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Predicting the effect of salt on heat tolerance of *Listeria monocytogenes* in meat and fish products

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Listeria monocytogenes is a potentially fatal foodborne pathogen that can be found in various food products, including meats. It can tolerate adverse conditions such as high salt concentrations, thus, the elimination of the organism is difficult in food processing. This study was conducted to enable prediction of the effect of salt on heat tolerance of *L. monocytogenes* in food. The obtained model enables food processors to design proper thermal processes to eliminate *L. monocytogenes* in meat products to ensure safety and prevent foodborne listeriosis.

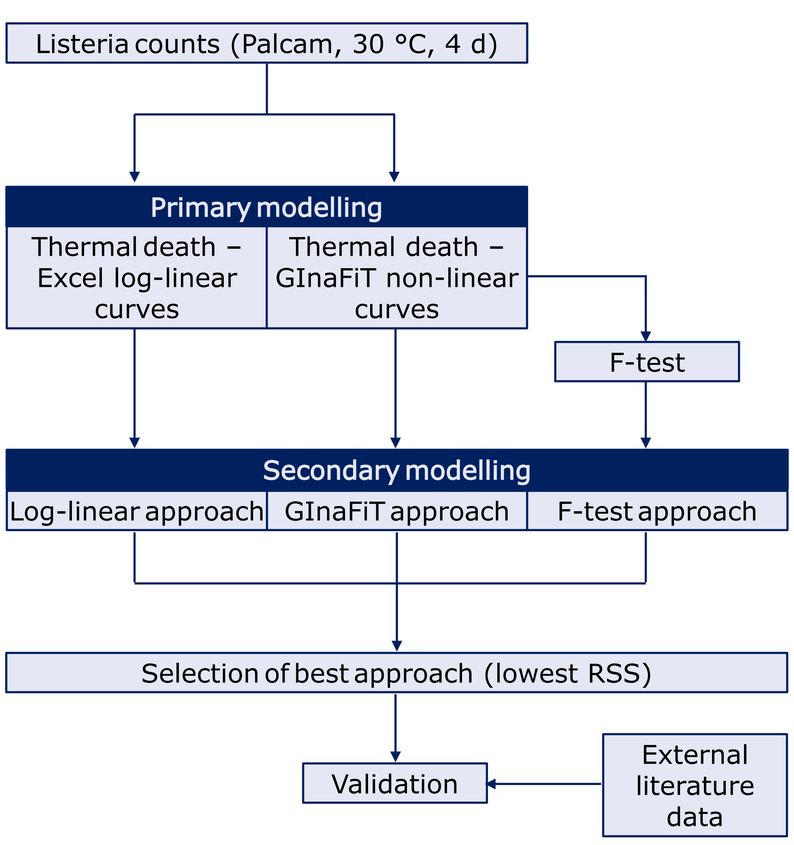

Figure 1. Overview of modelling procedure.

Methodology

The work involved minced pork, chicken and salmon with different water phase salt (WPS) concentrations from 0 to 5.6 % inoculated with late-stationary phase *L. monocytogenes* cultures from three strains associated with fish, meat and industrial environment. Samples were vacuum-packaged in sterile bags, immerged in water bath, and held at constant temperatures from 57 to 65 °C.

Modelling

Heat tolerance was defined as the time to achieve 3 decimal reductions, *i.e.* 3D-values, by using both log-linear and non-linear-regression models (Figure 1). Development of a secondary predictive model describing the combined effect of temperature and WPS was carried out.

