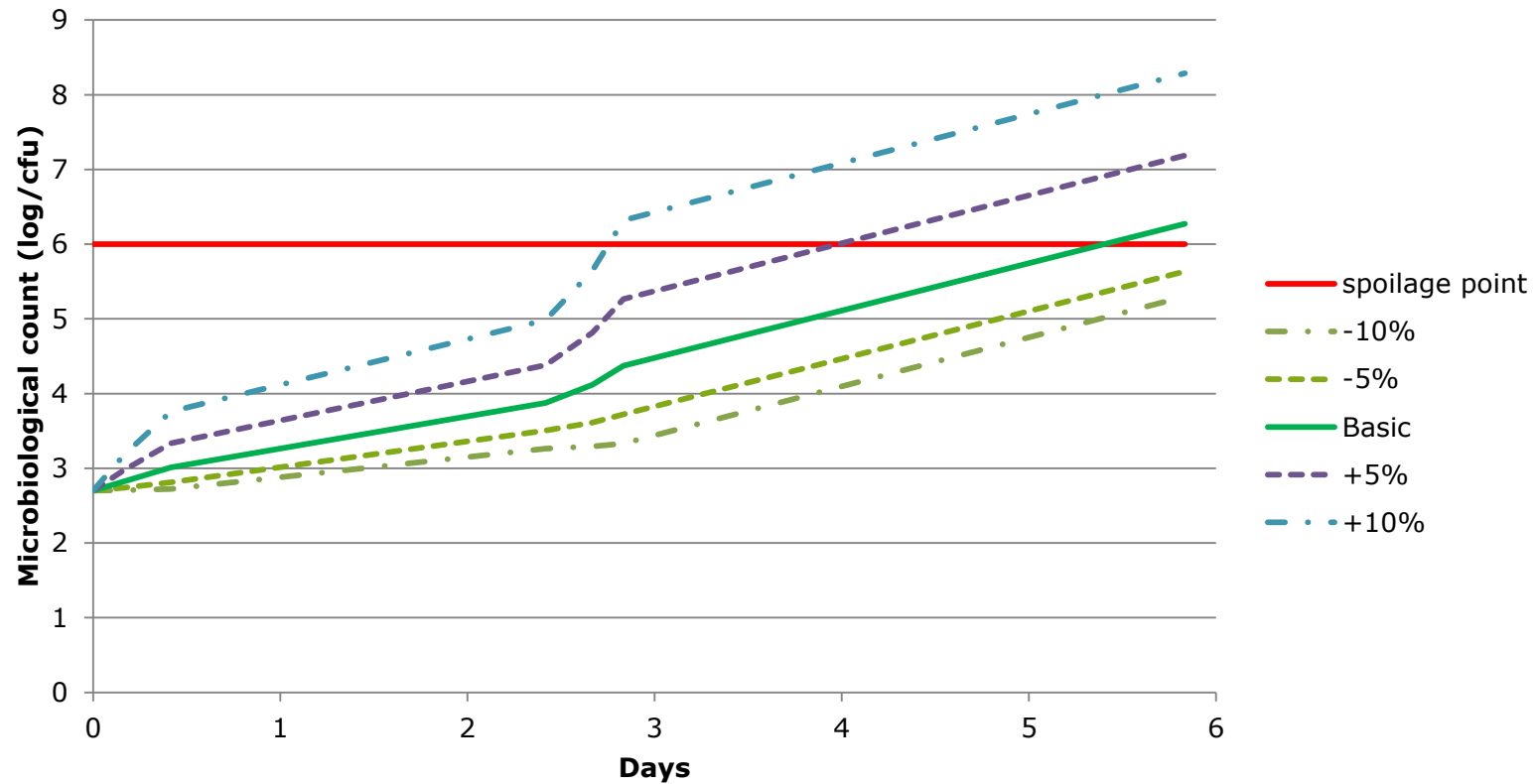






# Parameter changes

$$N = A + C * e^{-e^{-B(t-M)}}$$





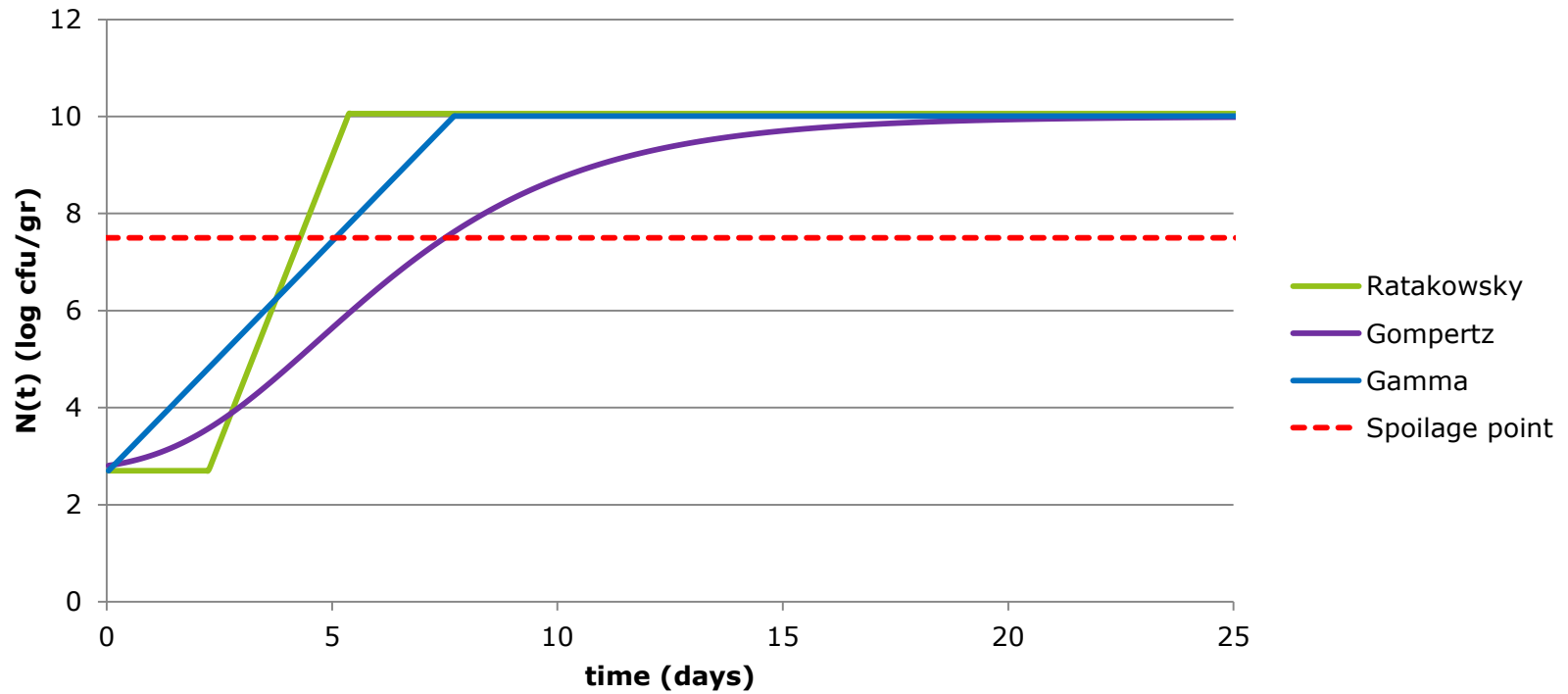
# Influence of alternative growth models

- 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

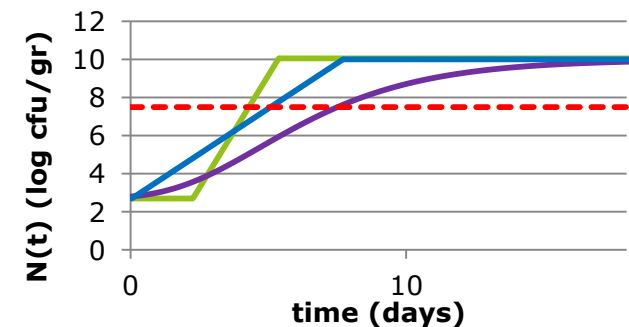
## Bacterial count at 3°C





## 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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## More Information about REFRESH

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