Hungarian University of Agriculture and Life Sciences

UDDER HEALTH ASSESSMENTS IN DAIRY COWS AND GOATS IN HUNGARY

DOCTORAL DISSERTATION THESIS

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1. INTRODUCTION

Milk and dairy product consumption represents an important quantitative and qualitative factor in human nutrition (MICHA ET AL., 2017). Adequate intake and appropriate composition of dairy products play a significant role in a healthy diet (KORHONEN ET AL., 2006). The health status of animals, particularly udder health, substantially influences both the quantity and composition of produced milk in dairy cattle and goats alike (ALBERT AND HUSZENICZA, 2000; HAENLEIN, 2002). In modern dairy herds, whether goat or cattle, mastitis remains a major and persistent problem (ROTA ET AL., 1993; HAENLEIN, 2002). An increase in milk somatic cell count (SCC) generally indicates an underlying health issue. Prevention relies on appropriate housing and feeding conditions, strict hygiene practices, and conscious selection targeting udder traits.

In my thesis, I investigated udder health and milk quality parameters in dairy cattle and goats. Specifically, I evaluated the effects of age, parity, kidding type, and month of kidding on milk production in dairy goats, as well as the effect of horn status on milk quality. Relatively few studies—particularly domestic publications—are available on Alpine goat herds in this field. Furthermore, I examined the relationship between udder health status and milk quality in goats and cows and assessed the effect of teat morphology on goat milk quality. International literature addressing these topics is also scarce. Additionally, I investigated colostrum quality and calf health in a domestic Holstein-Friesian herd, and evaluated changes in somatic cell count during the first 28 days postpartum in multiparous, clinically healthy Holstein-Friesian cows.

1.1. Objectives

The objectives of my research were as follows:

- to examine the effects of selected factors (age, parity, kidding type, month of kidding) on milk production in Alpine goats;
- to assess the effect of horn status on milk quality and temperament of dairy does;
- to evaluate relationships between udder health status and milk composition in dairy goat herds;
- to investigate the effect of teat shape on goat milk quality;
- to assess udder health status at drying-off and at first milking after calving in Holstein-Friesian cows, as well as maternal immunity in their calves;
- to evaluate changes in milk somatic cell count in multiparous Holstein-Friesian cows during the postpartum period.

2. MATERIALS AND METHODS

2.1. Effects of selected factors on milk production in Alpine goats

The study was conducted at a commercial Alpine goat farm located near Kiskunfélegyháza, Hungary. A total of 65 dairy does were included, for which complete datasets were available.

The evaluated factors included age, parity, litter size (single or twin), and month of kidding. The does ranged from 2 to 10 years of age and from 1 to 6 parities. Kidding occurred either in February or June. The following traits were analyzed: lactation length, total milk yield, peak daily milk yield, persistence index (percentage ratio of average daily milk yield to peak daily milk yield), and reproductive rate (number of kids per 100 does kidding).

The herd was housed indoors and fed ad libitum alfalfa hay, supplemented daily with 300 g concentrate per animal (40% barley, 20% wheat, 20% maize, 20% wheat bran). Milking was performed twice daily in a four-stall milking parlor, followed by post-milking teat dipping.

Statistical analysis

Statistical analyses were conducted using SPSS 21.0 software, including the Kolmogorov–Smirnov test, descriptive statistics, general linear model (GLM), LSD and Tukey tests, Mann–Whitney U test, and Kruskal–Wallis test. Milk yield, peak daily milk yield, and persistence index showed normal distribution, while lactation length and reproductive rate did not; therefore, non-parametric methods were applied for the latter traits.

The effects on lactation milk yield, peak daily milk yield, and persistence index were evaluated using GLM. The applied model was:

$$Y_{ijkl} = \mu + A_i + B_j + C_k + D_l + e_{ijkl}$$

where Y_{ijkl} is the observed trait, μ is the overall mean, A_i is the effect of age (8 fixed classes), B_j is the effect of parity (6 fixed classes), C_k is the effect of kidding type (2 fixed classes), D_l is the effect of month of kidding (2 fixed classes), and e_{ijkl} is the random error. Interaction effects were tested but excluded from further analysis due to lack of significance.

2.2. Effects of horn status on milk quality and temperament of dairy goats

This study was conducted on a commercial goat farm in Pest County, Hungary, housing 120 polled and 60 horned goats. From the herd, 38 polled and 28 horned multiparous Alpine goats without clinical signs of mastitis were randomly selected. The goats were in their second (n = 37) or third (n = 29) lactation, kidded in February, and had an 8-week kid-rearing period. Udder morphology was comparable among individuals.

The two groups were housed separately in deep-litter pens, providing at least 2.0 m² lying area and 40 cm feeding space per animal. From early April, goats were machine-milked twice daily and fed a diet based on alfalfa hay. Nutrient supply was adjusted according to NRC (2007) recommendations. Goats received ad libitum medium-quality alfalfa hay (NEL: 4.74 MJ/kg DM; crude protein: 183 g/kg DM) and 400 g/day of commercial concentrate (NEL: 7.1 MJ/kg DM; crude protein: 180 g/kg DM; vitamins A, D_3, E). Salt blocks and drinking water were freely available.

Milking was performed twice daily in a Westfalia-type 2 × 12 milking parlor (vacuum: 48 kPa; pulsation ratio: 60:40; pulsation rate: 90/min). The two groups were milked separately.

Temperament scoring and milk sampling were conducted during evening milking on days 56, 118, and 196 of lactation. Temperament was assessed using a 5-point scale (BUDZYNSKA ET AL., 2005).

Milk samples were analyzed for composition (fat, protein, lactose) using a LactoScope™ (Delta Instruments, Netherlands), and SCC was determined using a Bentley FCM analyzer. Bacteriological analyses were conducted using Columbia esculin blood agar and conventional identification methods.
Animals were categorized into four groups based on pathogen occurrence across sampling periods. No obligate udder pathogens were detected.

