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Metabolic homeostasis and level of productivity of first-heifers in the conditions of the industrial complex

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Abstract. Collection of primary information and research was conducted on a herd of cows at the dairy production complex «Yekaterynoslavskyi» Dnipropetrovsk region of Ukraine. To study the productive qualities of Brown Swiss cows were selected 75 heifers of the same age, live weight and pregnancy period. For biochemical studies in healthy heifers (9 goals), and after their calving, blood was taken from the median caudal vein of the tail in vacuum tubes before the morning distribution of feed . Studies of the biochemical composition of the blood of cows were performed at 8 months of pregnancy, and the first heifers – at 2 months of lactation. After calving of heifers took into account the level of milk yield per day and lactation (kg), the mass fraction of fat and protein (%). Researches have shown that the concentration of albumin in the serum of experimental heifers was insignificant, as it averaged 22.6 g/l and was slightly lower than normal. The level of albumin in the serum of first heifers was inferior to the lower limit of normal by 13.5% and was, respectively, 26.33 g/l, while exceeding indicate of heifers by 14.2%. The globulin fraction of heifer exceeded the index after calving and during lactation by 16.7%. Despite the significant difference in the indicators of albumins and globulins, the protein coefficient in experimental first heifers was satisfactory and averaged 0.65 units. Indicate of serum nitrogen in urea during pregnancy and during the first lactation was practically at the lower limit of norm and averaged 7.30–7.34 mg%. Thus, metabolic homeostasis in the first pregnancy is naturally dynamic and corresponds to the level of physiological processes of the organism and the provision of vital nutrients of the general-mixed ration. The metabolic homeostasis of first heifers is in a tense state, which is determined by the first lactation function and adaptation to the harsh conditions of the industrial complex. This allows animals to realize their genetic potential of milk productivity for 376.4 days at the level of 9228.5 kg with a mass fraction of fat 4.15% and protein – 3.45%. Brown Swiss first heifers were characterized by satisfactory indicators of reproductive function. The reproductive ability was at the level of 0.87, and the insemination index did not exceed 2.83 units.

Keywords: cows; metabolic homeostasis; milk yield; reproductive function

Метаболічний гомеостаз та рівень продуктивності нетель-первістка в умовах промислового комплексу

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Анотація. Збір первинної інформації та дослідження на стаді корів проводили на базі молочно-виробничого комплексу «Єкатеринославський» Дніпропетровської області України. Для вивчення продуктивних якостей швіцьких тварин було відібрано 75 нетелей одного віку, живої маси та періоду тільності. Для проведення біохімічних досліджень у здорових нетелей (9 гол.), а після їх отелення у первісток відбирали кров до ранкової роздачі кормів з підхвостої вени у вакуумні пробірки. Дослідження біохімічного складу крові ремонтного молодняку проводили на 8 місяці тільності, а первісток – на 2 місяці лактації. Після отелення нетелей враховували рівень удою за добу та лактацію (кг), масову частку жиру та білка (%). Як показали дослідження концентрація альбумінів у сироватці крові піддослідних нетелей була незначною, оскільки становила у середньому 22,6 г/л та дещо поступалася нормі. Альбумінова фракція білків сироватки крові первісток поступалася нижній межі норми на 13,5% і становила відповідно 26,33 г/л, при цьому перевищувала показник періоду першої тільності (нетель) на 14,2%. У цей же час глобулінова фракція білків сироватки крові нетелей перевищувала показник після отелення та під час лактації на 16,7%. Не дивлячись на суттєву різницю у показниках альбумінів і глобулінів білковий коефіцієнт у піддослідних первісток був задовільним, оскільки становив у середньому 0,65 одиниці. Показник азоту сечовини в сироватці крові як під час вагітності, так і під час першої лактації практично знаходився на нижній межі норми і становив у середньому відповідно 7,30–7,34 мг%. Таким чином, метаболічний гомеостаз у першу вагітність природно динамічний і відповідає рівню фізіологічних процесів організму та забезпеченістю життєво важливими поживними речовинами загально-змішаного раціону. Натомість, метаболічний гомеостаз первісток знаходиться в напруженому стані, що визначається першою лактаційною функцією та адаптацією до жорстких умовах промислового комплексу. Це дає можливість тваринам реалізувати свій генетичний потенціал молочної продуктивності упродовж 376,4 доби на рівні 9228,5 кг з масовою часткою жиру 4,15%, а білка – 3,45%. Швіцькі первістки характеризувалися задовільними показниками відтворної функції. Так, коефіцієнт відтворної здатності знаходився на рівні 0,87. При цьому, індекс осіменіння не перевищував 2,83 одиниці.

