THE VARIATION IN AMMONIA EMISSION FROM DAIRY CATTLE FARMS DUE TO THE EFFECT OF BREEDING REGION

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Summary

Test-day records of dairy cattle were used for the analysis of variability of daily milk yield, milk urea nitrogen, and ammonia emission due to breeding regions (Eastern, Central, and the Mediterranean). Based on the analysis it was determined that Holstein cows bred in Mediterranean Croatia had highest daily milk production, milk urea nitrogen and ammonia emission. The lowest values of daily milk yield (20.23 kg), milk urea nitrogen (9.87 mg dL-1) and ammonia emission (74.68 g/cow daily) were recorded in Holsteins in Central Croatia. On the other hand, the highest recorded daily milk yield was in Simmental cows bred in Eastern Croatia (16.55 kg); while the milk produced in Mediterranean Croatia had the highest content of milk urea nitrogen and therefore those cows had the highest ammonia emission. The lowest values of milk urea nitrogen and ammonia emission were recorded in Central Croatia. The results indicate significant effect of breeding region on the variability of ammonia emission. Besides, test day records can be used not just for evaluating animal productivity but also for estimation of ammonia pollution from dairy cattle farms.

Key words: *precision farming, test-day records, dairy cattle, ammonia emission*

INTRODUCTION

One of the most important topics that affect global dairy farming development is precision dairy farming. By the term precision dairy farming is meant the use of different technologies for measuring physiological, behavioural, and production indicators on particular animals. A meaningful problem regarding intensification and consolidation of livestock production is the impact of animal production on the environment, especially on climate and ecosystems. Global production of milk, meat, and eggs has risen quickly within the last decades, especially in developing countries (FAO, 2009). Economic growth, rising incomes, urbanization, and population growth

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are notable initiators of sector growth. With global production about 553 million tonnes of milk in the year 2007 (FAOSTAT, 2010) and 34 million tonnes of meat from the dairy-related herd (FAO, 2010), dairy is a vital part of the total livestock sector. Moreover, it is rapidly developing: crude milk production increased by 44% between the year 1980 and 2007. Besides, accordingly to FAO (2004), livestock will continue to be the most dynamic agricultural sub-sector: globally milk production is predicted to rise from 580 to 1043 million tonnes in the year 2050. Production growth must be followed by suitable environmental protection measures, because modern dairy production, besides high milk production, also results in the production of large amounts of manure. According to Hristov *et al.,* (2011) an essential component of cattle manure nitrogen, especially from urinary urea, is converted into ammonia and lastly lost to the atmosphere as ammonia. Ammonia jeopardizes the health of farmworkers, animals and the environment. Process in which the nitrogen in animal manure (urine and feces) is released in the environment through biochemical and mass transfer reactions (Burgos *et al.,* 2010) is called ammonia evaporation. Defining ammonia emissions from cattle is complicated because ammonia volatilization is regulated by numerous nature factors, such as manure management, ambient temperature, wind speed, and manure composition and pH. For estimation of the amount of nitrogen in feed and the content of urea in blood and urine, the milk urea content is mostly used because it is easy to discover it, also gathering and analysing specific (urine or feces) samples are not necessary (Broderick and Huhtanen, 2013, Jonker *et al.,* 2002 and Ruska *et al.,* 2015). Additionally, for evaluating environmental pollution and digestive efficiency can be used milk urea content because it presents a lack of raw protein for a dairy cow, especially excess in the digestive tract (Broderick and Clayton, 1997, Hof *et al.,* 1997 and Burgos *et al.,* 2010). One instance of environmental measures is in the Netherlands, where farms are controlled based on urea content in milk. This makes it possible to identify potential sources of pollution and inform farms about precautionary measures (Bijgaart, 2003). In accordance to Ruska *et al.,* (2015), the desirable amount of urea in the milk in Europe is set at 15–30 mg/dL. In order to achieve environmentally sustainable animal production that will help farmers and society as a whole, it is crucial to reduce ammonia emissions from beef and dairy cattle production. The objective of this paper was to determine the variability of daily milk yield, milk urea nitrogen, and ammonia emission from dairy cattle regarding breeding regions (Eastern, Central, and the Mediterranean) using a precision farming methodology (test-day records).

