



ORIGINAL ARTICLE

EVALUATION OF CHANGES IN MILK PRODUCTION AND QUALITY IN DAIRY COWS WITH MASTITIS DEPENDING ON ETIOLOGICAL AGENTS

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Ethical considerations: When reporting experiments on animals Observation of the ARRIVE guidelines 2.0: Updated guidelines for reporting animal research, published on July 14, 2020 (DOI: [10.1371/journal.pbio.3000410](https://doi.org/10.1371/journal.pbio.3000410)), is applied. The authors ensure that all procedures were performed in compliance with the guidelines for animal care of their institutions or with national/international guidelines.

ABSTRACT

Mastitis negatively impacts both milk production and milk quality. The aim of this study was to evaluate changes in milk production and composition in dairy cows with mastitis (n = 111) compared to controls (n = 111) and to assess the effect of a specific mastitis pathogen on selected milk quality indicators. The most common pathogen was *Streptococcus uberis*. Most mastitis cases were detected in summer (35%), in dairy cows in their fourth and higher lactations (52%), at 101–200 days of lactation (37%). A statistically significant difference ($p < 0.001$) was found between control and mastitis cows in milk yield (32.3 vs 28.4 kg), lactose content (5.01 vs 4.72%), somatic cell count (4.84 vs 5.96 log), and fat-to-lactose ratio (0.83 vs 0.91). The somatic cell count in mastitis caused by *Escherichia coli* (3,270,000/ml) was significantly higher than in mastitis caused by other pathogens ($p < 0.001$). The lactose content was also lowest in *Escherichia coli* mastitis compared to other mastitis cases (4.45%; $p < 0.001$). It was found that the influence of specific pathogens on selected milk parameters varies considerably. The results obtained may provide a basis for optimizing preventive and therapeutic strategies in dairy cattle breeding.

Keywords: dairy cow; mastitis; milk quality; milk yield; somatic cells

INTRODUCTION

Mastitis is a disease with many etiological causes related to the cattle production system and rearing environment. It manifests as various changes in mammary gland tissue [1, 2, 3], resulting from tissue inflammation and other defensive responses to the presence of microorganisms within the mammary gland [4]. Mastitis can be classified as subclinical or clinical. In both cases, there is a signifi-

cant reduction in milk production [5] and a decline in milk quality, resulting in substantial economic losses. These losses are estimated at approximately €134 to €198 per cow with mastitis per lactation [6, 7, 8, 9]. Common mastitis pathogens include *Staphylococcus aureus*, *Streptococcus agalactiae*, *Streptococcus dysgalactiae*, *Streptococcus uberis*, and *Escherichia coli* [10, 11, 12, 13, 14, 15].

The somatic cell count (SCC) is likely the most important indicator in the diagnosis of mastitis; from a hygiene

perspective, it is also a key parameter for determining milk quality [16]. These are blood cells (specifically white blood cells—leukocytes) and, to a lesser extent, mammary gland epithelial cells, which are released into the mammary alveoli during milk production [17]. Lactose content is another sensitive indicator of mammary gland integrity in mastitis. Lactose content decreases from physiological levels to 4.01–4.51%, a phenomenon the authors attribute to a disruption of the so-called tight junctions between alveolar epithelial cells, which allow lactose to pass back from milk into the bloodstream [18, 19]. Mastitis is also associated with a decrease in casein content and an increase in whey protein concentration, particularly immunoglobulins (especially IgG) and serum albumin [20, 21]. Elevated levels of these proteins are considered part of the mammary gland's defense response, as immunoglobulins neutralize pathogens and promote phagocytosis, while albumin serves as a transport protein [22, 23].

During mastitis, there is a significant increase in the concentration of sodium (up to 40%) and chloride in milk, accompanied by a parallel decrease in potassium [20, 21]. However, some studies point out that sensitivity to individual minerals may differ [24].

Numerous scientific studies have shown that the bacterial pathogen responsible for mastitis significantly affects milk composition. The aim of this study was to compare the quality characteristics of milk from healthy dairy cows and dairy cows with mastitis caused by various bacterial pathogens.

MATERIALS AND METHODS

Selection of experimental groups of dairy cows

The study was conducted on a dairy farm (1,850 head of cattle, including 800 dairy cows) located in the Vysočí-

na Region at an elevation of 566 meters above sea level. Milking takes place twice daily in a parallel milking parlor (2×16), and the milk is collected daily.

Data for evaluating the impact of mastitis on milk yield and milk quality parameters were collected from dairy cows with clinical mastitis over the course of one year. The cows met the following criteria: 1) purebred Czech Fleckvieh dairy cows, 2) only one pathogen was detected in the milk sample, specifically *Streptococcus uberis*, *Escherichia coli*, *Streptococcus dysgalactiae*, *Klebsiella pneumoniae*, 3) for each dairy cow meeting the above criteria, a “control” cow in the herd was also selected, matched for parity and stage of lactation, with a SCC of $\leq 135,000/\text{ml}$.

A total of 111 cows with mastitis and 111 control cows were included in the study (Table 1).