Ключові слова: корови; метаболічний гомеостаз; надої молока; репродуктивна функція

Introduction

Complete feeding with balanced general-mixed rations is the basis of a high level of intensity of metabolic processes, which ensures high viability and realization of the genetic potential of animals. However, in the production environment it is not always possible to organize a balanced feeding of animals, using only feed specific to this species, which in turn leads to the need to supplement feed rations with various available and cost-effective feed additives. Metabolic disorders in cows occur as a result of unbalanced feeding by proteins, carbohydrates, vitamins and minerals (Veretennikova et al., 2015; Razumovskiy & Pakhomova, 2016; Batrakov et al., 2017). In addition, during storage in canned feed changes the chemical composition of vital macro-and micronutrients – copper, zinc, cobalt, iodine, selenium and others. Altered chemical structure of feed causes a change in the synthesis of biologically active substances, in particular enzymes, hormones and vitamins in organism animals. This leads to metabolic diseases and metabolic reorientation of the organism, which ultimately affects the health, quantity and quality of products and reproductive function (Curtis et al., 1985; Goff & Horst, 1997; Godden et al., 2003; Samokhin, 2003), which is of great importance for the welfare and economy of industrial complexes for milk production (Curtis et al., 1983; Curtis et al., 1984; Houe et al., 2001).

However, a change in approach of organization to feeding can lead to more nutrients, which will allow animals to realize their productive potential (Carpenter et al., 2018). Even with good feeding, it should be taken into account that before calving, animals feed intake decreases, which causes a negative energy balance and metabolic stress (Sordillo & Raphael, 2013; Bradford et al., 2015). This increases the risk of various diseases (Dyk et al., 1995; Cameron et al., 1998). The aim of the research was to study the features of metabolic homeostasis in animals in the transition period from the first pregnancy (heifers) to the first lactation (first heifers) at a large industrial complex with feeding general-mixed rations. The task of the research was to establish compliance with the reference values of the main biochemical parameters of the serum of animals in different physiological periods.

Materials and Methods

Collection of primary information and research was conducted on a herd of cows at the dairy production complex "Yekaterynoslavskyi" Dnipropetrovsk region of Ukraine. At the high-tech dairy complex cows are kept in easy-to-assemble cowsheds, with boxes in which soft rubber mats are placed for rest. Each technological section of the cowshed is equipped with a feeder with salt, chalk and soda. Milking of cows three times of the days on the installation "Parallel" 2×20 of the firm "De Laval" with the monitoring system of the herd "Dairy Comp-350". In cowsheds automatic adjustment of artificial lighting, using red light at night. Gates provide the planned movement of animals to a certain technological group or for medical therapy. Watering of animals is provided with free access to group drinking bowls with water heating in winter. The reproduction system is based on artificial insemination of cows with using hormonal correction of estrus and synchronization of ovulation on the ovaries. After artificial insemination after 31 days, all animals are tested for pregnancy. The dry period of cows is carried out on the 235th day of pregnancy, or under conditions of reduced milk yield less than 13 kg of milk per day. To study the productive qualities of Brown Swiss cows during exploitation at a high-tech industrial complex with a high concentration of animals in a limited space, 75 heifers of the same age, live weight and pregnansy period were selected. Feeding of the herd is carried out by general-mixed rations, which include a group of succulent, coarse, concentrated feed and protein-mineral-vitamin mixtures, which were distributed twice a day on the feed tables. This uses a multifunctional loader, shredder and mixer of different types of feed, the quantity and quality of which is controlled according to a computer program. The robot in the cowshed automatically conducts hilling of feed to the animal section. After consuming the feed, this multifunctional mobile distributor selects the residues, and the program determines the amount of feed consumed by a certain technological group of animals. The main logistical approaches to the organization and technology of feeding were carried out according to generally accepted approaches (Kalashnokov et al., 2003; Ruban & Vasilevskiy, 2015).

