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THE VARIABILITY IN THE ESTIMATED PREVALENCE RISK OF METABOLIC DISORDERS (KETOSIS/ACIDOSIS) IN SIMMENTAL FIRST PARITY COWS DUE TO RECORDING SEASON

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Abstract: The purpose of this research was to determine the prevalence risk of subclinical disorders of Simmental first parity cows regarding the recording season. Test-day records of Simmentals collected during the five years (January/2008 – December/2012) given by the Croatian Agricultural Agency were used for the statistical analysis. During the regular milk recording performed monthly following the alternative milk recording method (AT4 / BT4) on dairy cattle farms in Croatia, test-day records were gathered. The highest daily fat content (4.31%) and the highest daily protein content (3.54%) was ascertained in winter. The lowest values of daily fat (3.83%) and protein content (3.33%) were determined in summer period. Additionally, the lowest value of fat to protein ratio (F/P) was observed in summer in amount of 1.16. Higher value of F/P (1.22) was observed in winter period. Further, the study showed that daily fat and protein content, together with F/P ratio significantly, differ due to recording month 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. Mentioned factors should be taken into consideration when predicting the ketosis/acidosis prevalence in dairy cows based on milk recording data because they influence the variability of daily fat and protein content, and therefore the fat to protein ratio along with the prevalence risk of metabolic disorders.

Key words: metabolic disorders, ketosis, acidosis, test-day records, Simmental cows

Introduction

In terms of physiology, postpartum period is one of the most critical periods for dairy cows. In the first 10 days after calving, postpartum disorders usually occur *(Ingvartsen et al. 2003; LeBlanc, 2010; Antanaitis et al. 2015)*. In accordance to *Mulligan and Doherty (2008)*, the cause of stress might be environmental circumstances, for example, reorganization, while *Broucek et al. (2007)*, pointed out inappropriate (micro)climatic conditions. In lactating dairy cows, the most frequent disorders are ketosis and acidosis. Ketosis is a disorder that can appear both in clinical and subclinical forms. According to *Gillund et al. (2001)*, clinical ketosis frequently occurs in high-producing cows at the start of lactation (2^{nd}-7^{th} weeks) as a consequence of an unbalanced diet and management of the farm. Ketosis preponderance could vary because of breed, parity, season, and herd-connected circumstances *(Dohoo and Martin, 1984; Rajala-Schultz et al., 1999)*. Further, clinical ketosis causes economic losses for farmers for the sake of reduced milk production, decreased reproduction, treatment costs, and ultimately increased animal elimination rates *(Rajala-Schultz and Gröhn, 1998; Suthar et al., 2013)*. A developing problem in high-productive dairy cows is also subacute ruminal acidosis (SARA), because of that, prevention and animal surveillance are extremely significant. The greatest prevalence of SARA was determined in animals at maximum dry matter intake and in peak of lactation *(Dirksen et al., 1985; Bramley et al., 2005; Oetzel, 2005; O'Grady et al., 2008)*. Given that both metabolic disorders (ketosis / acidosis) cause high costs on dairy farms, it is extremely important to detect a possible disorder in a timely manner and prevent the occurrence of the clinical form. For this purpose, the results of milk recording, i.e. the ratio of milk fat and protein, can be used as an excellent indicator of the prevalence risk. Since many factors affect the variability of the daily milk content and consequently the fat to protein ratio (F/P), this study aimed to determine the variability in daily milk fat and protein content, the F/P ratio as well as in prevalence risk of subclinical disorders of Simmental first parity cows, depending on the recording season.

Materials and Methods

Test-day records of first parity Simmental cows reared in Eastern Croatia were used for the statistical analysis. The records were collected in period from January/2008 to December/2012 within the regular milk recording that is performed accordingly to the alternative milk recording method (AT4 / BT4). Sampled milk was analysed in the laboratory in accordance with accredited laboratory methods; infrared spectrophotometry using MilkoScan FT 6000. The 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 excluded from the dataset. After logical control dataset consisted of 59,150 test day records from 11,258 first parity Simmental cows reared on 1,591 farms in Eastern Croatia. Further, in relation to the date of recording, the test day records were categorized into four seasons: spring (March, April and May), summer (June, July and August), autumn (September, October and November), and winter (December, January and February). Basic statistical parameters of analysed traits (daily milk yield, daily fat and protein content, as well as fat to protein ratio) are shown in Table 1.