MATERIALS AND METHODS

Test-day records of dairy cows (Holstein and Simmental) collected in the period from January 2004 to December 2013 provided by the Croatian Agency for Agriculture and Food were used for the statistical analysis. Test-day records were collected during the regular milk recording performed monthly in accordance to the alternative milk recording method (AT4 / BT4) on dairy cattle farms in Croatia. At each recording,

measuring and sampling of milk were performed during the evening or morning milkings.
Test-day records with lactation stage in (< 5 days and > 500 days), age at first calving in (< 21 and > 36 months), missing parity, missing breed, and missing or nonsense daily milk traits (ICAR standards, 2017) were deleted from the dataset. After logical control dataset consisted of 2,663,687 test-day records from 134,189 Holsteins reared on 9640 farms and 3,487,587 test-day records from 176,150 Simmental cows reared on 15,724 farms.
The milk urea nitrogen (MUN) content was calculated using milk urea content (UREA) accordingly to the following equation:

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

The ammonia emission (AM-EMISS) was calculated using milk urea nitrogen (MUN) accordingly to the following equation:

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

Accordingly, to the parity, cows were divided into four classes: I., II., III., and IV. (animals in fourth and higher lactations). Furthermore, in accordance to the recording date, test day records were divided into four season: spring (March, April, and May), summer (June, July, and August), autumn (September, October, and November), winter (December, January, and February).
Basic statistical parameters of analysed traits for Holstein and Simmental cows are shown in Table 1.

Table 1. Basic statistical parameters of analysed traits (daily milk traits, milk urea nitrogen and ammonia emission)

Variable	N	Mean	SD	CV	Minimum	Maximum
Holstein breed						
DMY	2663687	21.32	8.73	40.92	3.00	99.20
DFC	2555404	4.15	0.97	23.46	1.50	9.00
DPC	2584665	3.41	0.47	13.83	1.03	7.00
UREA	2444378	22.07	10.04	45.50	0.50	60.00
MUN	2444378	10.15	4.62	45.50	0.23	27.60
EMISS	2444378	76.07	23.24	30.54	26.16	163.83
Simmental						
DMY	3487587	15.63	5.85	37.39	3.00	98.00
DFC	3337447	4.17	0.94	22.45	1.50	9.00
DPC	3381315	3.45	0.46	13.43	1.07	7.00
UREA	3069309	19.36	10.69	55.22	0.50	60.00
MUN	3069309	8.90	4.92	55.22	0.23	27.60

EMISS	3069309	69.79	24.73	35.44	26.16	163.83

*DMY – daily milk yield (kg); DFC – daily fat content (%); DPC – daily protein content (%); MUN – milk urea nitrogen (mg/dL); EMISS – ammonia emission (g/cow daily)

For the estimation of the effect of breeding region on the variability of daily milk yield; milk urea nitrogen and ammonia emission in dairy cows (Holstein and Simental breed) following statistical model was used:

$$y_{ijklmn} = \mu + b_1(d_i/305) + b_2(d_i/305)^2 + b_3 \ln(305/d_i) + b_4 \ln^2(305/d_i) + S_j + A_k + P_l + R_m + e_{ijklmn}$$

where y_{ijklm} = estimated trait;
μ = intercept;
b_1, b_2, b_3, b_4 = regression coefficients;
d_i = days in milk (i = 5 to 500 day);
S_j = fixed effect of recording season class j (j = spring, summer, autumn, winter);
A_k = fixed effect of age at calving class k (k = 21 to 36 month);
P_l = fixed effect of parity l (l = I., II., III., and IV.);
R_m = fixed effect of region (Eastern, Central, and Mediterranean).
e_{ijklm} = residual.