Mastitis pathogen determination

Milk samples were aseptically collected from infected quarters of cows with clinical mastitis (oedema, redness, pain, changes in milk secretion and appearance, positive NK test results). The samples were analyzed by inoculation into three-part chromogenic culture media (ClearMilk test; LabMedia Servis, s.r.o.; the Czech Republic), which are selective for streptococci, staphylococci, and Gram-negative bacteria. Cultivation conditions were 37 °C for 24–48 hours. A farm-specific atlas was used to identify pathogens; it was compiled based on milk sample cultivation results and subsequent PCR identification of mastitis pathogens performed by the Veterinary Research Institute Brno. For this study, the four most frequently identified pathogens were used.

Milk yield and quality indicators

Data on milk yield and milk quality parameters were evaluated based on the results of performance testing. Milk quality analyses were conducted at the ČMSCH,

Table 1. Characteristics of Czech Fleckvieh dairy cows selected for the study

Group of dairy cows	n	Parity	Days in milk		
		X	S_x	X	S_x
Control	111	3.7	2.0	143	90
Mastitis	111	3.7	2.0	142	87
of which:					
<i>Streptococcus uberis</i>	59	3.3	2.0	139	97
<i>Escherichia coli</i>	18	3.7	1.7	134	73
<i>Streptococcus dysgalactiae</i>	15	3.8	2.2	134	74
<i>Klebsiella pneumoniae</i>	19	4.7	2.2	164	82

a.s. laboratory in Brno-Tuřany. The following parameters were recorded: milk yield (kg), fat, protein, casein, lactose, non-fat solids (NFS), all in g/100 g, urea content (mg/100 ml), citric acid (%), acetone (mmol/l), β -hydroxybutyric acid (BHB) (mmol/l), SCC ($\times 10^3$ cells/ml) using a Combi-FossTM FT 60000 (Foss Electric, Denmark), comprising a MilkoScan 6000 analyzer and a FossomaticTM 5000 flow cytometer. In addition, the fat-to-protein (F/P), fat-to-lactose (F/L), and casein-to-protein (C/P) ratios were calculated. SCC were logarithmically adjusted.

Statistical analysis

Statistica 12.0 (StatSoft CR s.r.o.) was used to analyze the collected data. For the relevant datasets, the assumptions required for parametric methods (normal distribution of data and homogeneity of variances) were assessed.

A student's t-test was used to compare milk production and quality between control and mastitis dairy cows, and one-way analysis of variance was used to determine the effect of the bacterial cause of mastitis. Group comparisons were verified using Tukey's HSD test for unequal n at standard significance levels.

RESULTS AND DISCUSSION

The highest proportion of mastitis cases was diagnosed in the summer (35%), while the lowest proportion occurred in the winter (18%). The fact that 52% of mastitis cases occurred in the fourth lactation or later confirms the general trend of an increasing risk of this disease with age – these data are not included in the table. This phenomenon may be related to a decline in the immune function of the mammary gland and to a gradual teat sphincter damage during previous lactations. A higher incidence of mastitis with advancing age has also been reported in other studies [25, 26, 27]. The highest incidence of mastitis (37%) was recorded during the 101–200-day lactation stage, which corresponds to the period when milk production declines slightly after the peak of lactation yet remains at a high level. Moosavi et al. [28] reported that mastitis most commonly occurs in the postpartum period due to metabolic stress associated with the onset of lactation. Other studies also consider the postpartum period to be the time when the incidence of various diseases, including mastitis, is highest [29, 30]. Our study did not confirm this finding.

Table 2. Comparison of daily milk yield and milk quality parameters in the control group and in the mastitis group

Indicator	Groups				p
	Control (n = 111)		Mastitis (n = 111)		
	Mean	SD	Mean	SD	
Milk yield (kg)	32.3	6.8	28.4	7.6	<0.001
SCC (log)	4.84	0.12	5.96	0.46	<0.001
Fat (%)	4.13	0.53	4.26	0.62	0.0951
Protein (%)	3.50	0.33	3.66	0.48	0.0037
Casein (%)	2.81	0.32	2.89	0.45	0.1278
Lactose (%)	5.01	0.16	4.72	0.40	<0.001
NFS (%)	9.19	0.36	9.01	0.60	0.0052
Urea (mg/100 ml)	19.83	7.50	19.40	9.27	0.6992
Citric acid (%)	0.17	0.03	0.17	0.04	0.1559
Acetone (mmol/l)	0.09	0.13	0.09	0.19	0.8032
BHB (mmol/l)	0.07	0.18	0.08	0.19	0.5176
F/P	1.19	0.16	1.17	0.17	0.5746
F/L	0.83	0.12	0.91	0.18	<0.001
C/P (%)	80.03	2.74	78.66	3.95	0.0029

SCC – somatic cell count; BHB – β -hydroxybutyric acid; NFS – non-fat solids; F/P – fat/protein; F/L – fat/lactose; C/P – casein/protein; SD – standard deviation

Milk production and quality in cows with mastitis and in the control group

A comparison of production performance and milk quality parameters between cows with mastitis and control cows revealed statistically significant differences (Table 2). Mastitis-affected dairy cows had significantly lower milk yield ($p < 0.001$) compared to control animals, confirming that mastitis negatively impacts the herd's production capacity. At the same time, a significant change in milk quality was observed in mastitis-affected dairy cows, particularly a decrease in lactose and NFS.

