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Variability of milk urea, milk urea nitrogen, and ammonia emission from dairy Simmental and Holstein cows based on the milk recording month

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Abstract

The subject of this paper was to define the variability of milk urea, milk urea nitrogen, and ammonia emission from dairy Simmental and Holstein cows relating to months of milk recording through the precision farming methodology. Test-day records of dairy cows used in the statistical analysis were collected over five years. Regarding the parity, the animals were divided into four classes; regarding the recording date, test-day records were divided into twelve recording months, from January to December. The analysis was performed separately for each breed. The significance of the differences between the recording months was tested by the Scheffe's method of multiple comparisons (using the PROC GLM procedure in SAS). In terms of results, lower ammonia emission per cow was determined in the winter, while the ammonia emission was higher in the summer. Also, higher values of milk urea, milk urea nitrogen, as well as higher ammonia emission per animal, were determined in the Holstein than in Simmental cows.

Key words: precision farming, ammonia emission, dairy cattle, milk recording

Introduction

The milk recording process begins with the collection of animal identification, a calving date of milking cows, the amount of milk given, and the date with time or time frame of a day (ICAR, 2017). Milk recording enables farmers to track their best and worst animals. Consequently, farmers can make management choices such as which cows do not produce sufficient amount of milk and might be suitable to cull or which cows are more proper for breeding replacements (ICBF, 2019). Furthermore, milk recording data (daily milk yield and contents) enables indirect estimation of several important parameters for dairy farm management optimization. Currently, the animal production sector causes the production of vast amounts of manure, which is the source of ammonia. Ammonia is dangerous for the health of farmworkers, animals, and the environment. The important challenge during the increasing and strengthening of the animal production sector is the impact of animal husbandry on the environment – especially on climate and ecosystems (FAO, 2009). The reduction of greenhouse gases, in particular, ammonia emissions from dairy cattle farms, represents one of the major goals in achieving environmentally sustainable dairy production. A prerequisite for reduction is a quick, simple, and accurate estimation based on already available data which in the case of dairy farms means usage of milk recording data (test-day records). In accordance to van den Bijgaart (2003) in the Netherlands, farms are controlled based on urea content in milk that enables the determination of potential pollution and early information of farmers regarding the necessary measures. Therefore, the aim of this paper was to determine the variability of milk urea, milk urea nitrogen, and ammonia emission from the dairy Simmental and Holstein cows based on the milk recording month using a test-day record that applies the precision farming methodology.

Material and Methods

Test-day records of dairy cows (Holstein and Simmental breed) used in the statistical analysis were collected over five years (January 2008 – December 2012). Test-day records were collected during the regular milk recording that is performed according to the alternative milk recording method (AT4 / BT4) on dairy cattle farms in Croatia on a monthly basis (every four weeks). The alternative milk recording method implies measuring and sampling milk during the evening or morning milking. In Croatia, milk recording is performed by the field officers of the Croatian Agency for Agriculture and Food while the milk samples are analysed in the Central Laboratory for Milk Quality Control. During the logical control of datasets, test-day records with lactation stage in (< 5 days and > 500 days), age at first calving in (< 21 and > 36 months), missing parity, missing animal breed data, and missing or nonsense daily milk traits in accordance to standards of ICAR (ICAR standards, 2017) were deleted from the dataset. After logical control dataset consisted of

805,247 test-day records collected from 69,368 Holsteins reared on 4,998 farms as well as 845,514 test-day records collected from 78,540 Simmentals reared on 7,242 farms. The milk urea nitrogen and ammonia emission were derived based on daily milk urea content using the following equations:

MUN (mg/dL) = UREA * 0.46 (Spiekers & Obermaier, 2012)

AM-EMISS (g/cow daily) = 25.0 + 5.03 * MUN (Burgos et al., 2010)

Where:

UREA = daily milk urea content (mg/dL),
MUN = milk urea nitrogen (mg/dL),
AM-EMISS = daily ammonia emission (g/cow daily).

Regarding parity, animals were divided into four classes: I, II, III, and IV (animals in fourth and higher lactations). Furthermore, regarding the recording date, test-day records were divided into twelve recording months: from January to December.

Basic statistical parameters of daily milk yield, daily milk urea, milk urea nitrogen, and ammonia emission are presented in Table 1.