Statistical analysis

Statistical analyses were performed using SPSS 25.0. Kruskal–Wallis and Mann–Whitney U tests were applied for temperament scores. SCC data were log-transformed following Shapiro–Wilk testing. Effects of lactation stage, parity, and horn status on SCC were analyzed using GLM:

$$Y_{ijk} = \mu + LS_i + PN_j + PH_k + e_{ijk}$$

where Y_{ijkl} is the observed trait, μ is the overall mean, LS_i is the effect of section of lactation (3 fixed classes), PN_j is the effect of parity (2 fixed classes), C_k is the effect of presence of horn (2 fixed classes), and e_{ijkl} is the random error.

Differences between the group means of somatic cell counts in the two goat groups were evaluated using an F-test followed by Student's *t*-test. ANOVA was used to evaluate SCC differences in relation to udder pathogen occurrence. Pairwise comparisons were performed using Tukey's HSD test.

2.3. Relationship between udder health status and milk composition in dairy goats

The study was conducted on a commercial dairy goat farm located in Pest County, Hungary. Thirty-eight multiparous Alpine goats were randomly selected that showed no clinical signs of mastitis (udder swelling, redness, or pain) and

were comparable in parity (2–3 lactations), kidding period (February), kid-rearing duration (8 weeks), and udder morphology.

From early April, the goats were machine-milked and housed indoors. Feeding was based on alfalfa hay, and nutrient supply was adjusted according to NRC (2007) recommendations for energy and protein requirements of dairy goats. Animals were fed ad libitum medium-quality alfalfa hay (NEL: 4.74 MJ/kg dry matter (DM); crude protein: 183 g/kg DM) and supplemented with a commercial concentrate (400 g/day; NEL: 7.1 MJ/kg DM; crude protein: 180 g/kg DM) containing vitamins A, D_3, and E. Commercial salt blocks were freely available. Milking was performed twice daily using a Westfalia-type 2 × 12 milking parlor (vacuum: 48 kPa; pulsation ratio: 60:40; pulsation rate: 90/min).

Milk samples were collected on four occasions during evening milking (days 56, 118, 196, and 224 of lactation) from completely milked udders. In total, 152 individual composite milk samples were obtained. All samples were analyzed for somatic cell count (SCC), milk composition (fat, protein, lactose), and the presence of udder pathogenic bacteria. Only pathogen-free samples (n = 50) were included in further analyses. Based on SCC, samples were classified into two groups:

1. < 400,000 cells/mL (n = 19), and
2. 1,000,000 cells/mL (n = 20).

Thus, a total of 39 milk samples were included in the subsequent analyses (11 samples with SCC values between 400,000 and 1,000,000 cells/mL were excluded).

For bacteriological analysis, 0.1 mL of milk was plated on Columbia esculin blood agar (Biolab Inc., Budapest, Hungary) containing 5% sheep blood and 0.5% esculin and incubated at 37 °C for 48 h at ÁT Ltd. (Gödöllő). Isolates were identified using conventional microbiological methods, including Gram staining, colony morphology, and hemolysis.

Milk fat, protein, and lactose contents were determined using a LactoScope™ analyzer (Delta Instruments Ltd., Netherlands), while SCC was measured using a Bentley FCM analyzer (ÁT Ltd., Gödöllő).

Further analyses of the 39 selected samples included determination of mineral content (Na, K, Ca, Mg, Zn, Cl) and fatty acid profile. Mineral concentrations were measured by inductively coupled plasma optical emission spectrometry (ICP-OES; MATE, Department of Chemistry). Sample preparation involved microwave-assisted acid digestion of 2.5 mL milk using 10 cm^3 of 65% (v/v) nitric acid and 1 cm^3 of 35% (v/v) hydrogen peroxide (Milestone Microwave Acid Digestion system).

The analytical wavelengths were as follows: Na: 589.592 nm; K: 766.490 nm; Ca: 315.887 nm; Mg: 285.213 nm; Zn: 213.857 nm. Chloride ion concentration was determined according to the Hungarian Standard (1982).

Fatty acid methyl esters were analyzed by gas chromatography (GC-2010, Shimadzu, Kyoto, Japan) equipped with a flame ionization detector (FID) and a CP-SIL-88 capillary column (100 m × 0.25 mm × 0.20 μm). The split injection

ratio was 50:1, helium was used as the carrier gas at a linear velocity of 28 cm/s. Injector and detector temperatures were set at 270 °C and 300 °C, respectively. The oven temperature program was as follows: 80 °C for 0 min, increased at 2.5 °C/min to 205 °C with a 20-min hold, then increased to 225 °C at 10 °C/min with a final hold of 5 min. Fatty acids were identified based on retention times of standard methyl esters (Mixture Me 100, Larodan Fine Chemicals AB, Sweden), and quantities were expressed as percentages of total detected fatty acids.

Statistical analysis

Statistical analyses were performed using SPSS 23.0 software. Normality was assessed using the Shapiro–Wilk test. SCC data were not normally distributed; therefore, SCC values were log-transformed and analyzed using the Mann–Whitney U test. In other cases, F-tests and Student's t-tests were applied.

2.4. Effect of teat morphology on goat milk quality

The study was conducted at a commercial goat farm in Pest County, Hungary. The investigated animals were Alpine dairy does that kidded in January and were milked from mid-February. Goats were of mixed parity but in the same lactation stage and showed no clinical signs of mastitis.

