Meta-regression models describing the effects of added lactic acid bacteria on pathogen inactivation in milk and cheese

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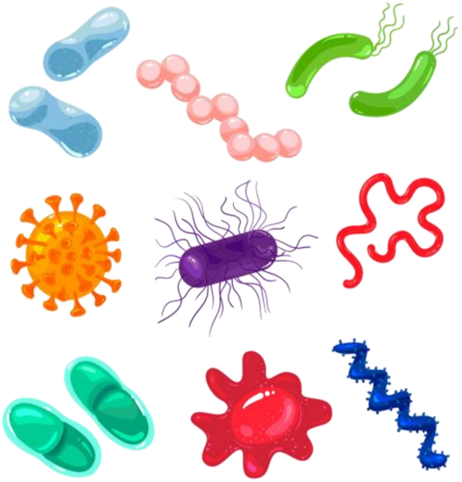
MOTIVATION

- Various **biopreservatives** have been proposed as **hurdles** to increase microbiological safety of food products

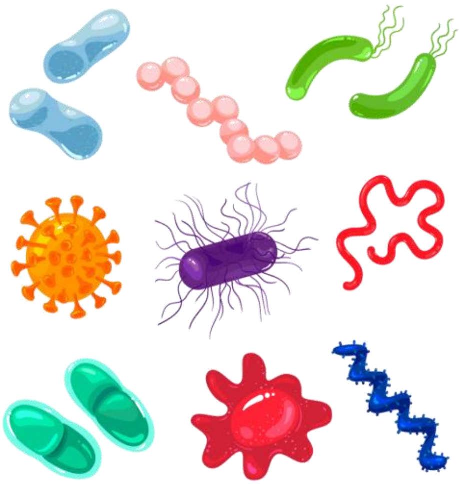
Lactic acid bacteria (LAB)

- *B. cereus, C. perfringens, L. monocytogenes, L. innocua, S. aureus,* and *E. coli* can be found in milk and dairy products, such as fermented milk and cheese



MOTIVATION

- Available literature describing the effect of this biopreservation method against several bacteria
- **Meta-regression models** can be used to understand pathogen growth, allowing optimisation of hurdles that provide long term stability and safety to milk and cheeses



OBJECTIVES

To collect available literature on pathogen inactivation in milk and cheese containing added LAB

- *B. cereus*
- *L. monocytogenes* and *L. innocua*
- *E. coli*
- *C. perfringens*
- *S. aureus*

To harmonise the retrieved data by constructing two separate meta-regression models that summarise LAB effectiveness

METHODOLOGY

Systematic literature search

Modelling in R Studio

(*nlme* package)

Mixed-effects linear models with weights

(i) Milk

Pathogens: *B. cereus, L. monocytogenes, S. aureus*

Tested variables:

- Antimicrobial concentration (C)
- √Exposure time (√t)

$$\sqrt{R_{ik}} = \beta_{0i} + \beta_1 C + (\beta_2 + \beta_{3k}) \times \sqrt{t} + \varepsilon_{ik}$$

(ii) Cheese

Pathogens: *B. cereus, C. perfringens, L. innocua, E. coli*

Tested variables:

- Application type (App)
- Inoculum concentration (Inoc)
- √Exposure time (√t)

$$\sqrt{R_{ikm}} = \beta_{0i} + \beta_{1m} App_m + \beta_2 Inoc + (\beta_3 + \beta_{4k}) \times \sqrt{t} + \varepsilon_{ikm}$$

Response variable: √ Log Reduction (log CFU/ml or /g)

RESULTS

Retrieved:

