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Changes of fat-to-protein ratio from start to the mid-lactation and the impact on milk yield

Zmeny pomeru tuku a bielkovín od začiatku po stred laktácie a vplyv na mliekovú úžitkovosť

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Abstract

The aim of the study was to evaluate the changes of fat-to-protein ratio (F/P ratio) from early to mid-lactation and the impact on milk yield. 208 Holstein cows from 3 dairy farms in west Slovakia calved between years 2012 and 2015 were observed. Into the study 908 test-day records of milk yield were included. Cows were from 5 to 150 days in milk (DIM). Statistical analysis and analysis of influence of F/P ratio on milk yield were performed by SAS. The sample of observed cows produced 35.25 ± 11.55 kg*day^{-1} of milk. The average day in milk was 77.40 ± 41.17 and the average F/P ratio was 1.19 ± 0.25. In acidosis risk were 19.71% of all observation and 8.92% were in ketosis risk. The occurrence of acidosis risk increased and the occurrence of ketosis risk decreased from early to mid-lactation. The model described the variation of milk yield by 44.20%. All of the selected effects except the year of calving had high statistical significant (P<0.01) influence to variation of milk yield. The effect of F/P ratio decreased the milk yield by 4.97 kg*day^{-1}. The highest impact of F/P ratio was observed between 5 and 30 DIM and decreased the milk yield by 6.31 kg*day^{-1}. The average F/P ratio of observations between 5 and 30 DIM was 1.32 ± 0.30. The smallest impact of F/P ratio was found between 61 and 90 DIM and decreased the milk yield by 3.74 kg*day^{-1}. The average F/P ratio of observation between 61 and 90 DIM was 1.16 ± 0.22. It is possible to use F/P ratio as non-invasive indicator of metabolic status to decrease the negative impact to milk yield.

Keywords: fat-to-protein ratio, Holstein cows, metabolic disorder, test-day

Abstrakt

Cieľom tejto štúdie bolo zhodnotenie zmien pomeru tuku a bielkovín od začiatku po stred laktácie a jeho vplyv na mliekovú úžitkovosť. Pozorovaných bolo 208

holštajnských kráv z 3 fariem na západnom Slovensku otelených medzi rokmi 2012 a 2015. Zahrnutých do štúdie bolo 908 záznamov mliekovej úžitkovosti z kontrolných dní. Kravy boli od 5 do 150 dní. Štatistická analýza a analýza vplyvu pomeru tuku a bielkovín na mliekovú úžitkovosť boli vykonané v programe SAS. Vzorka pozorovaných kráv produkovala 35,25 ± 11,55 kg*deň$^{-1}$ mlieka. Priemerný deň laktácie bol 77,40 ± 41,17 a priemerný pomer tuku a bielkovín bol 1,19 ± 0,25. V riziku acidózy bolo 19,71% všetkých pozorovaní a 8,92% v riziku ketózy. Výskyt rizika acidózy vzrastal a výskyt rizika ketózy klesal zo skorej laktácie po stred laktácie. Model popisoval zmenu mliekovej úžitkovosti na 44,20%. Všetky vybrané efekty okrem roku mali vysoko štatisticky preukazný vplyv na zmenu mliekovej úžitkovosti ($P<0.01$). Efekt pomeru tuku a bielkovín znižoval mliekovú úžitkovosť o 4,97 kg*deň$^{-1}$. Najvyšší vplyv pomeru tuku a bielkovín bol pozorovaný medzi 5 a 30 dňom laktácie a znižoval mliekovú úžitkovosť o 6,31 kg*deň$^{-1}$. Priemerná hodnota pomeru tuku a bielkovín medzi 5 a 30 dňom laktácie bola 1,32 ± 0,30. Najmenší vplyv pomeru tuku a bielkovín bol zistení medzi 61 až 90 dňom laktácie a znižoval ($P>0,05$) mliekovú úžitkovosť o 3,74 kg*deň$^{-1}$. Priemerná hodnota pomeru tuku a bielkovín medzi 61 až 90 dňom laktácie bola 1,16 ± 0,22. Pomer tuku a bielkovín je možné použiť ako neinvazívny ukazovateľ na zníženie negatívneho dopadu metabolického stavu na mliekovú úžitkovosť.

