



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

Marjolein Buisman

R. Haijema, J.M. Bloemhof, J. Snels

Wageningen UR,
Operations Research and Logistics group, NL

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WAGENINGEN UR
For quality of life



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

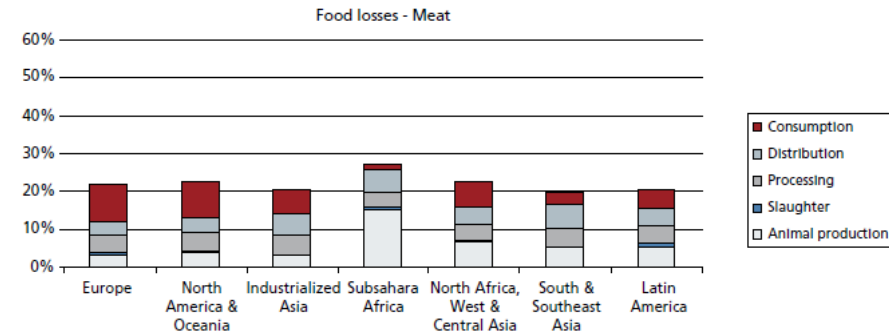




Literature/background

- 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

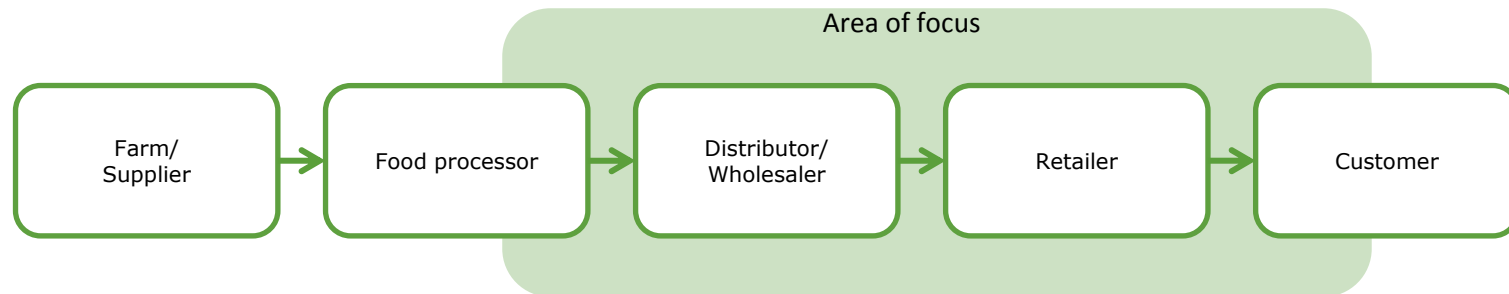
Research question

- 🥦 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

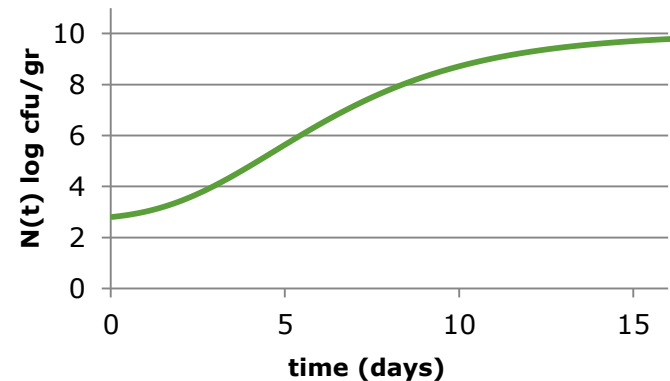
- 🥦 Retailer orders product at DC (R,S policy)
- 🥦 Products sold to consumers either FIFO or LIFO
- 🥦 Products are wasted at the end of shelf life
 - 🥜 Based on date
 - 🥜 Based on microbiological count



