Maintenance of the cold chain during storage and transport of meat

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efsa
European Food Safety Authority

BACKGROUND

- Mandate from EC requesting a scientific opinion on the public health risks related to the maintenance of the cold chain during storage and transport of meat
- Resulted in four scientific outputs:
  - **Part 1 (meat of domestic ungulates) (03/2014)**
  - Part 2 (minced meat from all species) (07/2014)
  - Clarification on Parts 1 and 2 (10/2015)
  - Growth of spoilage bacteria during storage and transport of meat (06/2016)

EU LEGISLATION FOR TRANSPORT AND STORAGE OF MEAT

In the case of meat from animals other than poultry:

- Immediate chilling after *post-mortem* to ensure a temperature throughout the meat of not more than 3° C for offal and **7° C for other meat** along a chilling curve that ensures a continuous decrease of the temperature.
- Meat must reach the temperature specified before transport, and remain at that temperature during transport.

No indication of time

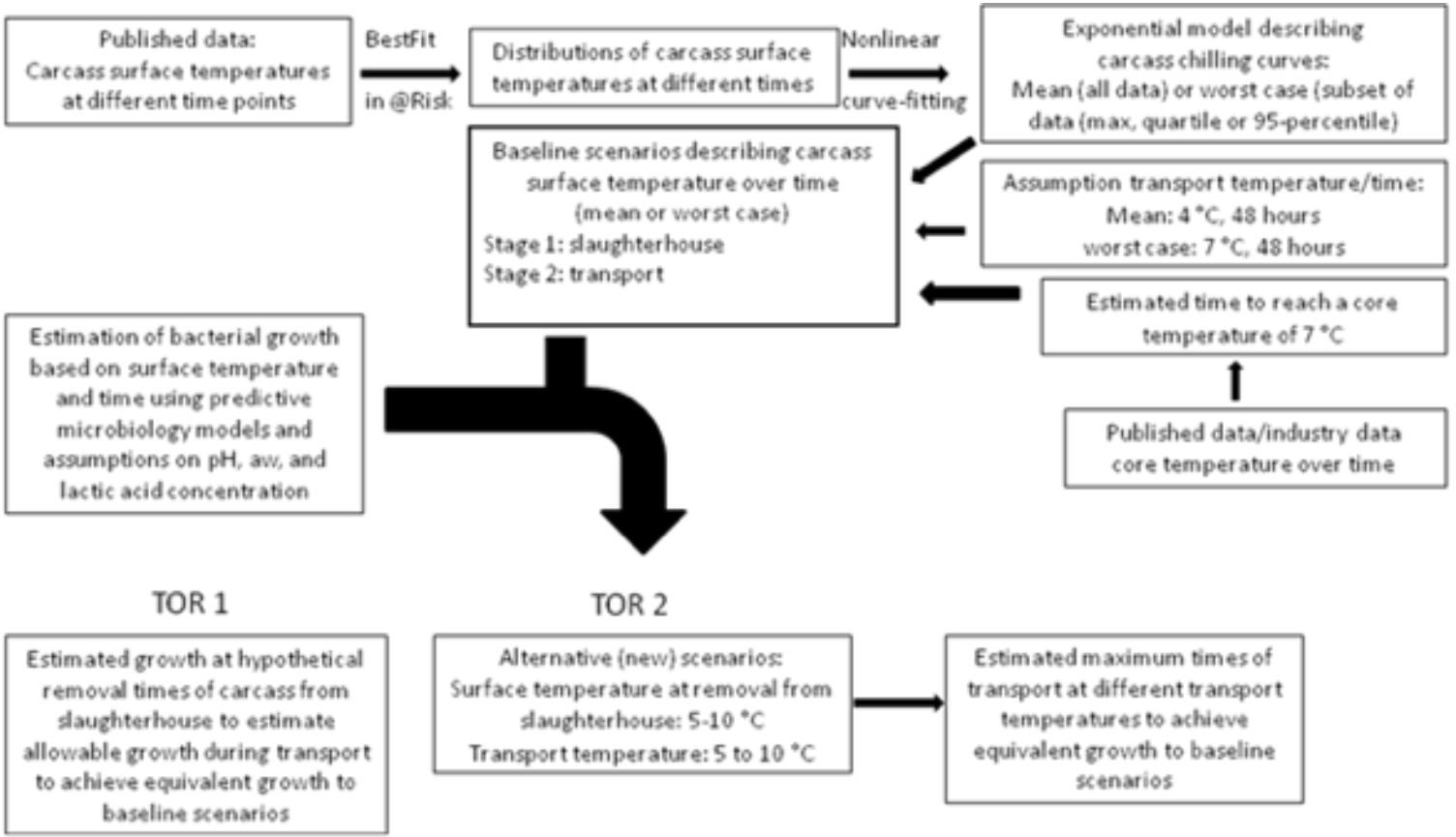
TERMS OF REFERENCE (PART 1) MEAT DOMESTIC UNGULATES

1. To assess if it is possible to apply **alternative core temperatures**, higher than 7 ° C, in combination with **specific transport durations** for the transport of meat (carcasses) after the slaughter, without increasing significantly the risk linked to the microbiological growth of potentially harmful microorganisms, and
2. To recommend, if appropriate, in relation to such risk, combinations of a maximum core temperature for the loading of meat (carcasses) and a maximum time for transportation.

APPROACH TO ANSWERING THE TORS