Kľúčové slová: pomer tuku a bielkovín, holštajnské kravy, metabolická porucha, kontrolný deň

Introduction

A successful adaptation to the onset of lactation and the resulting negative energy balance can provide for a healthy and productive lactation, whereas a poor adaptive response can lead to a multitude of problems including clinical disease and impaired milk production (Duffield et al., 2009). Also Esposito et al. (2014) reported that transition cows in particular face the challenge of negative energy balance (NEB) and disproportional energy metabolism (fatty liver, ketosis, subacute, acute ruminal acidosis); disturbed mineral utilization (milk fever, sub-clinical hypocalcemia); and perturbed immune function (retained placenta, metritis, mastitis). Subclinical ketosis (SCK) is a major dairy cow metabolic disorder caused by strong dietary negative energy balance around calving (Duffield et al., 2009) and the estimated prevalence in Europe is at 25 % (Raboisson et al., 2014). The SCK is defined as concentrations of ß-hydroxybutyrate (BHBA) ≥ 1.2 to 1.4 mmol/L in blood and it is considered as a gateway condition for clinical ketosis (Suthar et al., 2013). The SCK decreased milk yield in early lactation (Ospina et al., 2010) and may cause great economic losses because of decresed milk yield, several postpartum diseases and increased culling (Chapinal et al., 2012, McArt et al., 2012, Suthar et al., 2013).

Subacute ruminal acidosis (SARA) is a metabolic disorder particularly prevalent in high-producing dairy herds, mainly caused by feeding excessively fermentable diets (Gao and Oba, 2015). The SARA is characterized by repeated episodes of depressed pH below 5.6 (Plaizier et al., 2008) in rumen. SARA has negative economic impact on dairy production due to the association with decreased feed intake (Nagaja and Lechtenberg, 2007), diarrhea, laminitis (Nocek, 1997) and milk fat

depression (Kleen et al., 2003). Early diagnosis of SARA during the transition period is important to prevent complications at an early stage and enhance cow health (Humer et al., 2015).

Buttchereit et al. (2010) reported that F/P ratio reflects the energy balance status of a cow in early lactation. Paura et al. (2012) reported that optimal F/P ratio is 1.1 - 1.5 and Čejna and Chládek (2005) reported that the optimum F/P ratio is 1.2 - 1.4. Lower values are likely to lead to subclinical rumen acidosis and higher values signals energy deficit and subclinical ketosis. Negussie et al. (2013) found the highest values of F/P ratio in early lactation and then the decrease to mid lactation. Also Čejna and Chládek (2005) reported the highest F/P ratio in early lactation.

The objectives of this study were to describe the changes of F/P ratio as indicator of metabolic status and the influence of F/P ratio on milk yield.

Materials and methods

Observed Holstein cows (n=208) from 3 dairy farms located in west part of Slovakia were calved between years 2012 and 2015. Into the study the dataset of 908 test-day records of milk yield of selected cows (from 5 to 150 DIM) was included. Animals were fed with Total Mix Ratio. Data of test-day records were provided by the Breeding Services of Slovakia, s. e. According to the methodology of Gantner (2015) by F/P ratio were test-day records of milk yield divided into 3 groups:
K when F/P ratio ≥ 1.5 meaning ketosis risk,
N when F/P ratio 1.0 – 1.5 meaning normal conditions,
A when F/P ratio < 1.0 meaning acidosis risk.

Influence of F/P ratio on milk yield was analysed with general linear models of SAS (version 9.2, SAS Institute Inc., Cary, NC). The model equation:
$Y_{ijklmn} = Herd_i + NoLact_j + CalvYear_k + CalvSeason_l + DIM_m + F/Pratio_n + e_{ijklmn}$
where Y_{ijklmn}- milk yield and the fixed effects as follows:
$Herd_i$ – herd (i=3, PD Močenok, VPP SPU Oponice, PD Bošáca)
$NoLact_j$- number of lactation (j=3, first lactations, second lactations, third and higher lactations)
$CalvYear_k$- year of calving (k=4, 2012, 2013, 2014, 2015)
$CalvSeason_l$- calving season (l=4, winter- December to February, spring -March to May, summer -June to August and autumn -September to November) and the random effects as:
DIM_m- days in milk (from 5 to 150)
$F/Pratio_n$- F/P ratio
e_{ijklmn}- random eror

DIM and F/P ratio were assumed as random as to be sampled from a normal distribution of effects (Freund et al., 1991).

