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Feed conversion efficiency in different groups of dairy cows

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It was estimated the conversion of feed into milk, content of urea, fat, protein, somatic cells in the milk of cows of different breeds in different seasons and months of the year. It was established that the peculiarities of the organization of feeding process significantly influence the productive indicators. Thus, in the conditions of a modern milk complex for 1500 cows with an unattached system of keeping in boxes and feeding with the use of mixed rations, the average value of feed conversion (the measures of digestibility of the feed when it "converted" into dairy products) is 1.38 kg of milk per kilogram of dry matter of feed, and the ratio of fat to protein is 1.10, which is lower than the existing standards. It was established that changes in the conditions by months of the year significantly influenced practically all analyzed qualitative characteristics of milk. And this fact entails the corresponding monthly fluctuations of indicators of safety of products, emissions of by-products of metabolism, and, consequently, fluctuations of dairy cattle breeding impact on the environment and ecology. It was found that milk yield positively and significantly (P≥0.999) correlated with the consumption of feed dry matter (r = 0.454) and feed conversion rate (r = 0.547). At the same time, the milk yield is negatively related to the fat content (r = –0.211) and the protein content (r = –0.192) in milk. The level of urea in milk positively correlates with the content of protein in milk (r = 0.130; P≥0.99). The influence of the factor "breed" on the following important economic-useful traits such as daily milk yield (η^2 = 0.131) and feed conversion rate (η^2 = 0.130) are proved.
Keywords: milk yield; milk; somatic cells; feed; urea; conversion; genetic group; season; ration; breed

Introduction

The production of animal protein is often criticized because of the low level of plant protein conversion into animal protein. According to some experts (Ertl et al., 2016; Ruban et al., 2017), it is necessary to take into account the fact that plant's proteins may be inedible to humans, and their transformation is possible only through domestic animals. Ertl P. et al (2016) conducted a study in 30 Austrian dairy farms. They defined that there was a difference of 27-53% between the amount of feed protein (input protein) and animal protein of milk (output protein), or a ratio of 1 : 1.4-1.87 in favor of the feed protein. Such approaches imply the need for an assessment of the effective transformation from feeds into products (as milk) (Arndt et al.,2011, Detmann et al., 2014, Reed et al., 2015, Ruban et al., 2017, Zamani, 2011,). In addition, according to Virginia Ishler (n.d.), low levels of feed protein use contribute to their higher "ejection" along with animal excrement, which can negatively affect the environment, and especially in the case of large dairy farms.

P. Huhtanen et al. (2008) for the estimation of conversion added the level of urea in the urine, which is closely correlated with the level of urea in milk. According to experts from the Illinois University of the USA (Hutjens, 2005), the effectiveness of conversion can be estimated by the ratio of milk amount standardized by fat and protein content to the amount of dry matter of feed that was consumed by cows.

The authors note that the optimal values of this indicator are at the level of 1.4-1.8 kg of milk (that is, from 1 kg of dry matter of feeds, consumed by cows, was synthesized 1.4-1.8 kg of milk with a certain composition). It is also important to assess the impact on the specified criteria of such factors as lactation phase, age and size of the cow, fatness, body weight, feed quality, feed additives and farm management features (feed rate multiplicity, time and multiplicity of milking, microclimate, etc.).

M.F. Hutjens (2005) refers the values of the Dairy Efficiency (DE), which varies from 1.1 kg to 2.0 kg depending on the technological groups of animals.

The first attempts at systematic use of MUN (milk urea nitrogen) were made by experts from the University of Maryland (USA) - Jonker et al. (2002), which, after lengthy studies, conducted on the basis of two milk processing enterprises and 454 milk farms, made some conclusions about the connection between the peculiarities of feeding with the level of MUN.

The authors combined a high level of MUN with a high nitrogen output along with excreta and milk. As a result of the research, they successfully solved the main tasks:

1) determined the optimal (threshold) values of MUN for dairy herds;

2) gave recommendations on the balance of nitrogen at the expense of exogenous (feed) components;

3) assessed the economic and environmental impacts of large "emissions" of nitrogen.