Animals were housed in a deep-litter barn and fed ad libitum alfalfa hay (NEL: 4.74 MJ/kg DM; crude protein: 183 g/kg DM), supplemented with a commercial dairy goat concentrate (NEL: 7.1 MJ/kg DM; crude protein: 180 g/kg DM) at 300 g/animal/day. Milking was performed twice daily in a SAC Westfalia-type 2 × 12 milking parlor (vacuum: 48 kPa; pulsation ratio: 60:40; pulsation rate: 90 min^{-1}). From the milked herd (n = 414), goats were classified into two groups based on teat shape: funnel-shaped and cylindrical. The distribution was 65% funnel-shaped and 35% cylindrical teats. From each group, 12 goats were randomly selected for sampling.

Milk samples were collected on three occasions during evening milking, corresponding to early, mid, and late lactation (day 56, day 118, and day 196). In total, 72 milk samples were obtained. After discarding the first milk streams, samples were collected into one 50-mL and one 10-mL container per animal.

Milk samples preserved with bronopol and natamycin (50 mL) were analyzed for milk fat, protein, lactose, somatic cell count, and total bacterial count. Milk composition was determined using a LactoScope™ analyzer (Delta Instruments Ltd., Netherlands). SCC and total bacterial count were measured using fluorescence-based optoelectronic instruments (Bentley FCM and IBC; ÁT Ltd., Gödöllő).

The 10-mL samples were used for bacteriological detection of mastitis-causing pathogens, including coagulase-negative staphylococci (CNS), Corynebacterium spp., *Staphylococcus aureus*, *Streptococcus uberis*, and *Streptococcus dysgalactiae*. Based on SCC values, milk samples were classified into three groups:

1. < 400,000 cells/mL (n = 28);
2. 400,000–1,000,000 cells/mL (n = 25);
3. 1,000,000 cells/mL (n = 19).

Statistical analysis

Statistical analyses were performed using SPSS 21.0 software. Descriptive statistics, Shapiro–Wilk and Chi-square tests, as well as F-tests and Student's t-tests were applied. SCC and total bacterial count did not follow normal distribution and were therefore log-transformed prior to further analyses.

2.5. Udder health status of Holstein–Friesian cows at dry-off and at first milking after calving, and evaluation of maternal immunity in their calves

The study was conducted at a commercial dairy cattle farm in Pest County, Hungary. The investigated cows were Holstein-Friesian of mixed parity but identical lactation stage and showed no clinical signs of mastitis during the study. From the milked herd (n = 769), 81 multiparous cows (2–5 parities) with average udder and teat morphology (udder attachment, suspension, depth, teat length) were randomly selected. During lactation, cows were housed in freestall barns, and during the dry period in deep-litter housing. Pre- and post-milking teat disinfection was routinely applied.

In the first part of the experiment, individual composite milk samples were collected aseptically from the 81 cows after the last milking before drying-off on four occasions between September 2018 and June 2019. Sampling times were September (n = 27), December (n = 18), April (n = 22), and June (n = 14). Teats were cleaned with disinfectant wipes prior to sampling and disinfected again using alcohol wipes, with separate wipes for each teat. After milking, cows received a long-acting intramammary antibiotic, and teats were dipped in a dry-cow teat sealant.

After calving, aseptic milk sampling was repeated at the first milking from the same cows. Samples were frozen and transported to the laboratory for analysis. Mastitis-causing bacteria (including CNS, *Streptococcus uberis*, *Enterococcus* spp., *Corynebacterium* spp., and *Streptococcus dysgalactiae*) were detected using surface plating methods (ÁT Ltd., Gödöllő).

In the second part of the study, blood samples were collected from the jugular vein of calves at approximately 7 days of age. After coagulation, serum was separated and total protein concentration was estimated using an optical refractometer to assess immunoglobulin levels. Based on Brix values, calves were classified into two groups:

1. Brix < 8.4% (n = 34);
2. Brix ≥ 8.4% (n = 44).

Calves were fed high-quality colostrum (22% Brix), assessed using a colostrometer (hydrometer). Colostrum was pasteurized and frozen after milking.

Statistical analysis

Statistical analyses were performed using GraphPad InStat®. Kruskal–Wallis tests were applied for distribution analysis, and descriptive statistics, F-tests, and Student's t-tests were used. Detection rates of udder pathogens and treatment frequencies in calves were compared using Chi-square tests.

2.6. Changes in somatic cell count in the milk of multiparous Holstein–Friesian cows during the post-calving period

The study was conducted at the Hunland Dairy Ltd. farm. At the time of the study, the farm housed 1,766 lactating Holstein-Friesian cows and their offspring.

Sampling

For the analysis of milk SCC and blood beta-hydroxybutyrate (BHB) levels, 28 cows were randomly selected. Samples were collected on days 2, 7, 10, 14, 21, and 28 postpartum. Milk fat and protein content were analyzed from samples collected during the first and fourth weeks.

Blood samples were obtained from the vena caudalis mediana using a tail-hold technique. BHB concentration was measured using a NovaVet device. Milk samples for SCC analysis were collected during morning milking following the protocol described in Section 2.5. SCC was determined using a Bentley FCM analyzer. Milk fat, protein, and lactose contents of samples collected on days 7 and 28 were measured using a Bentley FTS FTIR analyzer (ÁT Ltd., Gödöllő).

On day 7 of lactation, quarter-level aseptic milk samples were collected from selected cows for bacteriological examination. Bacteriological analyses were performed at Márkus Milk Laboratory Ltd.

Statistical analysis

Statistical analyses were performed using GraphPad InStat®. Kruskal–Wallis tests were applied for distribution analysis, and descriptive statistics, F-tests, and Student's t-tests were used. Detection rates of udder pathogenic bacteria were compared using Chi-square tests.

3. RESULTS

3.1. Effects of selected factors on milk production in Alpine goats

The effects of month of kidding on the evaluated production traits are summarized in Table 1.

