Effect of lemon balm and spearmint extracts on the survival of *S. aureus* in goat's raw milk cheese

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Motivation

S. aureus prevalence in goat raw milk: 35.2% (95% CI: 23.2–49.3%)[1]

S. aureus prevalence in goat milk cheeses: 16.0% (95% CI: 7.92–29.8%)[1]

Spearmint and lemon balm hydroethanolic extracts present antimicrobial capacity against *S. aureus*[2]

Objectives

- Evaluate the antimicrobial effect of spearmint and lemon balm extracts against *S. aureus* in goat's raw milk cheeses during maturation
- Characterise the survival kinetic parameters of *S. aureus* by means of an extended Bigelow model

Methodology

Lyophilised lemon balm and spearmint extracts were obtained using ethanol 70% (*v/v*) as solvent in a shaking water bath (150 rpm, 60 °C, 90 minutes).

Milk was inoculated with *S. aureus* to reach ~5 log CFU/g in the cheese, and 1% (*w/w*) of each extract was added to the cheese curd during the manufacturing process.

Cheeses were kept in a chamber at 10 °C and 98% RH for 15 days. *S. aureus* counts and pH were determined at specific days.

For every treatment, a log-decay function with tail in differential form as primary model (with varying D-value; Equation 1), coupled to a secondary model Bigelow equation of D-value as a function of pH (Equation 2) was adjusted:

$$\frac{dN}{dt} = -kN\left(\frac{1}{1+C_c}\right)\left(1-\frac{N_{res}}{N}\right) \quad (1)$$

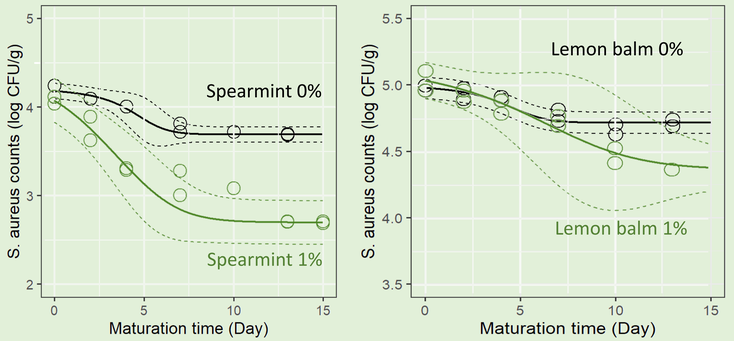
$$\log D = \log D_{ref} - \left(\frac{pH - pH_{ref}}{z_{pH}}\right)^2 \quad (2)$$

Equation 1
N: population density
k: inactivation rate = $\frac{\ln(10)}{D}$
C_c: physiological state of the cells
N_{res}: residual population density

Equation 2
D: decimal reduction time at 10 °C and at the pH of the cheese
pH_{ref}: reference pH (set to 7.0)
D_{ref}: decimal reduction time at pH_{ref}
z_{pH}: distance of pH from pH_{ref} which leads to a ten-fold change in D

Results

Treatment	Bigelow parameters	Mean (SE)	Pr (>|t|)	Goodness-of-fit measures
Spearmint 0%	z_{pH}	1.727 (0.392)	0.001	S^2=0.0017
$C_c(0)$=1.5	log D_{ref}	0.932 (0.166)	<.0001	RMSE=0.0403 MAE=0.0357
Spearmint 1%	z_{pH}	3.172 (0.660)	<.0001	S^2=0.0147
$C_c(0)$=0.1	log D_{ref}	0.621 (0.061)	<.0001	RMSE=0.1172 MAE=0.0978
Lemon balm 0%	z_{pH}	1.851 (0.007)	<.0001	S^2=0.0015
$C_c(0)$=1.5	log D_{ref}	0.996 (0.056)	<.0001	RMSE=0.0374 MAE=0.0330
Lemon balm 1%	z_{pH}	2.339 (0.835)	0.019	S^2=0.0042
$C_c(0)$=0.1	log D_{ref}	1.189 (0.200)	<.0001	RMSE=0.0633 MAE=0.0556



- The addition of plant extracts significantly decreased the time to achieve one log reduction
- pH drop during maturation was affected by the presence of extracts, as supported by the higher z_{pH} values
- In practical terms, the addition of plant extracts led to up to 1.36 log CFU/g reduction by the end of maturation

Conclusions

- Lemon balm and spearmint extracts can be used to control *S. aureus* in raw milk cheeses during maturation
- The dynamic model characterises *S. aureus* survival parameters in goat's raw milk cheese

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