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The cow reproductive perspective in relation to the colostrum quality and udder health in early lactation

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Abstract. The study aimed to evaluate cow reproductive performance in relation to colostrum quality measured using a digital Brix refractometer and udder health in early lactation. A dataset of 676 cows was collected from one commercial dairy farm in Latvia over 36 months in 2022–2024. Colostrum Brix% was associated with the year and season of the year. The colostrum quality, as measured by the Digital Brix refractometer, was acceptably high, ranging from 23 to 30 in all cows during the study. The main individual factors associated with colostrum Brix% were the number of lactations, the sex of the calf, and lactose content in the first milk recording after calving. No association was detected between colostrum Brix% and the length of the dry period or the last milk recording data. Neither somatic cell count nor colostrum Brix% was associated with reproductive performance, service period, or the number of inseminations.

Key words: Brix, immunoglobulins, milk lactose, somatic cell count.

INTRODUCTION

Colostrum quality is a crucial prerequisite for ensuring passive immunity in a calf during the postnatal period and the first weeks of life. Measurements of colostrum quality by a refractometer can be easily applied at any farm. The obtained results can guide immediate decisions about the suitability of colostrum for the calf, either by direct use or by freezing and storing it in a freezing chamber for later use. If the refractive index of colostrum or Brix% is less than 21, the colostrum is suboptimal for the rise in passive immunity in a new-born calf because it might contain insufficient level of immunoglobulins (IgG < 50 g L^{-1}) (Quigley et al., 2013). Feeding of good-quality colostrum with Brix% > 22 from another cow or using thawed colostrum from a storage might serve as a preferable option.

The amount and composition of colostrum produced vary depending on multiple individual-level, herd-level, and seasonal factors (Westhoff et al., 2024).

A recent study highlighted the importance of metabolic status, nutrient utilisation, and the increasing availability of antioxidants during the last six weeks of gestation for volume of colostrum and immunoglobulin content of the colostrum (Rossi et al., 2023). The hypothesis proposed in this context is that colostrum quality measurement data might serve not only as a parameter for immediate action in favour of optimal building up of strong passive immunity in calves, but also as an indicative measure of cow preparedness for entering a new lactation with a successful reproductive and udder health perspective. However, there are no studies on evaluating hypotheses about possible associations of colostrum quality data and cow further reproductive performance in the new-started lactation. Therefore, the aim of the current study was to assess cow reproductive performance in relation to colostrum Brix percentage and udder health during early lactation. To achieve the aim, the objectives were as follows: evaluate yearly and seasonal fluctuations of the colostrum Brix% over a whole two-year period of time; compare colostrum Brix% values between cows in 1st and 2nd lactation with older cows; evaluate associations between colostrum Brix% and the number and sex of calves born to the cow; check for the possible impact of the length of the dry period on the colostrum quality; check for associations between colostrum quality and somatic cell count before and after the dry period; check the associations between colostrum quality, length of service period, and the number of inseminations.

MATERIALS AND METHODS

The study was conducted on a commercial dairy farm located 100 meters above sea level in Latvia in a moderate climate zone (56°28′10″N; 22°53′27″E) over 36 months in 2022–2024. Cows were included in this study if colostrum was visually acceptable (free of blood and debris) and the amount was more than one litre. Cows were excluded from the study due to a lack of colostrum, mastitis at calving, or trauma to the udder or teats. Cows after colostrum investigation were followed up throughout the entire service period (from parturition to conception) until pregnancy was confirmed. Infertile cows were followed up until they were removed from the herd, but no longer than 400 days of the lactation.

Colostrum quality was measured using a digital Brix refractometer (MA871, Milwaukee Electronics Kft, Hungary), within the first calf feeding process (within 2 hours after calving), and the values were recorded for each calving as Brix%.

For each cow included in the study, milk recording data were obtained from the cow pedigree cards of the Agricultural Data Centre. The dataset was supplemented by the cow's milk yield, somatic cell count, fat percentage, protein percentage, and lactose percentage recorded during the first milk recording after calving. For multiparous cows, the dataset was supplemented by the cow's milk yield, somatic cell count, fat percentage, protein percentage, and lactose percentage recorded during the last milk recording before drying off at the end of the previous lactation. For all cows with a full lactation, the dataset was supplemented with the cow's total milk yield, average somatic cell count, average fat percentage, average protein percentage, and average lactose percentage for a standard 305-day lactation. The length of the dry period preceding the calving was also registered for all multiparous cows.