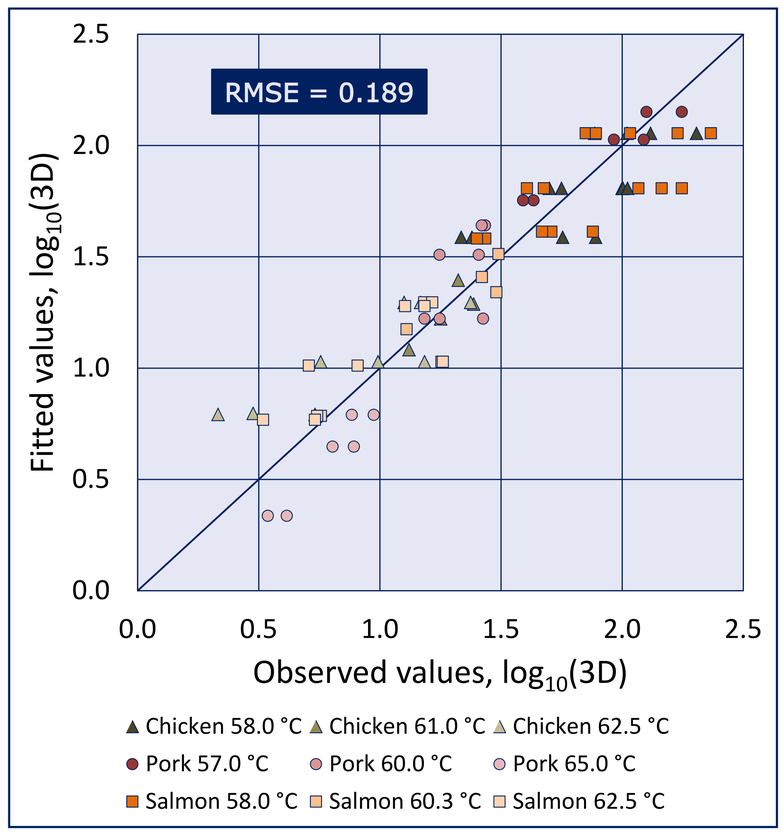

Figure 2. Secondary model - fitted values versus observed values of $\log_{10}$(3D) for *Listeria monocytogenes* heated in meat and fish products. Diagonal line: perfect fit.

The mathematical structure of the model was adopted from Li *et al.* (Food Control 73:406, 2017):

$$\log_{10}(3D) = a + b \times Temp + c \times Temp \times WPS$$

Three different approaches i) Log-linear, ii) GInaFiT and iii) F-test were applied for selection of the 3D-values to be included as responses in the development of the model (Figure 1).

The F-test approach resulted in best fit (Table 1) with a=11.8476, b=-0.1771 and c=0.00142. Goodness-of-fit is shown in Figure 2.

Validation

The secondary model was validated using 86 external literature values from six different sources (Figure 3). WPS from 0 to 6 %, temperatures from 57.5 to 65.0 °C and salmon roe, minced meat (beef and pork) and pork slurry were represented.

The bias and accuracy factors were 2.92 and 3.14, respectively, when D-values were used as response. When $\log_{10}$(3D)-values were used, the bias factor was 1.78 and the accuracy factor was 1.81.

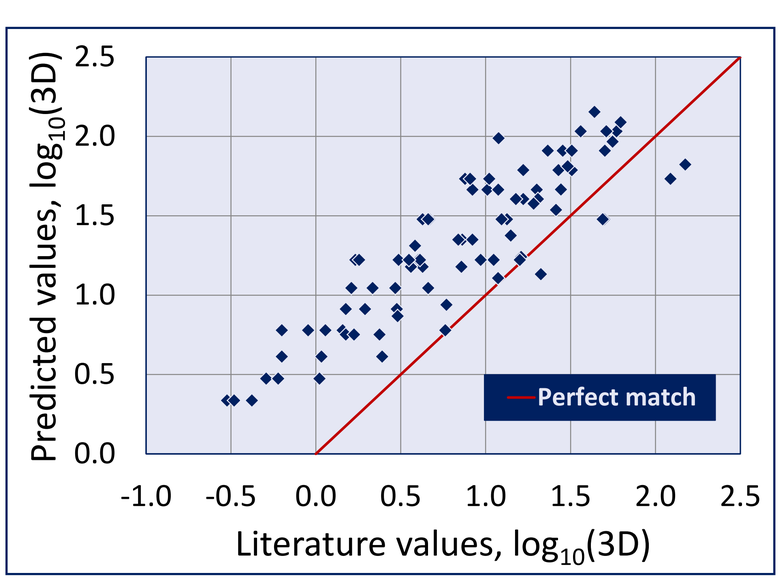

Figure 3. Validation – predicted values versus literature values of $\log_{10}$(3D) of *Listeria monocytogenes* heated in meat and fish products.

Temp. °C	WPS %	3D log-linear (min)	3D GInaFiT (min)	3D F-test (min)
57	0	41	46	43
57	3.4	108	97	94
57	4.9	151	154	144
60	0	20	28	20
60	3.4	22	23	23
60	4.9	27	32	29
65	0	3.8	4.4	4.4
65	3.4	7.1	5.3	6.9
65	4.9	8.6	8.2	8.7
RSS – $\log_{10}$(3D)		0.323	0.375	**0.257**

Table 1. Heat tolerance of *Listeria monocytogenes* in pork products estimated using three approaches. Average of two trials.