The significance of the differences between the breeding region was tested by Scheffe's method of multiple comparisons (using the PROC GLM procedure in SAS (14)) separately for each breed (Holstein and Simmental).

RESULTS AND DISCUSSION

The analysis of variance of daily milk yield, milk urea nitrogen, and ammonia emission showed a statistically highly significant effect ($p < 0.001$) of all effects involved in the used statistical model. LSmeans values of daily milk yield, milk urea nitrogen, and ammonia of Holstein cows in accordance to the breeding region (Eastern, Central, and the Mediterranean) are presented in Table 2. All analysed traits differ statistically highly significant ($p < 0.001$) regarding the breeding regions.

Table 2. LSMs of daily milk yield, milk urea nitrogen and ammonia emission accordingly to the breeding region for Holstein cows

Breeding region	DMY	MUN	EMISS
Eastern	23.77^{A}	11.40^{A}	82.35^{A}
Central	20.23^{B}	9.87^{B}	74.68^{B}
Mediterranean	23.92^{C}	12.33^{C}	87.03^{C}

*DMY – daily milk yield (kg); MUN – milk urea nitrogen (mg/dL); EMISS – ammonia emission (g/cow daily); LSMs marked with different letters (A, B, C) differ statistically significant ($p < 0.001$)

Daily milk yield, milk urea nitrogen and ammonia emission were the highest in Mediterranean Croatia. The lowest values of daily milk yield (20.23 kg), milk urea nitrogen (9.87 mg dL-1) and ammonia emission (74.68 g/cow daily) were recorded in Central Croatia.
The results of analyses of variance of daily milk yield, milk urea nitrogen and ammonia emission of Simmental cows in accordance to breeding regions (Eastern, Central, and the Mediterranean) are shown in Table 3. Once more there were statistically highly significant ($p < 0.001$) differences for all analysed traits regarding the breeding region.

Table 3. LSMs of daily milk yield, milk urea nitrogen and ammonia emission accordingly to the breeding region for Simmental cows

Breeding region	DMY	MUN	EMISS
Eastern	16.55^{A}	9.92^{A}	74.88^{A}
Central	15.30^{B}	8.68^{B}	68.66^{B}
Mediterranean	15.20^{C}	10.34^{C}	76.99^{C}

*DMY – daily milk yield (kg); MUN – milk urea nitrogen (mg dL-1); EMISS – ammonia emission (g/cow daily); LSMs marked with different letters (A, B, C) differ statistically significant ($p < 0.001$)

The highest recorded daily milk yield was in Eastern Croatia (16.55 kg); while the milk produced in Mediterranean Croatia had the highest content of milk urea nitrogen and therefore those cows had the highest ammonia emission. The lowest values of milk urea nitrogen and ammonia emission were recorded in Central Croatia. Significantly higher urea content in milk produced in the farm with a tie-stall housing system during the summer period was determined by Ruska *et al*., (2015). Productivity properties are correlated with urea content in milk. According to Spohr and Wiesner (1991) and Spann (1993), complications connected with providing highly productive dairy cows with fodder dosage having sufficient amounts of energy and protein are revealed by increased urea in milk. In accordance to Kohn et al. (2002) and Bucholtz *et al*., (2007), numerous studies conducted in Europe have used urea content in milk; on the other hand, researches conducting in the USA are normally using milk urea nitrogen (MUN) content; MUN shows the amount of urea detected in milk and desirable MUN is 8.0–12.0 mg/dL. If the MUN threshold is above the allowable values, then farms must pay attention to the usage of proteins in fodder and their balancing with energy in a single feed dose. According to Aguilar et al. (2012), to reach the MUN limit of 12 mg / dL it is essential to reduce the amount of protein in food to 12.8% in dry matter, according to data collected in the USA on feed proteins and MUN content. For estimating and projecting the farming model, using urea content is recommended from the side of experts from countries evaluating nitrogen use and efficiency, with which nitrogen in a single feed dose is used (Godden *et al*., 2001 and Haig *et al*., 2002). To determine metabolic processes in the animal body, as well as predicting potential diseases (ketosis, acidosis) in time and managing agricultural efficiency, it has been confirmed that milk content traits can also be used for this and not just for estimating animal productivity. It was proved that there is a meaningful correlation between urea content in milk and nitrogen content in urine and animal manure (Burgos *et al.,* 2010, Eckersall and Bell, 2010, Klein *et al*., 2011 and Spek *et al.,* 2013).