The number of calves (single or twins) was registered and included as a covariate when building a regression model. The gender of the calf (female or male) was also recorded.

Reproductive performance of individual cows was evaluated by the calving intervals, length of the service period, and the number of inseminations required to get the cow pregnant.

Cows with somatic cell count higher than 200,000 cells mL^{-1} were assumed to be suffering from some udder inflammation or any other problems of milk secretion. For the somatic cell count results to match the data normality assumption, the absolute value was converted to a somatic cell count score (SCS) standardised log2 units using formula (1), or in cows with a low somatic cell count of less than 12,000 cells mL^{-1}, to SCS = 0. After the conversion, the somatic cell count threshold value of 200,000 cells mL^{-1} corresponds to SCS = 4.0 log_2 units (Shook, 1993).

$$SCS = log_2(SCC \cdot 10^{-5}) + 3 \quad (1)$$

where SCS – somatic cell count score, log_2 units; SCC – somatic cell count, cells mL^{-1}.

Statistically, proportions were compared using the Pearson Chi-square test and Fisher's exact test. The length of the dry period, calving interval, and service period were compared between cow groups using the Student t-test; however, associations were evaluated by multiple linear regression.

Linear regression coefficients and all differences between groups were considered statistically significant if $P < 0.05$.

RESULTS AND DISCUSSION

During a thirty-six-month period of the study, $n = 676$ calving were followed up, and colostrum samples were obtained at each calving. The proportion of primiparous cows among all cows was 36.9%, 33.3%, and 34.3% in the first, second, and third years of the study. The proportion of second-parity cows was 26.2%, 23.9%, and 28.7%, respectively (Table 1). There were no significant differences in the parity distribution between the three years of the current study. This should be noted because the volume of colostrum in older cows increases, and a recent study (Rossi et al., 2023) showed a negative low correlation between colostrum volume and IgG ($r = -0.28$), IgA ($r = -0.15$), but not with IgM.

Table 1. The number (proportion) of heifers and second-parity cows among all cows during the three-year study (year 2022, 2023, and 2024)[1]

Parity	Year 1	Year 2	Year 3	TOTAL
1st lactation	100 (36.9%)	99 (33.3%)	37 (34.3%)	236 (34.9)
2nd lactation	71 (26.2%)	71 (23.9%)	31 (28.7%)	173 (25.6%)
3rd lactation	52 (19.2%)	56 (18.9%)	20 (18.5%)	128 (18.9%)
4th lactation	30 (11.1%)	51 (17.2%)	10 (9.3%)	91 (13.5%)
5th lactation	6 (2.2%)	16 (5.4%)	6 (5.6%)	28 (4.1%)
6th lactation	7 (2.6%)	3 (1.0%)	4 (3.7%)	14 (2.1%)
7th lactation	4 (1.5%)	1 (0.3%)	0 (0.0%)	5 (0.7%)
8th lactation	1 (0.4%)	0 (0.0%)	0 (0.0%)	1 (0.2%)
TOTAL	271 (100.0%)	297 (100.0%)	108 (100.0%)	676 (100.0%)

[1]The difference between years was not significant ($p > 0.05$).

The colostrum quality, as measured by the Digital Brix refractometer, was acceptably high in all cows during the study. The minimum value of colostrum Brix% was 23 but the maximum was up to 30. However, there was higher proportion ($p < 0.05$) of Brix% values of 25–26 in Year 2 and Year 3 if compared to the Year 1 of study (Table 2).

Table 2. The number (proportion) of cows in three Brix% categories during the three-year study[1]

Brix%	Year 1	Year 2	Year 3	TOTAL
23–24	104 (38.4%)	42 (14.1%)	15 (13.9%)	161 (23.8%)
25–26	148 (54.6%)	231 (77.8%)	83 (76.9%)	462 (68.3%)
27–30	19 (7.0%)	24 (8.1%)	10 (9.3%)	53 (7.8%)
TOTAL	271 (100.0%)	297 (100.0%)	108 (100.0%)	676 (100.0%)

[1]The difference between years is statistically significant ($p < 0.05$).

