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Evaluation of feed conversion efficiency for different dairy cows breeds by milk yield, milk content and faecal amount

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Abstract. The objective of this study was to evaluation of feed conversion efficiency for Latvian Brown (LB) and Holstein Black and White (HM) dairy cows breeds to define optimal crude protein (CP) content in the feed. In the research study were completed three (A, B, C) dairy cows group (8 cows in each group) with LB and HM breed's cows in the early lactation period, from 10 till 30 lactation days. Each groups cows were feeder with total mixed ration (TMR) with different CP content (approx. 18.0%, 17.5%, 17.0% accordingly). In the research period were controlled the amount of feed fed and regularly collected feed samples. After 21 days feeding was controlled milk yield, collected milk samples for content testing, and faecal amount and samples. Milk samples were analysed for fat, total protein (%) and urea content (mg dL^{-1}). Milk samples for content parameters were analysed in an accredited milk quality laboratory. The statistical analyses were performed with the SPSS program package. The results acquired show that in all studied parameters were not significant differences between study groups. To evaluate the feed conversion efficiency during the study, we used the energy corrected milk (ECM) and the feed dry matter content during research and calculated the coefficient for each cow individually and on average in the study group. Milk yield, protein and faecal amount were significantly different among breeds. Milk urea content was average 28.5 mg dL^{-1} for all LB breed cows in all groups, for HM breeds it was 23.6 mg dL^{-1}. These results show that LB breed cows did not converse feed proteins wholesome. Total milk and faecal amount were decreased in a group with CP 17% in feed by 10% and 7% accordingly. By using this data, the farmer may make evaluations and forecast of farming efficiency; cows breed preference and environmental threats.

Key words: milk yield, milk urea, faecal, protein in feed.

INTRODUCTION

The volatility of the world dairy market and climate change are encouraging farmers to seek the most efficient use of available resources to reduce the environmental impact of their production process and thus reduce production costs. Therefore, it is important to evaluate the composition of the feed ration and to monitor its use.

Increasing the conversion efficiency of cattle feed is that less nutrients are excreted in the manure, so feed conversion efficiency affects both economic and environmental efficiency. One of parameter that recommended using for conversion efficiency control is milk urea content (Zhai et al., 2006; Gruber & Poetsch, 2012; Ruska et al., 2017). For an accurate assessment of feed conversion efficiency, is recommended to use Energy

Corrected Milk (ECM) to calculate productivity, which will allow comparisons to be made between cows, groups, or farms with different technologies and breeds. One of the recommended calculations of feed conversion efficiency is the ratio of ECM to dry matter intake, depending on lactation and day of lactation (Hutjens, 2005). According to the US National Science Council (NRC), farmers exceed on average 6.6% nitrogen in their diet, resulting in 16% increase nitrogen content in their urine and 2.7% increase nitrogen in their manure (Jonker et al., 2002). By feeding a balanced diet to dairy cows after calving, when the amount of feed ingested can also affect the animal's health, we can ensure control over productivity, health and costs.

One of the factors that stay influence on feed conversion efficiency coefficient is cow genotype. Results of previous studies confirm that Jersey and Holstein–Friesan crossbreed cows produce more milk from lower feed inputs (Coffey et al., 2017). While other study results with Holstein and Swedish–Red and Jersy or Holstesin crossbred dairy cows does not find interaction for any milk production parameters by milk solid yield (Ferris et al., 2018).

Research in the Netherlands at the end of the last century has shown that keeping dairy cows and thus milk production account for the greatest amount of nitrogen pollution in the surrounding environment. Calculations predicted an average nitrogen release from total nitrogen intake in 29% faecal, 50% in urine, 19% in milk and 2% in dairy cow to maintain body condition (Tamminga, 1992). Later, the results of the studies performed corrected this distribution for the following average nitrogen excretion in faecal 37%, urine 35%, milk 27% and 0% for body maintenance. The distribution of this may be affected by the influence of various factors that require in-depth study (Straalen, 1995).

The objective of this study was to evaluate difference of feed conversion rate between Latvian Brown (LB) and Holstein Black and White (HM) dairy cows breeds.

