Evaluation of Lactose Percentage in Relation to the Somatic Cells Count in Milk of Dairy Cows of the Slovak Spotted Cattle

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Abstract
The aim of this study was to evaluate lactose percentage in relation to the somatic cells count in milk of Slovak Spotted cattle. A total of 468,082 control milk samples from 28,848 dairy cows born from 2000 to 2014 were used for investigating lactose percentage (LP), milk yield (MY), lactose yield (LY), fat percentage (FP), proteins percentage (PP) and somatic cells count (SCC). Data were analysed using the SAS version 9.4 and linear model with fixed effects: farmer (F), years-month of control (YM), order of lactation (OL), sire (S), coding of SCC (CS). In the dataset the average of LP was 4.78±0.27 %, while the one of MY, LY, FP, PP and SCC were 20.44±8.65, 0.98±0.43, 4.04±0.80, 3.49±0.37 and 455.95±1,296.16 cells *1000/ ml. The correlation of LP with MY, LY, FP, PP, and SCC was equal to r = 0.33205, r = 0.41609, r = -0.11414, r = -0.24404 and r = -0.31175. These correlation coefficients were statistically highly significant P <0.0001. Among all fixed effects in the analysis of variance of LP, the most relevant effect was observed for CS (P<.0001).

Keywords: cattle, dairy cows, milk components, lactose, somatic cells count, correlation

1. Introduction

Lactose is a major component of milk that is not usually directly considered in national genetic improvement programs of dairy cattle [1, 2]
The lactose percentage and other traits of milk production in percentage may be used in indirect selection for health and fertility traits, which are economically important, but of low heritability as shows [3-5].
The lactose percentage in milk is influenced by multiple factors as are genetic [6, 7 and 8] and no-genetic it's mainly nutrition as they states these authors [9, 10].
The relation between lactose and somatic cells count was the subject of the research of many authors, such as [11-14].
The evaluation of production traits, somatic cells count and relation between each other in dairy cows shows authors in Slovakia [15-17], in others country as [18-20] and other authors.
The aim of this study was to evaluate lactose percentage in relation to the somatic cells count in milk of Slovak Spotted cattle.

2. Materials and methods

Data for evaluation of milk components and somatic cells count in population of dairy cows of

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the Slovak Spotted cattle was provided from the database of Breeding Services of the Slovak Republic [21].

A total of 468,082 control milk samples from 28,848 of dairy cows of the Slovak Spotted cattle born from 2000 to 2014 were used for estimation of parameters for lactose content in % (LP) and correlations with other milk yield in kg (MY), lactose yield in kg (LY), percentage of fat in % (FP), percentage of proteins in % (PP) and somatic cell count in cells/ml.10^3 (SCC).

We divided dairy cows only breed-type S_0 - cows with genetic proportion of pure Slovak Spotted cattle blood into 87.5 % [22] and divided into 5 groups according to the SCC values: I.- up to 200 000 SCC cm^{-3}; II.- 201 000- 400 000 SCC cm^{-3}; III.- 401 000- 700 000 SCC cm^{-3}; IV.- 701 000- 1 million SCC cm^{-3} and V. > 1 million SCC cm^{-3}.

The population of dairy cows was divided into 3 groups according to the average lactose yield in kg (LY): ***1*** lower than mean minus 1 SD - (L1), *2* from mean minus 1 SD to mean plus 1 SD- (L2), ***3*** higher than mean plus 1 SD- (L3).

The basic statistical and variability characteristics (least square means, standard deviations) were evaluated using the Statistical System (SAS) version 9.4 (TS1M2) Enterprise Guide 7.12 [23].

For actual computation a linear model with fixed effects was used:

$$y_{ijklm} = \mu + F_i + YS_j + OL_k + S_l + CS_m + e_{ijklmn}$$

where: μ = mean value of depended variable, F_i = fixed effect of farmer (1 - 302), YM_j = fixed effect of years-month of control (1 - 34), OL_k = fixed effect of order of lactation (1 - 13), S_l = fixed effect of sire (1 - 594), CS_m = fixed effect of coding of SCC (1 - 5), e_{ijkl} = residual error.