The same model was used to analysis of milk yield from first to fifth months of lactation, separately for each month. First month was from 5 to 30 DIM. The last fifth month was from 121 to 150 DIM. The occurrence of risk of metabolic disorders as SARA and SCK in first 5 month of lactation was observed.

On PD Bošáca were observed 89 cows (403 records of test-day), on PD Močenok 53 cows (207 records of test-day) and on VPP SPU Oponice 66 cows (298 records of test-day). According to the number of lactation on the first was 165 observations (records of test-day), on the second 384 observations and on the third and higher was 359 observations. In year of calving 2012 was 14 observations, in 2013 was 337, in 2014 was 407 and in 2015 was150. In calving season winter was 263 observations, in spring was 198, in summer 214 and in autumn was 233.

Results

Totally 908 test-day records of milk yield of 208 Holstein cows (from 5 to 150 DIM) were included into the study.

Table 1. Descriptive statistic of observed Holstein cows

Tabuľka 1. Sumárna štatistika pozorovaných holštajnských kráv

Variable	Mean	Std dev	Minimum	Maximum	n
Milk (kg)	35.25	11.55	4.2	76.2	908
Fat (%)	3.73	0.77	2.02	7.81	908
Protein (%)	3.16	0.33	2.24	4.4	908
Day in milk	77.40	41.17	5	150	908
F/P ratio	1.19	0.25	0.58	2.55	908

The sample of observed cows produced 35.25 ± 11.55 kg*day^{-1} of milk (Figure 1). The average DIM was 77.40 ± 41.17 day and the average F/P ratio was 1.19 ± 0.25. In acidosis risk were 19.71% of all observation and 8.92% were in ketosis risk.

Table 2. Model for milk yield

Tabuľka 2. Model pre mliekovú úžitkovosť

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	46.260	2.238	20.67	<0.0001
Herd 1	-8.145	0.786	-10.37	<0.0001
Herd 2	9.771	1.198	8.16	<0.0001
Herd 3	Referent	.	.	.
Lactation 1	-4.957	0.966	-5.13	<0.0001
Lactation 2	-2.458	0.670	-3.67	0.0003
Lactation 3+	Referent	.	.	.
Year of calving 2012	5.099	2.852	1.79	0.0741
Year of calving 2013	2.942	1.572	1.87	0.0617
Year of calving 2014	0.716	1.307	0.55	0.5839
Year of calving 2015	Referent	.	.	.
Calving season Winter	-0.065	0.897	-0.07	0.942
Calving season Spring	2.063	0.947	2.18	0.0297
Calving season Summer	-2.944	0.863	-3.41	0.0007
Calving season Autumn	Referent	.	.	.
Days in milk	-0.039	0.007	-5.27	<0.0001
F/P ratio	-4.966	1.242	-4	<0.0001

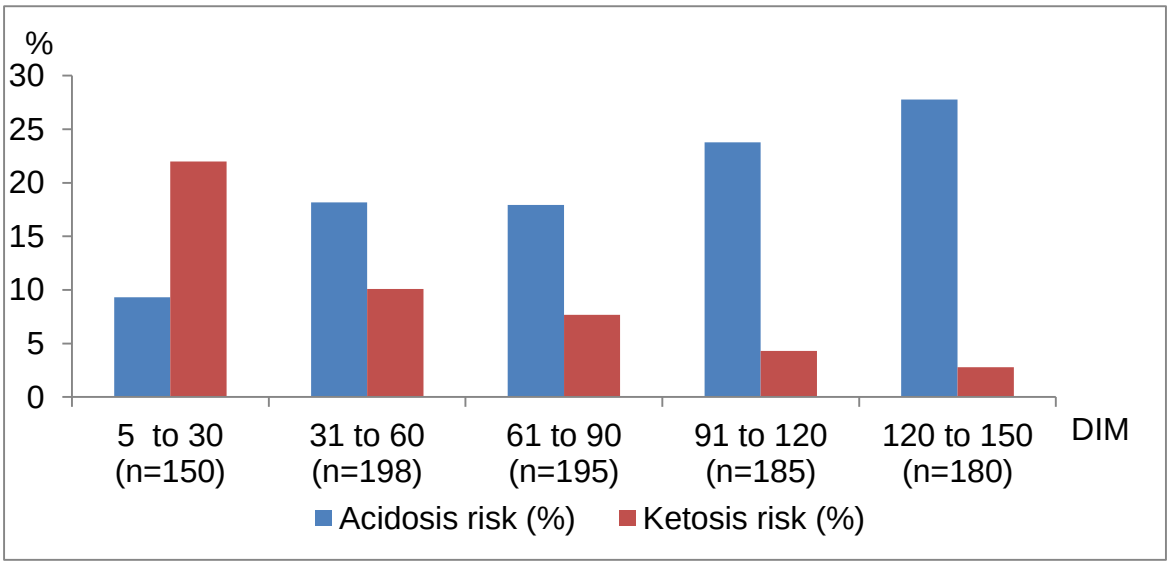
The model described the variation of milk yield by 44.20%. This model represents the alternative with the highest coefficient of determination. The average milk production was 35.25 kg*day^{-1}. The effect of F/P ratio decreased the milk yield by 4.97 kg*day^{-1} ($P<0.01$) as shows Table 2.