MATERIALS AND METHODS

The study was conducted from begin of May till the end of July 2019 at the research and study farm Vecauce of the Latvia University of Life sciences and Technologies (LLU MPS Vecauce). Twenty four dairy cows were completed in three groups within Latvian Brown and Holsten Black and white breeds in each group were presented. Cows were in early lactation phase from 10 to 30 lactation day, with second and third lactation. The cows were housed in a 3×3 Latin square design experiment, three diets over three periods each lasting 21 days. In this paper were analysed data from first phase of experiment (accordingly lactation phase from 10 to 40 days).

The cows fed with in farm used prepared total mixed rations (TMR) which differ by crude protein content in diet (A, B, C groups 18.0%; 17.5%; 17.0% accordingly). Feed compositions were completed within farm used maize silage, grain, soya seed, rapeseed cakes and mineral additives. All cows were fed *ad libitum*. Refused feed were collected and weighted every day separately for each cow. Water intake was recorded for each individual cow every day. To control the composition of the feed ration, TMR samples for testing are taken from the feed table every second or third day (n = 24 samples). In the Table 1 presented chemical composition of TMR is the average of the compound feed and not of each ingredient individually. Feed composition were analysed in accredited laboratory of LLU for dry matter (%), fat (%), protein (%), fibre content (%) etc.

Table 1. Chemical composition of feed compounds during the study

Traits	A group (n = 8)	B group (n = 8)	C group (n = 8)
Dry matter, %, included:	45.62	40.57	38.29
Crude protein in dry matter, %	18.02	17.89	16.99
Ash in dry matter, %	6.88	7.14	8.40
Crude fibre in dry matter, %	13.46	15.27	19.17
NDF, %	28.93	32.15	36.62
ADF,%	16.78	19.46	23.40
Fats in dry matter, %	3.30	3.20	3.17
Digestibility of organic substances, %	78.12	76.49	71.38

The crude protein content of the feed ranged from 16.99% to 18.02%, depending on the group to be fed. It meets the needs of dairy cows depending on milk yield. The crude fibre ranged from 13.46% to 19.17% and met the needs of high-yielding cows (NRC, 2001). The NDF content in all TMR groups meets the needs of dairy cows in begin of lactation.

Milk yield (kg) recording and sampling were on first, seven, eleven, fifteenth and twenty first days (n = 63 samples), separate for each milking time. Milk composition was analysed in accredited laboratory for milk quality control for content of fat (%), crude protein (%), urea (mg dL^{-1}) and somatic cell count for quality characterising.

Total faecal amount after 21 days were collected over 72 hours from each cow separately (n = 24 samples). Daily feces was collected, weighed, mixed thoroughly, and subsampled for each cows. Faecal sample composition were analysed in accredited laboratory of LLU for dry matter (%), nitrogen (N, %), phosphor (P, %), potassium (K, %) content.

For data processing, the feed and faecal dry matter and crude protein content, as measured as a percentage of dry matter in the laboratory were recalculated to amount (kg) according to ICAR guidelines (ICAR, 2017). Also content of dry matter and nitrogen in faecal was recalculated in compliance with formula (1).

$$Amount, kg = (yield, kg \times \% \, of \, content)/100 \quad (1)$$

With an aim to compare and evaluate study results between groups and estimate feed conversion rate, milk yield and content were transformed in ECM (ICAR, 2017) by following formula:

$$ECM = (fat\,yield, kg \times 38.3 + protein\,yeild, kg \times 24.2 + \\ + milk\,yield, kg \times 0.7832)/3.14 \quad (2)$$

Statistical processing of the data was carried out with *MS for SPSS* (SPSS Inc. Chicago, Illinois, USA) and *MS Office* programme *Excel*. Images were created with *MS Office* programme *Excel*.

RESULTS AND DISCUSSION

The choice of cow breed is important in terms of farming model, feeding and productivity. Dairy cows breed may have significant influence on milk productivity and quality traits, therefore feed and water intake by cows. The research groups consisted of two breeds of cows and evaluated the influence of the breed on productivity and feed consumption parameters. The results of the study show significant differences in productivity, feed utilization and faecal output in all study groups between breeds. Average milk productivity traits per cow in the control day in study are present in the Table 2.