According to Allen Yonng (2001), in most US farms, the level of urea in milk is strongly influenced by the peculiarities of feeding and, to a lesser extent, the breed, the season of the year, the lactation period. The high level of urea, according to the author, indicates high content of protein in the forage and low content of energy; as a rule, this situation is "amplified" by the small amount of readily available carbohydrates precisely in the cow's rumen and the extremely high level of digestible protein (RDP - rumen degradable protein - a protein that collapses in the rumen). Offering the term "depression" of milk fat (a reduction in milk fat in protein overfeeding), the researcher states that most of the herds under control were at risk of developing ketosis. In this regard, for most US farms, the recommended MUN norm is 12-16 mg / decilitre or 12-16 mg%, and in certain states of the United States, such as Pennsylvania, the recommended MUN is much more stringent (10-14 mg%).

Michael Hatjens (n.d.) sets requirements for the ratio of fat content to protein content in animals of different breeds. He notes that the content of fat and protein in milk depends primarily on the peculiarities of feeding: the ability to provide a diet of cows with certain feed components, or the proportion of certain feeds. M.Hatchen highlights the following basic approaches to controlling the level of protein in milk: 1) the need to assess the level of amino acids in feed and especially the possibilities for their synthesis, since the microbial process in the rumen can provide up to 60% of the cow's body's needs in amino acids; 2) RUP - rumen undegraded protein evaluation and possibilities to use body reserves to provide energy balance; 3) bringing the level of lysine and methionine to the norm level 6,2-6,6% and 2-2,2% respectively, at a ratio of 3 : 1.

M. Hatjens proposed a methodology for assessing the efficiency, which can be used for any production conditions without significant costs for its implementation (Hutjens, 2005). For its exact application it is necessary to determine the amount of residual feed that was not consumed by cows of a technological group. The mass of residues should be deducted from the distributed feed to determine the amount of feed consumed by cows (Ruban et al., 2017).

Methods

As an experimental base we used cows of LLC “MPC Ekaterinoslavsky” of the Dnipropetrovsk region (the number of 1500 heads). The maintenance of cows is in groups. There are boxes with rubber rugs. The rearing of young animals is in group sections under the canopies using deep litter of straw. Milking of cows conducts three times per day at the milking parlor "Parallel" 2 x 20 by company "De Laval" with the computer system of herd monitoring "Dairy Comp - 350".

As a criterion for evaluating the protein intake and milk-derived protein, we used the formula of the GECP (Grosse Efficiency of Crude Protein) (Jonker et al., 2002; Ruban et al., 2017):

$$GECP = \frac{CPM}{CPI},$$

where CPM – protein yield in milk; CPI – crude protein intake.

The dynamics of possible changes in the reciprocal efficiency of pure protein (GECP) depends at values of the input (feed) and the output (milk) proteins. Conversion efficiency is high in cases where the total amount of source protein reaches 40-50% of the consumed inbound protein. As a group indicator for certain technology groups, the value of GECP indirectly indicates the possibility of protein synthesis due to action of microbial flora of the rumen in cows.

In the conditions of LLC “MPC Ekaterinoslavsky” for each of the technological groups daily we fixed the following indicators: the number of animals in the technological group (heads); milk yield for group (kg); fat and protein content in milk (%); the level of somatic cells in milk (thousand pcs / ml); urea content in milk (mg%); the amount of feed consumed by cows in the form of dry matter of feed, minus residues (kg). Animals of Brown Swiss breed were kept in production sections Nos. 33 and 34, and cows of domestic ukrainian breeds kept in production section No.3. In addition, we analyzed 478 daily observations during the year (from May 2016 to May 2017) in twelve technological groups, which included dairy cows at different stages of the lactation and with different health conditions.

For dairy cows three feeding rations were used, which are calculated for the corresponding level of productivity and live weight of cows (Table 1). Thus, the first diet is calculated on a live weight of cows of 635 kg, daily milk yield of 32 kg; the second diet – respectively 650 kg and 24 kg, the third diet – respectively 635 kg and 24 kg. The estimated fat and protein content in all three diets was 4.0% and 3.4%, respectively.

Diets for feeding cows are drawn up and balanced on the basis of a computer program with participation of representatives of the company "Kargil". At the same time the requirements for feeding dairy cattle (Hutjens, 2006; National..., 2001; Ruban et al., 2015) were used.