Table 3. The effects of model for milk yield

Tabuľka 3. Efekty modelu pre mliekovú úžitkovosť

Effect	R^2	F Value	Pr > F
Herd	0.3774	274.28	<0.0001
Number of Lactation	0.1012	50.95	<0.0001
Year of Calving	0.2239	86.91	<0.0001
Calving Season	0.0620	19.93	<0.0001
Days in Milk	0.0254	23.65	<0.0001
F/P ratio	0.0037	3.36	0.0669

The table 3 shows that all of the selected effects except the F/P ratio had high statistical significant (P<0.01) influence on variation of milk yield. The effect of F/P ratio was non-significant.



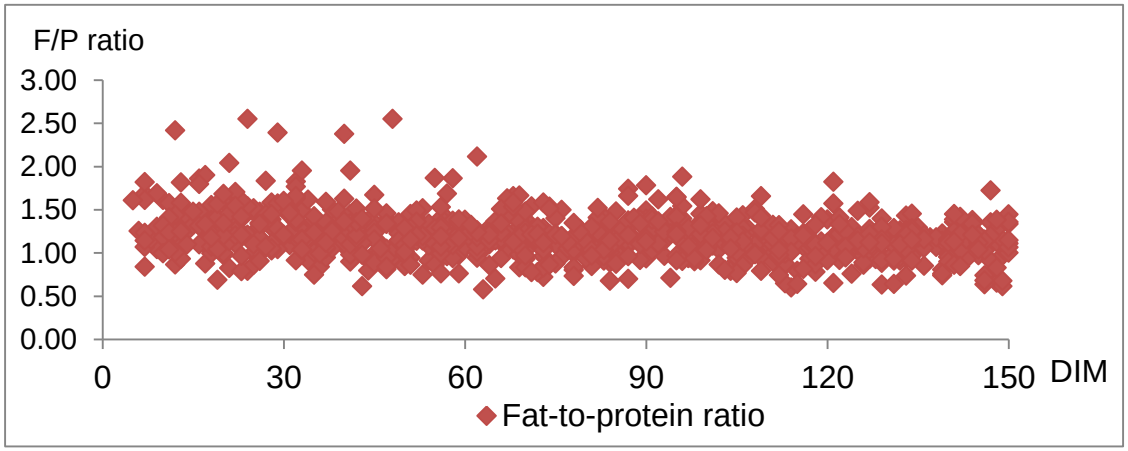
DIM- days in milk

DIM- laktačné dni

Figure 1. Occurrence of acidosis risk and ketosis risk from 5 to 150 days in milk

Obrázok 1. Výskyt rizika acidózy a ketózy od 5 do 150 dní laktácie

In this study the occurrence of acidosis risk was increased from 5 to 150 DIM (Figure 1). The occurrence between 31 to 60 and 61 to 90 DIM was approximately the same (18.18% and 17.95%).In first month of lactation the occurrence of acidosis was 9.33% and in fifth month was 27.78%. The occurrence of ketosis risk decreased from 5 to 150 DIM. In first month of lactation the occurrence of ketosis risk was 22% and in fifth month was 2.78%.