Table 1. Basic statistical parameters of analysed traits

Variable	N	Mean	SD	CV	Minimum	Maximum
DMY	58893	15.773	5.195	32.938	3.000	82.400
FAT	56606	4.093	0.900	21.988	1.500	9.000
PROTEIN	57286	3.457	0.458	13.240	1.440	6.900
F/P	56598	1.193	0.269	22.513	0.347	4.194

*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 Simmental 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:

yi_{jklmn} = 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 l (l = I., II., III., and IV.);

M_j = fixed effect of recording month m (m = January to December);

e_{ijklmn} = residual.

The significance of the differences between recording 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 results of analyses of daily fat content, daily protein content, and fat to protein ratio associated with the season of milk recording (spring, summer, autumn, winter) are presented in continuance. Statistically highly significant effect ($p < 0.001$) of all independent variables (days in milk – lactation stage; daily milk yield; age at first calving class; and season of milk recording) involved in the used statistical model on analysed traits (daily fat content, daily protein content, and fat to protein ratio) was ascertained (Table 2).

Table 2. Significance of the effects included in statistical model on analysed traits

Effects		**FAT**			**PROTEIN**			**F/P**		
Source	**DF**	**MS**	**F Value**	**Pr > F**	**MS**	**F Value**	**Pr > F**	**MS**	**F Value**	**Pr > F**
DMY	1	705.812	969.60	<.0001	52.668	363.14	<.0001	29.641	82.66	<.0001
AFC	1	8.905	12.23	0.0005	5.246	36.17	<.0001	0.013	0.03	0.8708
sch1	1	66.665	91.58	<.0001	1.232	8.50	0.0036	5.410	980.35	<.0001
sch2	1	88.703	121.86	<.0001	11.879	81.91	<.0001	3.031	356.28	<.0001
sch3	1	19.525	26.82	<.0001	14.380	99.15	<.0001	9.252	11.74	0.0006
sch4	1	2.730	3.75	0.0528	33.642	231.96	<.0001	8.660	121.67	<.0001
season	3	1597.157	731.36	<.0001	138.407	954.28	<.0001	11.154	160.47	<.0001

*DMY – daily milk yield (kg); AFC – age at first calving; sch1 – 4; regression coefficients of lactation curve (effect of days in milk); *FAT – daily fat content (%); PROTEIN – daily protein content (%); F/P – fat to protein ratio

The LSmeans of analysed traits (daily fat content, daily protein content and fat to protein ratio) regarding the recording season class (spring, summer, autumn and winter) are shown in the Table 3.

Table 3. LSmeans of daily fat, daily protein content, as well as fat to protein ratio regarding the recording season

SEASON	FAT	PROTEIN	F/P
Spring	4.07^{A}	3.41^{A}	1.20^{A}
Summer	3.83^{B}	3.33^{B}	1.16^{B}
Autumn	4.14^{C}	3.52^{C}	1.18^{C}
Winter	4.31^{D}	3.54^{C}	1.22^{D}

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

All analysed traits differed statistically highly significant ($p < 0.001$) regarding the seasons. Furthermore, the highest daily fat content was determined in winter (4.31%), while the highest daily protein content (3.54%) was also ascertained in winter. The lowest values of daily fat (3.83%) and protein content (3.33%) were determined in summer period. Additionally, the lowest value of fat to protein ratio (F/P) was observed in summer in amount of 1.16. Higher value of F/P (1.22) was observed in winter period. Determined results prove that daily fat and protein content together with F/P ratio particularly vary as a consequence of recording season. Higher LSMs values of F/P ratio in the winter period imply higher ketosis prevalence risk, on the other hand, lower LSMs values of F/P ratio signify higher acidosis prevalence risk throughout the summer period. Accordingly, *Palmquist et al. (1993), Doreau et al. (1999),* stated that elements that can cause a decrease in the percentage of milk fat are increased milk production, reduced 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. If high levels of milk fat occur in cows after calving, it is a sign of digestive diseases and is correlated with ketosis, fast weight loss, reduced milk yield, lasting liver damage, rennet dislocation, mastitis, and many different infections. On the other hand, at the end of lactation, high values of milk fat are normal given the reduction in milk yield, that signifies they are not a sign of digestive disorders. Numerous factors such as breed, order and stage of lactation, season (of calving, of milk recording), milking frequency, udder health, nutrition (energy supply and the proportion of voluminous feed in the meal), and individual characteristics of the animal are regulating the fat content of milk *(Hargrove and Gilbert, 1984; Arsov, 1986; Keowen et al., 1986; Erdman and Varner, 1995; Klei et al., 1997; Ouweltjes, 1998; Weiß et al., 2002).* In accordance to *Palmquist et al. (1993), Doreau et al. (1999),* the increased proportion of voluminous feeds, more frequent feeding, feeding with acclaimed oilseed levels (< 2.5 kg), feeding with a bigger proportion of saturated fats such as palmitic (c 16:00) and stearin (c 18:00), reduced fitness and weight loss are components that can improve milk fat content. Moreover, factors like nutrition (amount of digestible