Table 1. Characteristics of feeding rations of various technological groups (data on the amount of dry matter of feed - DMF*)

Indicators	Rations of dairy cows			Dry cows	
	1	2	3	A (early)	B (late)
Foods in the diet:					
Alfalfa haylage	4.5	5.8	2.1	1.5	1.4
Corn silage	3.9	3.0	5.0	5.7	6.1
Brewer's grain 24% DMF	2.4	1.0	1.4	0.9	-
Corn grain, dry	4.4	3.6	1.5	0.220	-
Soybean oilcake	1.8	1.5	1.8	0.260	1.0
Grass hay (cereal)	1.7	2.7	1.1	4.1	3.0
Molasses	1.1	-	0.8	-	-
Triticale	0.590	0.500	1.7	0.250	0.200
Premix	0.200	0.160	0.200	0.030	0.200
Additives	0.400	0.170	0.210		0.100
Distillery dreg	-	0.5	1.2	-	-
Total DMF, kg	20.78	19.0	17.0	13.0	12.0
Crude protein, %	16.332	16.424	17.010	12.986	14.167
RDP - *rumen degradable protein, %*	10.9	10.8	10.9	8.61	9.50
RUP - *rumen undegradable protein, %*	5.34	5.56	6.04	4.86	4.66
Net energy of lactation, MJ	6.945	6.64	7.09	6.134	6.02
NDF – neutral detergent fiber, %	30.65	32.98	31.70	45.5	42.7
NDFd – neutral detergent fiber digestible, %	16.223	16.348	17.0	20.5	19.2
ADF – Acid detergent fiber, %	17.887	20.8	17.8	28.7	27.4
Starch, %	22.5	20.5	21.45	13.756	14.0

Note. *DMF - *dry* matter of feed*; 1 - high-yield, 2-low-yield, 3 - immediately after calving.*

The crude protein balance (CPB) was calculated using the formula:

$$CPB = CPI - CPM.$$

Biometric processing of digital material was carried out according to the methods of E.K.Mercurieva (1983) and using the standard licensed package of applied statistical software.

Results and discussion

The number of observations for each specified technological group was n = 478 with the number of 130-135 cows in each group. According to data received for 12 months, controlled by all seasons of the year, the average daily milk yield amounted to 27.1 kg with a fat content of 3.68%, and a protein content of 3.32% (Table 2).

Table 2. Indicators of productivity in groups of the cash cows

Indicators	Average	Standard deviation
Daily milk yield, kg	27.132	5.2125
Fat content in milk, %	3.680	0.3508
Protein content in milk, %	3.321	0.1363
Somatic cells in milk, thousand pcs / ml	277.52	28.694
Urea content in milk, mg%	17.336	2.537
Consumed dry matter of feed, kg	19.916	3.162
Feed conversion	1.384	0.2964
The ratio "fat content: protein content"	1.10	-

The peculiarities of the organization of feeding process significantly influenced the productive indicators, which corresponds to Shablia (2014). Thus, the average value of feed conversion (the measures of digestibility of the feed when it "converted" into dairy products) was 1.38 kg of milk per kilogram of dry matter of feed, and the ratio of fat to protein was 1.10, which is lower than the existing standards.

In some cases, and especially in the transitional spring-summer period, the practice of most farms in Ukraine (and the investigated farm is no exception) provides the gradual addition to the mixed diet of green mass of legumes, cereals or industrial crops.

Such actions in the farms are associated with certain production possibilities, as well as the need for additional portion of cheap vitamin and protein components at the expense of the green mass. All this, combined with climate change, affected the seasonal fluctuations in milk production and its quality in the conditions of LLC “MPC Ekaterinoslavsky” (Yonng, 2001).

When using analysis of variance it was established (Table 2) that the feeding diet significantly influences on: daily milk yield (the measure of the effect $\eta^2 = 0.639$, the confidence level P≥ 0.999), the fat content ($\eta^2 = 0.368$, P≥0.999), the protein content ($\eta^2 = 0.093$, P≥0.999), the somatic cells in milk ($\eta^2 = 0.10$, P≥0.999).
The season of the year significantly influenced the traits of milk yield ($\eta^2 = 0.087$, P≥0.999), fat and protein content in milk ($\eta^2 = 0.161$, P≥0.999 and $\eta^2 = 0.044$, P≥0.999), as well as the level of somatic cells count ($\eta^2 = 0.09$, P≥0.999). There is not established influence of the peculiarities of feeding or the level of protein in diet on the urea content in milk (Table 3).