Tab. 1. Basic statistical parameters of daily milk yield, milk urea, milk urea nitrogen, and ammonia emission regarding breed (Holstein and Simmental)

Variable	N	Mean	SD	CV	Minimum	Maximum
			Holstein breed			
DMY	794640	21.75	9.09	41.80	3.00	96.00
UREA	777464	22.01	9.84	44.71	0.50	60.00
MUN	777464	10.13	4.53	44.71	0.23	27.60
AM-EMISS	777464	75.93	22.77	29.99	26.16	163.83
			Simmental breed			
DMY	844252	16.13	6.14	38.03	3.00	94.00
UREA	807680	19.55	10.91	55.83	0.50	60.00
MUN	807680	8.99	5.02	55.83	0.23	27.60
AM-EMISS	807680	70.24	25.25	35.95	26.16	163.83

*DMY – daily milk yield (kg); UREA – daily urea content (mg/dL); MUN – milk urea nitrogen (mg/dL); AM-EMISS – ammonia emission (g/cow daily)

For the evaluation of the effect of recording month on the variability of daily milk urea, milk urea nitrogen, and ammonia emission in dairy cows was used following the statistical model:

$$y_{ijklmn} = \mu + b_1(d_i/305) + b_2(d_i/305)^2 + b_3\ln(305/d_i) + b_4\ln^2(305/d_i) + b_5 m_j + A_k + P + M_{ml} + e_{ijklmn}$$

Where:

y_{ijklmn} = estimated trait (daily milk urea, milk urea nitrogen and ammonia emission);
μ = intercept;
b_1, b_2, b_3, b_4, b_5 = regression coefficients;
d_i = days in milk (i = 5 to 500 day);
m_j = daily milk yield (j = 3.00 to 96.00 kg);
Aj = fixed effect of age at calving class j (j = 21 to 36 month);
P_l = fixed effect of parity l (l = I., II., III., and IV.);
M_j = fixed effect of recording month m (m = January, …, December);
e_{ijklmn} = residual.

The analysis was performed separately for each breed. The significance of the differences between the recording months was tested by the Scheffe's method of multiple comparisons (using the PROC GLM procedure in SAS (SAS Institute Inc., 2000).

Results and Discussion

All the effects included in the statistical model used for the evaluation of the influence of recording month on the variability of daily milk urea, milk urea nitrogen, and ammonia emission in dairy cows showed to be statistically highly significant ($p < 0.001$). The results of testing the significance of the differences (by the Scheffe's method of multiple comparisons) in analysed traits due to the recording months are presented in Table 2. LSMs of daily milk urea, milk urea nitrogen, and ammonia emission per animal differed statistically marked as highly significant ($p < 0.001$) due to the month of milk recording. In the Holstein cows, the highest value of daily milk urea (UREA) was determined in July (26.35 mg/dL) while the lowest value was in January (18.19 mg/dL). Similarly, in the Simmental cows, the highest UREA was determined during the summer period, in July (85.96 mg/dL), with the lowest value obtained during the winter period in December (15.86 mg/dL). Lower values of milk urea nitrogen (MUN) were determined during the winter period (December, January, and February) with the lowest value determined in January (Holstein) or December (Simmental). The highest values of MUN were determined during the summer period (June, July, and August) with the highest value observed in July in both breeds. Consequently, lower ammonia emission per cow was determined in the winter, while the ammonia emission was higher in the summer. Also, higher values of milk urea, milk urea nitrogen, as well as higher ammonia emission per animal, were determined in the Holstein than in Simmental cows.

Tab. 2. LSMs of daily milk urea, milk urea nitrogen, and ammonia emission regarding the recording month separately for each breed (Holstein and Simmental)

Recording month	**Holstein**			**Simmental**		
	UREA	**MUN**	**AM_EMISS**	**UREA**	**MUN**	**AM_EMISS**
January	18.19^{A}	8.37^{A}	67.09^{A}	16.05^{A}	7.38^{A}	62.12^{A}
February	19.32^{B}	8.89^{B}	69.71^{B}	17.02^{B}	7.83^{B}	64.39^{B}
March	19.32^{B}	8.89^{B}	69.70^{B}	16.96^{C}	7.80^{B}	64.25^{B}
April	21.77^{C}	10.01^{C}	75.37^{C}	19.42^{D}	8.93^{C}	69.94^{D}
May	22.71^{D}	10.45^{D}	77.54^{D}	21.07^{E}	9.69^{D}	73.74^{E}
June	26.08^{E}	11.99^{E}	85.34^{E}	23.78^{F}	10.94^{E}	80.02^{F}
July	26.35^{E}	12.12^{E}	85.96^{E}	25.25^{G}	11.62^{F}	83.42^{G}
August	25.66^{F}	11.80^{F}	84.36^{F}	23.87^{F}	10.98^{E}	80.23^{F}
September	22.68^{G}	10.43^{C}	77.47^{D}	21.09^{E}	9.70^{G}	73.79^{E}
October	20.91^{H}	9.62^{G}	73.39^{G}	19.21^{D}	8.83^{C}	69.44^{D}
November	20.51^{I}	9.43^{H}	72.45^{H}	17.30^{BD}	7.96^{B}	65.03^{B}
December	18.79^{J}	8.64^{I}	68.47^{I}	15.86^{A}	7.30^{A}	61.70^{A}