Table 2. Average cow milk productivity traits by breed in experiment first phase

Traits	Study groups					
	A		B		C	
	Breeds					
	LB (n = 6)	HM (n = 15)	LB (n = 6)	HM (n = 15)	LB (n = 6)	HM (n = 15)
Milk yield, kg	28.9 ± 2.52[a]	47.5 ± 1.92[b]	28.2 ± 2.73[a]	46.8 ± 1.94[b]	26.1 ± 2.27[a]	47.8 ± 2.74[b]
Fat content, %	4.00 ± 0.015[a]	3.14 ± 0.181[b]	3.94 ± 0.104[a]	3.18 ± 0.338[b]	4.14 ± 0.149[a]	2.49 ± 0.309[b]
Crude protein content, %	3.50 ± 0.162[a]	2.91 ± 0.086[b]	3.28 ± 0.95[a]	2.64 ± 0.287[b]	3.18 ± 0.080[a]	1.85 ± 0.304[b]
Urea content, mg dL^{-1}	28.3 ± 3.55[a]	26.3 ± 1.14[a]	28.7 ± 2.04[a]	21.5 ± 3.14[a]	28.6 ± 3.42[a]	22.9 ± 4.88[a]
ECM, kg	29.1 ± 2.54[a]	40.6 ± 1.81[b]	27.6 ± 2.47[a]	39.3 ± 2.81[b]	26.2 ± 2.62[a]	33.2 ± 2.98[b]

[a; b] – productivity indicators with unequal letter differed significantly among the breeds in separate group ($p < 0.05$).

The milk yield on the control day differs significantly between breeds in all study groups but does not differ between groups within the breed.

The LB breed yield ranged from 26.1 kg in C group to 28.9 kg in A group. The HM yield ranged from 46.8 kg in group B to 47.8 kg in group C. The fat and crude protein content of milk differed significantly between breeds, but there was not significant difference between the groups within one breed. The fat content of LB breed milk were ranged from 3.94% in group B to 4.14% in group C. The HM breed fat ranged from 2.94% in group C to 3.18% in group B. The crude protein content of LB breed milk ranged from 3.18% in group C to 3.50% in group A. The HM crude protein content was significantly lower and ranged from 1.85% in group C to 2.91% in group A. Other scientists have also conducted studies to compare the milk composition of Red and White and black cows. It was found that Swiss brown cows had significantly higher crude protein content in milk compared to Holstein cows (DeMarchi et al., 2008). Estonian red cow's milk has been found to have a higher content of crude protein than Estonian Holstein cows (Joudu et al., 2008).

The mean urea content in milk during the study was within optimal limits for all breeds, 21.5 mg dL^{-1} to 28.7 mg dL^{-1}. In Europe, the optimal urea content in milk is considered to be 15 mg dL^{-1} to 30 mg dL^{-1} (Bijgaart, 2003). The milk urea contents are not significantly different between breeds and groups. Previous studies with Holstein, Jersey and Switzerland Brown cows show a significant difference in crude protein and urea content in milk depending on the breed of dairy cow (Carroll et al., 2006).

Average feed and water intake differs significantly between breeds in all study groups, but not between groups (Tabel 3).

Table 3. Average feed traits and water intake per day by breed in experiment first phase

Traits	Study groups					
	A		B		C	
	Breeds					
	LB (n = 72)	HM (n = 120)	LB (n = 72)	HM (n = 120)	LB (n = 72)	HM (n = 120)
Feed intake, kg	35.5 ± 1.56[a]	38.8 ± 2.90[b]	34.7 ± 1.03[a]	42.6 ± 3.69[b]	37.6 ± 0.82[a]	47.7 ± 1.26[b]
Dry matter intake, kg	16.2 ± 0.71[a]	17.7 ± 1.32[b]	14.1 ± 0.42[a]	17.3 ± 1.49[b]	14.4 ± 0.31[a]	18.3 ± 0.49[b]
Crude protein intake, kg	2.92 ± 0.130[a]	3.19 ± 0.239[b]	2.52 ± 0.078[a]	3.09 ± 0.268[b]	2.44 ± 0.053[a]	3.10 ± 0.082[b]
Water intake, L	80.2 ± 6.20[a]	113.2 ± 3.79[b]	76.9 ± 3.15[a]	127.7 ± 15.54[b]	74.7 ± 2.30[a]	110.1 ± 9.89[b]

