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ORIGINAL ARTICLE

Effect of morphological and biochemical blood composition on milk yield in Simmental breed cows of different production types

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We studied the blood morphological and biochemical parameters of mature cows of different production types of Simmental breed at 2–3, 5–6, and 8–9 months of lactation and relation of these parameters with milk yields. We found that morphological and biochemical parameters of blood in cows depended on lactation period. We marked the highest level of hemoglobin content, red blood cells, content of glucose, total protein, albumins, α- and β-globulins, albumin-globulin ratio, and the highest levels of aspartate aminotransferase activity and alkaline phosphatase (ALKP) at the beginning of lactation period (2-3 month), that is period with pronounced milk yield. We also registered the differences in blood morphology and biochemistry in animals of different production types. Cows of the dairy-meat production type had the highest red blood cells number, hemoglobin content, total protein, albumins and coefficient of albumin-globulin ratio; the cows of dairy productive type had the highest globulins and α- and γ-globulins content, whereas the cows of the meat-dairy production type had the highest β-globulins, glucose content, aspartate aminotransferase, and alkaline phosphatase activities. These specific intertypical traits in the morphological and biochemical blood composition indicate the higher intensity of oxidative and metabolic processes in the body of animals of combined production type. We did not observe the significant differences between calcium and phosphorus content in the blood. We revealed the highest correlation between calcium and milk content in the blood for cows of meat-dairy production type (r = 0.234), and between the phosphorus content in cows of dairy-meat productive type (r = 0.256). We concluded this indicated the higest level of transformation of calcium and phosphorus from blood into the milk in cows of these production types. We revealed that all groups of animals have the high positive correlation between daily yield and blood hemoglobin content (r = 0.501–0.572), glucose (r = 0.368–0.495), alkaline phosphatase activity (r = 0.439–0.520) and strong negative correlation between daily yield and γ-globulins content (r = -0.365-0.625). The power of production type factor on the morphological and biochemical blood composition was higher (6.7–49.9%) compared to the power of lactation period factor (2.7–16.9%). We suggested that these factors mostly influenced the protein composition in blood serum and alkaline phosphatase activity.

Key words: cows, Simmental breed, production type, blood, morphological and biochemical parameters, mineral composition, daily yield, correlation coefficients, strength of influence.

Introduction

Improvement of breeds with purpose to increase performance and breeding qualities of animals is impossible without studying the physiological and biochemical processes in organism. In this aspect, blood plays an important role in maintaining the vital functions of the body. Its main function is the body metabolism and combining all its structures. Blood composition can be easily evaluated at any stage of ontogeny. It is characterized by relative stability, which ensures the conservation of species, breed and individual characteristics of animal. Blood parameters are used not only to monitor the health of animals, but also to study their constitutional and productive qualities (Fedorovych & Siratskyi, 2004; Babik & Fedorovych, 2013).

Recently, there has been held an intensive search for ancillary biological tests that could accelerate and improve the accuracy of zootechnical practice and methods of animal assessment. Researches revealed the connection between blood morphological and biochemical parameters and the productive qualities of animals and domestic fowl (Mazzullo et al., 2014; Zaplatinsky & Fedorovych, 2017). In particular, it was found that animals with more intensive metabolic process had higher milk productivity parameters (Montanholi et al., 2017). Low level of total protein, total cholesterol and glucose in blood with high-ranking urea nitrogen are indicators of problems with the reproductive function of cows (Widayati et al., 2018). However, many researchers report about significance of considering the fattening and keeping conditions, animal physiological state, lactation period, season of the year when studying the blood indicators (Brun-Hansen et al., 2006; Cozzi et al., 2011; Moretti et al., 2017; Cônsolo et al., 2018; Dillane et al., 2018). Nowadays, there are many data about the connection of a number of interior indicators with productive qualities of animals, however, some results are quite controversial. Therefore, we need to define the effective and reliable biological tests that can serve as markers in the animal selection.

Thus, our aim was to study the morphological and biochemical parameters of blood of mature cows of different production types of Simmental breed at 2–3, 5–6, and 8–9 months of lactation, and to determine effect of these parameteres on milk productivity.

