Predicting growth of C. perfringens in ready-to-eat foods kept hot for three hours

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Predicted growth of *C. Perfringens* in warm ready-to-eat foods

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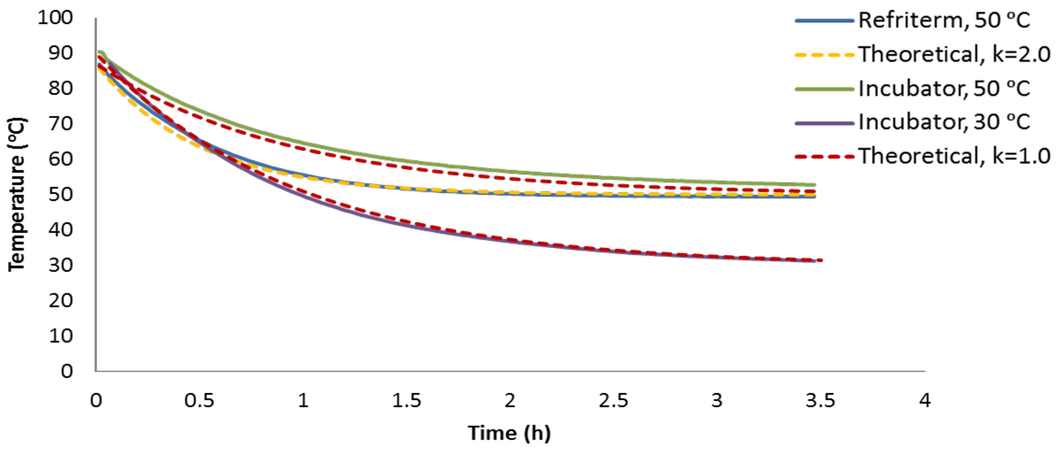
Aim

To tabulate the temperatures at which ready-to-eat foods can be kept for three hours, without increasing the level of *C. perfringens* with more than 1 log cfu/g, when varying the pH, NaCl and cooling constant.

Actual cooling vs. theoretical cooling



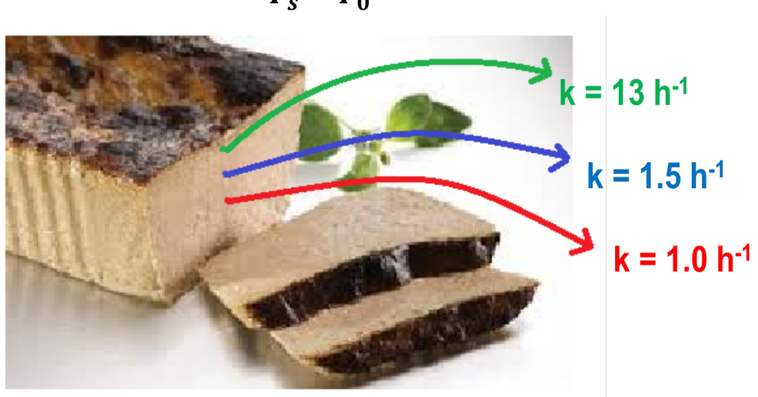
Good agreement between actual cooling and theoretical based on the cooling constant, k. k is dependent on the overall heat transfer coefficient, but inpedentent of the surrounding temperature.

Summary

Danish supermarkets would like be able to keep ready-to-eat foods hot for up to three hours before selling them. The predicted growth of *C. perfringens* in pre-heated ready-to-eat foods kept at temperatures between 20 °C and 60 °C was therefore evaluated.
In order to investigate the significance of only measuring centre-temperature when estimating growth, the cooling constant, k, was calculated at different locations in two model foods of different size - liver paste and meat balls.
The cooling constant differed significantly within the food – especially in the larger types of food, indicating that it is not sufficient to evaluate the growth of *C. perfringens* in the centre of the foods.
As a result several temperature intervals proved not to be suitable for hot-holding of ready-to-eat foods.

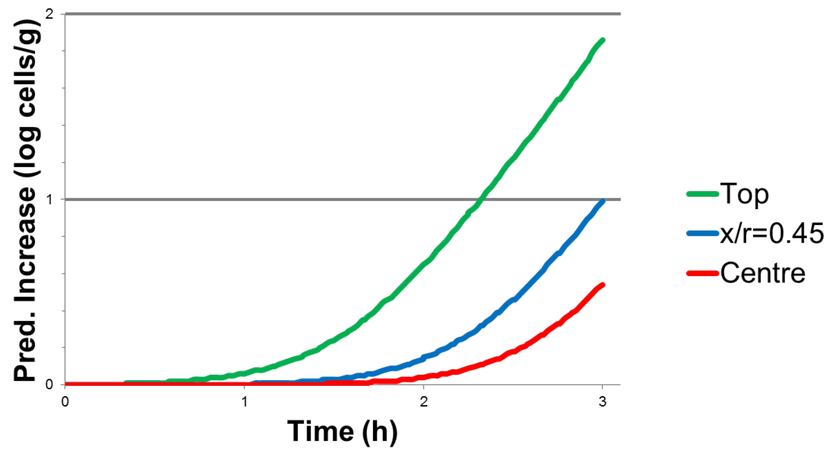
Dependence of k on location in the food

$$\Omega = \frac{T_s - T}{T_s - T_0} = e^{-k \cdot t}$$



The cooling constant increases when decreasing the distance from the surface, resulting in a more rapid cooling to the surrounding temperature.

