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REDUCING THE IMPACT OF DAIRY FARMS ON THE ENVIRONMENT OF SUBURBAN SETTLEMENTS THROUGH EARLY ASSESSMENT OF METABOLIC DISORDERS IN HOLSTEIN COWS

Abstract

The aim of this study was to define the prevalence risk of subclinical disorders of Holstein first parity cows depending on recording season and enable farm management optimization and consequently the reduction of the environmental impact of dairy farms. Test-day records of Holstein first parity cows gathered during the five years (January/2008 – December/2012) on farms in Eastern Croatia were used for the statistical analysis. The analysis indicated that daily fat and protein content, and F/P ratio, significantly differ due to recording season with the higher values of F/P ratio in winter period indicating higher ketosis prevalence risk, and lower values of F/P ratio in summer period indicating higher acidosis prevalence risk. Considering that many factors influence the variability of daily fat and protein content, and therefore the fat to protein ratio along with the prevalence risk of metabolic disorders, these factors should be taken into consideration when assessing the ketosis/acidosis prevalence in dairy cows based on milk recording data. Finally, accurate and timely assessment of prevalence risk of subclinical disorders will prevent the development of the clinical form of disorder and enable farm management optimization and consequently reduction of the impact of dairy farms on the environment of suburban areas.

Key words: *environmental impact, early assessment, metabolic disorders, Holstein cows, milk recording*

INTRODUCTION

Throughout the transition period, dairy cows could feel different disorders as a consequence of differences in diet, decreased food intake, quick weight loss, negative energy balance, or hypocalcemia. LeBlanc (2010) pointed out that metabolic disorders (up to 50%) principally happen at the start of lactation (first two weeks). Besides, Mulligan and Doherty, 2008, noted that the cause of stress could be environmental circumstances, for instance, reorganization, while Broucek et al., 2007 mentioned unsuitable (micro)climatic conditions. Amongst the most frequent disorders in lactating dairy cows are ketosis and acidosis. A disorder that can happen equally in clinical and subclinical forms is ketosis. In accordance to Gillund et al. (2001), as a result of an unbalanced diet and management of the farm, clinical ketosis mostly happens in highproducing cows at the start of lactation (2^{nd}-7^{th} weeks). Ketosis prevalence could differ because of breed, season, parity, and herd-associated circumstances (Dohoo and Martin, 1984; Rajala-Schultz et al., 1998). In addition, the appearance of clinical ketosis causes financial losses for milk producers because of decreased milk production, weakened reproduction, treatment expenses, and finally raised animal culling rates (RajalaSchultz and Gröhn, 1999; Suthar et al., 2013). Furthermore, prevention and animal surveillance have become very important because subacute ruminal acidosis (SARA) becomes a growing difficulty in high-productive dairy cows. In lactation and animals at maximum dry matter intake was ascertained the greatest prevalence of SARA (Dirksen et al., 1985; Bramley et al., 2005; Oetzel, 2005; O'Grady et al., 2008). Early detection of these disorders is one of the key conditions for enabling sustainable business because these disorders cause significant farm costs and increase the environmental impact of dairy farm. Based on already available data, i.e. using the test-day records (TDR), it is possible to quickly and easily detect the possibility of disorders in its early phase and the prevention of more difficult phases. TDR include data concerning the daily milk yield, fat and protein content, and fat to protein ratio (F/P ratio). Taking into account that many factors influence the variability of daily milk contents, this study aimed to define the prevalence risk of subclinical disorders of Holstein first parity cows depending on the season enabling farm management optimization and consequently reduction of the impact of dairy farms on the environment of suburban areas.

MATERIAL AND METHODS

Test-day records of Holstein first parity cows gathered during the five years (January/2008 – December/2012) provided by the Croatian Agricultural Agency 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 Eastern Croatia. At each recording, measuring and sampling of milk were performed during the evening or morning milkings.

Moreover, test-day records with missing information regarding parity, breed, and missing or nonsense daily milk traits accordingly to standards of ICAR (ICAR standards, 2017) were removed from the dataset.

Relating 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). After logical control dataset consisted 175,162 test day records from 23,368 animals reared on 1,132 farms in Eastern Croatia. Basic statistical parameters of analysed traits (daily milk yield, daily fat and protein content, along with fat to protein ratio) is presented in Table 1.

