

# 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%)<sup>1</sup>



*S. aureus* prevalence in goat milk cheeses: 16.0% (95% CI: 7.92–29.8%)<sup>1</sup>



Spearmint and lemon balm hydroethanolic extracts present antimicrobial capacity against *S. aureus*<sup>2</sup>

## 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<sub>c</sub>*: physiological state of the cells

*N<sub>res</sub>*: residual population density

**Equation 2**

*D*: decimal reduction time at 10 °C and at the pH of the cheese

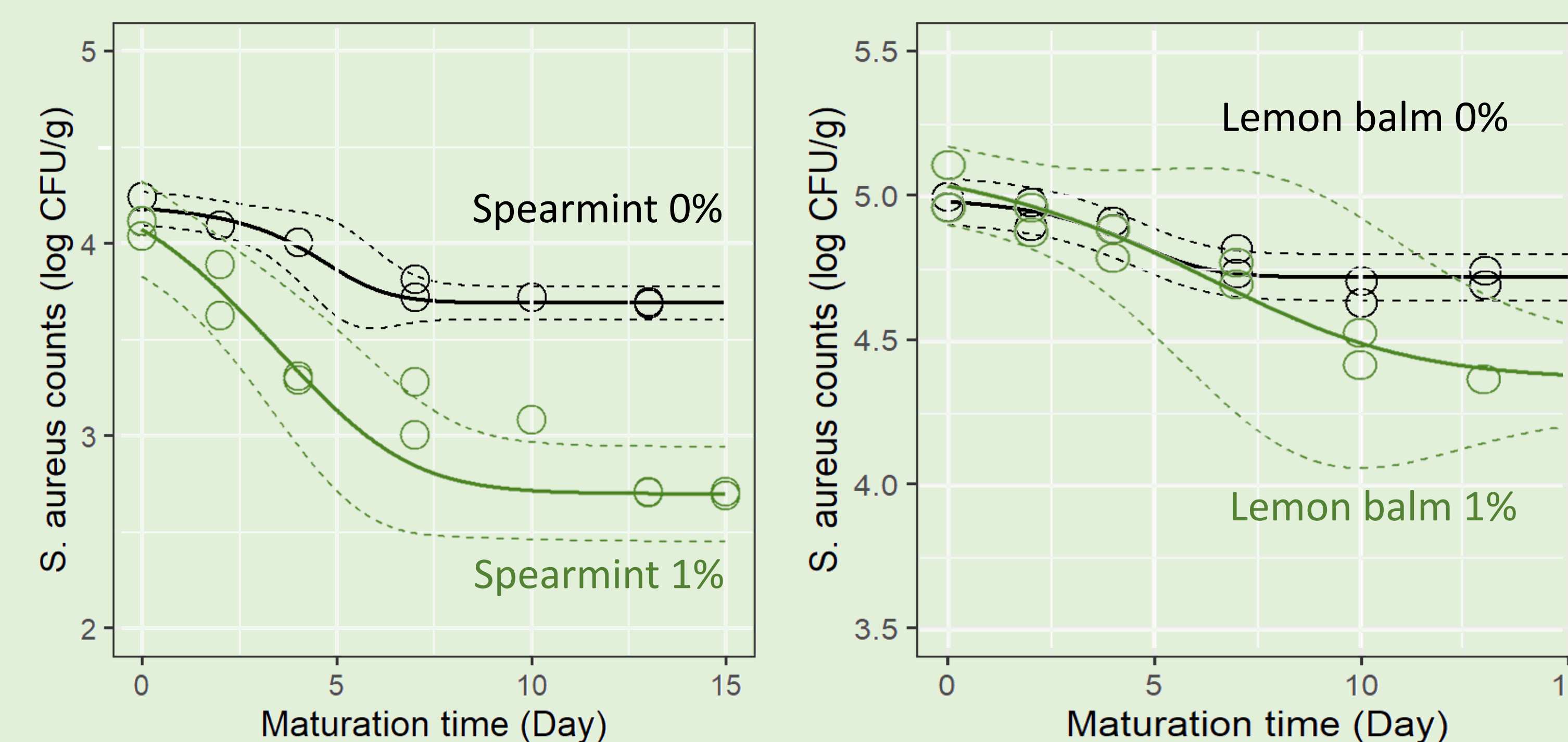
*pH<sub>ref</sub>*: reference pH (set to 7.0)

*D<sub>ref</sub>*: decimal reduction time at *pH<sub>ref</sub>*

*z<sub>pH</sub>*: distance of pH from *pH<sub>ref</sub>* which leads to a ten-fold change in *D*

## Results

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



- ★ 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<sub>pH</sub>* 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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## References

<sup>1</sup>Gonzales-Barron, U., Gonçalves-Tenório, A., Rodrigues, V., & Cadavez, V. Foodborne pathogens in raw milk and cheese of sheep and goat origin: a meta-analysis approach. *Curr Opin Food Sci* 2017, 18, 7-13. <sup>2</sup>Silva, B.N.; Cadavez, V.; Ferreira-Santos, P.; Alves, M.J.; Ferreira, I.C.F.R.; Barros, L.; Teixeira, J.A.; Gonzales-Barron, U. Chemical Profile and Bioactivities of Extracts from Edible Plants Readily Available in Portugal. *Foods* 2021, 10, 673.