Meta-analysis of the microbial inactivation under non-thermal high pressure processing of fruit and vegetable juices and purees

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INTRODUCTION

High pressure processing (HPP) is a non-thermal preservation technology alternative to thermal pasteurisation for juices and purees, with an increasing market trend thanks to its minimal effect on nutritional and organoleptic characteristics.

OBJECTIVE

To **collect** and **meta-analyse** available data **on HPP inactivation** of ***Listeria*** **spp.**, ***Salmonella*** **spp.** and ***Escherichia coli*** in processed **fruit** and **vegetable** products.

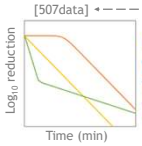
METHODOLOGY

Data collection

Literature Search and Screening → 55 selected articles → Data extraction → Product, pH, pressure, time Log_{10} reduction [1633 data]

Primary model fitting

[507data]



Log-linear
Log-linear with shoulder
Biphasic

Performance criteria: 5 Log_{10} reduction of the relevant pathogens

FDA HACCP Rules for fruit juices (21 CFR Part 120)

D_P (85 values) $D5_P$ (85 values)

Principal Components Analysis (PCA)

To identify **factors** explaining data variability

To spot **products** with different behaviour

Meta-analysis

Mixed models

Factors:

Fixed effects
- Pressure
- pH category*
- Microorganism

Random effects
- Strain (nested to microorganism)
- Study

*pH categories: Low-acid (pH>4.5); Acid (4≤pH≤4.5); High-Acid (pH<4)

Global fitting to Log D_p and Log $D5_p$

Bigelow type model

$$Log\ D = Log\ D_{ref} + \frac{(P_{ref}^{400\ MPa} - P)}{z_P}$$

$Log\ D_{ref}$: Depending on: *pH category and/or microorganism*

z_P: Depending on: *microorganism*

Model validation [1126 data]

Predicted Log_{10} reduction [$Log\ D_p$ model] — % ? — Observed Log_{10} reduction [not used for model development]

± 1 Log_{10} Acceptable Prediction Zone

Model application

*Which are the **HPP requirements** (pressure and time) to comply with the target performance criterion ?*

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CONCLUSIONS

The proposed global ***Log D_p*** and ***Log D5*** **models** are **conservative tools** useful for **risk assessment**, **benchmarking** and **setting HPP conditions** to ensure 5 Log_{10} reduction of vegetative bacterial pathogens in fruit and vegetables

RESULTS AND DISCUSSION

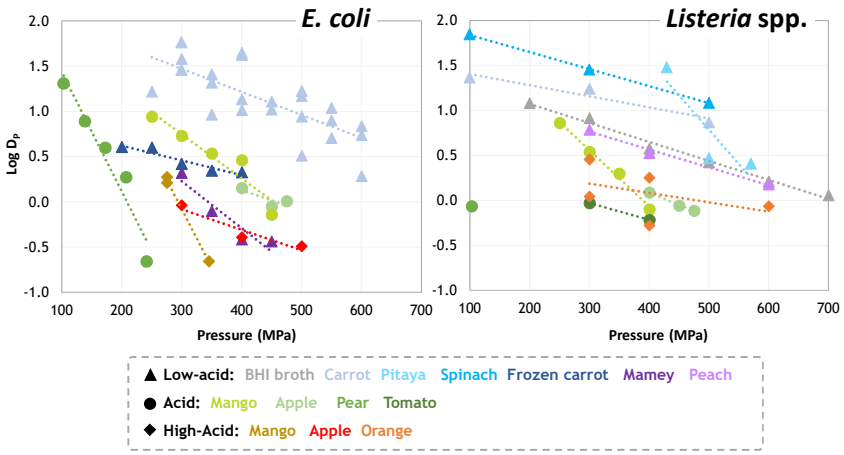


Figure 1: Estimated Log D_P for E. coli *and* Listeria *spp. as a function of pressure with their corresponding linear regression line*

PCA **91-93%** of the data **variability** explained by **Pressure** and **pH category**

Global fitting

$Log\ D_{ref}$ depended on **pH category**

z_P common for **pH categories** and **microorganisms**

Mixed models

Statistical significant factors: pressure, pH category and microorganism

Food products with non-consistent data: frozen carrots, mamey and pear

Little amount of *Dp* data for *Salmonella* spp.: not used for global fitting

Model predictive performance

Table 1: Comparison between model predictions (Log D_p model) and observed values (not used for model fitting) regarding high pressure inactivation (Log_{10} reduction) of Listeria *spp.,* E. coli*, and* Salmonella *spp.*

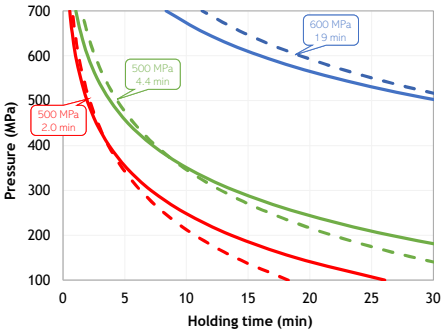
Microorganism	n[(a)]	Fail dangerous[(b)]	Within ASZ[(c)]	Fail safe[(d)]	ASZ + fail safe
***Listeria* spp.**	303	14 %	30 %	56 %	**86 %**
E. coli	472	20 %	21 %	59 %	**80 %**
***Salmonella* spp.**	351	6 %	21 %	74 %	**94 %**

[(a)]: Number of experimentally observed Log_{10} reduction data (collected from literature) used to validate the model
[(b)]: Log_{10} reduction provided by the *LogD* model (simulation) being at least 1 Log_{10} higher than the observed value.
[(c)]: ASZ=Acceptable Simulation Zone; Log_{10} reduction provided by model being within ± 1 Log_{10} unit range compared with the observed value.
[(d)]: Log_{10} reduction provided by the *LogD* model (simulation) being at least 1 Log_{10} lower than the observed value.

Model application

Figure 2: Isoreduction plots for pressure and holding time combinations providing 5 Log_{10} reduction as predicted by the developed predictive models for Log D (dashed lines) and Log $D5_P$ (solid lines).

Low-acid (pH>4.5)
Acid (4≤pH≤4.5)
High-Acid (pH<4)



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