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Experimental evaluation of milk yield and selected traits of milk quality in Clun Forest ewes

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Abstract: In general, it can be stated that the economics of non-dairy sheep breeding in the Czech Republic experienced a worsening trend in recent years. One of the ways to improve this situation is to use some of these breeds also for milk production. One of the possible breeds usable for milk production, especially for the good milk production of mothers, is the Clun Forest (CF). The aim of our experiment was to evaluate the daily milk yield (DMY) and the contents of fat (F), total protein (TP) and lactose (L), pH, titratable acidity (TA), concentration of urea (CU) and somatic cell count (SCC) in CF ewes during lactation. In our experiment, the following means of individual traits for the whole lactation were found: DMY: 579 g, contents of F, TP and L: 6.73%, 5.82% and 4.98%, pH: 6.55, TA: 8.74 °SH, CU: 36.08 mg/100 ml and log SCC: 4.71. The stage of lactation had a significant ($P < 0.01$) effect on DMY, contents of F and TP and pH and TA. The results of our experiment show that CF ewes had lower DMY than dairy breeds (DB). However, the majority of the milk quality traits was comparable to DB. Moreover, the high fat and protein contents and the values of most other milk quality traits are good prerequisites for high cheese yield and optimal final quality of other sheep's milk products. The results of our experiment suggest that CF ewes could be used for milk production while the milk production of CF ewes should ensure an improvement in the economics and competitiveness of smaller farms in particular.

Keywords: basic milk composition; acidity of milk; somatic cells; stage of lactation

In the last thirty years, sheep breeding in the Czech Republic has been mainly focused on the production of heavy lambs. However, especially on smaller farms, this production has been economically problematic for a long time. This fact was mainly manifested from 2016 to 2021. During this period, the number of sheep in the Czech Republic decreased by approximately 20%. In our opinion, this decrease was mainly influenced by the decline in the opportunity to sell lambs to restaurants during the Covid-19 crisis and by lower subsidies for sheep breeding than for the breeding of beef cattle. Some breeders also significantly reduced their numbers of sheep or even stopped breeding due to repeated wolf attacks on their flocks. In general, the economics of dairy sheep farms in the Czech Republic is better in the long term than the economics of farms

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focused only on meat production. The main reasons for this fact lie in the continuous growth of consumer interest in sheep's milk products and relatively affordable farm prices for these products.

One of the ways to improve the economics of non-dairy sheep farming, which primarily concerns smaller farms, is to use these sheep for milk production as well. The assessment of milk production in non-dairy sheep is generally infrequent. However, studies carried out by Sakul and Boylan (1992), Peeters et al. (1992), Ochoa-Cordero et al. (2002), Morgan et al. (2006), Shrestha et al. (2008), Kremer et al. (2010) and Milerski et al. (2020) were primarily focused on this issue. These studies mainly show that in non-dairy ewes, the milk yield is usually lower, and the length of lactation is shorter than that of traditional dairy ewes, but the contents of protein and fat in milk are comparable.

Due to the good milk yield of the mothers, one of the possible atypical dairy breeds that could also be used for milk production is the Clun Forest (CF) breed. There is not much information about the milk production of this breed; the only study we managed to find was a relatively old study carried out by Ashton et al. (1964). This study, which focused on the evaluation of the milk composition, showed that the milk of CF ewes has relatively high levels of fat, protein and calcium. So, although there is limited information on the milk production of CF ewes, we presume that this breed could also be used for milk production, preferably on smaller farms. Considering the above, the aim of our experiment was to evaluate the daily milk yield and selected traits of milk quality in CF ewes during lactation.

MATERIAL AND METHODS

Animals, nutrition and experimental design

The experiment was carried out on an organic sheep farm located in the Vysočina Region of the Czech Republic (an altitude of 460 m above sea level; average annual temperature of 8.5 °C; annual precipitation of 775 mm).

Experimental procedures and animal care conditions followed the recommendation of European Union Directive 86/609/EEC and were approved by Expert Commission for Ensuring the Welfare of Experimental Animals of Mendel University in Brno.

Nine ewes of the CF breed in the second lactation were included in the experiment. All monitored ewes lambed singles. The number of monitored ewes in our experiment was relatively low. However, in the CR there is a relatively small population of the ewes of the CF breed, when the average number of ewes per farm is about 15 heads. Therefore, it was practically impossible to carry out the evaluation of milk yield and selected traits of milk quality in a larger number of ewes respecting the same lactation number and litter size.

At the beginning and throughout the experiment, all ewes were clinically healthy. The lambing occurred in the second half of March. During the experiment, all ewes with lambs were reared together on pasture in one common pen. The daily feed ration of ewes consisted of pasture (*ad libitum*), oat (400 g), meadow hay (*ad libitum*) and mineral lick (*ad libitum*). All ewes and lambs also had uninterrupted access to drink water. The weaning of lambs was carried out after the end of the experiment. During our experiment, all ewes and lambs were kept under identical conditions without any discernible differences in their nutrition or management.