Table 1. Basic statistical parameters of daily milk yield, daily fat and protein content, as well as fat to protein ratio

Variable	N	Mean	SD	CV	Minimum	Maximum
DMY	170660	22.01	7.87	35.77	3.00	85.20
FAT	169014	4.08	0.94	23.14	1.50	9.00
PROTEIN	170099	3.42	0.43	12.60	1.26	6.94
F/P	169010	1.20	0.27	22.69	0.32	3.97

* DMY – daily milk yield (kg); FAT – daily fat content (%);
PROTEIN – daily protein content (%); F/P – fat to protein ratio

For the evaluation of the effect of recording season on the variability of analysed traits (daily fat and protein content, together with fat to protein ratio) in Holstein first parity cows following statistical model was used:

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

Where:

y_{ijklm} = estimated trait (daily fat and protein content, as well as fat to protein ration);
μ = intercept; b_1, b_2, b_3, b_4, b_5 = regression coefficients;
d_i = days in milk (i = 5 to 500 day) as the polynomial regressions by Ali and Schaeffer (1987); m_j = daily milk yield
(j = 3.00 to 96.00 kg);
A_j = fixed effect of age at first calving class j (j = 21 to 36 month);
P_l = fixed effect of parity 1 (1 = I., II., III., and IV.);
M_j = fixed effect of recording month m (m = January, ..., December);
e_{ijklm} = residual.

The significance of the differences between season classes was tested by Scheffe's method of multiple comparisons (using the PROC GLM procedure in SAS (SAS Institute Inc., 2019)).

RESULTS AND DISCUSSION

The analysis of variance revealed that cow's daily productivity, stage of lactation, parity, age at first calving, and season of milk recording statistically highly significant ($p < 0.001$) affected daily fat and protein content, along with fat to protein ratio. The results of testing the significance of the differences in LSMs of analysed traits respectively to Scheffe's method of multiple comparisons are shown in Table 2. In Holstein first parity cows, the highest daily fat content was determined in winter (4.22%), also the highest daily protein content (3.51%) was ascertained in winter. The lowest values of daily fat (3.87%) and protein content (3.29%) were determined in summer period. Additionally, the lowest value of fat to protein ratio (F/P) was observed in summer and autumn in amount of 1.19. Higher values of F/P (1.21) were observed in winter and spring period. Ascertained outcomes show that daily fat and protein content along with F/P ratio notably differ as a result of milk recording season. Higher LSMs values of F/P ratio in the winter period mean higher ketosis prevalence risk, while lower LSMs values mean higher acidosis prevalence risk during the summer period.

Table 2. LSmeans of daily fat, daily protein content, as well as fat to protein ratio regarding the season

Season	FAT	PROTEIN	F/P
I (spring)	4.09^{A}	3.41^{A}	1.21^{A}
II (summer)	3.87^{B}	3.29^{B}	1.19^{B}
III (autumn)	4.13^{A}	3.47^{A}	1.19^{B}
IV (winter)	4.22^{A}	3.51^{C}	1.21^{A}

* FAT – daily fat content (%); PROTEIN – daily protein content (%); F/P – fat to protein ratio; LSMs marked with different letters (A, B, C) differ statistically highly significant ($p < 0.001$)

In accordance to Palmquist et al., 1993; Doreau et al., 1999, raised milk production, decreased feed particle size, feeding with too much starch (> 28% of the total meal), a diet with the addition of polyunsaturated fatty acids (linoleic and linolenic) as free oils and heat stress are factors that can make a drop in the percentage of milk fat. The high value of milk fat in cows after calving is a sign of digestive dysfunctions and is associated with loss of appetite, ketosis, fast weight loss, decreased milk yield, lasting liver damage, rennet dislocation, mastitis, and numerous other infections. Additionally, high values of milk fat at the end of lactation are normal in view of the decrease in milk yield, which means they are not an indicator of digestive dysfunctions. Palmquist et al., 1993; Doreau et al., 1999 pointed out that the risen proportion of voluminous feeds, more frequent feeding, feeding with recommended oilseed levels (< 2.5 kg), feeding with a higher proportion of saturated fats such as palmitic (c 16:00) and stearin (c 18:00), reduced fitness and weight loss are elements that may increase milk fat content. Moreover, the fat content of milk is controlled by many factors like breed, order and stage of