- The growth of ***Salmonella* spp., VTEC, *L. monocytogenes* and *Y. enterocolitica*** was predicted for **pork, beef and lamb**, using the carcass surface temperature profiles obtained when the carcasses were chilled to a core temperature of 7° C.

- Evaluate and compare different time-temperature surface chilling curves, representing **baseline and alternative chilling scenarios**, in terms of the estimated potential bacterial growth during chilling.


Published data:
Carcass surface temperatures at different time points
BestFit
in @Risk
Distributions of carcass surface temperatures at different times
Nonlinear
curve-fitting
Exponential model describing carcass chilling curves:
Mean (all data) or worst case (subset of data (max, quartile or 95-percentile)
Baseline scenarios describing carcass surface temperature over time (mean or worst case)
Stage 1: slaughterhouse
Stage 2: transport
Assumption transport temperature/time:
Mean: 4 °C, 48 hours
worst case: 7 °C, 48 hours
Estimated time to reach a core temperature of 7 °C
Published data/industry data core temperature over time
Estimation of bacterial growth based on surface temperature and time using predictive microbiology models and assumptions on pH, aw, and lactic acid concentration
TOR 1
TOR 2
Estimated growth at hypothetical removal times of carcass from slaughterhouse to estimate allowable growth during transport to achieve equivalent growth to baseline scenarios
Alternative (new) scenarios:
Surface temperature at removal from slaughterhouse: 5-10 °C
Transport temperature: 5 to 10 °C
Estimated maximum times of transport at different transport temperatures to achieve equivalent growth to baseline scenarios