protein in the meal), season (lower content is typical for summer season), breed, order and stage of lactation, udder health, and specific characteristics of each cow, cause variation in protein content in milk *(Hargrove and Gilbert, 1984; Arsov, 1986; Keowen et al., 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 values of 3.2% - 3.8% is the most desirable for protein content in milk. Furthermore, low protein content signifies lack of energy and digestible protein, while too high protein content means the general overnutrition of the animal. The values of 1.1 - 1.5 are the ideal values of fat to protein ratio (F/P). The variation in the value of the ratio is slight in healthy animals in good condition. Differences in the F/P ratio can be caused by lacking feed, unsuitable environmental conditions of occurrence of animal disorder/disease *(Duffield, 2004; Eicher, 2004)*. This study shows that daily production level, stage of lactation, parity, age at first calving, and milk recording season statistically highly significant ($p < 0.001$) influenced the variability of daily fat and protein content as well as the F/P ratio. Furthermore, the results of the study show that the prevalence risk of metabolic diseases significantly differ throughout the year with registered higher ketosis prevalence risk in the winter period, along with higher acidosis prevalence risk during the summer period.

Conclusion

The purpose of this research was to determine the prevalence risk of subclinical disorders of Simmental first parity cows regarding the milk recording season. The carried analysis determined an important 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. Further, the study showed that daily fat and protein content, together with 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. Mentioned factors should be taken into consideration when predicting the ketosis/acidosis prevalence in dairy cows based on milk recording data because they influence the variability of daily fat and protein content, and therefore the fat to protein ratio along with the prevalence risk of metabolic disorders.

Varijabilnost u procenjenom riziku prevalencije metaboličkih poremećaja (ketoza/acidoza) kod simentalskih prvotelki pod uticajem sezone kontrole mlečnosti

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Rezime

Svrha ovog istraživanja bila je da se utvrdi rizik od prevalencije subkliničkih poremećaja kod simentalskih prvotelki u odnosu na sezonu kontrole mlečnosti. Za statističku analizu korišćeni su podaci kontrole mlečnosti prikupljeni tokom pet godina (januar/2008. - decembar/2012.), Hrvatske poljoprivredne agencije. Tokom redovne kontrole mlečnosti mesečno prema alternativnoj metodi kontrole mlečnosti (AT4 / BT4) na farmama mlečnih goveda u Hrvatskoj, prikupljeni su podaci za test dane. Najveći dnevni sadržaj masti (4,31%) i najveći dnevni sadržaj proteina (3,54%) utvrđeni su zimi. Najniže dnevne vrednosti za mast (3,83%) i protein (3,33%) utvrđene su u letnjem periodu. Pored toga, najniža vrednost odnosa masti i proteina (F/P) zabeležena je leti u iznosu od 1,16. Veća vrednost F/P (1,22) primećena je u zimskom periodu. Dalje, studija je pokazala da se dnevni sadržaj masti i proteina, zajedno sa odnosom F/P značajno razlikuju pod uticajem meseca kontrole mlečnosti, sa većim vrednostima odnosa F/P u zimskom periodu što ukazuje na veći rizik od prevalencije ketoze i niže vrednosti F/P odnosa u letnjem periodu koji ukazuje na veći rizik od prevalencije acidoze. Navedene faktore treba uzeti u obzir pri predviđanju prevalencije ketoze/acidoze kod muznih krava na osnovu podataka iz kontrole mlečnosti, jer oni utiču na varijabilnost dnevnog sadržaja masti i proteina, a samim tim i odnos masti i proteina zajedno sa rizikom prevalencije metaboličkih poremećaja.

Ključne reči: metabolički poremećaji, ketoza, acidoza, podaci iz test dana, simentalske krave

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