Statistical evaluations of the differences between traits were tested at the levels of statistical significance: $^{+}$ P<0.05, $^{++}$ P<0.01, $^{+++}$ P<0.001 or $^{-}$ P>0.05.

3. Results and discussion

The basic traits of lactose percentage (LP), milk yield (MY), lactose yield (LY), fat percentage (FP), proteins percentage (PP), and somatic cell count (SCC) are presented in Table 1. The least square means of LP, MY, LY, FP, PP and SCC in selected population dairy cows were similar to the national means for evaluated traits dairy cows in Slovak Republic (The Breeding Service of the Slovak Republic, S.E., 2017).

Table 1. Statistical characteristic of LP, MY, LY, FP, PP and SCC in population of dairy cows of the Slovak Spotted cattle (S_0)

Traits	n[1]	Statistical parameter			
		LS[2] ± SD[3]	CV[4]	MODE[5]	MEDIAN[6]
Lactose in (%)	28,848	4.78 ± 0.27	5.75	4.84	4.82
Milk yield in (kg)		20.44 ± 8.65	42.30	16.6	20.0
Lactose yield in (kg)		0.98 ± 0.43	43.78	0.91	0.96
Fat in (%)		4.04 ± 0.80	19.76	3.89	3.99
Proteins in (%)		3.49 ± 0.37	10.48	3.52	3.48
SCC in (ml^{-1} x 10^3)		455.95 ± 1,296.16	284.27	22.0	120.0

[1]number of observation, [2] least square means, [3]standard deviation, [4]coefficient of variation, [5]mode (value that appears most often in a set of data), [6]median (value separating the higher half from the lower half of a data sample)

By evaluation of milk yields we found out that the least square means of control samples of milk production during the examined period in all 468,082 control samples in 28,484 dairy cows were for lactose percentage 4.78 ± 0.27%, 20.44 ± 8.65 kgs of milk yield, 0.98 ± 0.43 kgs of lactose yield, 4.04 ± 0.80 % of fat percentage, 3.49 ± 0.37 % of proteins percentage and 455.95 ± 1,296.16 cells/ml.10^3 of SCC. The mean of lactose percentage (4.76 %) was comparable in this study than that reported in literature (4.49% to 5.09%). These results are similar with conclusions as Bujko (2011), Strapák (2013), Atasever and Stádník (2015), Alesio et al. (2016), Bujko et al. (2019) and Costa et al. (2018, 2020).

Table 2. Relation between LP and other traits (MY, LY, FP, PP and SCC)

Traits	MY[1]	LY[2]	FP[3]	PP[4]	SCC[5]
LP[6]	0.33205^{+++}	0.41609^{+++}	-0.11414^{+++}	-0.24404^{+++}	-0.31175^{+++}

[1]milk in kg, [2]lactose in kg, [3]fat in %, [4]proteins in %, [5]somatic cell count in cells/ml.10^3, [6]lactose in %, $^{+++}$ P<0.001

The correlation among the traits of milk production and the somatic cells count, for example lactose in % with milk in kg, fat in %, protein in %, and somatic cells count in cells/ml.10^3, was found as follows r = 0.33205, r = 0.41609, r = -0.11414, r = -0.24404 and r = -0.31175. These coefficients were statistically highly significant p <0.0001. These results are correspondence with results Sneddon, (2016) and Haile-Mariam, Pryce (2017), Satoła et al. (2017) and Costa et al. (2020). In dairy cattle, several studies focused on the negative relationship between LP and SCC and recognized LP as a potential indicator of mastitis and udder health, as shows Miglior et al. (2007) and Costa et al. (2020).

Alessio (2021) where they state that lactose content in milk was positively associated with fat and protein contents as well as negatively associated with somatic cell count (SCC) and total bacteria count (TBC).