Methods

Three groups of mature cows (the third lactation) of the Simmental breed were formed in order to carry out the research: Group I – dairy production type, Group II – dairy-meat production type and Group III – meat-dairy production type. The distribution of animals into production types was carried out according to the method proposed by Z. Aysanov (1997). It was taken blood from the jugular vein of 10 cows of each production type on 2–3, 5–6, and 8–9 months of the third lactation to study the morphological and biochemical parameters of blood. To obtain serum and plasma, blood samples were centrifuged. Using the biochemical analyzer "Humalyzer 2000" were defined hemoglobin concentration, red blood cell count, white blood count, total protein amount, aspartate aminotransferase activity (AST), alanine aminotransferase (ALAT), alkaline phosphatase (ALKP) in blood serum. Glucose content in blood was determined by o-toluidine and protein fractions in blood serum – by polyacrylamide gel electrophoresis technique (PAGE) (Vlizlo et al., 2012). The content of total calcium and inorganic phosphorus in the blood of cows in the above-mentioned lactation periods after burning the samples was determined by use of atomic adsorption spectrophotometer C-115 PC (SELMI).

Statistical processing of research results was carried out by mathematical statistics and biometrics methods using Statictica v. 6.1 software. The degree of intergroup differentiation was assessed by comparing group arithmetic mean values on each studied trait. The significance (probability) of the difference between the group mean values was evaluated by the t-test. The difference between the mean values was considered statistically significant at $P<0.05$, $P<0.01$, and $P<0.001$. Data in the Tables presented as average and standard devation.

Results

We found that blood morphological and biochemical parameters in Simmental cows depended on lactation period and production type of animals (Table 1). The highest hemoglobin level in the blood of cows of different production types was observed in the first months of lactation (2–3 months). The highest red blood cells count was observed at the beginning of the lactation period. These parameters became lower later on and reached the lowest points at 8-9 months. However, it should be noted that reliability of hemoglobin level and red blood cells count changes during the lactation period were only in some cases.

Thus, the results of our studies indicate common pattern – increase of oxidative processes in the blood of cows with an increase of milk yields and a gradual hemoglobin level and red blood cells count decrease with decline of productivity. White blood cells count increased during lactation in cows of different production types. In particular, this indicator increased by 0.5 from 2–3 to 8–9 months of the lactation period in cows of dairy production type, in animals of dairy-meat type – by 0.7 ($P<0.05$) and in cows of meat-dairy type – by 0.7 109/l ($P<0.05$). The changes of glucose content in blood of cows were insignificant. However, this indicator increased slightly in the animals of the studied groups, which in turn led to an increase fat in milk and lactose content at the end of the lactation period.

The blood enzymes cause milk synthesis, the activity of which reflects the level of milk productivity. We found that the activity of alanine aminotransferase (ALAT) in blood serum increased during lactation in blood of cows of different production types, and the activity of aspartate aminotransferase (AST) decreased. However, only dairy type animals had significant ($P<0.05$–0.01) changes in these parameters during the lactation period.

Table 1. Dynamics of blood morphological and biochemical parameters in mature cows of different production types (n = 10)