[a; b] – traits with unequal letter differed significantly among the breeds in separate group ($p < 0.05$).

Feed intake for LB breed cows were ranged from 34.7 kg in group B to 37.6 kg in group C. The HM breed feed intake were from 38.8 kg in group A to 47.7 kg in group C. Feed dry matter intake were significantly high for the HM breed cows (17.3 kg to 18.3 kg), but does not achieve nutritional requirement for milk yield of experiment cows. Dry matter intakes are affected by many factors: physiological, diet, environmental. Is it possible predict dry matter intake by dairy cows lactation, lactation day, milk yield etc. Daily dry matter intake could be less on begin of lactation than in the end by 5 kg per day (Weiss, 2015). Dry matter intake for LB breed cows were from 14.1 kg to 16.2 kg which provide nutritional requirement for their milk yield. Feed crude protein intake were ranged from 2.44 kg to 2.92 kg for LB breed cows and was significantly lower than for HM breed cows were ranged from 3.09 kg to 3.19 kg. Water intake is depending on dry matter intake. Is it possible to predict water intake by estimation. Our study results conform previous studies where average dry matter intake 18.3 kg per day require 75.2 kg water per day for lactating cows (Appuhamy et al., 2016). There we find significant differences between LB and HM breeds cows water intake.

Found out differences between breeds in feed intake and milk productivity consequence related to faecal output (Tabel 4). Faecal amount was significantly lower for LB breed cows (ranged from 29.7 kg to 27.6 kg), but there was not differences among study groups. The HM breeds cow faecal amount was higher and ranged from 39.5 kg in group A to 49.9 kg in group C.

Table 4. Average faecal traits output per day by breed in experiment first phase

Traits	Study groups					
	A		B		C	
	Breeds					
	LB (n = 6)	HM (n = 15)	LB (n = 6)	HM (n = 15)	LB (n = 6)	HM (n = 15)
Faecal, kg	29.7 ± 1.17[a]	39.5 ± 1.56[b]	30.1 ± 1.07[a]	45.0 ± 6.99[b]	27.6 ± 1.89[a]	49.9 ± 4.19[b]
Dry matter, kg	3.85 ± 0.058[a]	5.36 ± 0.203[b]	3.64 ± 0.176[a]	5.93 ± 0.856[b]	3.41 ± 0.355[a]	6.02 ± 0.497[b]
Nitrogen, kg	0.13 ± 0.004[a]	0.17 ± 0.004[b]	0.11 ± 0.006[a]	0.19 ± 0.030[b]	0.10 ± 0.010[a]	0.18 ± 0.020[b]

[a; b] – traits with unequal letter differed significantly among the breeds in separate group ($p < 0.05$).

Feed conversion efficiency is estimation of how much produced for each unit of feed consumed. For evaluation of feed conversion efficiency of dairy cows usually calculate the ratio of milk yield to feed dry matter intake. Feed efficiency is useful tool to control feed costs. Therefor breeding organisation start to use it for selection works, to control potential for lower maintenance requirements of the cow herd, reduce overall feed intake, improve feed conversion ratio, reduce methane emissions and reduce manure nitrogen, phosphorus and potassium production (Berry & Crowley, 2013). To estimate feed conversion efficiency lactating animals is more complicated than for growing animals. Lactating cows under lactation curve characterized by rapid catabolism of body reserves after calving than anabolism of body reserves until next calving (Roche et al., 2009).

To evaluate the conversion efficiency of the feed during the study, we used the ECM and the feed dry matter content and calculated the coefficient for breeds and on average in the study group (Fig. 1).