Table 3. Factors affecting of lactose percentage (LP) in population of dairy cows of the Slovak Spotted cattle (S_0)

Sources of variability	DF[1]	Mean Square	F- Value	Pr> F	R-Square (R^2) Lactose percentage
Farmer (F)	301	5.645016	78.46	<.0001	0.0481
Years-month (YM)	34	43.597137	601.65	<.0001	0.0407
Order of lactation (OL)	13	218.696106	3127.53	<.0001	0.0742
Sire (S)	594	6.799397	101.48	<.0001	0.1140
Cod_SCC (CS)	4	1583.583092	25542.1	<.0001	0.1792

[1]degree of freedom, [2] coefficient of determination (R^2)

The linear model to represent coefficients of determination on lactose percentage with all fixed effects R^2 = 0.3179 %. These effects were significant (P<.0001). In Table 3 showed the analyses by the effects on lactose percentage (LP) reviled higher effect of Cod_SCC (CS) R^2 = 0.1792 than effect of site R^2 = 0.1140. These effects were significant, P<.0001 (Table 3). These results are similar with results Hagnestam-Nielsen, (2009), Haygert-Velho et al. (2018), Tančín et al. (2018) Bujko et al. (2019) and Costa et al. (2020). Alhussien and Dang (2018) shows that the lactose percentage in milk is influenced by cell count, parity, and season.

4. Conclusions

Data shows that of lactose percentage and SCC negatively correlated and measuring of lactose percentage can reveal a chance in SCC of Slovak Spotted dairy cow's milk. The correlation among lactose in % with milk in kgs, fat in %, protein in %, and somatic cells count in cells/ml.10^3 was found as follows r = 0.33205, r = 0.41609, r = -0.11414, r = -0.24404 and r = -0.31175. The analyses by effects on lactose percentage reviled higher effect of Cod_SCC, where coefficient of determination (R^2) is 0.1792 % than effect of sire, where R^2 = 0.1140 %. These effects were high statistical significant (P<.0001).