Parameters	Lactation period, months			At average
	2–3	5–6	8–9	
		Dairy type		
Hemoglobin, g/L	121.3±1.01	118.8±2.28	115.7±2.07*	118.6±1.11
Red blood cells, 10^{12}/L	7.1±0.28	6.8±0.22	6.9±0.25	6.9±0.14
White blood cells, 10^{9}/L	7.5±0.29	7.9±0.19	8.2±0.23	7.9±0.12
Glucose, mmol/l	2.2±0.12	2.4±0.15	2.5±0.13	2.4±0.08
ALAT, unit/L	23.9±0.37	24.8±0.67	25.9±0.81*	24.9±0.39
AST, unit/L	37.0±0.36	37.4±0.93	34.2±0.77**	36.2±0.48
Alkaline phosphatase, unit/L	122.4±0.59	121.1±1.16	118.4±1.07**	120.6±0.62
		Dairy-meat type		
Hemoglobin, g/L	124.0±0.91	123.4±0.72	121.7±0.70^{0}	123.0±0.46^{00}
Red blood cells, 10^{12}/L	7.9±0.17^{0}	7.8±0.22^{00}	7.3±0.29	7.4±0.13^{0}
White blood cells, 10^{9}/L	8.0±0.22	8.2±0.10	8.5±0,11*	8.3±0.10^{0}
Glucose, mmol/L	2.3±0.09	2.5±0.12	2.5±0.09	2.5±0.06
ALAT, unit/L	24.4±0.69	24.9±0.80	25.5±0.60	24.9±0.39
AST, unit/L	38.2±0.55	37.5±0.70	36.4±0.61^{0}	37.4±0.37
Alkaline phosphatase, unit/L	124.3±0.91	122.8±0.86	121.0±0.76*	122.7±0.53^{0}
		Meat-dairy type		
Hemoglobin, g/L	117.0±1.63^{0}	115.0±0.91	116.4±0.79	116.1±0.66
Red blood cells, 10^{12}/L	7.4±0.10	7.2±0.16^{0}	7.0±0.18*	7.2±0.09
White blood cells, 10^{9}/L	7.7±0.15	8.0±0.18	8.4±0.17**	8.0±0.10
Glucose, mmol/L	2.7±0.09^{00}	2.8±0.18	2.8±0.09^{0}	2.8±0.05^{000}
ALAT, unit/L	26.1±0.62^{0}	27.3±0.34^{00}	25.8±0.74	26.4±0.35^{0}
AST, unit/L	38.5±0.47^{0}	38.9±0.42	39.4±0.56^{000}	38,9±0.27^{000}
Alkaline phosphatase, unit/L	127.4±0.50***^{000}	123.9±0.62^{0}	125.8±0.59^{000}	125.7±0.41^{000}

Here and then: * indicates the reliability of the difference in parameters compared to 2-3 months of lactation, ^{0} indicates the reliability of the difference in comparison with animals of dairy production type.

The activity of alkaline phosphatase in blood of cows of the studied production types decreased during lactation. In particular, it decreased in the period from 2–3 to 8–9 months of lactation by 4.0 (P <0.01) in animals of dairy production type, in dairy-meat type – by 3.3 (P<0.05) and meat-dairy type – by 1.6 unit/L.

Cows of different production types also had different morphological and biochemical blood composition. The highest hemoglobin level, red and white blood cells count are observed in animals of dairy-meat production type, and the highest glucose content and the activity of ALAT and AST enzymes and alkaline phosphatase - in animals of dairy-meat and dairy types with mostly reliable difference between the average values of the parameters in cows of these groups. In particular, the level of hemoglobin in animals of dairy-meat type was higer than in cows of dairy and meat-dairy types by 4.4 (P<0.01) and 6.9 unit/L (P<0.001) respectively, red blood cells count – by 0.5 (P<0.05) and 0.2 10^{12}/L and white blood cells count – by 0.4 (P<0.05) and 0.3 10^{9}/L. The glucose content in blood of meat-dairy cows was more higher compared with animals of dairy and dairy-meat type – by 0.4 (P<0.001) and 0.3 mmol/L (P<0.01), ALAT activity - by 1.5 (P<0.05) and 1.5 unit/L (P<0.05), AST activity – by 2.7 (P<0.001) and 1.5 unit/L (P<0.01), alkaline phosphatase activity – by 5.1 and 3.0 unit/L (P<0.001) respectively.

The given intertypical differences in the morphological and biochemical blood composition in cows may indicate a higher intensity of oxidative and metabolic processes in animals of combined (dual-purpose) type of production.

Proteins as the part of composite complexes of enzyme systems are important in body metabolism and synthetic processes (Fedorovych & Siratskyi, 2004; Gutyi et al., 2017; 2018; 2019; Kulyaba et al., 2019; Borshch et al., 2020). Also, blood serum proteins are characterized by a low degree of variability, which may indicate its high genetic determination. Modeling of selection of animals by blood serum protein content is effective and efficient, and the simplicity and accessibility of the determination indicate the feasibility of using it in selection of cow. In addition to fattening, blood serum total protein concentration is influenced by many factors, one of which is lactation period. It was found that the highest total protein content in the blood serum in cows of different production types was on 2–3 months of the lactation period that is the peak of lactation (Table 2). Subsequently, its content decreased and the lowest level was marked by 8–9 months of the lactation period, which is obviously due to the pregnancy of cows, when in last months body uses a large amount of protein as a material for growth and development of the fetus. Total protein content in cows of dairy production type went down from 2–3 to 8–9 months of lactation by 3.6 (P<0.01), in animals of dairy-meat and dairy types – by 4, 2 and 4.5 g/L (P<0.05) respectively.