Table 1

Effect of month of kidding on the milk production (LSM±SEM)

Time of kidding	n	Milk production, kg	Daily milk yield, kg	Length of lactation, day	Litter size
February	52	557.4±75.9	1.92±0.42	288.5±40.8	1.63±0.49
June	13	294.3±41.9	1.23±0.13	240.0±23.0	1.00±0.40
P		<0.001	<0.001	<0.001	<0.001*

*=Mann-Whitney test

Age had a statistically significant effect on lactation milk yield, average daily milk yield, peak daily milk yield, and persistence index. The highest milk production was observed in goats aged between 3 and 7 years ($P < 0.05$). Based on the results, age also had a significant effect on lactation length and reproductive rate. The longest lactations were recorded in does aged 3–7 years, ranging from 270 to 325 days.

Parity had a significant effect on lactation milk yield, average daily milk yield, peak daily milk yield, and persistence index. The highest milk yields were produced by goats in their second to fourth lactations ($P < 0.05$). The greatest milk production was observed during the second lactation, while a decline in milk yield began during the fourth lactation, although this decrease was not statistically significant. From the fifth lactation onward, milk yield decreased significantly.

A significant difference was observed in milk production and lactation length between does giving birth to single kids and those giving birth to twins ($P < 0.001$). Does that kidded twins produced approximately 0.4 kg more milk per day on average compared to does that gave birth to a single kid.

Significant differences were found in milk production traits according to the month of kidding. Does inseminated in autumn and kidding in February–March had significantly longer lactation lengths and higher milk yields during the study period compared to does kidding in June–July ($P < 0.001$).

Regarding reproductive performance, a significant relationship was observed between the month of kidding and reproductive rate. During the spring kidding season, the reproductive rate was 1.63, whereas in the summer kidding season it was only 1.0. Thus, does kidding in summer produced approximately 39% fewer kids on average compared to those kidding in spring ($P < 0.001$).

3.2. Effects of horn status on milk quality and temperament of dairy goats

The presence of horns had a significant effect on temperament scores in goats ($P < 0.05$), whereas no significant difference was observed between the two groups with regard to somatic cell count. The temperament scores of hornless and horned Alpine goats are presented in Table 2.

Table 2

Temperament acore of the horned and polled goats

Temperament scores	Polled (n=38)		Horned (n=28)		P
	n	%	n	%	
2	1	2.63	1	3.57	N.S.
3	4	10.53	6	21.43	N.S.
4	17	44.74	17	60.71	<0.05
5	16	42.11	4	14.29	<0.001
4+5	33	86.84	21	75.00	<0.05

N.S.= not significant difference

Polled Alpine goats were significantly calmer (mean score: 4.19) than horned goats (mean score: 3.80). In the hornless group, 42.2% of the animals received a score of 5 (calm animals), 44.7% a score of 4, 7.9% a score of 3, and 2.6% a score of 2. In contrast, among horned Alpine goats, 14.3% received a score of 5, 60.7% a score of 4, 21.4% a score of 3, and 3.6% a score of 2.

The proportion of calm animals differed between the hornless and horned groups: 86.8% of hornless goats received a score of 4 or 5, compared with only 75% of horned goats ($P < 0.05$). The overall mean proportion of calm animals (scores 4 and 5) across both groups was 81.8%. During milking, the proportion of goats displaying unfavorable temperament traits remained relatively low (less than 20%). These findings are consistent with previous observations by PÓTI ET AL. (2015) and TÓTH ET AL. (2017), who reported that approximately 80% of dairy Alpine goats and 85% of dairy sheep exhibited calm behavior.

The average detection rate of udder pathogens was 55%; however, the prevalence differed markedly between the two groups. The most favorable results were observed in the hornless group, where the detection rate of udder pathogens was 47.4%, compared with 65.5% in horned animals ($P < 0.05$). Two types of minor udder pathogens were identified: coagulase-negative *Staphylococcus* (CNS) and *Corynebacterium* spp. In a small proportion of the samples, the simultaneous presence of these pathogens was detected. The overall detection rate of CNS bacteria was 73.5%, with no pronounced difference between the groups: 68.5% in the hornless group and 78.2% in the horned group.

The detection rates of udder pathogens in the two groups are summarized in Table 3.

Table 3

Prevalence of udder pathogenic bacteria in the two goat groups

Udder pathogens	Polled (n=38)	Horned (n=28)	Total	P
Negative samples	52.6	34.5	44.95	<0.05
Infected samples	47.4	65.5	55.05	<0.05
Udder pathogens from infected samples				
CNS	68.5	78.2	73.4	N.S.
Corynebacterium sp.	22.2	12.7	17.4	N.S.
CNS + *Corynebacterium* sp.	9.3	9.1	9.2	N.S.

CNS = Coagulase-negative *Staphylococcus,* N.S.=not significant difference

The mean somatic cell count was 796,000 cells/mL (5.90 log cells/mL), with values of 5.94 and 5.86 log cells/mL in hornless and horned goats, respectively. In healthy goats, somatic cell counts generally remain below 1 million cells/mL; accordingly, most animals in the present study did not exhibit signs of subclinical mastitis (LEITNER ET AL., 2016).

3.3. Relationship between udder health and milk composition in dairy goats

The chemical and physical properties of milk according to somatic cell count (SCC) categories (< 400,000 cells/mL and > 1,000,000 cells/mL) are summarized in Table 4.