Milk recording and sampling

Individual milk recording and sampling of each ewe were carried out from the beginning of May to the middle of August on the mean 46, 79, 114 and 146 days of lactation. The evening before each recording and sampling, all lambs were separated from their mothers (from 18:00 to 8:00 the next morning) into a pen that was next to the pen with their mothers. In this pen, the lambs had plenty of pasture and space, as well as free access to water, hay and mineral lick. During this period all ewes were milked in the morning at 7 a.m. All monitored ewes were always milked by hand. Subsequently, milk yield recording and milk sampling were carried out. After milk sampling all individual milk samples were cooled to 5–8 °C and transported to the specialised milk laboratory at Mendel University in Brno and to the private Laboratory for Milk Analysis in Brno-Tuřany (Bohemian-Moravian Association of Breeders, a.s.). The daily milk yield (DMY; in g) was de-

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termined on the basis of the weight of the milk from the morning milking. The conversion factor of morning milk weight to total daily milk yield was 1.8 (Association of Sheep and Goat Breeders in the Czech Republic 2020).

Milk analysis

Fat (F) content (in %) was determined by the Gerber acid-butyrometric method (Czech Technical Standard ISO No. 2446). Total protein (TP) content (in %) was determined according to the Czech Technical Standard EN ISO 8968-1 using a Kjeltec analyser (Foss Electric, Hillerod, Denmark). Lactose (L) content (in %) was determined polarimetrically (Czech Technical Standard No. 570530). Active acidity (pH) was measured with the WTW 95 pH-meter with the WTW SenTix 97 probe. Titratable acidity (TA, in °SH) was determined by titration using the Soxhlet–Henkel method (Czech National Standard No. 570530). Determination of milk urea concentration (CU; in mg/100 ml of milk) was carried out according to ČSN ISO 14637 (570102) by the enzymatic-conductometric method on a Ureakvant instrument. The SCC was determined using a BENTLEY 2500 fluoro-opto-electronic counter (Czech National Standard EN ISO No. 13366-2).

Statistical analysis

The SCCs were transformed into logarithmic forms to normalise their frequency distribution before performing a statistical analysis. The Statistica v12 software was used to perform the statistical analysis (StatSoft CR s.r.o., Prague, Czech Republic). Data was analysed via the analysis of variance procedure, one-way ANOVA (*post hoc* analysis using the Tukey test). The effects of the stage of lactation were included in ANOVA model. The differences between means were considered statistically significant at $P < 0.05$ and $P < 0.01$. Pearson's correlation coefficients were calculated for all measured traits via Statistica v12 software ($^{*}P < 0.05$; $^{**}P < 0.01$).

RESULTS AND DISCUSSION

The effect of the stage of lactation (SL) on all monitored traits is presented in Table 1. The correlations between all monitored traits are presented in Table 2.

The DMY of non-dairy sheep breeds is usually lower than that of traditional dairy sheep. This fact was also found in our experiment. However, DMY in CF ewes in the present experiment was also comparable or even higher than that of dairy breeds

Table 1. Evaluation of DMY, basic milk composition, acidity, concentration of urea and SCC in Clun Forest ewes during lactation

Trait	Mean day of lactation				Range of individual samples	Overal mean	Significance
	46	79	114	146			
DMY (g)	756^{BCD}	670^{ACD}	499^{ABD}	390^{ABC}	288–864	579.00	**
Fat (%)	5.82^{CD}	6.28^{D}	6.76^{AD}	8.04^{ABC}	5.46–9.11	6.73	**
TP (%)	5.05^{CD}	5.54^{D}	5.94^{AD}	6.75^{ABC}	4.58–8.03	5.82	**
Lactose (%)	5.01	5.05	4.96	4.91	4.48–5.35	4.98	NS
pH	6.62^{cD}	6.56	6.50^{a}	6.53^{A}	6.31–6.68	6.55	**
TA (^{0}SH)	6.94^{BCD}	8.54^{AD}	9.38^{A}	10.11^{AB}	5.92–11.64	8.74	**
Urea (mg/100 ml)	34.89	35.56	38.00	35.89	19–78	36.08	NS
SCC	91 111	51 333	68 111	83 000	6 000–267 000	73 389	NS
Log SCC	4.81	4.61	4.66	4.76	3.78–5.40	4.71	NS

DMY = daily milk yield; NS = $P > 0.05$ (not significant); SCC = somatic cell count; TA = titratable acidity; TP = total protein

$^{**}P < 0.01$, tested by one-way ANOVA

$^{a–c}$The same characters on one line indicate the statistically significant difference between individual samples (tested by paired Student's *t*-test) $P < 0.05$