The total blood protein in cows consists of two fractions – albumins and globulins. The normal level of these fractions in the blood is very important because albumins are used for the synthesis of specific tissue proteins in hydrolysis process (Pishchan, 2017).

Table 2. The content of total protein and its fractions in the blood serum, mature cows of different production types (n = 10)

Parameters	Lactation period, months			Mean
	2–3	5–6	8–9	
		Dairy type		
Total protein, g/L	82.9±0.84	80.7±0.66	79.3±0.52**	81.0±0.46
albumins ,%	46.4±0.80	44.7±0.70	43.3±0.55**	44.8±0.44
globulins,%	53.6±0.80	55.3±0.70	56.7±0.55**	55.2±0.44
α-globulins,%	13.1±0.60	12.6±0.37	12.2±0.46	12.6±0.27
β-globulins,%	11.4±0.48	10.7±0.57	10.0±0.58	10.7±0.32
γ-globulins,%	29.1±1.29	32.0±1.04	35.5±0.80***	31.9±0.71
A/G	0.87±0.028	0.81±0.024	0.77±0.018**	0.82±0.015
		Dairy-meat type		
Total protein, g/L	88.5 ± 1.91^{0}	$86,4\pm0,88^{000}$	84.3 ± 0.73^{000}	86.4 ± 0.77^{000}
albumins ,%	48.4±0.80	$47,4\pm0,84^{00}$	47.0 ± 0.85^{00}	47.6 ± 0.47^{000}
globulins,%	51.6±0.80	$52,6\pm0,84^{00}$	53.0 ± 0.85^{00}	52.4 ± 0.47^{000}
α-globulins,%	12.7±0.27	12,4±0,30	11.6±0.32*	12.3±0.18
β-globulins,%	13.2 ± 0.15^{00}	$12,9\pm0,37^{00}$	12.6 ± 0.25^{000}	12.9 ± 0.15^{000}
γ-globulins,%	25.7 ± 0.89^{0}	$27,3\pm1,09^{00}$	$28,7\pm1,07^{*000}$	27.2 ± 0.60^{000}
A/G	0.94±0.031	$0,91\pm0,030^{0}$	$0,89\pm0,030^{00}$	0.91 ± 0.017^{000}
		Meat-dairy type		
Total protein, g/L	86.9±1.95	84.5 ± 1.24^{00}	$82.4\pm0.71^{*0}$	84.6 ± 0.83^{00}
including: albumins ,%	46.9±0.69	46.1±0.71	45.2±0.92	46.1±0.45
globulins,%	53.1±0.69	53.9±0.71	54.8±0.92	53.9±0.45
α-globulins,%	11.8±0.41	11.5±0.41	11.0 ± 0.29^{0}	11.4 ± 0.21^{00}
β-globulins,%	14.2 ± 0.45^{000}	13.5 ± 0.29^{000}	13.3 ± 0.19^{000}	13.7 ± 0.20^{000}
γ-globulins,%	27.1±0.90	28.9 ± 0.75^{0}	$30.5\pm0.98^{*000}$	28.8 ± 0.55^{00}
A/G	0.89±0.024	0.86±0.024	0.83±0.030	0.86±0.015

In the blood serum of studied cows, the content of these fractions was within the physiological norm, but during lactation some changes were observed. The highest content of albumins in the blood was during 2–3 months of the lactation period, and in the subsequent (up to 8–9 months) – became lower: in cows of dairy type – by 3.1 (P<0.01), dairy- meat type – by 1.4 and meat-dairy – by 1.7%. Therefore, the content of the total protein globulin fraction in the blood serum of the studied production types cows increased during lactation and reached its maximum level by 8–9 months.

Analysis of the content of globulin fractions in the blood in cows of different production types showed that the number of α- and β-globulins was the highest at the beginning of lactation. In dairy production type animals, the content of these fractions decreased from 2–3 to 8–9 months of lactation by 0.9 and 1.4, respectively, in dairy type cows by 1.1 (P<0.05) and 0.6 and meat-dairy types – by 0.8 and 0,9%. The content of γ-globulins in the blood serum of cows, on the contrary, increased from 2–3 to 8–9 months of lactation, depending on the production type, by 3.0–6.4% (P<0.05; 0.001).