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



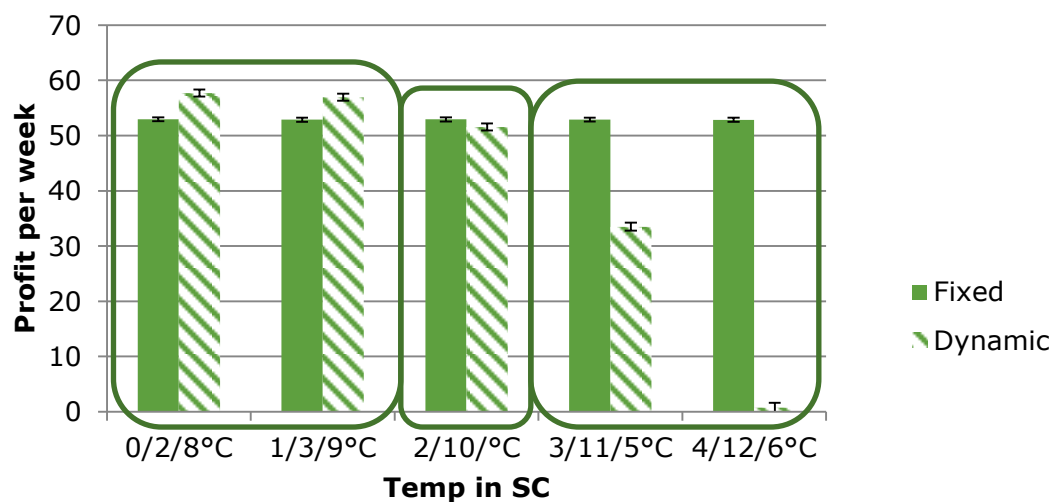
Scenario's tested

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

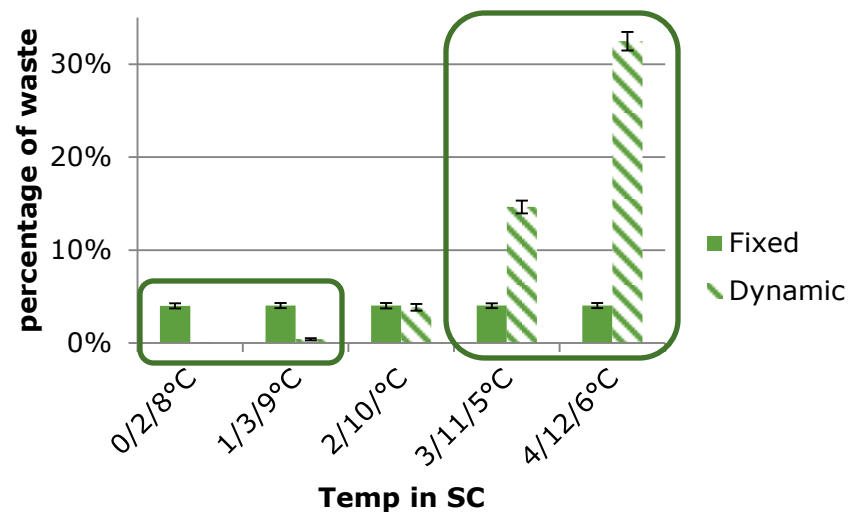
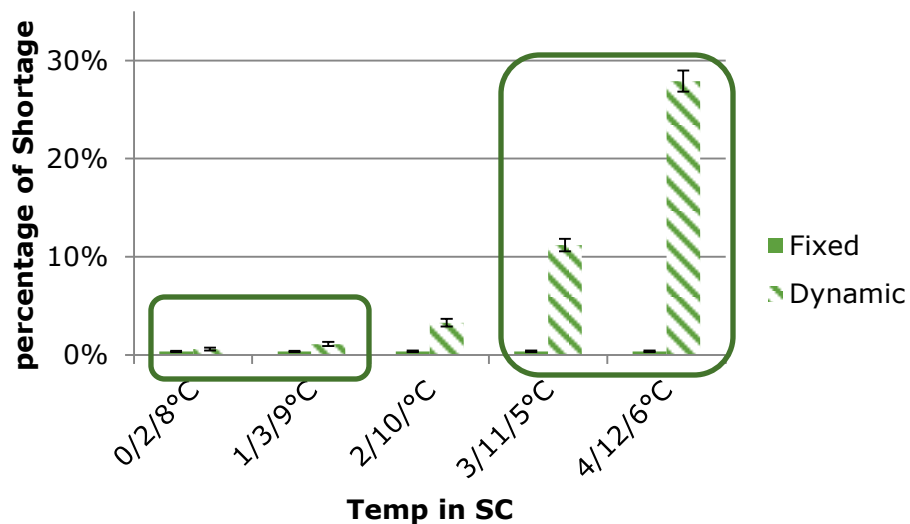
Profit