$^{A–D}$The same characters on one line indicate the statistically significant difference between individual samples (tested by paired Student's *t*-test) $P < 0.01$

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Table 2. Pearson's correlation coefficients between all traits in the experiment

	DMY	Fat	TP	Lactose	pH	TA	Urea	Log SCC
DMY	1	–0.88**	–0.83**	0.32	0.55**	–0.79**	–0.06	0.02
Fat	–	1	0.92**	–0.23	–0.45**	0.74**	–0.04	0.07
TP	–	–	1	–0.30	–0.51**	0.79**	–0.07	0.16
Lactose	–	–	–	1	0.13	0.33*	0.03	–0.10
pH	–	–	–	–	1	–0.62**	0.19	0.30
TA	–	–	–	–	–	1	–0.20	–0.10
Urea	–	–	–	–	–	–	1	0.44**
Log SCC	–	–	–	–	–	–	–	1

DMY = daily milk yield; SCC = somatic cell count; TP = total protein; TA = titratable acidity
*$P < 0.05$; **$P < 0.01$

evaluated by Bendelja et al. (2009); Mioc et al. (2009) and Oravcova et al. (2018). Regarding the comparison with non-dairy breeds, in our experiment, the average DMY for the whole lactation period in CF was higher or comparable with the values found for this trait by Sakul and Boylan (1992) in Dorset, Lincoln, Rambouillet, Romanov and Suffolk ewes; Nudda et al. (2002) in Merino ewes; Shrestha et al. (2008) in Lincoln, Targhee, Dorset, Finnsheep, Romanov and Suffolk ewes and Kremer et al. (2010) in Corriedale ewes. On the other hand, the average DMY of CF ewes for the whole lactation was lower than reported by Slen et al. (1963) in Suffolk, Hampshire, Rambouillet, Canadian Corriedale and Rommelet ewes; Ochoa-Cordero et al. (2002) in Rambouillet ewes and Morgan et al. (2006) in Border Leicester and Coopworth ewes. In conclusion to the above, it is necessary to note that the milk yield in many of the above studies could be influenced not only by breed but also by other factors such as nutrition, climate and breeding management.

Regarding the effect of SL on DMY in our experiment, this factor had a significant ($P < 0.01$) effect on this trait when DMY gradually decreased during lactation, which is in agreement with Mioc et al. (2009), Bendelja et al. (2009) and Oravcova et al. (2018).

Many studies that were carried out in non-dairy breeds show that the F and TP contents are relatively high during lactation and are often comparable with those of dairy breeds. This fact was also found in the present experiment, when the contents of both fat and protein were higher or comparable with the data reported by Koutsouli et al. (2017) in Chios and Karagouniko ewes; Oravcova et al. (2018) in different dairy breeds in Slovakia; Paschino et al. (2019) in Sarda ewes; Figueroa Sanchez et al. (2021) in Manchega ewes and Pelayo et al. (2021) in Spanish Churra ewes. The average contents of F and TP in CF were also slightly higher than the data reported by Leitner et al. (2016) in samples from 226 ewe bulk milk tanks from Israeli herds from all over the country; Sakul and Boylan (1992) in meat and fertile breeds and Antunovic et al. (2017) in Merinolandschaf ewes. It is interesting to compare the F and TP contents in CF in our experiment with the results reported for the same breed by Ashton et al. (1964). This comparison primarily shows that in our experiment, the average TP content was higher compared to the values of this trait (5.82% vs 5.6% and 5.2%) reported in the 1964 study. On the other hand, Ashton et al. (1964) found a higher average F content (7.1% vs 6.73%) in the first year of their study. However, in the second year of their study, the content of this milk component was significantly lower (5.2%).

Regarding the effect of SL on the contents of F and TP in the present experiment, this factor had a significant ($P < 0.01$) effect on both these milk components when their contents gradually increased, which is in accordance with the data reported by Kuchtik et al. (2017), Oravcova et al. (2018) and Kawecka et al. (2020).

In contrast to F and TP contents, the content of lactose was very balanced during the entire lactation (from 4.91% to 5.05%) and SL did not have a significant effect on this trait, which is in line with Pazzola et al. (2014), Antunovic et al. (2017) and Oravcova et al. (2018). At the same time, however, it must be noted that the L content was higher in our experiment during the entire lactation than

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in the above-mentioned studies. On the other hand, Morgan et al. (2006) found the significantly higher content of this milk component in primiparous non-dairy crossbred ewes compared to our results. However, in the case of Morgan et al. (2006) study, only two samplings were carried out.