In mastitis, protein content typically increases. The physiological basis for this is an increase in IgG and serum albumin levels, which enter the mammary gland from the bloodstream [20, 21]. Casein content remains unchanged or decreases. Alhussien et al. [31] found higher total protein (3.70%) and lower casein (2.25%) in milk from cows with clinical mastitis than in milk from healthy dairy cows

(3.30% and 2.70%, respectively). In our study, milk from cows with clinical mastitis had significantly higher protein content than control milk. In contrast, no significant difference in casein content was found between the two groups. It may be assumed that this is related to differences in the parameters used to define clinical mastitis. The authors included only dairy cows with an SCC above 500,000/ml in the clinical mastitis group, whereas our study also included dairy cows with somewhat lower SCC (the lowest SCC was 201,000/ml, as shown in Figure 1).

The changes observed may affect the technological processability of milk, including its curdling properties and stability during heat treatment [32].

Milk production and quality depending on etiological agents

The most frequently isolated pathogen was *Streptococcus uberis* (53%). To a lesser extent, *Klebsiella pneu-*

Table 3. Effect of the selected mastitis pathogens on daily milk yield and milk quality parameters in dairy cows with clinical mastitis

Indicator	Pathogens								p
	Streptococcus uberis n = 59		Escherichia coli n = 18		Streptococcus dysga- lactiae n = 15		Klebsiella pneumoniae n = 19		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Milk yield (kg)	29.4	6.9	29.5	7.5	27.5	7.9	25.2	8.9	0.1739
SCC (log)	5.71 ^a	0.31	6.35 ^b	0.43	6.22 ^b	0.42	6.14 ^b	0.46	<0.001
Fat (%)	4.30	0.58	4.50	0.77	4.10	0.40	4.05	0.70	0.1152
Protein (%)	3.59	0.40	3.87	0.64	3.66	0.48	3.68	0.51	0.1929
Casein (%)	2.85	0.39	3.00	0.64	2.86	0.42	2.91	0.42	0.6287
Lactose (%)	4.84 ^b	0.17	4.45 ^a	0.65	4.81 ^b	0.37	4.54 ^{ab}	0.46	0.0002
NFS (%)	9.07	0.42	8.91	0.98	9.13	0.49	8.80	0.65	0.2731
Urea (mg/100 ml)	19.83	10.85	17.72	6.35	19.10	8.21	19.86	7.13	0.8577
Citric acid (%)	0.17 ^b	0.04	0.14 ^a	0.03	0.18 ^{ab}	0.04	0.16 ^{ab}	0.03	0.0058
Acetone (mmol/l)	0.06	0.05	0.17	0.33	0.18	0.33	0.08	0.05	0.0561
BHB (mmol/l)	0.04	0.03	0.18	0.39	0.13	0.25	0.08	0.08	0.0779
F/P	1.20	0.17	1.17	0.17	1.14	0.17	1.11	0.17	0.1527
F/L	0.89 ^a	0.13	1.04 ^b	0.30	0.86 ^a	0.10	0.90 ^{ab}	0.20	0.0077
C/P (%)	79.09	3.43	77.19	5.65	78.15	3.09	79.12	4.08	0.2974

SCC – somatic cell count; BHB – β -hydroxybutyric acid; NFS – non-fat solids; F/P – fat/protein; F/L – fat/lactose; C/P – casein/protein; ^{a, b} – means with different superscripts in rows differ at $p < 0.05$; SD – standard deviation

moniae (17%), *Escherichia coli* (16%), and *Streptococcus dysgalactiae* (14%) – Table 3. Poutrel et al. [33] also identified *Streptococcus uberis* as the most common pathogen, with a prevalence of 18–37%. A similar result was found by Davies et al. [34], where this pathogen was present in 38% of cases of clinical mastitis. In contrast, Cervinkova et al. [35] detected *Streptococcus uberis* in only 7.9% of cases. It can be assumed that this difference was due to their study including only dairy cows without clinical symptoms.

When evaluating the effect of selected mastitis pathogens on daily milk yield and milk quality, statistically significant differences were observed in SCC, lactose, citric acid, and F/L (Table 3).

Differences in milk yield were observed primarily in mastitis caused by *Streptococcus uberis* and *Klebsiella pneumoniae*; however, these differences were not statistically significant. Although more severe changes in milk production are generally observed with coliform mastitis compared to mastitis caused by environmental streptococci [36], the actual cause of the observed differences may not necessarily be related to the pathogen. Another possible explanation could be slightly higher variability, caused, for example, by individual differences among dairy cows or by the stage of lactation [37].

The results suggest that *Streptococcus uberis* constitutes a distinct group that differs significantly from the other three pathogens, among which no significant statistical differences were found.

As previously mentioned, the most significant indicator of mastitis is the SCC. An interesting finding was that *Streptococcus uberis* had a very low average SCC (719,000/ml) compared to other pathogens – Figure 1. Such a low value is typically reported for subclinical mastitis; however, our study included only dairy cows with clinical mastitis. A similar SCC value for mastitis caused by *Streptococcus uberis* was reported by de Haas et al. [38], although they attribute this value specifically to subclinical cases. This finding may provide a new diagnostic approach for the clinical management of mastitis of this etiology.