Profit increases when temperature decreases

Results Temperature changes

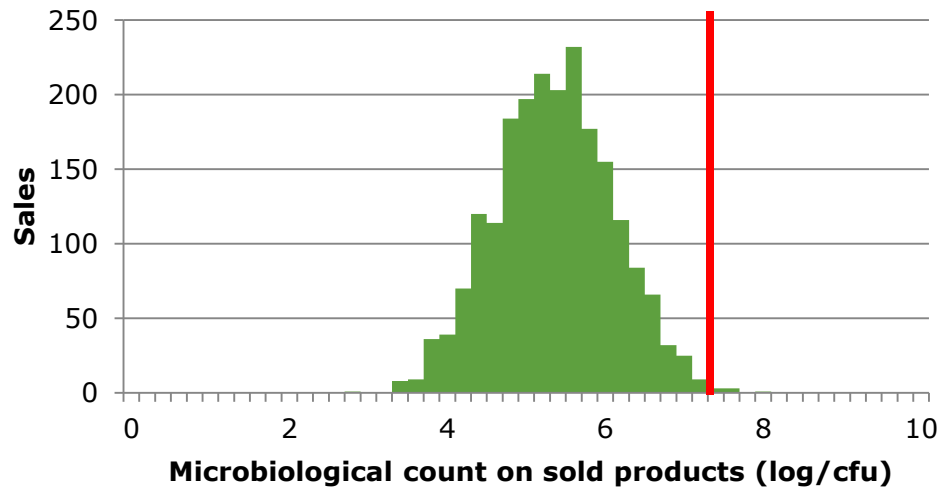
Shortages and waste



Shortages/waste decreases with lower Temp.