Ruska et al. (2017) emphasised that the optimal values of daily milk urea are in intervals 15–30 mg/dL. Furthermore, since milk urea identifies the content of urea in blood and urine, it is commonly used as an indicator for calculation of the amount of nitrogen used in feed, particularly for the determination of protein excess in the digestive tract (Broderick and Clayton, 1997; Hof et al., 1997; Jonker et al., 2002; Burgos et al., 2010; Broderick and Huhtanen, 2013). Ruska et al. (2017) determined that in a case when the amount of nitrogen amount in feed is more than 6.6%, the nitrogen content in urine increases by 16% and by 2.7% in manure.

In this study, the statistical analysis showed that all effects included in the used evaluation model (daily milk production, age at first calving, stage of lactation, parity, and recording month) statistically highly significantly influenced daily urea content, milk urea nitrogen as well as ammonia emission. Further analysis of the differences in analysed traits based on the recording month indicated higher values in the Holstein compared to Simmental breed. Also, higher values of daily milk urea, milk urea nitrogen, and ammonia emission were determined during the summer comparing with the winter period with peak values, in both breeds, in July.

Similarly, Ruska et al. (2017) determined significantly higher values of urea content in milk during the summer period. Furthermore, they determined the correlation between productivity and quality traits depending on urea content in milk indicating exceeded urea content (>45.0 mg/dL) in high productive cows (> 25.1 kg/day).

Increased milk urea could be an indicator of complications related to providing high productive animals with adequate fodder regarding energy and protein (Spohr and Wiesner, 1991; Spann, 1993). In Europe, the urea content in milk is usually used (Kohn et al., 2002; Bucholtz et al., 2007), while in the USA milk urea nitrogen (MUN) is commonly used as an indicator of feeding efficiency with desirable values in the interval 8.0–12.0 mg/dL (Aguilar et al., 2012). The exceeded MUN indicates unbalanced energy and protein in fodder, so farmers have to make certain ratio adjustments. Since there is a significant correlation between milk urea content and nitrogen content in animal urine and manure (Burgos et al., 2010; Eckersall & Bell, 2010; Klein et al., 2011; Spek et al., 2013) to optimise the management of dairy farm, milk urea should be used as an indicator of feeding efficiency as well as for assessment of the environmental impact of the farm (Godden et al., 2001; Haig et al., 2002).

Conclusion

Test-day records of the Holstein and Simmental cows were analysed on the variability in protein metabolism-related parameters (milk urea, milk urea nitrogen, and ammonia emission) based on the month of milk recording. The analysis results showed that all model effects (daily milk production, age at first calving, stage of lactation, parity and recording month) had a statistically highly significantly influence on analysed traits. Also, significant differences in analysed traits were found due to recording months with higher determined values in the Holstein comparing to Simmental breed. Finally, higher values of daily milk urea, milk urea nitrogen, and ammonia emission were determined during the summer compared with the winter period with peak values, in both breeds, in July.

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Варијабилност емисије урее млијека, азота и амонијака урее млијека од крава Симентал и Холштајн у односу на мјесец евидентирања млијека

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Сажетак

Циљ овог рада био је дефинисање варијабилности емисије урее млијека, азота млијечне урее и амонијака од крава Симентал и Холштајн у вези са мјесецима евидентирања млијека кроз методологију прецизне фарме. Евиденција дана музних крава коришћена у статистичкој анализи прикупљена је током пет година. Што се тиче паритета, животиње су биле подијељене у четири класе; што се тиче датума евидентирања, записи дана тестирања подијељени су у дванаест мјесеци евидентирања, од јануара до децембра. Анализа је извршена одвојено за сваку расу. Значај разлика између мјесеци евидентирања тестиран је Scheffe-овом методом вишеструког поређења (користећи поступак PROC GLM у SAS-у). У погледу резултата, зими је утврђена нижа емисија амонијака по крави, док је љети била већа емисија амонијака. Такође, утврђене су веће вриједности урее млијека, азота млијечне урее, као и већа емисија амонијака по животињи код Холштајн крава него код Сименталки.

Кључне ријечи: прецизна пољопривреда, емисија амонијака, мљекарство, евидентирање млијека

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