20 studies

=

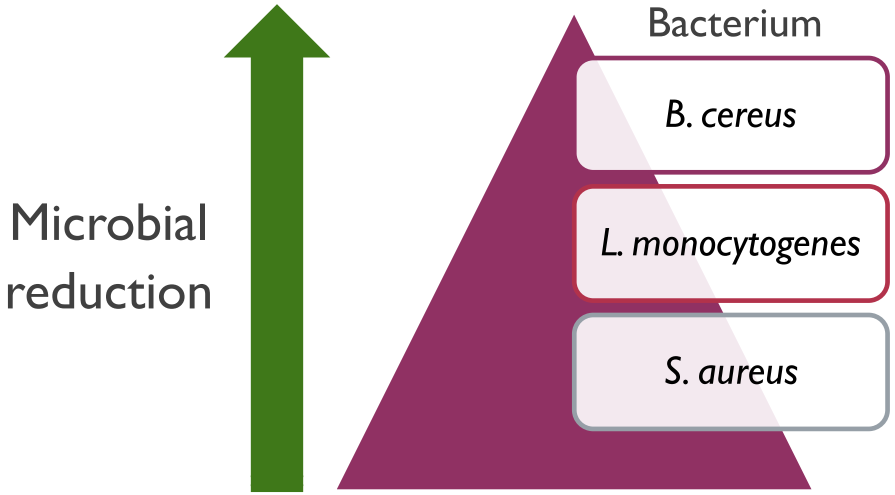
426 observations on log reduction data

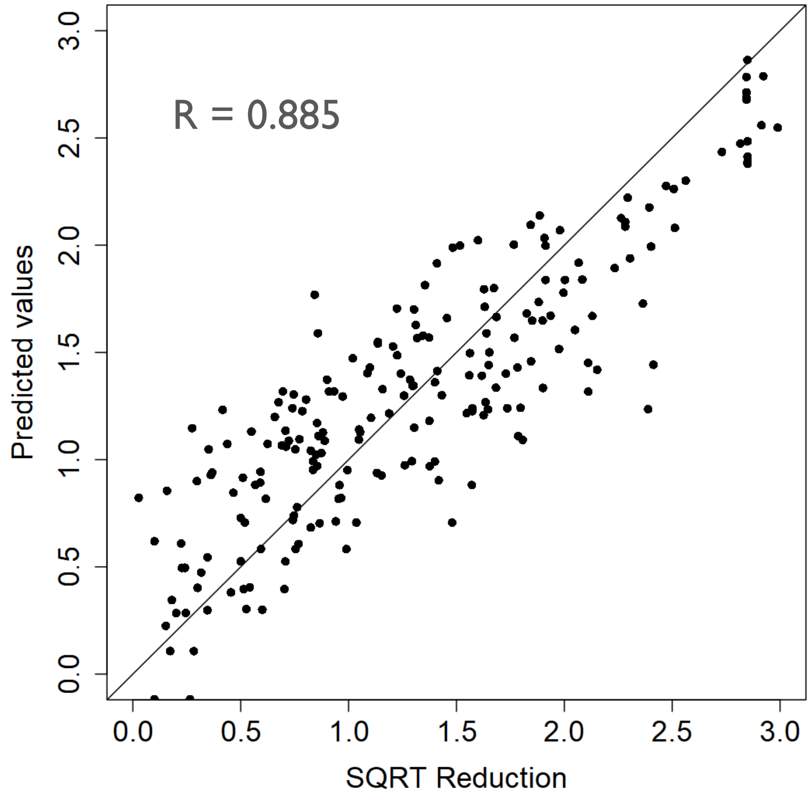
	Log reduction data	
	Milk	Cheese
Bacterium	*B. cereus*: 48 *L. monocytogenes*: 120 *S. aureus*: 48	*B. cereus*: 58 *C. perfringens*: 39 *L. innocua*: 25 *E. coli*: 88
Application type	Milk: 216	Milk: 34 Surface: 78 Mixture: 98
Inoculum level (log CFU/ml or /g)	---	[2, 4[: 96 [4, 6]: 114
Antimicrobial conc. (log CFU/ml)	[2.5, 5[: 3 [5, 7.5[: 192 [7.5, 9.6]: 21	---
Exposure time (days)	[0, 3[: 174 [3,6[: 32 [6, 10]: 10	[0, 20[: 106 [20, 40[: 56 [40, 60]: 48

RESULTS

(i) **Milk** meta-regression model

- Significant impact on pathogen inactivation:
  - ✓ Antimicrobial concentration (p=0.001)
  - ✓ √Exposure time (p<.0001)
  - ✓ √Exposure time * Bacterium (p<.0001)