Predicted growth of *C. perfringens*



Warm keeping of liver paste at 42 °C, with T_0= 75 °C, NaCl=1.5% and pH=6.0.
Predicted growth unproblematic in the centre but too high at the top of the liver paste

Conclusion

- Possible to model cooling constants
- Ready-to-eat foods can be kept hot for three hours regardsless of the other parameters, if:
  - pH < 5.5
  - NaCl > 2.8 %
  - Temperature > 52 °C
  - Cooling constant < 1 h^{-1}

Otherwise use of table is necessary

Materials and methods

Bic simula[1] was used to calculate the temperature profiles at different locations in ready-to-eat foods as a function of the overall heat transfer coefficient. A range of expected cooling constants was found based on this.
Combase Perfringens predictor[2] was then used to predict the growth of *C. perfringens* in a three hour period based on the concentration of NaCl and the pH.Two tables were constructed showing at which temperatures growth of over 1 log cfu/g is expected to take place when the pH is either 6.0 or 6.5. The table for pH = 6.0 is shown below.

References

[1] Created by J. Risum, National Food Institute, Technical University of Denmark;

[2] Created by Institute of Food Research, Norwich Research Park, Norwich, UK

Cooling constant

NaCl

	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2	2.2	2.4	2.6	2.8	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	9	10	12	14	16	18	20
0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	41-45	40-46	40-46	40-47	39-47	39-47	39-48	39-48	39-48	39-48	39-48	39-49	39-49	39-49	39-49	39-49	39-49
0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	41-45	41-46	40-46	40-47	39-47	39-47	39-48	39-48	39-48	39-48	39-48	39-48	39-49	39-49	39-49	39-49	39-49
0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	41-46	40-46	40-47	40-47	39-47	39-48	39-48	39-48	39-48	39-48	39-48	39-49	39-49	39-49	39-49	39-49
0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	42-45	41-46	40-46	40-47	40-47	40-47	40-48	39-48	39-48	39-48	39-48	39-48	39-48	39-49	39-49	39-49
0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	42-45	41-46	40-46	40-46	40-47	40-47	40-47	40-48	40-48	40-48	40-48	40-48	40-48	40-48	40-48
1	-	-	-	-	-	35-41	35-44	35-45	34-46	34-47	34-48	34-48	34-48	34-49	34-49	34-49	34-50	34-50	34-50	34-50	34-50	34-50	34-51	34-51	34-51	34-51	34-51	34-51	34-51	34-51	34-51	34-51
1.2	-	-	-	-	-	-	36-43	35-45	35-46	35-47	35-47	35-48	35-48	35-48	35-49	35-49	34-50	34-50	34-50	34-50	34-50	34-50	34-50	35-50	35-50	35-51	35-51	35-51	35-51	35-51	35-51	35-51
1.4	-	-	-	-	-	-	38-41	36-44	36-45	35-46	35-47	35-47	35-48	35-48	35-48	35-49	35-49	35-50	35-50	35-50	35-50	35-50	35-50	35-50	35-50	35-50	35-50	35-51	35-51	35-51	35-51	35-51
1.6	-	-	-	-	-	-	-	39-41	37-44	37-45	36-46	36-47	36-47	36-47	36-48	36-49	36-49	36-49	36-49	36-49	36-50	36-50	36-50	36-50	36-50	36-50	36-50	36-50	36-50	36-50	36-50	36-50
1.8	-	-	-	-	-	-	-	-	-	38-44	38-45	38-46	37-46	37-47	37-47	37-48	37-48	36-49	36-49	36-49	36-49	36-49	36-49	36-50	36-50	36-50	36-50	37-50	37-50	37-50	37-50	37-50
2	-	-	-	-	-	-	-	-	-	-	-	40-44	39-45	39-46	39-46	38-47	38-48	38-48	38-48	37-48	37-49	37-49	37-49	37-49	37-49	37-49	37-49	37-50	37-50	37-50	37-50	37-50
2.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	41-45	40-46	40-47	39-47	39-47	39-48	39-48	39-48	39-48	39-48	39-48	39-49	39-49	39-49	39-49	39-49	39-49
2.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	42-45	41-46	41-46	41-47	41-47	41-47	41-47	41-47	41-47	41-48	41-48	41-48
2.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Ambient temperature intervals where *C. perfringens* grows with more than1 log cfu/g in three hours , given a pH of 6.0 and an ambient temperature > 20 °C