Table 3. Estimation of the influence (η^2) of the factors "ration", "season of the year" and their interaction on daily milk yield and qualitative indicators of milk.

Influencing factors	Daily milk yield	Urea content in milk	Content		Somatic cells count
			fat	protein	
Ration	0.639***	0.007	0.368***	0.093***	0.10***
Season of the year	0.087***	0.024	0.161***	0.044***	0.09***
Interaction «Ration» x «season of the year»	0.029***	0.006	0.033*	0.028	0.077***

*Note. * – P≥0.95; *** – P≥0.999.*

The obtained data also prompted the verification of the working hypothesis concerning the influence of the factor "month of the year" on qualitative indicators of milk (Table 4).

Table 4. Estimation of the influence (η^2) of the factor "month of the year" on qualitative indicators of milk.

Indicators of milk quality	η^2	Confidence level P
Fat content in milk	0.138	≥0.999
Protein content in milk	0.140	≥0.999
Somatic cells in milk	0.078	≥0.999
Urea content in milk	0.043	=0.913
Acidity of milk	0.175	≥0.999

It was established that changes in the conditions by months of the year significantly influenced practically all analyzed qualitative characteristics of milk. And this fact entails the corresponding monthly fluctuations of indicators of safety of products, emissions of by-products of metabolism, and, consequently, fluctuations of dairy cattle breeding impact on the environment and ecology.

Table 5. Indicators of milk quality and quantity in different genetic groups

Indicators	All sample	including genetic groups		Difference Brown Swiss – domestic Ukrainian breeds	
		Brown Swiss *	domestic Ukrainian breeds **	±	Confidence level P
The number of cows in the section	130-140	130-140	130-140	-	-
Number of technological sections	3	2	1	-	-
Number of observations during the experiment	163	104	59	-	-
Daily milk yield, kg	30.96±0.255	31.840±0.315	29.42±0.356	+2.42	≥0.999
Fat content in milk, %	3.56±0.018	3.58±0.024	3.53±0.024	+0.05	<0.95
Protein content in milk, %	3.28±0.088	3.30±0.011	3.26±0.012	+0.04	*≥0.99*
Somatic cells in milk, thousand pcs / ml	277.27±6.105	296.97±7.94	242.54±7.57	+54.43	*≥0.999*
Urea content in milk, mg%	16.93±0.200	16.92±0.250	16.95±0.318	-0.03	<0.95
Acidity of milk, T°	17.60±0.110	17.60±0.144	17.61±0.16	-0.01	<0.95
Feed conversion	1.35±0.010	1.37±0.013	1.30±0.015	+0.07	<0.95

*Note. * – clean-bred Brown Swiss of European breeding (importation from Austria); ** - domestic breeds – Ukrainian black-and-white, Ukrainian red-and-white dairy breeds.*

In some cases, the variability of the content of urea in milk exceeds the average value of this indicator by 15-20%, which indicates the possible problems associated with acidosis in certain animals in certain technological sections.

As an option to confirm the opinion on the problem of acidosis in certain technological groups of the herd, we give a material on the correlation between the analyzed features. It was found that milk yield positively correlated with the consumption of feed dry matter (r = 0.454; P≥0.999) and feed conversion rate (r = 0.547; P≥0.999). At the same time, the milk yield is negatively related to the fat content (r = –0,211; P≥0.999) and the protein content (r = –0.192; P≥0.999) in milk. The level of urea in milk positively correlates with the content of protein in milk (r = 0.130; P≥0.99).

Separate cases of high levels of urea in milk indicate the need to review the content of feed protein in the ration in the direction of reducing it. The ratio of fat to protein content confirms the need for dietary correction in the direction of increasing the Neutral detergent fiber digestibility (NDFd). The data obtained gave the opportunity to reasonably make such proposals, which are successfully used in LLC "MPC Ekaterinoslavsky".

The efficiency of milk production by animals of different genetic groups was estimated (Table 5). It was found that the average milk yield was at the level of 30.96 kg of milk per day with a fat content of 3.56% and a protein content of 3.28%. The average level of somatic cells count and urea was within the normal range, which corresponds to the quality of milk in the "extra" class. The advantage of Brown Swiss breed cows in comparison with domestic Ukrainian black-and-white and red-and-white dairy breeds at the daily milk yield, fat and protein content, as well as feed conversion has been proved. Brown Swiss breed was characterized by elevated levels of somatic cells count in milk, which is possibly due to the characteristics of the mammary gland in highly productive cows.

