Prediction of the evolution of the contamination of *Listeria monocytogenes* during the manufacturing and the storage of delicatessen
Combined modelling of heat tranfer and bacterial behaviour

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Context

To ensure the microbial safety of food, we need informations relative to the:

• **food** : its physicochemical properties (pH, water activity –a_w- nature and concentration of inhibitor), inital level of contamination

• **process** (heat treatment, drying …) and the storage conditions (shelf life, temperature, gaseous environment…)

• **behaviour** (growth, inactivation) of microorganisms identified as health hazards

Annex II of commission regulation EC n°2073/2005 on microbiological criteria for foodstuffs is encouraging food business operators to use predictive microbiology
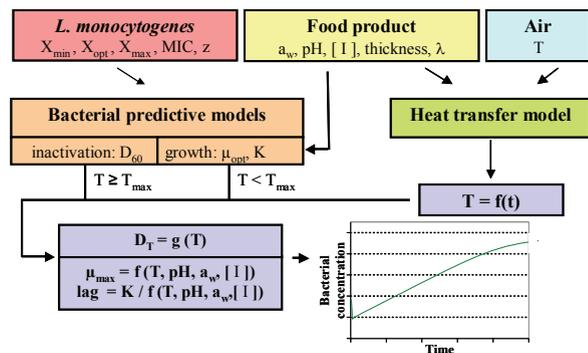
Objectives

To develop and validate the use of a **global modelling strategy** combining predictions of the :

• evolution of **temperature at each time and at each point** of delicatessen product processing

• **growth** of *L. monocytogenes* according to temperature (T), pH, a_w, nature and concentration of inhibitor [I]

• **inactivation** of *L. monocytogenes* according to T

Experiments

230 challenge tests concerning *L. monocytogenes* inoculated in irradiated **ground pork meat,**

• with adjusted pH (5 levels from 5.0 to 6.2), adjusted a_w (5 levels from 0.93 to 0.97), adjusted concentration of inhibitor according to their nature (sodium lactate, sodium acetate, potassium sorbate) and concentrations used by professionnals

• subjected to a thermal process (1h at 53°C, 1h at 48°C, 4h at 42°C) or not

• stored at controlled temperatures (4 or 20°C)

Heat transfer model and microbial models used

• **growth** : logistic model with delay (Rosso et al, 1996), cardinal model with interactions (Augustin et al, 2005) modified in order to take into account inhibitor(s) (Zuliani et al, 2007)

• **inactivation** : linear model of Chick (1908), Bigelow's model (1921)

• **heat transfer** : Fourier's model (Bimbenet et al, 2002)

Experimental estimation of parameters

➢ **Growth model**

μ_{opt}: optimal growth rate, **K** : constant which is the product between lag (lag time) and μ_{max} (maximal growth rate) specific to the couple *L. monocytogenes* / food product, **cardinal values***: minimal, optimal, maximal values for pH, a_w and temperature, specific to *L. monocytogenes,* **MIC values** (minimal inhibitory concentration) specific to *L. monocytogenes*

➢ **Inactivation model**

D_{60}: decimal reduction time at 60°C, specific to the couple *L. monocytogenes* / food product, **z*** : increase in temperature required to reduce D_T **(decimal reduction time) to one tenth of its value**, specific to *L. monocytogenes*

➢ **Heat transfer model**

λ: heat diffusivity, specific to the food product

* Parameters from bibliography

Modelling strategy

Results

Single validation of models

Heat tranfer model : comparison between simulations and measures of temperature in the core of the meat parallelepiped
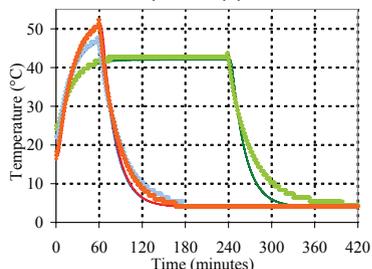
Measures: 1h/53°C; 1h/48°C; 4h/42°C
Simulations: 1h/53°C; 1h/48°C; 4h/42°C
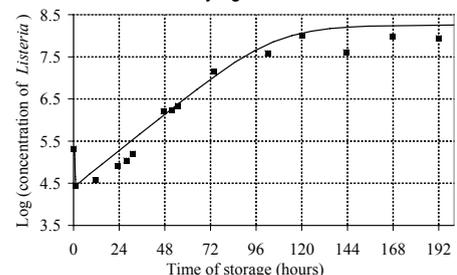Experimental conditions : heat process and storage at 4°C

Growth model : comparison between simulations and concentrations of *L. monocytogenes* measured in the meat
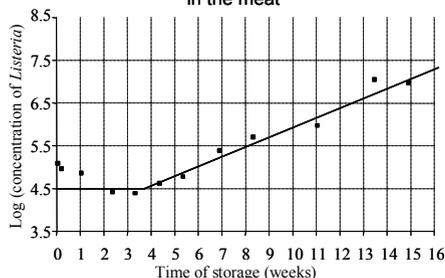
Enumerations: ■ Simulation : —
Experimental conditions: pH 5.9 – a_w 0.96 – storage at 4°C whitout heat process

Validation of the global modelling approach

Combined models (heat transfer – bacterial growth and inactivation) : comparison between simulations and concentrations of *L. monocytogenes* measured in the meat

Enumerations: ■ Simulation : —
Experimental conditions: pH 5.6 – a_w 0.95 – heat process 1h/53°C and storage at 20°C

Conclusion

A first conclusive step for the modelling of the process influence on the evolution of bacterial contamination

Strategy of combined modelling of heat transfer and predicitive microbial models, allowed to correctly predict the behaviour of *L. monocytogenes* in ground meat, according to heat process, formulation (pH, a_w, nature and concentration of inhibitors) and storage conditions.

References

Augustin, J.C., Zuliani V., Cornu M., Guiller, L. 2005. Journal of Applied Microbiology, 99, 1019-1042

Bigelow, W.D. 1921. Journal of Infectious Diseases, 29, 528

Bimbenet, J.J., Duquenoy, A., Tristram, G. 2002. Génie des procédés alimentaires, Dunod, Paris, France, 303p

Chick, H. 1908. Journal of Hygiene of Cambridge, 8, 92-158

Rosso, L., Bajard, S., Flandrois, J.P., Lahellec, C., Fournaud, J., Veit, P. 1996. Journal of Food Protection, 59, 944-949.

Zuliani V., Lebert I., Augustin J.C., Garry P., Vendeuvre J.L., Lebert A. 2006. Journal of Applied Microbiology, 103, 536-550