The seasonal fluctuations of the average Brix% values were less expressed during the first year of study (Fig. 1). There were no significant differences ($P > 0.05$). During the second year of the study, the highest average value of colostrum Brix% (25.5 ± 0.1) was reached in spring (March, April, May). A significantly lower average value of 25.1 ± 0.1 was detected in summer (June, July, August). Colostrum quality stayed at a similar level also in the next season (September, October, November). Although the dynamics of colostrum Brix% by season are unclear, the decrease in colostrum quality towards summer and fall can likely be attributed to the higher likelihood of thermal distress in late-stage pregnant cows. A research study showed decreased rumination, higher rectal temperatures, and reduced milk yield in cows during acute heat stress (Penev et al., 2021). Other researchers have found lower colostrum Brix% values in calving around August and September; therefore, banking high-quality colostrum might be one option to address fluctuations (Borchardt et al., 2022).

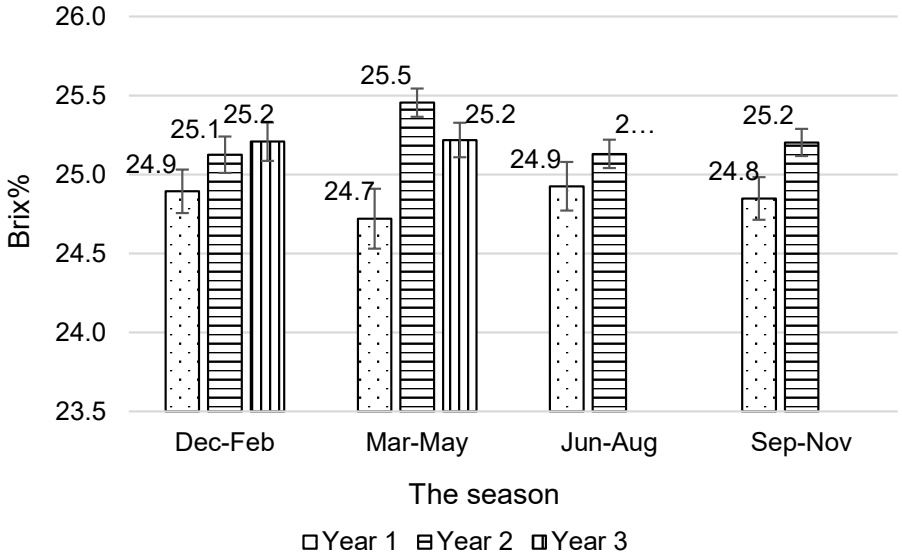

Figure 1. The seasonal fluctuations in the average colostrum Brix percentage.

The effect of cow lactation number or parity was displayed in the table to show a significant association (Table 3). In first parity cows, the Brix% was the lowest. Out of all primiparous cow calvings, 30.5% showed Brix% values in the lower category. Whereas in older cows, only 18.0% of all cows belonged to this category. The second-parity cows were in the middle position. The highest of all colostrum Brix% results were more often in the group of older cows (10.9%) in comparison to first parity cows (5.9%). The tendency for older cows to produce colostrum with considerably higher Brix% is primarily explained by the prolonged stimulation of the cow's immune system by various antigens (Borchardt et al., 2022). However, other explanations could also be accurate, such as the fact that second-lactation cows have a higher mammary secretory ability or that the hormonal and metabolic milieu differs between the first and second lactation, even for the same cow (Cattaneo et al., 2023). In the present study, comparison did not reveal a significant difference in colostrum Brix% between the second lactation and the first lactation in the same cow (25.1 ± 0.1 and 24.8 ± 0.2, $P > 0.05$). On the contrary, the third lactation Brix% and second lactation Brix% in the same cows were different (25.2 ± 0.2 and 24.5 ± 0.2, $P < 0.05$).

Table 3. The number (proportion) of cows in three Brix% categories depending on the cow parity[1]

Brix%	1st lactation	2nd lactation	3rd + lacttion	TOTAL
23–24	72 (30.5%)	41 (23.7%)	48 (18.0%)	161 (23.8%)
25–26	150 (63.6%)	122 (70.5%)	190 (71.2%)	462 (68.3%)
27–30	14 (5.9%)	10 (5.8%)	29 (10.9%)	53 (7.8%)
TOTAL	236 (100.0%)	173 (100.0%)	267 (100.0%)	676 (100.0%)

[1]The difference between years is statistically significant ($p < 0.05$).

There was no difference in colostrum Brix% between calving where single calves or twins were born. But there was a significant difference depending on the value of sex. The cows with male calves had higher Brix% than cows with female calves (Fig. 2).