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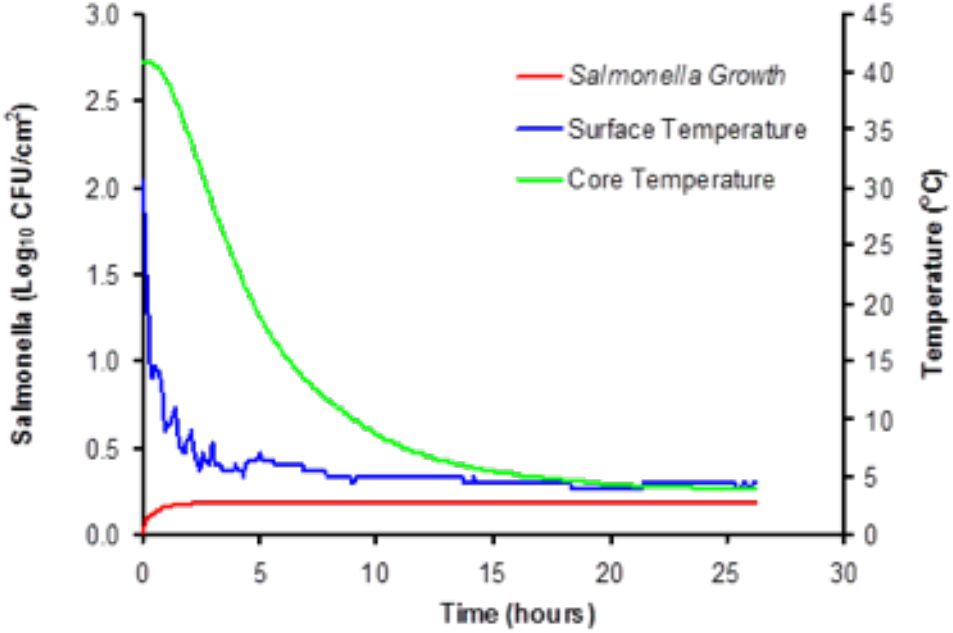
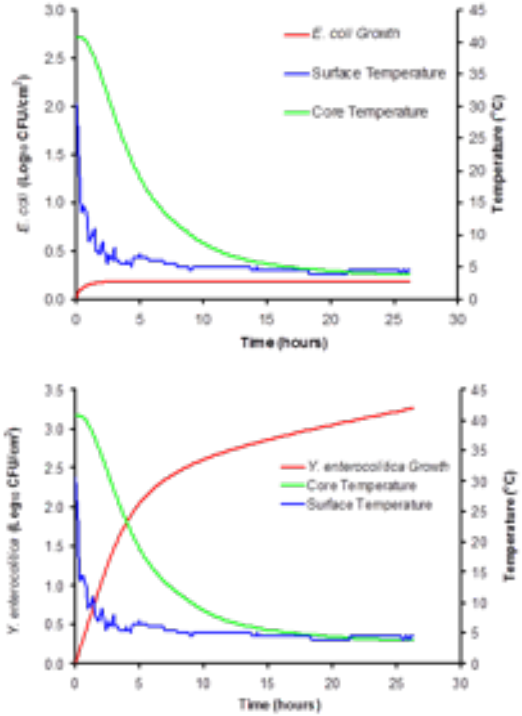
TOR 1: RESULTS





Predicted growth of *Salmonella* spp. on pork carcasses kept in the chilling room until core temperature reaches 7 °C.

TOR 2: COMPARISON BETWEEN CURRENT AND ALTERNATIVE SCENARIOS

- **Baseline scenarios**
  - **Mean**: Chilling of carcass at the mean estimated chilling temperature profile until the core temperature reaches 7° C and subsequent transportation with a surface temperature of 4° C.
  - **Worst case**: Chilling of carcass at the worst estimated chilling temperature profile until the core temperature reaches 7° C and subsequent transportation with a surface temperature of 7° C.
- **Alternative scenarios**
  - Chilling of carcass until the surface temperature reaches temperatures from 5 to 10° C and subsequent transportation with a surface temperature of 5 to 10° C.

TOR 2: RESULTS - CHILLING

Predicted growth for selected pathogens during **beef** carcass **chilling** based on the calculated **mean** temperature chilling profile. The time required for the carcass core temperature to reach 7 °C (current regulation) is compared to the time required for the surface to reach temperatures from 5 to 10 °C.