The highest SCC value (3,270,000/ml) was recorded in milk samples from which *Escherichia coli* was isolated. This result is characteristic of acute mastitis caused by Gram-negative bacteria. The differences between the *Escherichia coli* group and other pathogens were statistically highly significant ($p < 0.001$), confirming unique ability of this pathogen to induce a strong immune response. Hogan and Smith [39] report that SCC above 1,000,000/ml is typical of coliform mastitis. A study by Burvenich et

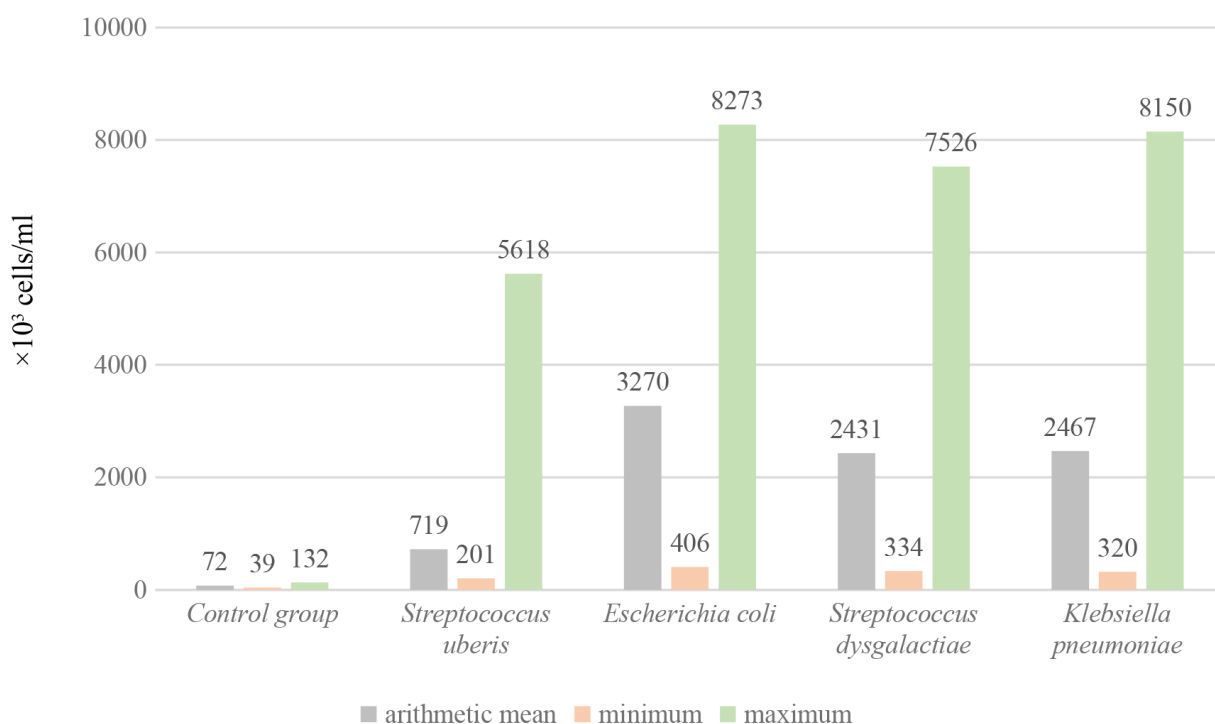


Fig. 1. Somatic cell counts in milk from healthy dairy cows and in milk from dairy cows with mastitis caused by selected pathogens

al. [40] shows that even a low dose of *Escherichia coli* (50 colony-forming units) can cause a dramatic increase in SCC and clinical signs within a few hours. Similarly, Fredebeul-Krein et al. [41] confirm that *Escherichia coli* infections are associated not only with high SCC values but also with severe systemic symptoms, such as elevated body temperature, decreased milk yield, and changes in milk consistency. Compared with Gram-positive pathogens, *Escherichia coli* has a significantly greater ability to trigger an inflammatory response.

The literature indicates that the extent of lactose decline varies depending on the bacterial pathogen. These differences are attributed to differences in the virulence of the pathogens and their effects on the inflammatory response of the mammary gland [42, 43, 44]. In our study, the lowest lactose content was found in milk with mastitis caused by *Escherichia coli* (4.45 g/100 g). Blum et al. [45] reported a decrease in lactose content in *Escherichia coli*-induced mastitis to as low as 3.5–4.0%. The study also notes that this decrease may persist even after mastitis has been cured, due to long-term damage to the mammary gland. Antanaitis et al. [44] state that, given the relatively constant lactose level in healthy dairy cows, a reduction in lactose can be considered a suitable biomarker for mastitis.

The F/L ratios ranged from 0.86 to 1.04. Since this ratio is not a standard indicator in the scientific literature, the value obtained in this study for the control dairy cows (0.83) was used as a physiological reference for discussion. It has been reported that this ratio increases particularly in cases of mastitis caused by *Escherichia coli*, as this bacterium metabolizes lactose as an energy source for its rapid growth in the mammary gland [46]. Paudyal et al. [47] reported values of 1.27–1.37 in dairy cows with mastitis. This higher value compared to our study can be explained by the fact that the authors only included dairy cows up to 60 days of lactation.