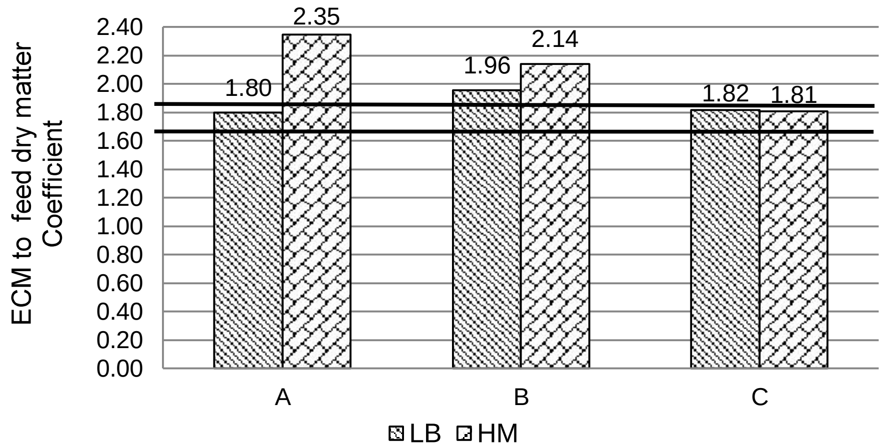

Figure 1. Feed conversion rate by dairy cows breeds in study groups.

The calculated coefficients show deficit of the dry matter in the feed ration, which was reflected in the reduction in live weight of individual cows as internal body reserves were used to provide milk yield. The average coefficients for LB breed cows were similar in all groups and did not differ significantly between groups and breeds. The average coefficients of groups A and B for HM breed cows were above the recommended level, and the coefficient of group C was within the recommended range corresponding to level 1.6–1.8 of second lactation, the initial lactation phase (Hutjens, 2005; Arndt et al., 2015). In the study feed conversion efficiency for group C cows for both breeds was most effective.

On farms, it is appropriate to apply the feed conversion efficiency coefficient at the herd or group level rather than for individual animals. The calculation of the coefficient requires weekly data on the dry matter content of the feed, the amount of uneaten feed and the milk productivity traits (ECM). The farm needs to record feed quality and consumption in order to be able to make the necessary changes to feed rationing in a timely manner.

Limited data are available on the comparative feed conversion efficiency of lactating LB and HM cows. In study where compare Friesian (F) and Jersey (J) breed cows were established that F cows was consumed more feed dry matter per day than J. Estimate efficiency parameter in this study (amount of milk produced per kg of dry matter consumed) was not find significant differences between breeds (Mackle et al., 1996).

Feed conversion efficiency possible to evaluate by crude protein utilization. In our study estimated crude protein amount in milk to crude protein intake (Table 5). Crude protein conversion coefficient of crude protein were ranged from 0.28 to 0.45 for HM breeds cows and form 0.34 to 0.36 for LB breed cows difference was significant between breeds. Study results are related with previous researcher estimation they predict 27% of total intake nitrogen extraction in milk and highly variable of this estimation 10% to 40% (Straalen, 1995; Calsamiglia et al., 2010).

Table 5. Feed crude protein conversion efficiency by dairy cows breeds in study groups

Breeds	A	B	C
LB	0.35 ± 0.024[a]	0.36 ± 0.028[a]	0.34 ± 0.020[a]
HM	0.45 ± 0.043[b]	0.39 ± 0.039[b]	0.28 ± 0.037[b]

[a; b] – traits with unequal letter differed significantly among the breeds in separate group ($p < 0.05$).

To evaluate feed conversion efficiency is it possible to analyse other productivity and utilisation parameters (Arndt et al., 2015).

CONCLUSIONS

Milk productivity traits and feed intake were different between LB and HM dairy cows. Milk yield, crude protein content, feed and water intake and faecal amount significantly differ between cows breeds. The conversion efficiency of the feed during the study was optimal for LB breeds cows in all study groups. For HM breeds cows this rate was optimal in C group, in A and B group coefficient was higher than recommended value.

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