		Growth (Log_{10} CFU/cm^2)			
Chilling temperature limit		***Salmonella* spp.**	***E .coli* (VTEC)**	***L. monocytogenes***	***Y. enterocolitica***
Bacterial growth on the carcass when chilled to a core temperature of 7 °C (26.6 hours)		1.00	0.95	1.14	1.57
Surface T (°C)	Time in chiller (hours)				
5	9.7	1.00			1.17
6	8.5	1.00			1.13
7	7.7	1.00			1.09
8	6.8	0.98			1.04
9	6.2	0.97	0.93	0.93	1.01
10	5.6	0.95	0.91	0.89	0.96

Less growth because shorter time in chiller

TOR 2: RESULTS - TRANSPORTATION

Predicted growth of *Salmonella* spp. during carcass transportation with various surface temperature and times

Salmonella spp.						
Time (h)	Surface temperature (°C)					
	5	6	7	8	9	10
	Log_{10} CFU/cm^2					
1	0.00	0.00	0.00	0.02	0.03	0.03
2	0.00	0.00	0.02	0.04	0.05	0.07
3	0.00	0.00	0.03	0.06	0.08	0.10
6	0.00	0.00	0.08	0.12	0.16	0.20
12	0.00	0.00	0.17	0.24	0.31	0.40
24	0.00	0.00	0.36	0.49	0.63	0.81
48	0.00	0.00	0.73	0.97	1.26	1.61

E. coli (VTEC)						
Time (h)	Surface temperature (°C)					
	5	6	7	8	9	10
	Log_{10} CFU/cm^2					
1	0.00	0.00	0.01	0.01	0.02	0.03
2	0.00	0.00	0.02	0.03	0.04	0.06
3	0.00	0.00	0.02	0.04	0.07	0.10
6	0.00	0.00	0.05	0.08	0.13	0.19
12	0.00	0.00	0.09	0.17	0.27	0.39
24	0.00	0.00	0.18	0.34	0.53	0.77
48	0.00	0.00	0.37	0.67	1.06	1.54

L. monocytogenes						
Time (h)	Surface temperature (°C)					
	5	6	7	8	9	10
	Log_{10} CFU/cm^2					
1	0.02	0.03	0.03	0.04	0.05	0.05
2	0.04	0.05	0.06	0.08	0.09	0.11
3	0.06	0.08	0.09	0.11	0.14	0.16
6	0.13	0.15	0.19	0.23	0.27	0.33
12	0.25	0.31	0.38	0.46	0.55	0.65
24	0.51	0.62	0.75	0.91	1.09	1.31
48	1.01	1.24	1.51	1.82	2.19	2.61

Y. enterocolitica						
Time (h)	Surface temperature (°C)					
	5	6	7	8	9	10
	Log_{10} CFU/cm^2					
1	0.04	0.04	0.05	0.06	0.07	0.08
2	0.08	0.09	0.10	0.12	0.14	0.16
3	0.12	0.13	0.16	0.18	0.20	0.23
6	0.23	0.27	0.31	0.36	0.41	0.47
12	0.46	0.54	0.62	0.71	0.82	0.93
24	0.93	1.08	1.24	1.43	1.64	1.86
48	1.86	2.16	2.49	2.86	3.27	3.73

CONCLUSIONS

- Carcass **surface temperature** is a more relevant of chilling effect on growth than core temperature

- Carcasses could be transported before the core temperature reaches 7° C in the slaughterhouse chiller without increasing any food safety risk associated with additional growth of pathogenic bacteria **so long as the bacterial growth is controlled by efficient chilling during transportation**.

CONCLUSIONS

It is possible to calculate surface temperature - transportation time combinations that would give the equivalent amount of bacterial growth to that which would be obtained with current chilling regimes.

Examples:

- carcass chilling to a surface temperature of 5 ° C (10 h) and transportation at 5 ° C for 45 hours
- carcass chilling to a surface temperature of 8 ° C (7 h) and transportation at 7 ° C for 1 hour

QUESTIONS?

For details refer to the Scientific Opinions published on the EFSA website:

- https://www.efsa.europa.eu/it/efsajournal/pub/3601
- https://www.efsa.europa.eu/it/efsajournal/pub/3783
- https://www.efsa.europa.eu/de/efsajournal/pub/4291
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