The average acetone levels in milk ranged from 0.06 mmol/l (*Streptococcus uberis*) to 0.18 mmol/l (*Streptococcus dysgalactiae*). For BHB, the lowest values were again recorded for *Streptococcus uberis* (0.04 mmol/l) and the highest for *Escherichia coli* (0.18 mmol/l). These findings suggest that specific bacterial pathogens may have distinct effects on milk components, reflecting metabolism in both the mammary gland and the entire body [48]. In milk samples containing Gram-negative bacteria (*Escherichia coli* and *Klebsiella pneumoniae*), higher concentrations of ke-

tone bodies were detected compared to those containing Gram-positive pathogens (*Streptococcus uberis* and *Streptococcus dysgalactiae*). This trend may be associated with the lipopolysaccharides in the cell walls of Gram-negative bacteria, which have an exceptional ability to induce an inflammatory response. Lipopolysaccharides activate the production of pro-inflammatory cytokines, which can affect lipid metabolism in the mammary gland and lead to increased β -oxidation of fatty acids. This fact was described by Du et al. [49], who demonstrated that the inflammatory response induced by the lipopolysaccharides of these pathogens leads to significant metabolic changes in the mammary gland.

Although the study yielded interesting findings, it should be noted that it was conducted on a single commercial dairy farm, which limits the generalizability of the results.

CONCLUSION

An interesting finding from this study is that the traditionally used parameter, somatic cell count, may not always be a sufficiently sensitive indicator of mammary gland health, particularly in mastitis caused by *Streptococcus uberis*. In these infections, monitoring the fat-to-lactose ratio appears to be more appropriate, as it may better reflect changes in milk composition induced by this pathogen. Based on the results obtained, it is recommended that mammary gland health monitoring not be limited to somatic cell count alone but that other indicators, such as lactose and citric acid, be implemented into routine practice. Also, the F/L ratio may serve as a promising complementary indicator warranting further validation. A comprehensive approach to evaluating milk composition can thus contribute to more accurate diagnosis of mastitis and more effective milk quality management in dairy herds.

Ethical Issues

Not applicable.

Data Availability

Data will be made available on request.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Authors' Contributions

Tereza Janů: writing – original draft, resources, conceptualization, writing – review & editing. **David Bílý:** methodology, investigation, writing – original draft. **Eva Samková:** methodology, investigation, conceptualization, writing – original draft, data curation. **Eva Baldíková:** writing – review & editing, resources. **Ilyasu Mohammed Sulaimam:** writing – review & editing, resources. **Lucie Hasoňová:** writing – original draft, writing – review & editing, methodology, investigation, conceptualization, funding acquisition, supervision.

Generative AI Statement

No generative artificial intelligence was used in writing the manuscript.

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REFERENCES

1. Hagnestam, C., Emanuelson, U., Berglund, B., 2007: Yield losses associated with clinical mastitis occurring in different weeks of lactation. *J. Dairy Sci.*, 90, 5, 2260–2270. DOI: [10.3168/jds.2006-583](https://doi.org/10.3168/jds.2006-583)
2. Hussain, R., Javed, M. T., Khan, A., 2012: Changes in some biochemical parameters and somatic cell counts in the milk of buffalo and cattle suffering from mastitis. *Pak. Vet. J.*, 32, 3, 418–421.
3. Lipkens, Z., Piepers, S., Visscher, A. D., Vliegheer, S. D., 2019: Evaluation of test-day milk somatic cell count information to predict intramammary infection with major pathogens in dairy cattle at drying off. *J. Dairy Sci.*, 102, 5, 4309–4321. DOI: [10.3168/jds.2018-15642](https://doi.org/10.3168/jds.2018-15642)
4. Bortolami, A., Fiore, E., Giancesella, M., Corrà, M., Catania, S., Morgante, M., 2015: Evaluation of the udder health status in subclinical mastitis affected dairy cows through bacteriological culture, somatic cell counts and thermographic imaging. *Pol. J. Vet. Sci.*, 18, 4, 799–805. DOI: [10.1515/pjvs-2015-0104](https://doi.org/10.1515/pjvs-2015-0104)
5. Gröhn, Y. T., Rajala-Schultz, P. J., Allore, H. G., DeLorenzo, M. A., Hertl, J. A., Galligan, D. T., 2003: Optimizing replacement of dairy cows: modeling the effects of diseases. *Prev. Vet. Med.*, 61, 1, 27–43. DOI: [10.1016/s0167-5877\(03\)00158-2](https://doi.org/10.1016/s0167-5877(03)00158-2)
6. Berry, E. A., Hogeveen, H., Hillerton, J. E., 2004: Decision tree analysis to evaluate dry cow strategies under UK conditions. *J. Dairy Res.*, 71, 4, 409–418. DOI: [10.1017/s0022029904000433](https://doi.org/10.1017/s0022029904000433)
7. Bar, D., Tauer, L. W., Bennett, G., González, R. N., Hertl, J. A., Schukken, Y. H., et al. 2008: The cost of generic clinical mastitis in dairy cows as estimated by using dynamic programming. *J. Dairy Sci.*, 91, 6, 2205–2214. DOI: [10.3168/jds.2007-0573](https://doi.org/10.3168/jds.2007-0573)
8. Cha, E., Bar, D., Hertl, J. A., Tauer, L. W., Bennett, G., González, R. N., et al., 2011: The cost and management of different types of clinical mastitis in dairy cows estimated by dynamic programming. *J. Dairy Sci.*, 94, 9, 4476–4487. DOI: [10.3168/jds.2010-4123](https://doi.org/10.3168/jds.2010-4123)
9. Dahl, M. O., Vries, A. D., Maunsell, F. P., Galvao, K. N., Risco, C. A., Hernandez, J. A., 2018: Epidemiologic and economic analyses of pregnancy loss attributable to mastitis in primiparous Holstein cows. *J. Dairy Sci.*, 101, 11, 10142–10150. DOI: [10.3168/jds.2018-14619](https://doi.org/10.3168/jds.2018-14619)
10. Lundberg, Å., Nyman, A., Unnerstad, H. E., Waller, K. P., 2014: Prevalence of bacterial genotypes and outcome of bovine clinical mastitis due to *Streptococcus dysgalactiae* and *Streptococcus uberis*. *Acta Vet. Scand.*, 56, 80, 1–11. DOI: [10.1186/s13028-014-0080-0](https://doi.org/10.1186/s13028-014-0080-0)
11. Ruegg, P. L., 2017: A 100-year review: mastitis detection, management, and prevention. *J. Dairy Sci.*, 100, 12, 10381–10397. DOI: [10.3168/jds.2017-13023](https://doi.org/10.3168/jds.2017-13023)
12. Tomazi, T., de Souza Filho, A. F., Heinemann, M. B., Santos, M.V.D., 2018: Molecular characterization and antimicrobial susceptibility pattern of *Streptococcus agalactiae*