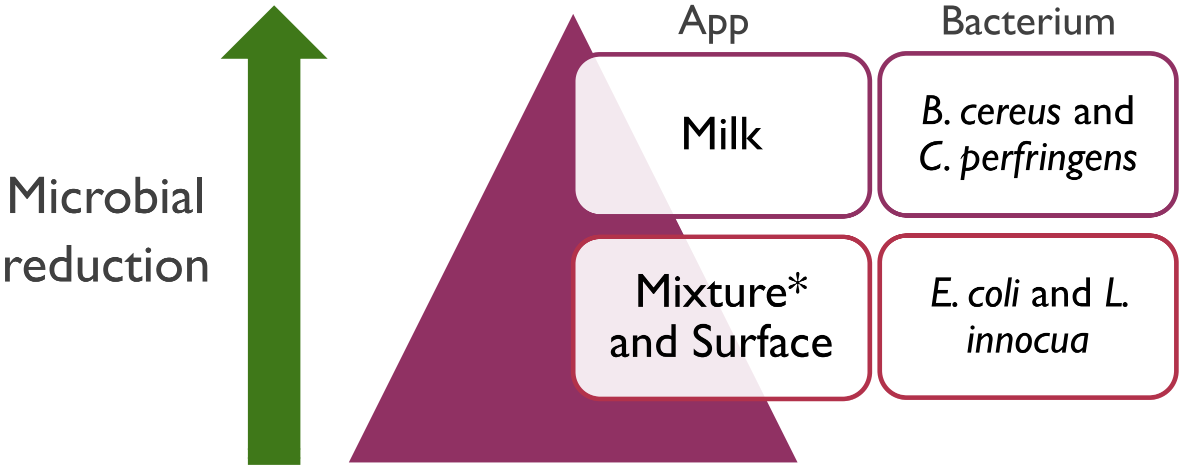


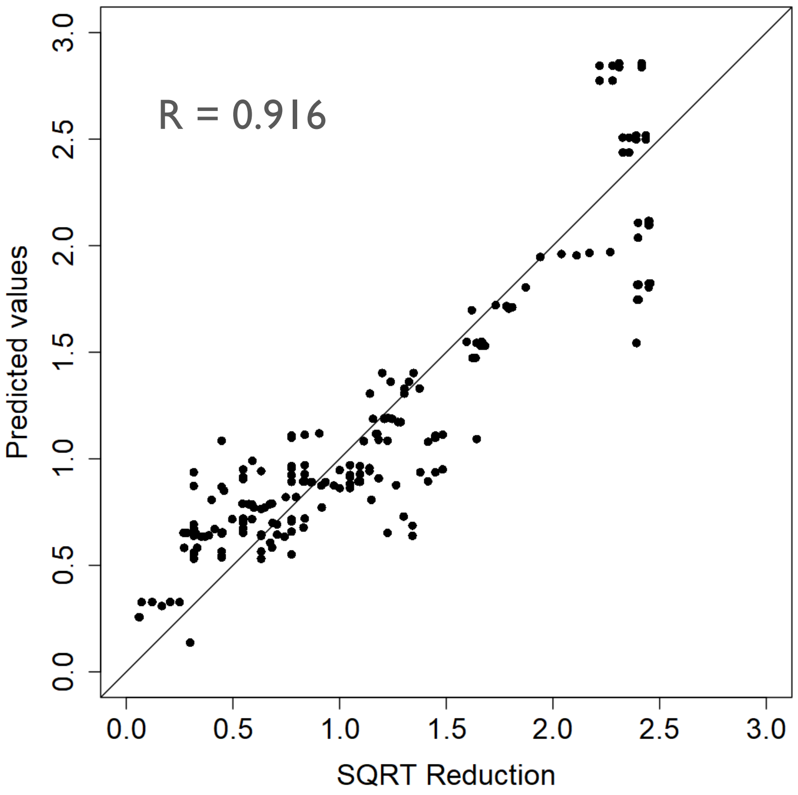


RESULTS

(ii) **Cheese** meta-regression model

- Significant impact on pathogen inactivation:
  - ✓ √Exposure time (p<.0001)
  - ✓ Application type (p<.0001)
  - ✓√Exposure time * Bacterium (p<.0001)
  - ✓ Inoculum concentration (p<.0001)





CONCLUSIONS

- Antimicrobials' effectiveness depends on exposure time, application type, antimicrobial concentration…
- Insight on the interaction between exposure time and bacterium
  - distinct inhibitory effect on different pathogens, for the same exposure time
- LAB incorporation in cheese mixture is not an adequate practice, as this method may underestimate the inhibitory effects LAB
- Other sources of variability: type of milk (raw vs. pasteurised), fermentation/ripening temperatures, application of selected single LAB strains vs. the use of LAB-cocktails, etc.
- LAB against Gram(+) and Gram(-) bacteria: further research needed

CONCLUSIONS

Meta-regression modelling can be used for the

experimental design of challenge tests and

to optimise manufacturing processes and the use of hurdles!

→ **ensure microbial safety of cheeses** ←

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ArtiSane Food

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Thank you for your attention!

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