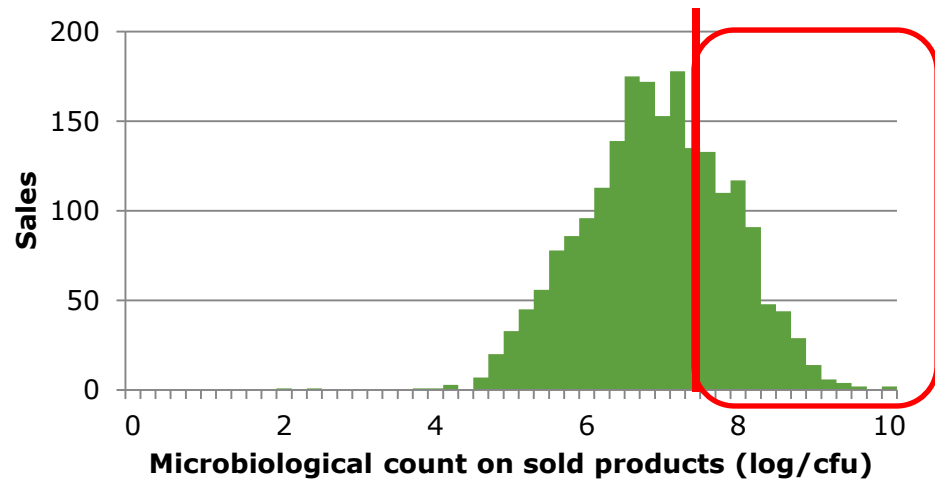


Results Temperature changes



 Fixed shelf life

 Basic temperature

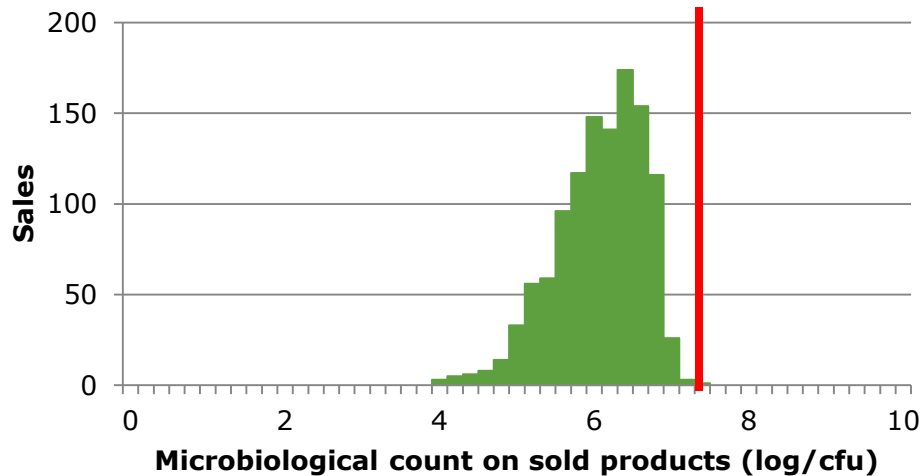
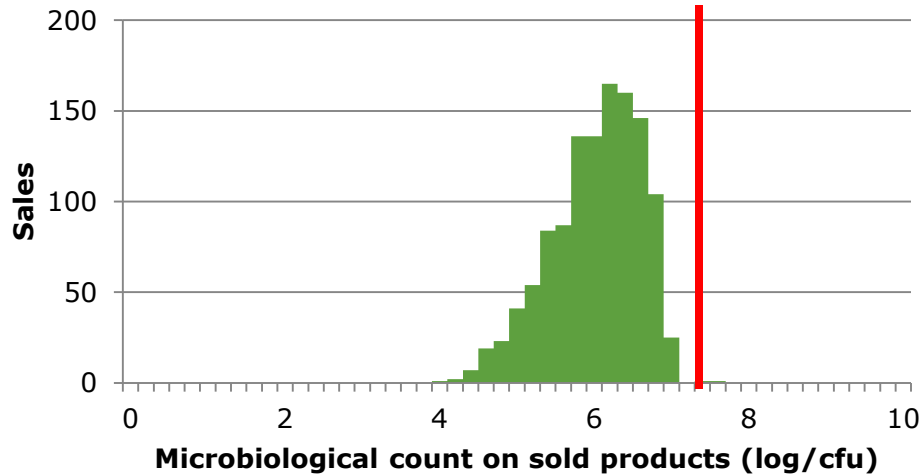


 Increase of 2°C

!!