DIM- days in milk

DIM- laktačné dni

Figure 2. Values of fat-to-protein ratio between 5 and 150 days in milk

Obrázok 2. Hodnoty pomeru tuku a bielkovín od 5 do 150 dní laktácie

Figure 2 shows the values of F/P ratio of observed group of cows during the first five months of lactation. The highest impact of F/P ratio was observed between 5 and 30 DIM. Milk yield was decreased by 6.31 kg*day^{-1}. The influence of F/P ratio to milk yield was statistical significant ($P<0.05$) and the average F/P ratio was 1.32 ± 0.30. In next period of 30 days the influence of F/P ratio was lower. The smallest impact of F/P ratio was found between 61 and 90 DIM. Milk yield was decreased by 3.74 kg*day^{-1} and the average F/P ratio was 1.16 ± 0.22. In fourth month (91 to 120 DIM) and fifth month of lactation (121 to 150 DIM) the impact of F/P ratio decreased the milk yield by 4.09 resp. 4.19 kg*day^{-1}. The average F/P ratio was 1.14 ± 0.21 resp. 1.11 ± 0.20. In both months the influence of F/P was not statistical significant.

Discussion

In the first month of lactation (5 to 30 days in milk) the occurrence of ketosis risk was 22% and then decreased. In the fifth month of lactation (121 to 150 days in milk) was 2.78%. These results are in accordance with Gantner (2015), who found the highest ketosis risk in early lactation (till 60 days in milk), confirming that ketosis has the highest negative impact on milk yield in early lactation. Increasing occurrence of acidosis risk from 5 to 150 days in milk is similar to greater risk of SARA for early and mid-lactation cows compared to late lactation cows reported by Gao and Oba (2014).

Cows from 6 to 90 DIM with optimal F/P ratio (1.1 – 1.5) had a shorter total length of lactation, shorter calving interval and less days open (Paura et al., 2012). Those facts can lead to better economic situation of dairy production. Negussie et al. (2013) found that genetic correlations between F/P ratio and milk yield in early lactation (until 50 DIM) were positive and ranged from 0.05 to 0.22. Later in lactation, correlations were close to zero or negative, indicating that cows may have come out

of negative state of energy balance. If comparing the presented results, the average F/P ratio from 5 to 30 DIM was 1.32 ± 0.30 and in next periods the average F/P ratio to mid lactation decreased, similarly to results of Negussie et al. (2013). They reported that the average test-day F/P ratio in early lactation (from 8 to 40 DIM) ranged from 1.32 to 1.42 and F/P ratio declined toward mid lactation. Also Čejna and Chládek (2005) confirmed this trend of F/P ratio and the highest values of F/P ratio ranging from 1.2 to 1.4 observed at the beginning of lactation.

Obtained results confirmed the use of F/P ratio as variable with potential to be early stage, reliable indicator of metabolic status. Within the fact that F/P ratio can be observed at any test-day its estimation doesn't increase cost of production. Presented results are in concordance with Buttchereit et al. (2012), who reported that F/P ratio and body condition score are potential variables to describe how well cows can adapt to the challenge of early lactation. Similarly, Heuer et al. (1999) reported that first test-day milk yield and first test-day F/P ratio were more reliable indicators of metabolic disease, other lactation diseases, fertility, milk yield and culling than were first body condition scores (BCS) postpartum or body condition loss from the first to second scoring. Buttchereit et al. (2010) and Zink et al. (2014) reported the possibility to use F/P ratio in selection for improving metabolic stability. As concluded by Negussie et al. (2013) milk F/P ratio is easily available from routine milk-recording schemes. It can be used as a low-cost monitoring tool of poor health and fertility in the most critical phases of lactation and as an important indicator trait to improve robustness in dairy cows through selection.

Conclusions

The results of this study show that F/P ratio is changing from early to mid-lactation and has negative influence on milk yield. The highest impact of F/P ratio on milk yield was found in first month of lactation. The occurrence of acidosis risk increased and of ketosis risk decreased from early to mid-lactation. Estimation of the F/P ratio can be easily observed from test-day records. The decreased milk production means lower income for farmers. Routine observation of F/P ratio in milk possible solution for diagnosing of metabolic disorders in the future as cheap, non-invasive and eventually fast way of metabolic disorder indication. Preliminary results exist from Precision Livestock Farming concepts by collection of sensor data (bolus) of rumen pH or using the method of measuring BHBA in milk or calculation of F/P ratio during milking. Further research based on larger dataset even entire population of animals is necessary to confirm the results obtained in this study.

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