Table 4

Test characteristics of goat milk samples by somatic cell categories

Items	400 thousand cells/ml >	1 million cells/ml <	SEM	P
Lactose, %	4.34	4.18	0.05	<0.05
Milk fat, %	3.04	3.82	0.23	<0.05
Milk protein, %	2.86	3.14	0.14	N.S.
Na, mg/l	300.50	373.79	23.66	<0.05
K, mg/l	949.00	811.14	70.19	N.S.
Ca, mg/l	1066.70	900.19	51.10	N.S.
Mg, mg/L	126.44	148.14	5.43	<0.01
Zn, mg/l	3.70	3.17	0.26	<0.05
Chloride, g/l	1.77	1.94	0.03	<0.05

N.S.=not significant difference

Milk fat and lactose contents changed markedly with increasing somatic cell count. Milk fat content increased significantly, whereas lactose content decreased significantly in the high SCC group. In the present study, the concentrations of Na, Mg, and Cl in milk were higher in the elevated SCC category. In addition, udder health influenced the zinc content of milk, as Zn concentration was considerably lower in the high SCC group.

Udder health had a significant effect on the concentration of short- and medium-chain fatty acids (from C4 to C14) in milk, which were lower in the high SCC category. With increasing SCC, changes were also observed in palmitic acid concentration. The milk fat of the low SCC group contained a higher proportion of palmitic acid compared with the high SCC group. In contrast, the concentration of long-chain fatty acids was higher in the elevated SCC group.

In the mammary gland, approximately half of the short- and medium-chain fatty acids, as well as palmitic acid, are synthesized de novo, primarily from acetate originating in the rumen; this process is referred to as de novo fatty acid synthesis. In the present study, the proportion of total de novo fatty acids was 50.0% in the low SCC group, compared with 46.7% in the high SCC group. Conversely, the concentration of total fatty acids containing 18 or more carbon atoms increased in the high SCC category.

In this study, goats with low SCC had lower oleic acid (17.03%) and monounsaturated fatty acid (MUFA) concentrations (18.41%) in milk compared with goats with high SCC (20.97% and 22.52%, respectively; $P < 0.05$). Oleic acid is the primary determinant of MUFA concentration. The ratio of oleic acid to palmitic acid was less favorable in the high SCC group, increasing from 0.52 to 0.70 ($P < 0.01$).

Among polyunsaturated fatty acids (PUFAs), n-3 PUFAs are of particular importance for human consumers due to their beneficial effects on human health. In the present study, PUFA concentrations were similar in both SCC categories.

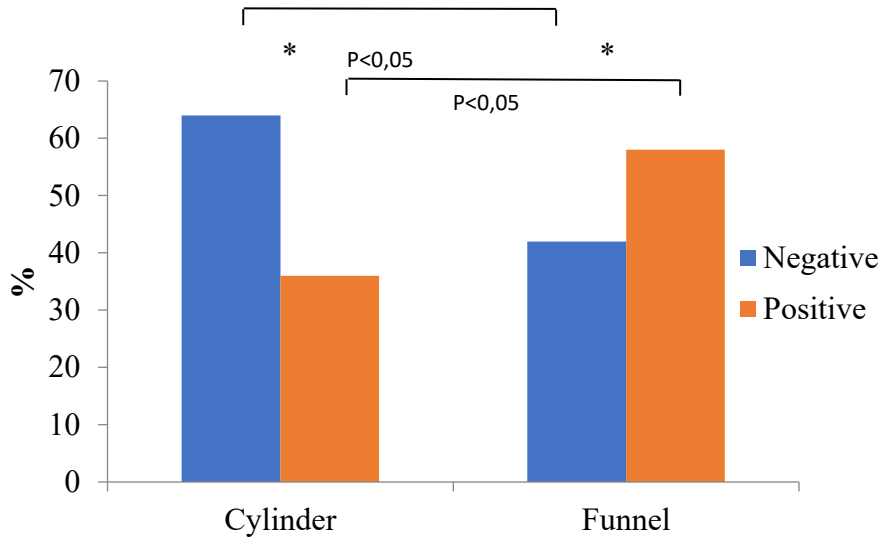
3.4. Effects of teat morphology on the quality of goat milk

Milk samples collected during the study contained *Corynebacterium* spp., coagulase-negative *Staphylococcus* (CNS), *Staphylococcus aureus*, and *Streptococcus dysgalactiae*. At least one pathogen was detected in 48% of all samples. The most frequently identified pathogens were coagulase-negative staphylococci, followed by various *Corynebacterium* species. Among milk samples positive for udder pathogens, CNS were detected in 56% and *Corynebacterium* spp. in 38%. In addition, one sample each contained a major udder pathogen.

The prevalence of udder pathogenic bacteria according to teat type is presented in Figure 1.

Figure 1

Prevalence rate of udder pathogenic bacteria in goat milk



*=P<0.05

Milk from goats with cylindrical teats was free of udder health–related pathogenic bacteria in 64% of the samples, whereas pathogens were detected in 36% of these samples. In contrast, pathogens were detected in 58% of the milk samples collected from goats with funnel-shaped teats. In milk from goats with cylindrical teats, only CNS and *Corynebacterium* spp. were identified. Among the samples from goats with funnel-shaped teats, *Staphylococcus aureus* was detected in one sample (680 colony-forming units), a finding of particular relevance for mastitis development. The distribution of pathogens differed significantly between the two teat morphologies, indicating that teat shape substantially influences the colonization of bacteria detrimental to udder health.

Based on somatic cell count, milk samples were classified into three categories: < 400,000 cells/mL, 400,000–1,000,000 cells/mL, and > 1,000,000 cells/mL. Milk quality was most favorable in goats with cylindrical teats: 42% (n = 15) of samples fell into the < 400,000 cells/mL category, while only 20% (n = 7) exceeded 1,000,000 cells/mL; this difference was statistically significant (P < 0.05). In contrast, among goats with funnel-shaped teats, no significant differences were observed between the three SCC categories, with samples distributed relatively evenly (36%, 31%, and 33%; n = 13, 11, and 12, respectively).