lactation, season (calving, milk recording), milking frequency, udder health, nutrition (energy supply and the proportion of voluminous feed in the meal), and individual characteristics of the animal (Hargrove and Gilbert, 1984; Arsov, 1986; Keowen and Everett, 1986; Erdman and Varner, 1995; Klei et al., 1997; Ouweltjes, 1998; Weiß et al., 2002). Likewise, the protein content in milk is a result of nutrition (supply of digestible protein in the meal), season (lower content is typical for summer season), breed, order and stage of lactation, udder health, and individual characteristics of every cow (Hargrove and Gilbert, 1984; Arsov, 1986; Keowen and Everett, 1986; Murphy and O'Mara, 1993; Erdman and Varner, 1995; Klei et al., 1997; Ouweltjes, 1998; Eicher et al., 1999; Weiß et al., 2002). The most favourable value of protein content in milk is in the interval 3.2% - 3.8%. Too high protein content implies the general overnutrition of the animal, on the other hand, low protein content means a lack of digestible protein and energy in the meal. The perfect values of fat and protein ratio (F/P) in milk are 1.1 - 1.5. In healthy animals that are in good condition, the difference in the value of the ratio is small. Inadequate feed, animal disorder/disease, or inappropriate environmental conditions principally make changes in the F/P ratio (Duffield, 2004; Eicher, 2004). This research indicates that daily production level, stage of lactation, parity, age at first calving, and season of milk recording statistically highly significant ($p < 0.001$) affected daily fat and protein content as well as the F/P ratio. Furthermore, the research results indicate that the prevalence risk of metabolic disorders significantly vary during the year with indicated higher ketosis prevalence risk in winter period, as well as higher acidosis prevalence risk during the summer period. The early assessment of metabolic disorders prevalence in dairy cows enable prevention of the development of clinical forms and reduces the environmental impact of dairy farms.

CONCLUSION

The aim of this study was to define the prevalence risk of subclinical disorders of Holstein first parity cows depending on the season and enable optimization of farm management and consequently the reduction of the environmental impact of dairy farms. Conducted statistical analysis showed significant effect of daily milk production, stage of lactation, parity, age at first calving, milk recording, and recording season on the variability of daily fat and protein content as well as F/P ratio. In addition, analysis indicated that daily fat and protein content as well as F/P ratio significantly vary due to recording season with the higher values of F/P ratio in winter period indicating higher ketosis prevalence risk, and lower values of F/P ratio in summer period indicating higher acidosis prevalence risk. Since, numerous factor affects the variability of daily fat and protein content, and consequently the fat to protein ratio as well as the prevalence risk of metabolic disorders, these factor should be taken into account when assessing the ketosis/acidosis prevalence risk in dairy cows based on milk recording data. Finally, accurate and timely assessment of prevalence risk of subclinical disorders will prevent the development of the clinical form of disorder and enabling farm management optimization and consequently reduction of the impact of dairy farms on the environment of suburban areas.

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УТИЦАЈ СЕЗОНЕ НА ПРОЦЕЊЕНИ РИЗИК ОД ПРЕВАЛЕНЦИЈЕ МЕТАБОЛИЧКИХ ПОРЕМЕЋАЈА (КЕТОЗА / КИСЕЛИНА) КРАВА ПРВОГ ПАРИТЕТА ХОЛШТАЈНА

Абстракт

Циљ ове студије био је да се утврди ризик од преваленције субклиничких поремећаја крава првог паритета Холштајна у зависности од сезоне контроле млечности и омогући оптимизација управљања фармама и сходно томе смањење утицаја на животну средину млечних фарми. За статистичку анализу коришћени су подаци о контроли млечности крава првог паритета Холштајна сакупљених током пет година (јануар / 2008 – децембар / 2012) на фармама у Источној Хрватској. Анализа је показала да се дневни садржај масти и протеина, као и однос Ф / П, значајно разликују због сезоне контроле млечности са вишим вредностима односа Ф / П у зимском периоду што указује на већи ризик преваленције кетозе, и нижим вредностима односа Ф / П лети период који указује на већи ризик од преваленције ацидозе. Узимајући у обзир да многи фактори утичу на варијабилност дневног садржаја масти и протеина, а самим тим и однос масти и протеина, заједно са ризиком преваленције метаболичких поремећаја, ове факторе треба узети у обзир приликом процене преваленције кетозе / ацидозе код млечних крава на бази података контроле млечности. На крају, тачна и правовремена процена ризика од преваленције субклиничких поремећаја спречиће развој клиничког облика поремећаја и омогућити оптимизацију управљања фармама и последично смањење утицаја млечних фарми на животну средину приградских подручја.

Кључне речи: *утицај на животну средину, рана процена, метаболички поремећаји, Холштајн краве, контрола млечности*