CONCLUSIONS

The objective of this paper was to determine the variability of daily milk yield, milk urea nitrogen, and ammonia emission from dairy cattle farms regarding the breeding regions (Eastern, Central, and the Mediterranean) by application of a precision farming methodology. Statistically highly significant ($p < 0.001$) effect on all traits (daily milk yield, milk urea nitrogen, and ammonia emission) was determined. In Holstein cows, daily milk yield, milk urea nitrogen and ammonia emission were the highest in Mediterranean Croatia. The lowest values of daily milk yield (20.23 kg), milk urea nitrogen (9.87 mg dL-1) and ammonia emission (74.68 g/cow daily) were recorded in Central Croatia. On the other hand, in Simmental cows, the highest recorded daily milk yield was in Eastern Croatia (16.55 kg); while the milk produced in Mediterranean Croatia had the highest content of milk urea nitrogen and therefore those cows had the highest ammonia emission. The lowest values of milk urea nitrogen and ammonia emission were recorded in Central Croatia. The results indicate significant variability in ammonia emission due to the breeding region of dairy cows (different animal nutrition, diet composition, manure handling…) Besides, test day records can be used not just for evaluating animal productivity but also for estimation of ammonia pollution from dairy cattle farms.

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VARIJABILNOST EMISIJE AMONIJAKA SA FARMI MLIJEČNIH GOVEDA USLIJED UTJECAJA UZGOJNE REGIJE

Rezime

Podaci kontrole mliječnosti mliječnih goveda korišteni su za analizu varijabilnosti dnevne proizvodnje mlijeka, dnevnog sadržaja uree u mlijeku i emisije amonijaka obzirom na uzgojnu regiju (istočna, središnja i mediteranska). Na temelju analize utvrđeno je da su holstein krave uzgajane u mediteranskoj Hrvatskoj imale najveću dnevnu proizvodnju mlijeka, sadržaja uree u mlijeku i emisije amonijaka. Najniže vrijednosti dnevnog prinosa mlijeka (20,23 kg), ureinog dušika u mlijeku (9,87 mg dL-1) i emisije amonijaka (74,68 g / krava dnevno) zabilježene su kod holstein krava u središnjoj Hrvatskoj. S druge strane, najveći dnevni prinos mlijeka zabilježen je kod simentalskih krava uzgajanih u istočnoj Hrvatskoj (16,55 kg); dok je mlijeko proizvedeno u mediteranskoj Hrvatskoj imalo najveći udio ureinog dušika u mlijeku pa su te krave imale i najveće emisije amonijaka. Najniže vrijednosti ureinog dušika u mlijeku te emisije amonijaka zabilježene su u Središnjoj Hrvatskoj. Rezultati ukazuju na značajan utjecaj uzgojne regije (različita hranidba životinja, sastav hranidbe, rukovanje gnojem...) na varijabilnost emisije amonijaka. Osim toga, kontrolni podaci mogu se koristiti ne samo za procjenu produktivnosti životinja, već i za procjenu zagađenja amonijakom s farmi mliječnih goveda.

Ključne riječi: *precizna poljoprivreda, podaci na kontrolni dan, mliječna goveda, emisija amonijaka*