The ratio of albumins and globulins characterizes the direction and intensity of protein metabolism in the body of cows. Distortion of its ratio is more informative than the change in the absolute number of albumins or globulins. Its increase, which happens very rarely, is not as important as its decrease, since the albumin fraction significantly decreases due to the relative growth of globulin. Normally, the albumin/globulin ratio should not exceed 1.1 units, but should not fall below 0.6 units (Pishchan, 2017). In cows of the studied production types, depending on the lactation period, this parametr was in the range of 0.77–0.94. The highest coefficient of albumin-globulin ratio was observed at 2–3 months of lactation, and later it gradually decreased.

The differences in the content of total protein and its fractions in the blood serum in cows of different production types were found. In particular, dairy type cows were characterized by the highest content of total protein and albumins. In comparison with dairy-meat type they had better paramenters by 5.4 g/l (P<0.001) and 2.8% (P<0.001) respectively, and better than meat-dairy type – by 1.8 g/l and 1.5% (P<0.05). These animals were characterized also by the highest parameters of the albumin-globulin ratio.

The dairy production type animals had the highest blood serum content of globulins, α- and γ-globulins. In comparison with dairy-meat type they had better paramenters by 2.8 (P<0.001), 0.3 and 4.7% (P<0.001) respectively, and better than meat-dairy type by 1.3; 1.2 (P<0.01) and 3.1% (P<0.01). On the other hand, cows of meat-dairy type had a higher content of β-globulins in blood serum by 2.2–3.0% (P<0.001) compared to animals of dairy and dairy-meat production types.

A proper attention should be paid to mineral metabolism in animal bodies, as microelements are actively involved in body and energy metabolism and impact on the conversion of feed nutrients into livestock products. Calcium and phosphorus belong to minerals that are vital for cows. The main storage site of calcium in the body is bone tissue. In the first stage of the lactation period, cows consume up to 40% calcium from bone tissue. Later on, the mobilization of this element out of the skeleton in

cows during lactation depends not only on its level in the diet and milk productivity, but also on the lactation period, age of the animals, etc. (Yefimov et al., 2016).

We registered that the blood mineral content of cows of the studied production types varied a little during lactation (Table 3). In particular, blood content of calcium in cows of the studied production types at 5–6 months of lactation was slightly higher, although unreliable, than at its beginning and at the end. These changes, apparently, are explained by the fact that at the beginning of lactation, when the highest milk yields of cows are observed, the highest amount of calcium is excreted with milk, resulting in a considerable deficiency in blood. At the end of lactation, a decrease of calcium in blood was explained by the body transportation of this element for the growth and development of the fetus.

Table 3. Mineral content of the blood, cows of different production types, Simmental breed (n = 10)

Parameters	Lactation period, months			Mean
	2–3	5–6	8–9	
		Dairy type		
Total calcium, mg	10.2±0.28	10.6±0.47	10.4±0.22	10.4±0.19
Inorganic phosphorus, mg/100	5.4±0.11	5.6±0.17	5.1±0.14	5.4±0.09
Ca : P	1.90 : 1	1.88 : 1	2.05 : 1	1.94 : 1
		Dairy-meat type		
Total calcium, mg/100	9.7±0.31	10.1±0.28	9.5±0.23^{00}	9.8±0.16^{0}
Inorganic phosphorus, mg/100	4.9±0.09^{00}	5.3±0.18	4.7±0.17	5.0±0.09^{00}
Ca : P	1.97 : 1	1.92 : 1	2.06 : 1	1.98 : 1
		Meat-dairy type		
Total calcium, mg/100	9.5±0.24	9.8±0.22	9.3±0.20^{00}	9.6±0.13^{00}
Inorganic phosphorus, mg/100	4.4±0.10^{000}	5.0±0.12**^{00}	4.9±0.07***	4.8±0.07^{000}
Ca : P	2.16 : 1	1.97 : 1	1.91 : 1	2.02 : 1