- isolated from clinical mastitis in dairy cattle. *PLoS One*, 13, 6, e0199561. DOI: [10.1371/journal.pone.0199561](https://doi.org/10.1371/journal.pone.0199561)
13. Cheng, W. N., Han, S. G., 2020: Bovine mastitis: risk factors, therapeutic strategies, and alternative treatments – a review. *Asian-Australas. J. Anim. Sci.*, 33, 11, 1699–1713. DOI: [10.5713/ajas.20.0156](https://doi.org/10.5713/ajas.20.0156)
14. Fu, S., Wen, C., Wang, Z., Qiu, Y., Zhang, Y., Zuo, J. et al., 2022: Molecular epidemiology and antimicrobial resistance of outbreaks of *Klebsiella pneumoniae* clinical mastitis in Chinese dairy farms. *Microbiol. Spectr.*, 10, 6, e02997-22. DOI: [10.1128/spectrum.02997-22](https://doi.org/10.1128/spectrum.02997-22)
15. Goulart, D. B., Mellata, M., 2022: *Escherichia coli* mastitis in dairy cattle: etiology, diagnosis, and treatment challenges. *Front. Microbiol.*, 13, 928346. DOI: [10.3389/fmicb.2022.928346](https://doi.org/10.3389/fmicb.2022.928346)
16. Moradi, M., Omer, A. K., Razavi, R., Valipour, S., Guimarães, J. T., 2021: The relationship between milk somatic cell counts and cheese production, quality, and safety: a review. *Int. Dairy J.*, 113, 104884. DOI: [10.1016/j.idairyj.2020.104884](https://doi.org/10.1016/j.idairyj.2020.104884)
17. Bradley, A., Green, M., 2005: Use and interpretation of somatic cell count data in dairy cows. *In Pract.*, 27, 6, 310–315. DOI: [10.1136/inpract.27.6.310](https://doi.org/10.1136/inpract.27.6.310)
18. Muhee, A., Malik, H. U., Asharaf, I., Shah, O. S., Jan, A., Muheet, et al., 2017: Biochemical and mineral alterations of milk chemistry in mastitis. *Int. J. Curr. Microbiol. Appl. Sci.*, 6, 7, 4591–4594. DOI: [10.20546/ijcmas.2017.607.480](https://doi.org/10.20546/ijcmas.2017.607.480)
19. Chen, Y., Ma, Y., Ji, Q., Yang, X., Feng, X., Yao, R., et al., 2021: Intracellular *Staphylococcus aureus* infection decreases milk protein synthesis by preventing amino acid uptake in bovine mammary epithelial cells. *Front. Vet. Sci.*, 8, 756375. DOI: [10.3389/fvets.2021.756375](https://doi.org/10.3389/fvets.2021.756375)
20. Bansal, B. K., Hamann, J., Grabowski, N. T., Singh, K. B., 2005: Variation in the composition of selected milk fraction samples from healthy and mastitic quarters, and its significance for mastitis diagnosis. *J. Dairy Res.*, 72, 2, 144–152. DOI: [10.1017/s0022029905000798](https://doi.org/10.1017/s0022029905000798)
21. Eckersall, P. D., Young, F. J., Nolan, A. M., Knight, C. H., McComb, C., Waterston, M. M., et al., 2006: Acute phase proteins in bovine milk in an experimental model of *Staphylococcus aureus* subclinical mastitis. *J. Dairy Sci.*, 89, 5, 1488–1501. DOI: [10.3168/jds.S0022-0302\(06\)72216-0](https://doi.org/10.3168/jds.S0022-0302(06)72216-0)
22. Wellnitz, O., Arnold, E. T., Bruckmaier, R. M., 2011: Lipopolysaccharide and lipoteichoic acid induce different immune responses in the bovine mammary gland. *J. Dairy Sci.*, 94, 11, 5405–5412. DOI: [10.3168/jds.2010-3931](https://doi.org/10.3168/jds.2010-3931)