The optimal pH values of raw sheep milk range from 6.4 to 6.8 while many studies have shown that the pH of milk is primarily affected by mastitis and that its value affects milk aptitude for rennet coagulation and cheese-making. All pH values in our experiment were in the optimal range and SL had no significant effect on this trait. Compared to that of dairy sheep, the average pH value in CF ewes was comparable to the data reported by Kuchtik et al. (2017) and Pelayo et al. (2021), slightly lower than that published by Matutinovic et al. (2011) and significantly lower than that published by Pazzola et al. (2014) and Pelayo et al. (2021). Regarding the pH of milk in non-dairy sheep, information on its values in these breeds has not been found in any other studies. Likewise, data from other studies on TA, CU and log SCC in these breeds were not found either.

Optimal values for the TA of raw cow milk range from 6.2 to 7.8 °SH. However, studies carried out by Novotna et al. (2009), Kuchtik et al. (2017) and Kawecka et al. (2020) show that the TA of sheep milk is higher. Kawecka et al. (2020) also stated that TA in sheep milk is significantly influenced by protein content. In our experiment, TA significantly increased from the beginning to the end of lactation, which is consistent with the trends published by Novotna et al. (2009), Kuchtik et al. (2017) and Kawecka et al. (2020), while the correlation between TP and TA was significantly positive, which is in line with Kawecka et al. (2020). The TA values in our experiment were also significantly higher than the optimal range of this trait in cow's milk, which is, however, in accordance with the data published by Novotna et al. (2009), Kuchtik et al. (2017) and Kawecka et al. (2020). It is interesting that the highest number of significant correlations with other traits was found for TA. However, as expected, due to increasing TA values and F and TP contents during lactation, the correlations between TA and F and between TA and TP were significantly ($P < 0.01$) positive. On the other hand, due to the decrease of DMY during lactation, a significant ($P < 0.01$) negative correlation between TA and DMY was found, when the same correlation was found by Kuchtik et al. (2017). In conclusion to the above correlations, it must be added that the correlation between TA and L content was significantly ($P < 0.05$) positive and the correlation between TA and pH was significantly ($P < 0.01$) negative, while the same correlation between TA and pH was reported by Pavic et al. (2002) and Kuchtik et al. (2008).

The CU in sheep milk can be affected by a number of other factors such as nutrition, breed, stage of lactation, body mass, daily production and chemical composition of milk, somatic cell count, season and milking methods (Bendelja et al. 2009). According to the same authors, normal milk CU in sheep milk ranges from 10 to 30 mg/100 ml. Due to the changing nutritional value of pasture during our experiment, it was expected that SL would have a significant effect on this trait. However, throughout the lactation, the values of this trait were quite balanced, and SL did not have a significant effect on this trait. In conclusion to this part, it should be added that the CU values in our experiment were slightly higher than the recommended range published by Bendelja et al. (2009). However, on the other hand, the CU values of CF ewes were significantly lower than the values of this trait reported by Mugetti et al. (2012).

The SCC is among the most important qualitative traits of sheep's milk (Tvarozkova et al. 2021). Many studies also show that this trait represents a sensitive marker for udder health. However, in the European Union, there is no legal limit for this trait, and the threshold or limit of SCC in sheep milk is still a debated topic (Albezio et al. 2019). According to the same authors, quite a lot of studies show that the threshold for SCC in a healthy ewe should not be higher than 250 000 cells/ml. During our experiment, all monitored ewes were in a very good state of health, which was reflected in relatively low and balanced values of SCC when SL did not have a significant effect on this trait. At the same time, it must be noted that in our experiment, the average values of SCC in all samplings were lower than the threshold of 250 000 cells/ml. In concluding an evaluation of CU and SCC, it should be added that not a single correlation of CU and SCC with any of the other monitored traits was significant, with the exception of the correlation between these traits themselves. In this case, a significant ($P < 0.01$) positive correlation was found.

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CONCLUSION

The results of our experimental evaluation of the milk yield of Clun Forest ewes show that the daily milk yield of these ewes is lower than that of most dairy breeds. However, the contents of fat and total protein in CF ewes were comparable with dairy breeds. The stage of lactation had a significant effect on daily milk yield, contents of fat and total protein, pH and titratable acidity. On the other hand, the stage of lactation had no significant effect on lactose content, concentration of urea and log SCC. Furthermore, during the entire experiment, the values of pH and log SCC were within the recommended values. The results found in our experiment, despite the relatively low number of evaluated ewes, suggest that CF ewes could also be used for milk production. In addition, the high F and TP contents and optimal values of pH and log SCC are good prerequisites for high cheese yield and optimal final quality of other sheep's milk products. In conclusion, it should be added that some interesting results of our experiment show that it is necessary to continue in more extensive and detailed studies regarding the dairy production of both the Clun Forest breed and some other non-traditional dairy breeds of sheep.

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Conflict of interest

The authors declare no conflict of interest.

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