Content of phosphorus in blood changed similarly, but the data are quite unreliable. Also important is the Ca/P ratio. According to the recommendations, it should be 2:1. In the studied production type cows, depending on the lactation period, the Ca/P ratio was in the range of 1.88–2.16:1, so it was within the normal range. There not defined some consistent patterns of this parameter during lactation. It should be noted that the highest levels of calcium and phosphorus were observed in dairy cows. These paremeters were better than dairy-meat and dairy by 0.6 ($P<0.05$) and 0.4 mg/100 ($P<0.01$) and 0.8 ($P<0.01$) and 0.6 mg/100 ($P<0.001$), respectively. We found positive relation between calcium and phosphorus content in blood and milk in cows of the studied production types and depending on the production type of the animals, they ranged from 0.112–0.234 and 0.154–0.256, respectively. The highest parameters of the relative variability of calcium content in blood and milk were observed in meat-dairy production type cows, and phosphorus content in dairy-meat production type cows, which may indicate a higher transformation of these elements from blood into milk in animals of dual-purpose type of production.

All groups of animals were characterised by most significant direct and reliable relation between daily milk yields and hemoglobins content (r = 0.501–0.572), glucose (r = 0.368–0.495), alkaline phosphatase activity (r = 0.439–0.520) and opposite relation - γ-globulins content (r = -0.365 – -0.625) (Table 4). In addition, cows of dairy and dairy-meat production types had high and reliable correlation coefficients between daily milk yields and aspartate aminotransferase activity (r = 0.467-0.508), total protein content (r = 0.474–0.532). Daily yields in dairy type cows were also closely correlated with albumins (r = 0.518) and β-globulins (r = 0.476). Relations were insignificant and generally unreliable between the daily yield and other blood morphological and biochemical parameters.

Table 4. Correlations between blood morphological, biochemical parameters, and daily yield

Correlation pairs	Production type of animals		
	Dairy	Dairy-meat	Meat-dairy
Hemoglobin – yield	0.572±0.327***	0.559±0.313***	0.501±0.251**
Erythrocytes – yield	0.127±0.016	0.308±0.095	0.131±0.017
Leukocytes – yield	-0.053±0.003	-0.417±0.174*	-0.099±0.009
Glucose – yield	0.494±0.244**	0.368±0.135*	0.495±0.245**
ALAT – yield	-0.241±0.058	-0.054±0.003	0.138±0.019
AST – yield	0.467±0.217**	0.508±0.258**	0.079±0.006
Alkaline phosphatase – yield	0.439±0.193*	0.520±0.271**	0.489±0.239**
Total protein – yield	0.532±0.283**	0.474±0.225**	0.078±0.006
Albumins– yield	0.518±0.268**	0.174±0.030	0.337±0.113
α-globulins – yield	0.227±0.052	0.511±0.261**	0.151±0.023
β-globulins – yield	0.476±0.227**	0.292±0.085	0.404±0.163*
γ-globulins – yield	-0.625±0.391***	-0.365±0.133*	-0.475±0.226**
Calcium – yield	-0.034±0.001	0.191±0.037	0.232±0.054
Phosphorus – yield	0.296±0.087	0.151±0.023	-0.338±0.114

The impact of lactation period and production type of animals on blood morphological and biochemical parameters in the animals was determined by one-way ANOVA. It was found that production type of animals had bigger influence on their blood

parameters than the lactation period (except for white blood cells count). The impact of production type of animals on the studied parameters was 6.7–49.9% in the total phenotypic variation, while the lactation period Hemoglobin – yield only 2.7–16.9%. The most significant influence of the production type of animals among the studied morphological and biochemical parameters of blood, was on the content of β-globulins (49.9%), alkaline phosphatase activity (34.7%), hemoglobin content (30.2%), total protein (25.3%) and γ-globulins (24.3%) in the blood serum. At the same time, the lactation period had the greatest influence on the content of γ-globulins (16.9%), total protein (13.9%), phosphorus content (12.6%) and alkaline phosphatase activity (12.5%).