23. Rainard, P., Gilbert, F. B., Germon, P., 2022: Immune defenses of the mammary gland epithelium of dairy ruminants. *Front. Immunol.*, 13, 1031785. DOI: [10.3389/fimmu.2022.1031785](https://doi.org/10.3389/fimmu.2022.1031785)
24. Haron, A. W., Abdullah, F. F. J., Tijjani, A., Abba, Y., Adamu, L., Mohammed, K., et al., 2014: The use of Na⁺ and K⁺ ion concentrations as potential diagnostic indicators of subclinical mastitis in dairy cows. *Vet. World*, 7, 11, 966–969. DOI: [10.14202/VETWORLD.2014.966-969](https://doi.org/10.14202/VETWORLD.2014.966-969)
25. Sharma, N., Kang, T. Y., Lee, S., Kim, J. N., Hur, C. H., Ha, J. C., et al., 2013: Status of bovine mastitis and associated risk factors in subtropical Jeju Island, South Korea. *Trop. Anim. Health Prod.*, 45, 8, 1829–1832. DOI: [10.1007/s11250-013-0422-3](https://doi.org/10.1007/s11250-013-0422-3)
26. Zeryehun, T., Aya, T., Bayecha, R., 2013: Study on prevalence, bacterial pathogens, and associated risk factors of bovine mastitis in small holder dairy farms in and around Addis Ababa, Ethiopia. *J. Anim. Plant Sci.*, 23, 1, 50–55.
27. Nitz, J., Wente, N., Zhang, Y., Klocke, D., Seeth, M. T., Krömker, V., 2021: Dry period or early lactation—time of onset and associated risk factors for intramammary infections in dairy cows. *Pathogens*, 10, 2, 224. DOI: [10.3390/pathogens10020224](https://doi.org/10.3390/pathogens10020224)
28. Moosavi, M., Mirzaei, A., Ghavami, M., Tamadon, A., 2014: Relationship between season, lactation number and incidence of clinical mastitis in different stages of lactation in a Holstein dairy farm. *Vet. Res. Forum*, 5, 1, 13–19.
29. Abuelo, A., Hernández, J., Benedito, J. L., Castillo, C., 2019: Redox biology in transition periods of dairy cattle: Role in the health of periparturient and neonatal animals. *Antioxidants*, 8, 1, 20. DOI: [10.3390/antiox8010020](https://doi.org/10.3390/antiox8010020)
30. Sahar, M. W., Beaver, A., von Keyserlingk, M. A. G., Weary, D. M., 2020: Predicting disease in transition dairy cattle based on behaviors measured before calving. *Animals*, 10, 6, 928. DOI: [10.3390/ani10060928](https://doi.org/10.3390/ani10060928)
31. Alhussien, M., Manjari, P., Mohammed, S., Sheikh, A. A., Reddi, S., Dixit, S., Dang, A. K., 2016: Incidence of mastitis and activity of milk neutrophils in Tharparkar cows reared under semi-arid conditions. *Trop. Anim. Health Prod.*, 48, 1291–1295. DOI: [10.1007/s11250-016-1068-8](https://doi.org/10.1007/s11250-016-1068-8)
32. Zalewska, M., Brzozowska, P., Rzewuska, M., Kawecka-Grochocka, E., Urbańska, D. M., Sakowski, T., et al., 2025: The quality and technological parameters of milk obtained from dairy cows with subclinical mastitis. *J. Dairy Sci.*, 108, 2, 1285–1300. DOI: [10.3168/jds.2024-25346](https://doi.org/10.3168/jds.2024-25346)
33. Poutrel, B., Bareille, S., Lequeux, G., Leboeuf, F., 2018:

