MODELLING INACTIVATION KINETICS OF *Listeria monocytogenes* IN A DAIRY PRODUCT

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OBJECTIVES

Modelling inactivation kinetics of *Listeria monocytogenes* Scott A in half cream.

Study of the parameters temperature dependence.

INTRODUCTION

The bacterial spoilage of foods and the survival of pathogens are of major importance to the food process industries, because it directly affects the consumer's health and safety. The use of accurate mathematical models, that describe the inactivation behavior of microorganisms, would be a considerable tool to predict target pathogen's survival within specific environmental conditions. It may also help to determine the extent to which existing thermal processes could be modified, in order to obtain major quality retention.

CASE STUDY

Inactivation data of *L. monocytogenes* in half cream at 52, 56, 60, 64 and 68ºC (Casadei *et al.* 1998)

Two- step regression procedure

Gompertz model was fitted to the experimental data ⟶ kinetic parameters (k_{max}, L)

Dependence of the parameters on temperature, using equations 1, 2, 3 and 4

One-step regression procedure

a global regression procedure was performed, using data at all temperatures, combining the Gompertz modified model and equations 1 and 4

MATHEMATICAL MODELS

Square-root model (1)

$$\sqrt{k}_{max} = \sqrt{c}\,(T - d)$$

c, d constants

Arrhenius type equation (2)

$$k_{max} = k_{ref}\,\exp\left(-\frac{E_a}{R}\left(\frac{1}{T} - \frac{1}{T_{ref}}\right)\right)$$

k_{ref} rate constant at T_{ref}
Ea activation energy

T_{ref} = 333 K

Gompertz modified model

$$\log N = \log N_0 - \log\left(\frac{N_0}{N_{res}}\right)\exp\left(-\exp\left(\frac{k_{max}\,e}{\log\left(\frac{N_0}{N_{res}}\right)}(L - t) + 1\right)\right)$$

Williams-Landel-Ferry model (3)

$$L = 10^{\left(\frac{a\,(T - T_{min})}{b + (T - T_{min})}\right)}$$

T_{min} = 310 K

a, b constants

Arrhenius type equation (4)

$$L = a\,\exp\left(b\left(\frac{1}{T} - \frac{1}{T_{ref}}\right)\right)$$

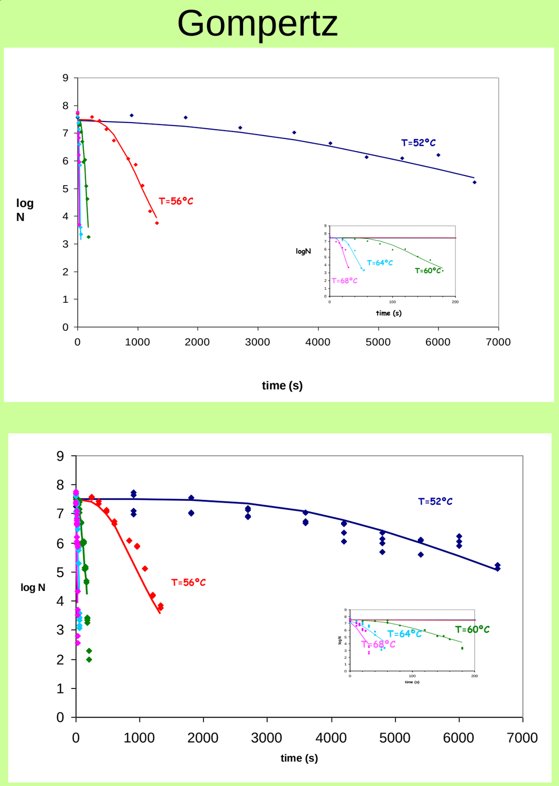
T_{ref} = 333 K

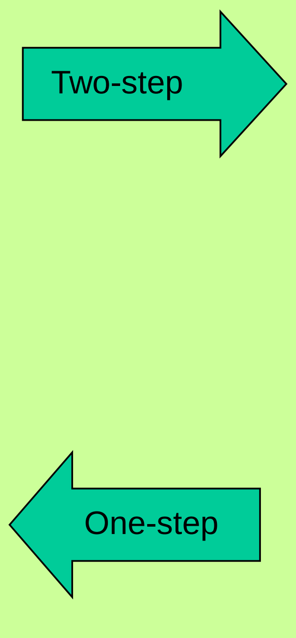
Where:

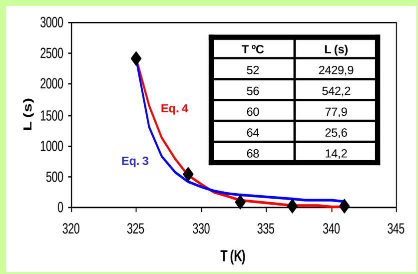
- N population size (CFU/unit volume)
- N_0 inicial population size = 3.1×10^7 CFU/unit volume
- N_{res} residual population size = 31.6 CFU/unit volume
- t processing time (s)
- T temperatura (K)
- L lag time (s)
- k_{max} reaction rate (s^{-1})