The differences between teat morphologies indicate that milk of more favourable hygienic quality can be expected from goats with cylindrical teats. For both teat types, udder pathogens occurred less frequently in milk samples with low somatic cell counts. However, milk samples from goats with cylindrical teats

showed more favourable values overall, as the proportion of pathogen-positive samples was significantly lower in the < 400,000 and 400,000–1,000,000 cells/mL SCC categories (20% and 36%, respectively) compared with samples from goats with funnel-shaped teats (38% and 55%, respectively; $P < 0.05$).

The proportions of coagulase-negative *Staphylococcus* and *Corynebacterium* spp. in the cylindrical teat groups were 13% and 7%, and 21% and 14%, respectively, whereas higher proportions were observed in goats with funnel-shaped teats (23% and 15%, and 33% and 17%, respectively). In the SCC category exceeding 1,000,000 cells/mL, pathogenic bacteria were detected in 71% and 83% of milk samples from cylindrical and funnel-shaped teats, respectively.

These results indicate that even milk samples with low somatic cell counts from goats with funnel-shaped teats frequently contained bacteria detrimental to udder health. The high prevalence of udder pathogens in low-SCC milk from funnel-shaped teats suggests a greater susceptibility of these animals to colonization by mastitis-associated bacteria. The observed differences between milk obtained from the two teat morphologies are likely related not only to the shape of the teat canal but also to its tissue structure, milk flow dynamics during milking, and additional factors, which require further investigation.

The total bacterial count in milk from goats with cylindrical teats averaged 4.08 ± 0.02 log cells/mL (12,027 cells/mL), whereas milk samples from goats with funnel-shaped teats showed a mean value of 4.86 ± 0.07 log cells/mL (72,463 cells/mL). From the perspective of bacterial milk quality, these values can be considered excellent. In samples with somatic cell counts exceeding 1,000,000 cells/mL, milk obtained from cylindrical teats exhibited markedly better bacterial quality, as the bacterial count of milk from funnel-shaped teats was approximately six times higher.

A significant relationship was observed between somatic cell count and total bacterial count. A moderately strong positive correlation was detected between SCC and bacterial count ($r = 0.39$; $P < 0.001$).

3.5. Udder health status of Holstein–Friesian cows at dry-off and at the first milking after calving, and assessment of maternal immunity in their calves

The dynamics of udder pathogenic bacteria detected in composite milk samples collected at dry-off and during the post-calving period are presented in Table 5.

In this study, composite milk samples were collected from a substantial proportion of the herd (10.5%), thus the results provide a reliable characterization of the udder health status of the population. Major udder pathogens were detected only sporadically in the milk samples. Among udder pathogens, coagulase-negative *Staphylococcus* (CNS) was the most frequently isolated species both before dry-off and after calving.

Table 5

Prevalence and number of udder pathogenic bacteria at dry off and kidding (n=81)

Udder pathogens	**Dry off**		**Kidding**		**P**
	n	%	n	%	
Negative samples	44	54.2	64	79.2	<0.05
Infected samples	37	45.8	17	20.8	<0.05
Major udder pathogens:	3	3.6	3	3.6	N.S.
Enterococcus sp.	1	1.2	1	1.2	N.S.
Streptococcus uberis	1	1.2	2	2.4	N.S.
Streptococcus uberis + Coagulase-negative *Staphylococcus*	1	1.2	-	0	N.S.
Minor udder pathogens:	34	42.2	14	17.2	<0.05
Coagulase-negative *Staphylococcus*	33	41.0	14	17.2	<0.05
Corynebacterium sp.	1	1.2	-	0	N.S.

N.S.=not significant difference

At dry-off, more than half of the composite milk samples (54%) were free of udder pathogenic bacteria. The proportion of samples positive for udder pathogens was 46%, of which the majority (42%) contained minor udder pathogens (41% CNS and 1.2% *Corynebacterium* spp.). In addition, major udder pathogens (*Enterococcus* spp. and *Streptococcus uberis*) were isolated from 2.4% of the composite milk samples. Furthermore, both major and minor udder pathogens were detected simultaneously in 1.2% of the samples.

In the post-calving period, the proportion of pathogen-negative samples increased significantly (from 54% to 79%; $P < 0.05$), while the proportion of pathogen-positive samples decreased from 46% to 21% ($P < 0.05$). Nevertheless, a prevalence of 21% remains considerable, highlighting the importance of udder treatments at dry-off. Considerable differences exist among dry-off management strategies, and reduction of antibiotic use during this period remains an important consideration.

Among the positive post-calving samples, CNS were detected most frequently (17%), while major udder pathogens (*Enterococcus* spp., *Streptococcus uberis*, and *Escherichia coli*) were isolated in the remaining 4%. Although the proportion of major udder pathogens increased slightly from 2.4% to 4%, no samples containing both major and minor udder pathogens were detected after calving. The high prevalence of CNS can be partly attributed to

their presence in the healthy teat canal and on the teat skin, which allows continuous potential for infection.

The prevalence of infections caused by minor udder pathogens detected at dry-off (42.2%) decreased markedly after calving (to 17.2%), likely due to treatments applied at dry-off. However, in some cases, infections were not present at dry-off but were detected after calving; minor udder pathogens were identified post-calving in 6% of the examined cows. Nearly half of the milk samples (47%) were free of udder pathogens both at dry-off and after calving. Furthermore, in 31% of the samples minor udder pathogens, and in 1.2% major udder pathogens, were no longer detectable after calving, indicating spontaneous or treatment-related recovery. Conversely, 1.2% of cows that were negative or infected with minor udder pathogens at dry-off became superinfected with major udder pathogens. Major udder pathogens were again detected in 1.2% of the cows after calving. A proportion of minor udder pathogen infections detected at dry-off (10%) persisted into the post-calving period. Identification of cows shedding udder pathogens after calving is particularly important, as emphasized by Hungarian authors, who recommend that milk from such cows should not be fed to replacement heifer calves (KOVÁCS ET AL., 2015). Following bacteriological evaluation of samples collected at dry-off and after calving, it is advisable to collect quarter milk samples from cows with positive post-calving results, especially when there is a strong suspicion of infection.

