Risk-Benefit based probabilistic assessment software for heat processed foods

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Context

The preservation of food quality during food processing is a key condition for food industries to remain competitive and respond to consumer demand. For that purpose, food industry must mediate among two objectives: preserve the nutritional benefits and ensure a high level of microbiological risk control.

The aim of this study is to develop a user friendly probabilistic tool able to assess quantitatively the risk and benefit of heat processed foods

Methods

The industrial risk considered in this study was that of the thermophilic bacterium ***Geobacillus stearothermophilus***, recognized as a major source of spoilage in canned foods. *G. stearothermophilus* heat resistance parameters (Dref, ZT and ZpH), used in this study, were estimated using hierarchical Bayesian modeling. Furthermore, nutritional benefit was that of **vitamine C**. The two bioactive forms of vitamin C were taken into account: DeHydroascorbic Acid (DHA) and Ascorbic Acid (AA). For both cases, activation Energy (Ea) and reaction rate (K) were considered. Monte Carlo based simulations were used in order to set up the destruction of *G. stearothermophilus* and both AA and DHA of vitamin C.

Bacterial reduction

The decision making tool developed in this study allows to **quantify the risk due to *G. stearothermophilus*** and displays the **distribution** based Monte-Carlo simulation of the **decimal reduction number** of the considered bacteria. The distribution is given with a target level user-defined (see figure 1).

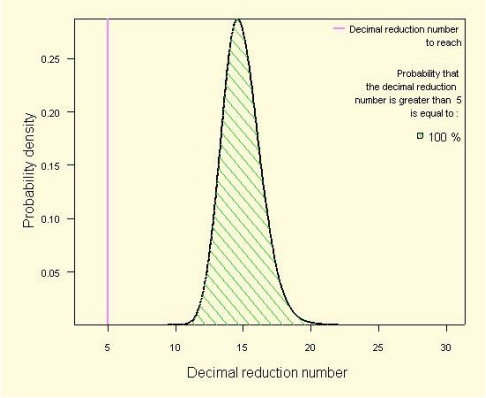

Figure 1 : G. stearothermophilus decimal reduction number distribution at the end of the heat treatment

Nutritional benefit

At the same time, the tool displays the distribution based Monte-Carlo simulation of the vitamin C concentration (mg/100g) at the end of heat treatment (figure 2).

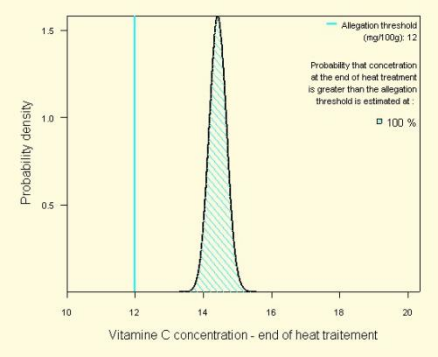

Figure 2 : Distribution of Vitamin C concentration at the end of the heat treatment

This distribution is given also with a user-specified allegation threshold for vitamin C. The probability to reach the allegation threshold is also given. Color codes are used to help users to decide on the risk-benefit compromise associated to a given heat processed food.

Conclusions & perspectives

A user friendly risk-benefit based probabilistic assessment tool for heat processed foods was developed in this study. This statistical tool could have a significant industrial impact to better assess temperature profiles applied during heat processing, because not only a microbiological risk is put forth but also the nutritional benefit. This tool will be integrated to the heat inactivation module of Sym'Previus.

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Industrial concerns and needs: Predict mold spoilage

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Context

Predictive modelling and microbial risk assessment have emerged as a comprehensive and systematic approach for addressing the risk of microbial spoilers in specific foods and processes. In the case of molds, a product is spoiled as soon as mycelium becomes visible, which usually occurs very shortly after lag time.

The study aims at 1) **building an operational tool to predict the appearance of moulds** 2) **defining boundaries for growth** and 3) **defining mycotoxin production** in order to **optimize product formulation and shelf-life.**

Methods

Step 1 : Mold strains, *i.e. Aspergillus candidus*[2], *Penicillium chrysogenum*[2], *Wallemia sebi*[2], *Cladosporium cladosporoides*[2], *Alternaria alternata*[3], were characterized on broth and agar-based media to evaluate growth ability.

Step 2 : Mold growth on bakery was evaluated by challenge-tests performed on 52 bakery and pastry product formulations with a_w ranging from 0.75 to 0.91 and storage incubation (15-25°C).

Step 3 : Based on experimental data and mathematical models, an operational tool was developed to further predict mold growth for a wide range of temperature and a_w.

Step 4 : For *Alternaria* on tomato puree, production of mycotoxins was estimated in the same conditions than growth ability.

[2] : work on pastry products, [3] work on tomato puree

A model to predict mold appearance time

Rather than growth rate, time to obtain visible mycelium was determined using both growth cardinal values (step1) and parameters determined by challenge-tests (step2) :

$$1/t_{v\ max} = 1/t_{v\ opt}.\rho(T).\delta(a_w)$$

Prediction showed satisfactory results as compared to experimental data, *i.e.* time to observe visible mycelium (1 mm).

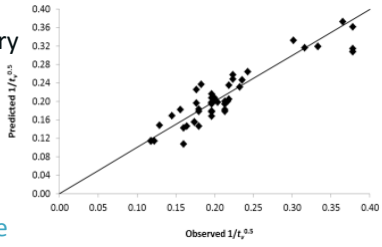

Figure 1 : model performance

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A tool to predict fungal spoilage on food

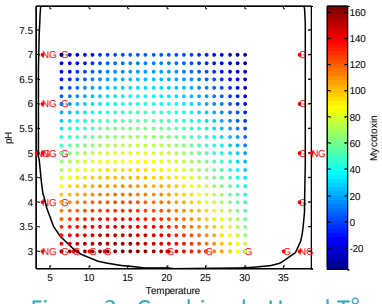
Developed approach was further included in a tool to predict appearance time of moulds as a function of aw and storage conditions : T°, film permeability, humidity (step 3).

This tool connect formulation (ingredients list) and storage conditions to the appearance time of molds

Figure 2 : operational tool to determine mold appearance time and impact of a change in food formulation

Conditions yielding mycotoxin production

The impact of environmental factors (pH, temperature and a_w) was determined on growth ability and mycotoxin production on tomato puree (step 4).



Note a large difference between environmental factors yielding to maximal *Alternaria* growth (20-30°C, pH6) and maximal mycotoxin production (10-12°C, pH3) in tested conditions

Figure 3 : Combined pH and T° conditions yielding mycotoxin production by *Alternaria* strain on tomato-based medium

Conclusions & perspectives

The proposed fungal risk assessment tool was successfully validated on a wide range of pastries taking into account the time to obtain visible mycelium which is an innovative and industrial relevant parameter.

This approach could further be used to 1) determine food product shelf-life 2) estimate the critical a_w value 3) minimize labor time and cost 4) estimate fungal risk

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