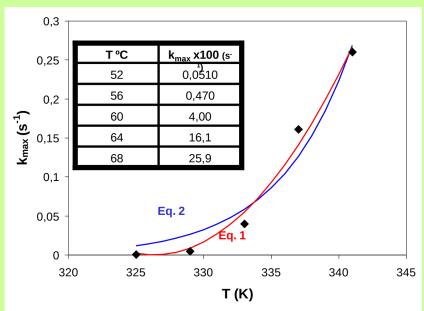
RESULTS AND DISCUSSION

Gompertz









Equations 1 and 4 selected

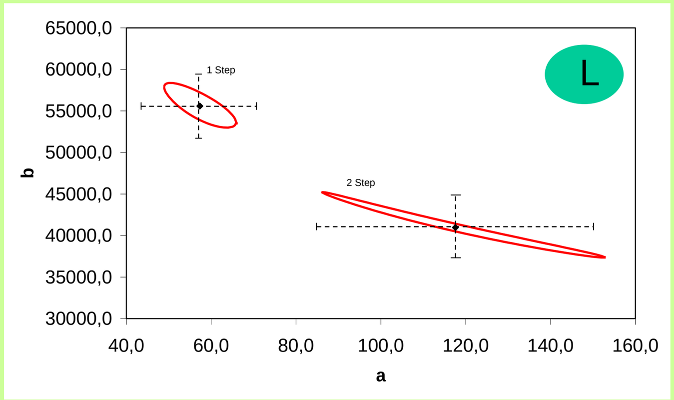
The criteria used to conclude about the best models were the quality of the residuals, the value of R^2_{adj} and the SHW of the estimates at 95%

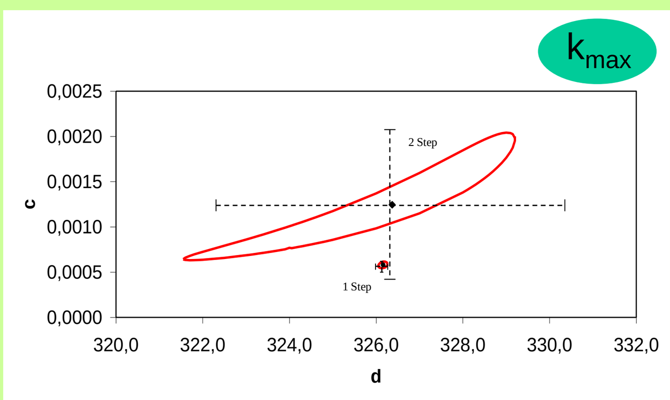
The **square-root** model describes better the dependence of k_{max} on temperature

The **Arrhenius** equation describes better the dependence of L on temperature

Models used in 1-step regression procedure

Joint confidence regions of the estimates at 90%





The dashed lines are the confidence intervals at 95%

Parameters estimation and relevant statistical data

Two-step regression procedure

k_{max}

Model	Parameter estimates				Regression analysis		
	k_{ref} or c	Ea or d	$SHW_{95\%}$ of k_{ref} or c	$SHW_{95\%}$ of Ea or d	R^2_{adj}	SSR/(n-p)	Randomness
Arrhenius	5.806×10^{-2}	1.808×10^{5}	180.1	128.9	0.9566	7.423×10^{-4}	✓
Square-Root	1.245×10^{-3}	3.264×10^{2}	127.7	2.428	0.9863	2.431×10^{-4}	✓

L

Model	Parameter estimates				Regression analysis		
	a	b	$SHW_{95\%}$ of a	$SHW_{95\%}$ of b	R^2_{adj}	SSR/(n-p)	Randomness
Arrhenius	1.176×10^{2}	4.097×10^{4}	55.4	18.6	0.9995	6.466×10^{2}	✓
WLF	1.413	-8.740	63.6	45.9	0.9896	1.808×10^{5}	✓

Statistica ® 6.0

One-step regression procedure

Model	Parameter estimates								Regression analysis		
	k_{max} (s^{-1})				L (s)						
	k_{ref} or c	Ea or d	$SHW_{95\%}$ of k_{ref} or Ea	$SHW_{95\%}$ of Ea or d	a	b	$SHW_{95\%}$ of a	$SHW_{95\%}$ of b	R^2_{adj}	SSR/(n-p)	Randomness
Arrhenius	-	-	-	-	5.733×10^{1}	5.559×10^{4}	47.5	14.0	0.8310	0.3467	✓
Square-Root	5.806×10^{-4}	3.262×10^{2}	18.9	8.585×10^{-2}	-	-	-	-			

$SHW_{95\%}$ standardised half width at 95% = $\frac{\text{standard error of the estimate at 95\%}}{\text{parameter estimate}}$
SSR sum of squares of residuals
n # experimental points
p # model parameters

CONCLUSIONS

The global fit improved parameter estimation, as expected ⟶ narrow confidence intervals

Nevertheless, the two different regression procedures lead to different parameter estimates, as observed by the contours of the joint confidence regions

REFERENCES

Casadei, M. A., Esteves de Matos, R., Harrison, S.T., Gaze, J.E. (1998). "Heat resistance of *Listeria monocytogenes* in dairy products as affected by the growth medium." Journal of Applied Microbiology **84**: 234-239.

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