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References

1. Sneddon, N. W. 2016. A genetic and economic evaluation of lactose in the New Zealand dairy industry. PhD Thesis. Massey University, Palmerston North, New Zealand. 211p.
2. Haile-Mariam M., Pryce J. E. 2017. Genetic parameters for lactose and its correlation with other milk production traits and fitness traits in pasture-based production systems. Journal of dairy science, 100(5): 3754-3766.
3. Miglior F. et al. 2017. A 100-Year Review: Identification and genetic selection of economically important traits in dairy cattle. J. Dairy Sci. 100: 10251-10271.
4. Costa, A., De Marchi, M., Cassandro, M., Visentin, G., Lopez-Villalobos, N., Penasa, M. 2018. Genetic association between milk lactose, freezing point and somatic cell score in Italian Holstein cows. In *Proceedings of the 11th World Congress on Genetics Applied to Livestock Production* (pp. 11-16).
5. Costa, A., Bovenhuis, H., Penasa, M. 2020. Changes in milk lactose content as indicators for longevity and udder health in Holstein cows. *Journal of dairy science*, *103*(12): 11574-11584.
6. Alessio, D. R. M., Neto, A. T., Velho, J. P., Pereira, I. B., Miquelluti, D. J., Knob, D. A., da Silva, C. G. 2016. Multivariate analysis of lactose content in milk of Holstein and Jersey cows. *Semina: Ciências Agrárias*, *37*(4): 2641-2652.
7. Bujko, J. et al. 2018. The impact of genetic and non-genetic factors on somatic cell count as a monitor of udder health in Slovak Simmental dairy cows. Acta Fytotechnica et Zootechnica, 21(4): 166-168.
8. Bujko, J. et al. 2019. Evaluation of Milk Components and Somatic Cells Count in breeding herd of the Slovak Spotted Cattle. Scientific Papers Animal Science and Biotechnologies, 52(2): 41-46.
9. Karcol, J. et al. 2017. Effect of feeding of different sources of NPN on production performance of dairy cows. Acta Fytotechnica et Zootech., 19(4): 163–166.
10. Juráček, M. et al. 2020. The effect of different feeding system on fatty acids composition of cow's milk. Acta Fytotechnica et Zootechnica, 23(1): 37- 41.
11. Atasever, S., Stádník, L. 2015. Factors affecting daily milk yield, fat and protein percentage, and somatic cell count in primiparous Holstein cows. *Indian Journal of Animal Research, 49*: 313-316.
12. Erdem, H.A., Okuyucu, İ.C. 2019. Influence of hygiene status of cows on somatic cell count and milk components during summer season. *Large Animal Review, 25*, 7-10.
13. Franzoi, M. et al. 2020. Effects of somatic cell score on milk yield and mid-infrared predicted composition and technological traits of Brown Swiss, Holstein Friesian, and Simmental cattle breeds. Journal of Dairy Science, 103(1): 791-804.
14. Alessio, D.R. et al., 2021. Lactose and its relationship with other milk constituents, somatic cell count, and total bacterial count. *Livestock Science, 252*, 104678.
15. Strapák. P. et al. (2013). Breeding cattle. Nitra: SUA, in Slovak.
16. Kasarda, R. et al. 2020. Genetic diversity and production potential of animal food resources. Acta fytotechn zootechn, 23(2): 102-108
17. Bujko, J. et al. 2020. Changes in production and reproduction traits in population of the Slovak Spotted Cattle. In Acta fytotechnica et zootechnica online. ISSN 1336-9245, 23(3): 161-166.
18. Haygert-Velho, I.M. et al. 2018. Multivariate analysis relating milk production, milk composition, and seasons of the year. *Anais da Academia Brasileira de Ciencias, 90 (4):* 3839-3852
19. Alhussien, M. N., Dang, A. K. 2018. Milk somatic cells, factors influencing their release, future prospects, and practical utility in dairy animals: An overview. Veterinary world, 11(5): 562–577.
20. Costa, A. et al. 2020. Milk somatic cell count and its relationship with milk yield and quality traits in Italian water buffaloes. Journal of Dairy Science, 103(6): 5485-5494.
21. The Breeding Service of the Slovak Republic. S.E. 2017. Results of milk production and control milk samples in control years in Slovak Spotted cattle in Slovak Republic at control years 2000 to 2014.
22. SAS INSTITUTE Inc. 2016. Base SAS® 9.4 Procedures Guide. Cary. NC: SAS Institute Inc., Carry, USA.
23. Slovak Simmental Breeders Association. (2022). Breed standard Slovak Spotted Cattle. In Association of Slovak Spotted Cattle Breeders - Cooperative [online]. Retrieved [cit. 2022-07-15], Available at: http:// www.simmental.sk/about-breed/breed-standard. html
24. Bujko, J. 2011. Optimalization Genetic Improvement Milk Production in Population Slovak Spotted Breed. Monograph. Nitra: SAU, 78 p.
25. Miglior F. et al. 2007. Genetic analysis of milk urea nitrogen and lactose and their relationships with other production traits in Canadian Holstein cattle. J. Dairy Sci. 90:2468–2479.
26. Hagnestam-Nielsen, C., Emanuelson, U., Berglund, B., Strandberg, E. 2009. Relationship between somatic cell count and milk yield in different stages of lactation. *Journal of Dairy Science*, *92*(7): 3124-3133.
27. Satoła A. et al. 2017. Genetic parameters for lactose percentage and urea concentration in milk of Polish Holstein-Friesian cows. Animal Science Papers and Reports, 35(2): 159-172.
28. Tančin, V. et al. 2018. Possible physiological and environmental factors affecting milk production and udder health of dairy cows: a review. Slovak J. Anim. Sci., 51(1): 32–40.