In the second part of the study, serum IgG concentrations of calves were determined using an optical refractometer and compared with their health status. The health status of heifer calves during the rearing period was further assessed by dividing the animals into two groups based on the 8.4% Brix threshold. The results are summarized in Table 6.

Table 6

Evolution of heifer calf treatments based on their Brix value (n=40)

Treatments	**Brix value**		**P**
	<8.4 (n=17)	**8.4< (n=23)**	
No treatments	24%	48%	<0.001
Treatments :	76%	52%	<0.001
Antibiotics (A)	12%	13%	N.S.
Electrolits (E)	23%	13%	N.S.
Together A and E	35%	17%	<0.05
Dead calves	6%	9%	N.S.

N.S.=not significant difference

Based on the results, 54% of the examined calves (58% of heifer calves, n=23) successfully acquired the minimum IgG concentration required for adequate passive immunity (10 g/L), corresponding to a Brix value of 8.4%. The results obtained for the examined herd fell markedly below this threshold, suggesting that high-quality colostrum may not have been provided in adequate quantity or at the appropriate time; however, this aspect was not evaluated in the present study.

The proportion of untreated calves that successfully acquired passive immunity was nearly 1.5 times higher than that of calves that failed to achieve adequate passive immunity. Similarly, the proportion of calves requiring antibiotic and electrolyte treatment was almost 1.5 times higher among calves that did not acquire sufficient passive immunity. Overall, the Brix value of heifer calves had a significant effect on both the frequency and type of treatments required during the rearing period ($P < 0.05$).

3.6. Changes in somatic cell count in the milk of multiparous Holstein–Friesian cows during the post-calving period

The between day 2 and day 28 of the monitoring period, the BHB levels of the examined cows did not exceed the accepted threshold value of 1 mmol/L. Subclinical ketosis is defined as a blood BHB concentration exceeding 1 mmol/L (Szelényi et al., 2015). The normal ketone levels observed during the first five days can be attributed to propylene glycol drenching, which was administered during this period. The drench effectively compensates for the reduced feed intake and the resulting negative energy balance commonly occurring after calving.

The results of the bacteriological examination of milk samples collected on day 7 of lactation are summarized in the following table. Fifty percent of the examined samples were negative, while coagulase-negative *Staphylococcus* (CNS) was the most frequently detected bacterium among the positive samples. A major pathogen, *Enterobacter aerogenes*, was identified in one sample; this sample was excluded from the evaluation of somatic cell count dynamics. General hygiene practices on the farm were adequate, and in the deep-litter housing system bedding was applied frequently and in sufficient amounts.

During the periparturient period, the somatic cell count of colostrum increases physiologically. Due to natural processes, very high SCC values are typically measured immediately after calving; these values subsequently decrease markedly. However, the literature does not provide a clear consensus on the exact time point at which milk SCC returns to physiological levels in multiparous cows under normal metabolic conditions and good udder health. In the present study, milk SCC reached physiologically normal levels between 7 and 10 days after calving.

4. CONCLUSIONS

4.1. Effects of selected factors on milk production in Alpine goats

Based on the results, it can be concluded that the age of the does and the number of lactations significantly influenced both milk production and the number of kids born. The highest milk yield was recorded in goats in their 2nd to 4th lactations ($P < 0.05$). From the 5th lactation onward, milk production decreased significantly. Does giving birth to twins produced more milk than those kidding single offspring.

The kidding season had a marked effect on both milk production and reproductive performance. Does kidding during the summer period produced less milk and showed lower prolificacy. In contrast to milk production, heat stress was likely to play a lesser role in reproductive performance, as the higher incidence of embryonic and fetal losses characteristic of early pregnancy occurred during a thermoneutral period (February–April).

4.2. Effects of horn status on milk quality and temperament of dairy goats

Based on the examinations, polled Alpine goats were found to be calmer than horned individuals. No relevant scientific literature is currently available on the temperament of polled Alpine goats. The proportion of calm animals (scores 4 + 5) was higher in the polled group (87%) than in the horned group (75%; $P < 0.05$). In the examined population, the overall proportion of calm goats was 82%. During milking, the proportion of goats exhibiting unfavourable temperament was relatively low (18%).

Milk samples from polled goats contained identified udder-pathogenic bacteria at a lower frequency compared to samples from horned goats. The detection rate of udder pathogens was 47.4% in the polled group, whereas it was significantly higher (65.5%) in horned animals ($P < 0.05$). However, no major udder pathogens were detected, which may indicate favourable milking hygiene. This is consistent with the favourable somatic cell count (SCC) values observed; the average SCC of the examined herd was 796,000 cells/mL. No significant difference in SCC was found between milk samples from horned and polled goats. These results suggest that horned does may be more sensitive and more susceptible to udder health problems.

4.3. Relationship between udder health and milk composition in dairy goats

The results demonstrated that increased somatic cell count in raw goat milk markedly affected the major chemical properties of the milk, leading to substantial compositional changes. Elevated SCC levels had a significant impact on milk composition and mineral content. In the high-SCC group, the concentrations of lactose, zinc (Zn), and potassium (K) decreased, whereas the

concentrations of fat, magnesium (Mg), sodium (Na), and chloride ions (Cl^-) increased.

Furthermore, udder health had a strong influence on the de novo synthesis of short- and medium-chain fatty acids in the mammary gland. Impaired udder health resulted in reduced secretory activity of the mammary gland, which led to lower concentrations of short- and medium-chain fatty acids in the high-SCC group. Short-chain fatty acids are particularly important, as they are known to influence the flavour of dairy products. In addition, the increased oleic acid content may affect milk processability; a higher proportion of oleic acid results in softer milk fat and consequently softer butter.