Discussion

Morphological and biochemical parameters of blood in mature Simmental cows depended on the lactation period. The highest levels of hemoglobin, red blood cells count, glucose, total protein, albumins, α- and β-globulins content, albumin-globulin ratio, as well as higher activity of aspartate aminotransferase and alkaline phosphatase were observed at 2–3 months, the period with the highest yields. Such results were obtained by Djoković et al. (2017). However, there is some other information in the literature. In particular, Fedorovych et al. (2002), Tkach (2013) revelaled that high-performing cows had the lowest level of hemoglobin and red blood cells content at the beginning of lactation, and with decreasing productivity subsequently those blood parameters rised. In the case of medium and low productivity, the oxidizing properties of blood (hemoglobin and red blood cells) changed in parallel with milk yield of cows, in other words as milk yields decreased, the hemoglobin content in blood and red blood cells count also decreased. According to Novak & Fedorovych (2009), in the cows of the Ukrainian Black-and-White dairy breed during lactation, the number of red blood cells count, the concentration of total glutathione and the number of total SH groups decreased while hemoglobin and total protein level slightly increased. The activity of aspartate aminotransferase in the blood serum during lactation increased, and the activity of alanine aminotransferase slightly decreased. The concentration of globulins (%), in the protein fractions, decreased during the lactation period, and there was no significant difference in the content of α-, β- and γ-globulins during the studied lactation periods. Metabolism processes in cows were more intense at the beginning of the lactation period.

Differences in morphological and biochemical parameters of blood in animals of different production types have been defined. Cows of dairy-meat production type had the highest parameters of red blood cells count, level of hemoglobin, total protein, albumins and albumin-globulin ratio, cows of dairy production type had the highest parameters of globulin, α- and γ-globulins content, and meat-dairy production type – content of β- globulins, glucose and activity of aminotransferases and alkaline phosphatase. Such specific intertypical traits in the morphological and biochemical blood composition of cows are related to their constitutional features and indicate a higher intensity of oxidative and metabolic processes in the body of animals of combined performance type. Similar differentiation in morphological and biochemical blood composition was obtained by Anysymova et al. (2011).

The calcium and phosphorus content in blood was not significantly different. The highest correlation coefficients between calcium content in blood and milk were observed in meat-dairy production type animals (r = 0.234), and between phosphorus content in dairy-meat production type cows (r = 0.256), what indicastes higher transformation of these elements from blood into milk in animals of these production types. All groups of animals were characterised by most significant direct and reliable relation between daily milk yields and hemoglobins content (r = 0.501–0.572), glucose (r = 0.368–0.495), alkaline phosphatase activity (r = 0.439–0.520) and opposite relation - γ-globulins content (r = -0.365 – -0.625).

The strength of impact of the production type of animals on the studied parameters of the morphological and biochemical composition of blood was higher (6.7–49.9%) compared to the influence of the period of lactation (2.7–16.9%). These factors influenced the most on protein composition of blood serum and alkaline phosphatase activity.

Conclusion

During lactation and depending on the production type of cows some changes in the morphological and biochemical parameters of blood in cows were observed. The highest values of most studied parameters were marked at 2–3 months of the lactation period. Cows of dairy-meat production type in all investigated lactation periods were characterized by the highest parameters of red blood cells count, hemoglobin level, total protein level, albumins and albumin-globulin ratio, dairy type animals had the highest content of globulin and α- and γ-globulins, and meat-dairy type - β-globulins, glucose content and activity of aminotransferases and alkaline phosphatase, which indicates a higher intensity of oxidative and metabolic processes in animals of dual-purpose type of production. There was no significant difference in the blood and phosphorus content of animals in the different groups.

The highest parameters of the relative variability of calcium content in blood and milk were observed in meat-dairy production type cows (r = 0.234) and phosphorus content in dairy-meat production type cows (r = 0.256), indicating a higher transformation of these elements from blood into milk in animals of these production types. All groups of animals were characterised by most significant direct and reliable relation between daily milk yields and hemoglobins content (r = 0.501–0.572), glucose (r = 0.368–0.495), alkaline phosphatase activity (r = 0.439–0.520) and opposite relation - γ-globulins content (r = -0,365 – -0,625). The strength of impact of the production type of animals on the studied parameters of the morphological and biochemical composition of blood was higher (6.7–49.9%) compared to the influence of the period of lactation (2.7–16.9%). These factors influenced the most on protein composition of blood serum and alkaline phosphatase activity.

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