- Prevalence of mastitis pathogens in France: antimicrobial susceptibility of *Staphylococcus aureus*, *Streptococcus uberis* and *Escherichia coli*. *J. Vet. Sci. Technol.*, 9, 2, 000522. DOI: [10.4172/2157-7579.1000522](https://doi.org/10.4172/2157-7579.1000522)
34. Davies, P. L., Leigh, J. A., Bradley, A. J., Archer, S. C., Emes, R. D., Green, M. J., 2016: Molecular epidemiology of *Streptococcus uberis* clinical mastitis in dairy herds: strain heterogeneity and transmission. *J. Clin. Microbiol.*, 54, 1, 68–74. DOI: [10.1128/jcm.01583-15](https://doi.org/10.1128/jcm.01583-15)
 35. Cervinkova, D., Vlkova, H., Borodacova, I., Makovcova, J., Babak, V., Lorencova, A., et al., 2013: Prevalence of mastitis pathogens in milk from clinically healthy cows. *Vet. Med. (Czech)*, 58, 11, 567–575. DOI: [10.17221/7138-VETMED](https://doi.org/10.17221/7138-VETMED)
 36. Muñoz-Boettcher, P., Klaas, I. C., Lombard, J., Velez, J., Manríquez, D., Pinedo, P., 2026: Association between mastitis pathogen category and milking behavior and performance in Holstein cows in an automatic milking system. *J. Dairy Sci.*, 109, 5, 5578–5593. DOI: [10.3168/jds.2025-27786](https://doi.org/10.3168/jds.2025-27786)
 37. Heikkilä, A. M., Liski, E., Pyörälä, S., Taponen, S. 2018: Pathogen-specific production losses in bovine mastitis. *J. Dairy Sci.*, 101, 10, 9493–9504. DOI: [10.3168/jds.2018-14824](https://doi.org/10.3168/jds.2018-14824)
 38. de Haas, Y., Veerkamp, R. F., Barkema, H. W., Gröhn, Y. T., Schukken, Y. H., 2004: Associations between pathogen-specific cases of clinical mastitis and somatic cell count patterns. *J. Dairy Sci.*, 87, 1, 95–105. DOI: [10.3168/jds.s0022-0302\(04\)73146-x](https://doi.org/10.3168/jds.s0022-0302(04)73146-x)
 39. Hogan, J., Smith, K. L., 2003: Coliform mastitis. *Vet. Res.*, 34, 5, 507–519. DOI: [10.1051/vetres:2003022](https://doi.org/10.1051/vetres:2003022)
 40. Burvenich, C., Merris, V. V., Mehrzad, J., Diez-Fraile, A., Duchateau, L., 2003: Severity of *E. coli* mastitis is mainly determined by cow factors. *Vet. Res.*, 34, 5, 521–564. DOI: [10.1051/vetres:2003023](https://doi.org/10.1051/vetres:2003023)
 41. Fredebeul-Krein, F., Schmenger, A., Wente, N., Zhang, Y., Krömker, V., 2022: Factors associated with the severity of clinical mastitis. *Pathogens*, 11, 10, 1089. DOI: [10.3390/pathogens11101089](https://doi.org/10.3390/pathogens11101089)
 42. Bannerman, D. D., Paape, M. J., Lee, J., Zhao, X., Hope, J. C., Rainard, P., 2004: *Escherichia coli* and *Staphylococcus aureus* elicit differential innate immune responses following intramammary infection. *Clin. Vaccine Immunol.*, 11, 3, 463–472. DOI: [10.1128/cdli.11.3.463-472.2004](https://doi.org/10.1128/cdli.11.3.463-472.2004)
 43. Leitner, G., Krifucks, O., Merin, U., Lavi, Y., Silanikove, N., 2006: Interactions between bacteria type, proteolysis of casein and physico-chemical properties of bovine milk. *Int. Dairy J.*, 16, 6, 648–654. DOI: [10.1016/j.idairyj.2005.10.020](https://doi.org/10.1016/j.idairyj.2005.10.020)
 44. Antanaitis, R., Juozaitienė, V., Jonike, V., Baumgartner, W., Paulauskas, A., 2021: Milk lactose as a biomarker of subclinical mastitis in dairy cows. *Animals*, 11, 6, 1736. DOI: [10.3390/ani11061736](https://doi.org/10.3390/ani11061736)
 45. Blum, S. E., Heller, E. D., Jacoby, S., Krifucks, O., Leitner, G., 2017: Comparison of the immune responses associated with experimental bovine mastitis caused by different strains of *Escherichia coli*. *J. Dairy Res.*, 84, 2, 190–197. DOI: [10.1017/s0022029917000206](https://doi.org/10.1017/s0022029917000206)
 46. Cobirka, M., Tancin, V., Slama, P., 2020: Epidemiology and classification of mastitis. *Animals*, 10, 12, 2212. DOI: [10.3390/ani10122212](https://doi.org/10.3390/ani10122212)
 47. Paudyal, S., Maunsell, F. P., Risco, C. A., Donovan, A., Vries, A. D., Manriquez, D., et al., 2016: Evaluating milk fat to protein ratio and milk fat to lactose ratio as indicators for early lactation disease. *J. Animal Sci.*, 94, 5, 69–70. DOI: [10.2527/jam2016-0147](https://doi.org/10.2527/jam2016-0147)
 48. Lan, R., Wan, Z., Xu, Y., Wang, Z., Fu, S., Zhou, Y., et al., 2021: Taurine reprograms mammary-gland metabolism and alleviates inflammation induced by *Streptococcus uberis* in Mice. *Front. Immunol.*, 12, 696101. DOI: [10.3389/fimmu.2021.696101](https://doi.org/10.3389/fimmu.2021.696101)
 49. Du, C., Zhao, X., Zhang, S., Chu, C., Zhang, X., Teng, Z., 2024: Milk metabolite profiling of dairy cows as influenced by mastitis. *Front. Vet. Sci.*, 11, 1475397. DOI: [10.3389/fvets.2024.1475397](https://doi.org/10.3389/fvets.2024.1475397)