To determine the influence of the factor "genetic group" on the main economically useful traits we conducted a one-factor analysis of variance, the results of which are given in Table. 6

Table 6. Estimation of the influence (η^2) of the factor "genetic group", on some indicators of productivity and quality of milk.

Indicators	η^2	Criterion F	Confidence level P
Daily milk yield, kg	0.131	23.592	0.999
Fat content in milk, %	0.011	1.831	0.822
Protein content in milk, %	0.025	4.105	0.956
Somatic cells in milk, thousand pcs / ml	0.113	20.575	0.999
Urea content in milk, mg%	0.010	0.003	0.045
Acidity of milk, T°	0.010	0.002	0.036
Feed conversion	0.130	20.690	0.998

The application of this method proved the significantly influence of the genetic group on the variability of the daily milk yield, protein content, somatic cells count in milk and feed conversion.

Based on absolute and relative estimates of genetic groups, we determined the effectiveness of milk production using conventional methods (Table 7).

Table 7. Estimation of milk production efficiency by cows of different genetic groups in the conditions of LLC "MPC Ekaterinoslavsky"

Indicators	All sample	including genetic groups		Brown Swiss ± comparatively domestic Ukrainian breeds
		Brown Swiss	domestic Ukrainian breeds	
Average daily milk yield, standardized for fat and protein content	31.37	32.39	29.65	+2.73
Consumed dry matter of feed (per day), kg	22.93	23.24	22.63	+0.61
«Input» feed protein	3.74	3.80	3.70	+0.10
«Output» milk protein	1.02	1.05	0.96	+0.09
Grosse Efficiency of Crude Protein (GECP) **	27.12	27.68	25.95	+1.73
Crude protein balance (CPB) ***	2.73	2.74	2.74	+0.01

** - Calculations are made according to the formula GECP; *** - Calculations are made according to the formula CPB

The obtained data allowed to confirm the superiority of Brown Swiss breed over others in the conditions of modern dairy farm. Thus, Brown Swiss cows had a higher daily standardized milk yield (+2.73 kg) compared to domestic Ukrainian dairy breeds.

One of the main advantages of the Swiss breed cows is the indicator of "the evaluation of the reciprocal efficiency of crude protein" or the ratio of the amount of "output" protein that we receive with milk, to consumed "input" protein intake. Mean values of protein use efficiency (GECP) in Swiss breed cows are 27.67%, which is 1.73% higher than those of other breeds.

Conclusions

The peculiarities of the organization of feeding process significantly influence the productive indicators. Thus, in the conditions of a modern milk complex for 1500 cows with free-stall housing and feeding with the use of mixed rations, the average value of feed conversion (the measures of digestibility of the feed when it "converted" into dairy products) is 1.38 kg of milk per kilogram of dry matter of feed, and the ratio of fat to protein is 1.10, which is lower than the existing standards.

It was established that changes in the conditions by months of the year significantly influenced practically all analyzed qualitative characteristics of milk. And this fact entails the corresponding monthly fluctuations of indicators of safety of products, emissions of by-products of metabolism, and, consequently, fluctuations of dairy cattle breeding impact on the environment and ecology.

It was established that the feeding diet significantly influences on: daily milk yield (the measure of the effect $\eta^2 = 0.639$, the confidence level P≥ 0.999), the fat content ($\eta^2 = 0.368$, P≥0.999), the protein content ($\eta^2 = 0.093$, P≥0.999), the somatic cells in milk ($\eta^2 = 0.10$, P≥0.999). The urea content in milk is positively correlated with the protein content in milk: correlation coefficient r = 0.130 (P≥0.95). The season of the year has a significant effect on milk yield ($\eta^2 = 0.087$, P≥ 0.999), fat content ($\eta^2 = 0.161$, P≥0.999), protein content in milk ($\eta^2 = 0.044$, P≥0.999), somatic cells content ($\eta^2 = 0.09$, P> 0.999).

The influence of the factor "breed" on the following important economic-useful traits such as daily milk yield ($\eta^2 = 0,131$) and feed conversion rate ($\eta^2 = 0,130$) are proved.

In view of the results obtained, it is promising to continue research in the same direction, but with the development of individual indicators for individual cows and taking into account the stages of lactation.

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