Results Temperature changes



 Dynamic shelf life

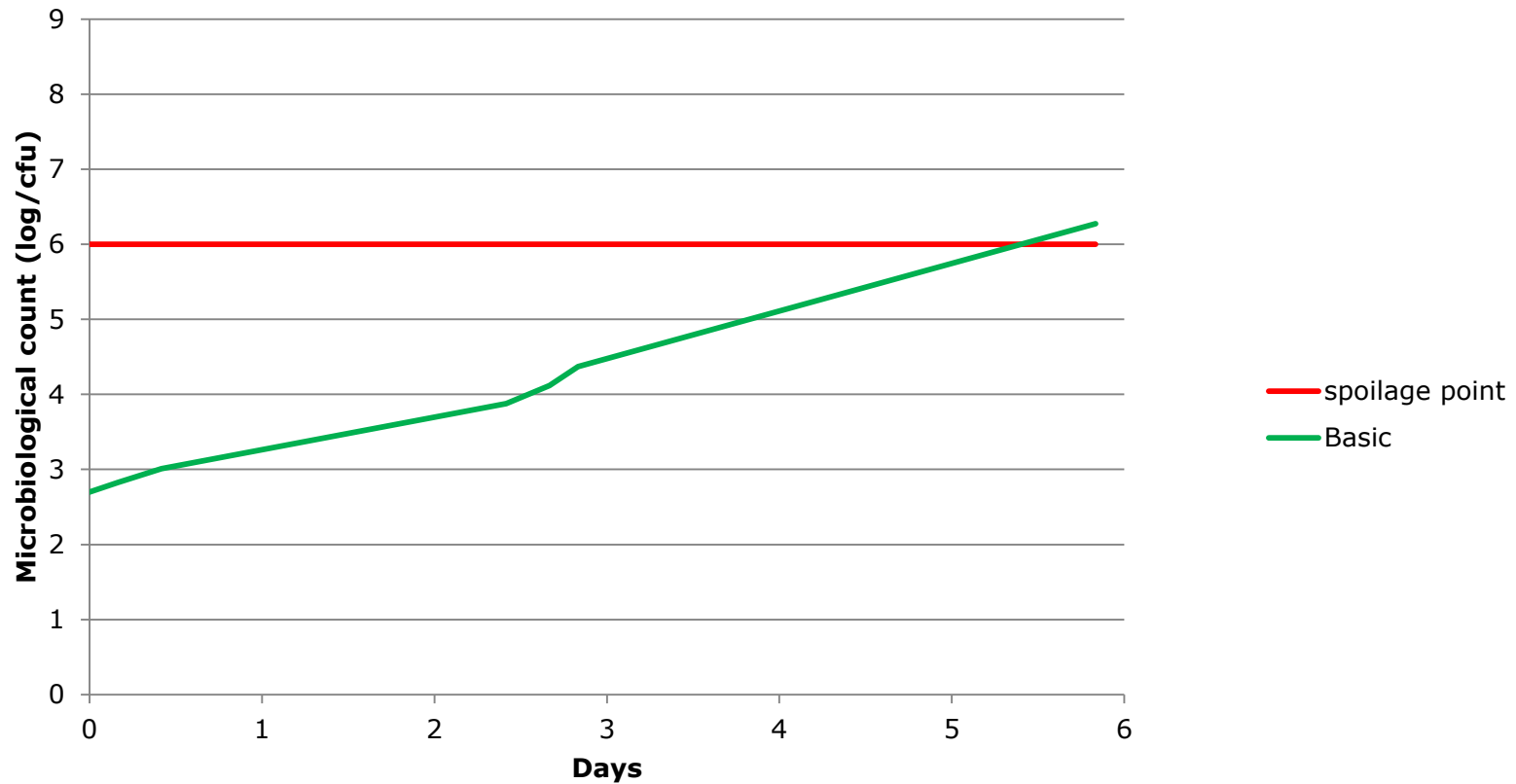
 Basic temperature

 Increase of 2°C

 **Safer products**



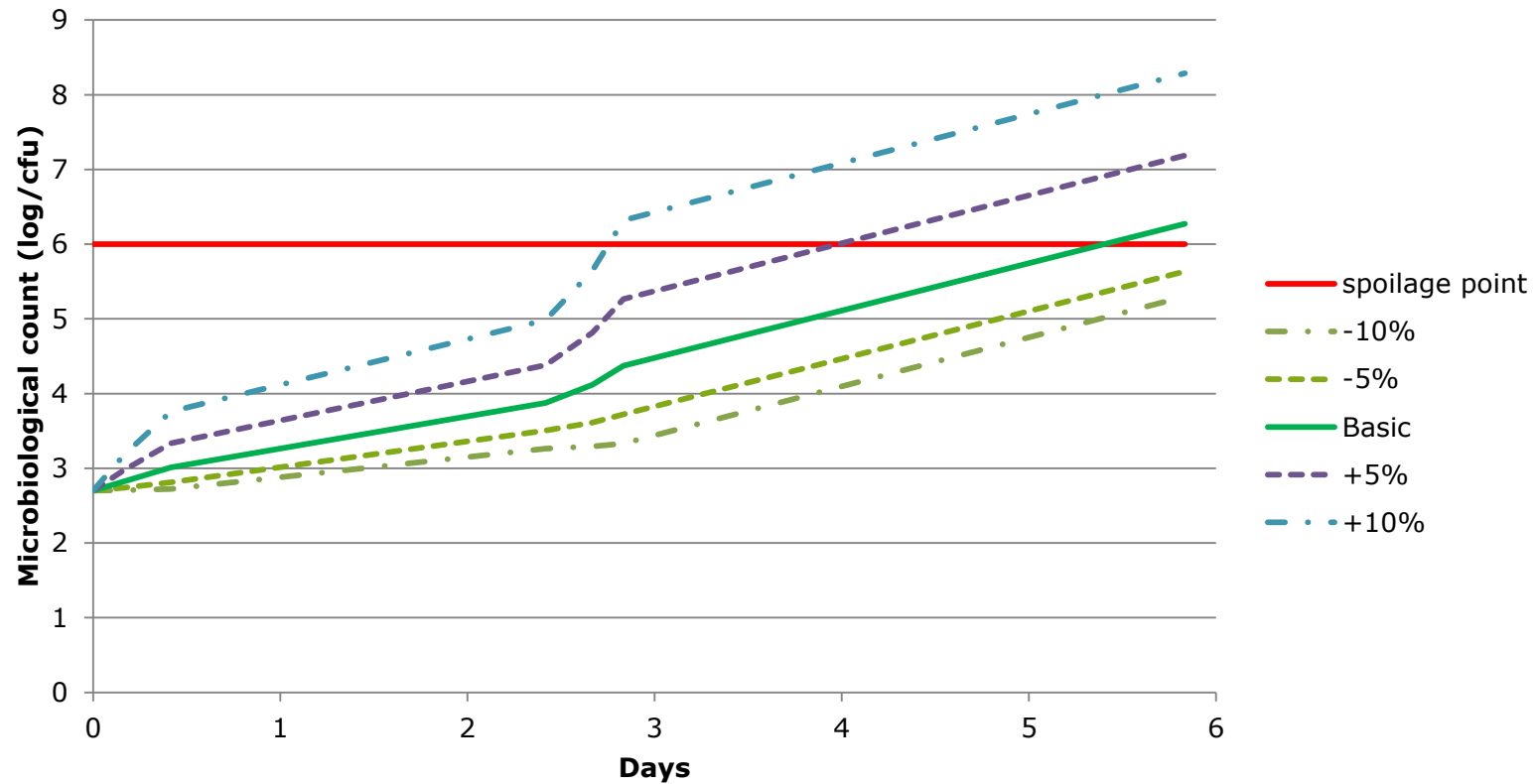
Parameter changes





Parameter changes