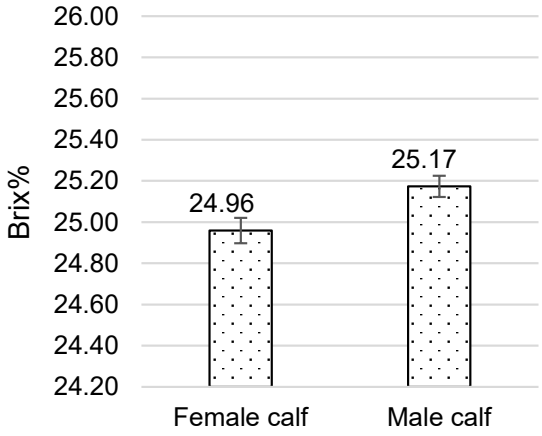

Figure 2. The difference in average colostrum Brix% for cows with male or female calves born.

There was no significant association between colostrum Brix% and the milk recording data (milk yield (L), fat %, protein %, lactose %, somatic cell score (SCS in points)) at the last milk control test-day of the previous lactation. There was no significant association with the length of the dry period for multi-parity cows, even though this is often found to be a factor affecting colostrum quality (Dunn et al., 2017; Borchardt et al., 2022). Average milk recording data from the new standard lactation were not associated with colostrum Brix%. Out of data obtained at the first milk control test-day after calving, only lactose % was associated with colostrum Brix%

(Table 4). This probably reflects a mechanism in the udder that is necessary for the transfer of immunoglobulins from blood into milk, but has been overlooked until now. This association is related to the age of the cow, as older cows had milk with lactose percentages above 5.0 and Brix percentages above 26. A negative correlation between the colostrum lactose percentage and the level of IgG has been found in studies by other authors, as colostrum has a lactose percentage as low as the mean ± SD = 2.7 ± 0.55 (Dunn et al., 2017) or even lower (Soufleri et al., 2021). The highest immunoglobulin levels can be found in the colostrum of cows that are in the 3rd–5th lactation, and the lowest in the primiparous cows (Puppel et al., 2019).

Table 4. Linear multivariable association of colostrum quality with cow-related factors from 1 commercial dairy farm; colostrum quality was assessed using a digital Brix refractometer

Variable	Estimate (% Brix)	SE[1]	Lower 95% CI	Upper 95% CI	*P*-value
Intercept	22.31	1.10	20.15	24.47	< 0.001
Lactose % at the first milk recording test	0.46	0.22	0.02	0.89	0.039
1st year of study	Referent				
2nd year of study	0.31	0.09	0.13	0.48	0.001
3rd year of study	0.29	0.12	0.04	0.53	0.021
Lactation number	0.10	0.03	0.04	0.16	0.001
Female calf	Referent				
Male calf	0.20	0.08	0.04	0.36	0.001

[1]Standard error.

Essential factors for the cow reproductive performance, namely, the service period (days to pregnancy) interval, along with evaluation of Brix% at the start of new lactation are displayed (Table 5).

Table 5. Potential predictors for the cow service period were tested along with colostrum Brix%; colostrum quality was assessed using a digital Brix refractometer

Variable	Estimate (days)	SE[1]	Lower 95% CI	Upper 95% CI	*P*-value
Intercept	13.6	41.1	-67.3	94.5	0.741
305-day lactation milk yield, 1,000 kg	4.2	0.7	2.7	5.7	< 0.001
Number of artificial inseminations	34.0	1.5	31.1	36.8	< 0.001
Brix% of colostrum	-0.8	1.6	-4.0	2.3	0.608

[1]Standard error.

The reproductive perspective of an individual cow in the dairy herd is strongly associated with milk productivity and successful insemination. No significant role was found for colostrum Brix% at the start of new lactation.

CONCLUSIONS

The Brix% of colostrum on a dairy farm is different from year to year. Lower and more variable Brix% values were observed in the summer and autumn seasons, possibly due to higher environmental temperatures and/or high air humidity, which may have

caused thermal discomfort for cows during the last weeks of gestation. Colostrum quality measured by digital Brix refractometer increases from first to second parity and from second to third parity. Some association was detected between Brix% and milk lactose% at the first milk control test-day. Brix% was higher in cows with male calves than in cows with female calves. No significant role was found for colostrum Brix% at the start of new lactation in predicting the reproductive performance of individual cows.

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