Overall, the results suggest that elevated somatic cell count adversely affects several chemical properties of milk, including the fatty acid composition of milk fat, which can significantly reduce milk quality. Therefore, reducing SCC is important not only from an animal health perspective but also for the production of high-quality dairy products.

4.4. Effects of teat morphology on goat milk quality

Milk from goats with cylindrical teats showed a lower prevalence of bacteria detrimental to udder health. In 64% of goats with cylindrical teats, no udder-pathogenic microorganisms were detected in the milk samples. In contrast, pathogens were identified in 58% of goats with funnel-shaped teats.

Goats with funnel-shaped teats may be more susceptible to bacterial infections and thus have a higher risk of developing udder health problems compared to goats with cylindrical teats. Based on the results, milk obtained from cylindrical teats exhibited more favourable somatic cell count values than milk from funnel-shaped teats. Selection for the cylindrical teat type is therefore recommended, as it may contribute to the production of raw milk with improved hygienic quality and enhance the quality and competitiveness of dairy products (e.g., cheeses and yogurts) derived from it.

4.5. Udder health status of Holstein–Friesian cows at dry-off and at first milking after calving, and evaluation of maternal immunity in their calves

In the examined cows, the importance of the dry-period management protocol for udder health was confirmed. Proper dry-off management can reduce the occurrence of udder-pathogenic microorganisms and increase the proportion of negative milk samples within the dairy herd. Udder pathogens identified at dry-off may still be detectable after calving, highlighting the importance of maintaining adequate environmental hygiene. It is therefore advisable to examine bulk milk from both dry-off cows and freshly calved cows for udder pathogens.

Milk from cows shedding udder-pathogenic bacteria should not be used for feeding heifer calves. Calves that failed to acquire adequate passive immunity (serum Brix value below 8.4) required significantly more veterinary treatments

(e.g., antibiotic therapy). Proper colostrum feeding and its monitoring can substantially reduce antibiotic use during calf rearing, thereby contributing to efforts against antimicrobial resistance. Routine or daily use of a refractometer is recommended under farm conditions to provide an immediate and reliable estimation of colostrum immunoglobulin content. Additionally, spot-check testing of calf serum immunoglobulin levels using a refractometer is suggested, as it allows monitoring of calf caretakers' performance and provides information on the current immune status of calves.

4.6. Changes in somatic cell count in the milk of multiparous Holstein–Friesian cows during the post-calving period

During the periparturient period, the somatic cell count of colostrum increases physiologically and subsequently decreases. Physiologically average SCC values are generally expected during the second week after calving. Accordingly, very high SCC values are observed during the calving and colostral period, followed by a marked decline after the colostral phase. However, the literature does not clearly define the exact time point at which milk SCC reaches physiological levels in multiparous cows under normal metabolic conditions and good udder health. A physiological SCC value is considered to be 100,000 cells/mL (JUOZAITIENE ET AL., 2006). In the present study, milk SCC reached physiologically normal levels between 7 and 10 days after calving. In cows from which udder pathogenic bacteria were detected, the somatic cell count of milk samples tended to reach the physiological range characteristic of bovine milk at a later stage of lactation. In these animals, somatic cell count values approached the physiological threshold of 100,000 cells/mL around day 28 postpartum, whereas in milk samples obtained from clinically healthy cows this level was reached earlier.

5. NEW SCIENTIFIC RESULTS

1. For the first time, I demonstrated that udder health in Alpine dairy goats has a substantial effect on the fatty acid composition of milk. Milk samples with an increased somatic cell count (above 1,000,000 cells/mL) exhibited a lower proportion of de novo synthesised fatty acids in the mammary gland compared to samples with a low somatic cell count (below 400,000 cells/mL) (50.3% vs. 46.7%; $P < 0.01$).

2. For the first time, I established that during milking, hornless Alpine goats exhibited a calmer temperament compared to their horned counterparts (4.2 vs. 3.8 points; $P < 0.01$). A total of 87% of hornless does received scores of 4 or 5, whereas only 75% of horned goats were classified as calm based on their temperament scores ($P < 0.05$).

3. For the first time, I demonstrated that hornless Alpine goats are characterised by more favourable udder health. The detection rate of mastitis-causing pathogens was 47.4% in the hornless group, whereas it was significantly higher in horned goats (65.5%; $P < 0.05$).

4. For the first time in a Hungarian dairy goat population, I demonstrated that the kidding season markedly influenced both reproductive performance and milk yield. Does kidding in summer showed a lower prolificacy rate (1.00) and produced less milk (294 kg) compared to those kidding in spring (1.63 and 557 kg, respectively; $P < 0.05$).

5. I demonstrated that teat morphology (cylindrical vs. funnel-shaped) in Alpine goats had a significant effect on the proportion of mastitis-causing bacteria detected in milk. Pathogenic bacteria were identified in 58% of milk samples from goats with funnel-shaped teats, whereas this proportion was only 36% in goats with cylindrical teats ($P < 0.05$). Furthermore, I established that milk samples collected from goats with funnel-shaped teats had a significantly higher somatic cell count (5.79 ± 0.42 log cells/mL) compared to those from goats with cylindrical teats (5.60 ± 0.42 log cells/mL; $P < 0.05$).

6. For the first time in a Hungarian dairy herd, I demonstrated that in clinically healthy, second-lactation Holstein–Friesian cows the milk somatic cell count reaches the physiological range characteristic of lactating cows (100,000 cells/mL) between days 7 and 10 postpartum. In contrast, in cows whose milk samples were positive for udder pathogenic bacteria, somatic cell count values reached this species-specific physiological range at a later stage of the postpartum period, typically around day 28.

Scientific publications of the author according to the topic so far

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Peer-reviewed publications with impact factor

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