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





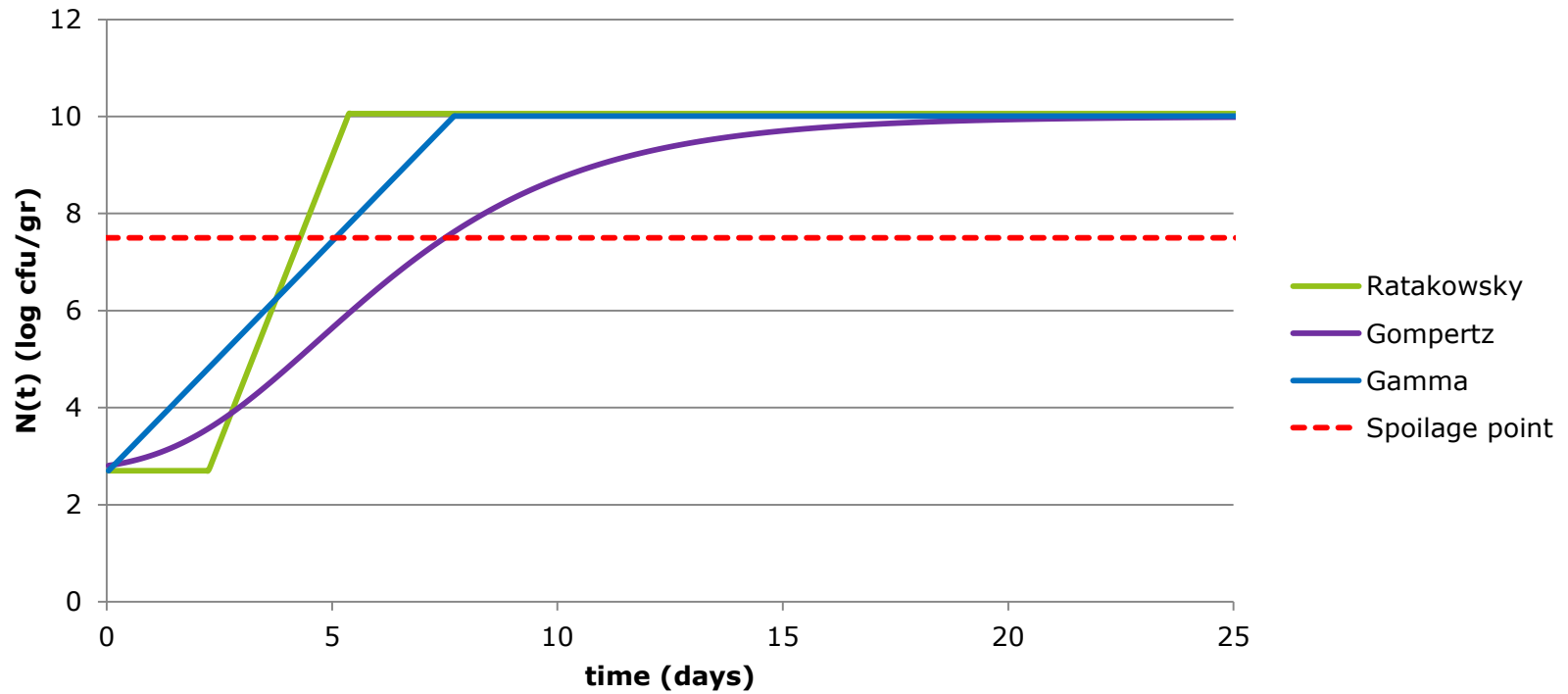
Influence of alternative growth models

- 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

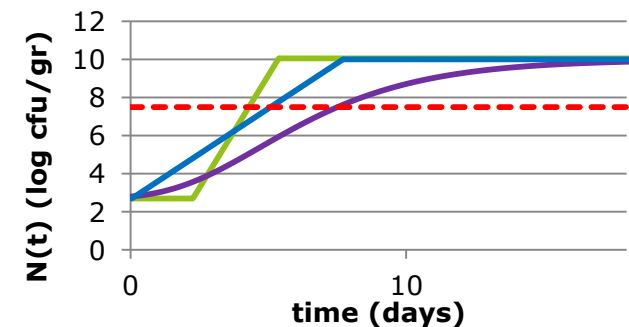
Bacterial count at 3°C





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?

Marjolein.Buisman@wur.nl

PhD candidate Wageningen UR
Operations Research and Logistics

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