For biochemical studies in healthy heifers (9 goals), and after their calving, blood was taken from the median caudal vein of the tail in vacuum tubes before the morning distribution of feed. Studies of the biochemical composition of the blood of cows were performed at 8 months of pregnancy, and the first heifers – at 2 months of lactation. Biochemical analysis of animal blood samples was performed at the Research Center for Biosafety and Environmental Control of Agroindustrial Resources of the Dnipro State Agrarian and Economic University (Kondrakhin et al., 2004; Retskiy et al., 2005; Gromyko, 2005). In experimental animals studied the level of protein, carbohydrate and lipid metabolism by indicators: albumin, globulin and total protein (g/l); protein coefficient (units); urea and glucose levels (mmol/l); creatinine (μmol/l); lipoproteins (mg%) and carotene (μg%). In animals of different physiological status were studied the level in serum of transaminases (AST and ALT, U/L), the de Ritis index (units) and alkaline phosphatase (U/L).

In the serum of animals was determined the concentration of bioessential elements: calcium and inorganic phosphorus (mmol/l) and their ratios. Analysis of the results of biochemical researches of animal blood was conducted relatively physiological norms.

After calving of heifers took into account the level of milk yield per day and lactation (kg), the mass fraction of fat and protein (%), as well as their products (kg), calculated the duration of the infertile period (days) and the loss of calves (heads). Experimental data were subjected to mathematical processing (Koksharova and Tsydypov, 2002) using Microsoft Excel.

Results and Discussions

The main task of feeding on an industrial complex is to ensure the organism with energy and all vital elements for optimal growth and development, fetal development and achieve maximum genetically determined productivity without harm to health and longevity (Sudarev et al., 2009; Morozova et al., 2013; Veretennikova et al., 2015).

In practice, rations are often enriched with an increased amount of concentrated feed, which leads to a decrease in the proportion of fiber and reduced the formation of acetic acid and increases butyric acid – the main source of ketone bodies. This leads to decrease in blood glucose levels, decreased buffer capacity of the blood, impaired liver function, and develops first acidosis and then ketosis (Tanaka et al., 2006). That is, ketosis should be considered as a complex of metabolic disorders, which is characterized specific symptoms: hyperketonemia, ketonuria, ketonolactia and hypoglycemia (Zharov et al., 1986; Deodato et al., 2006).

Thus, all the transformations in the animal's organism are united in a holistic process of metabolism, which is subject to the dialectical laws of interdependence, which involves the mutual transformation between different classes of organic matters. Such interactions are adequate to the physiological needs of the organism, as well as the feasibility of replacing the pathology of some classes of organic matter to others in terms of blocking any process.

Complete feeding is especially important for young cattle because they continue to grow, develop, and after calving begins the first lactation. Indicate of balance and intensity of physiological

processes in the organism of cows is protein, carbohydrate and lipid metabolism.

Research of biochemical indicators of blood (Gromyko, 2005; Zhukov & Ushakova, 2014) are an important link in the diagnostic chain of metabolic pathology and in the early stages of the disease make it possible to determine the beginning of pathological failures of metabolic processes in organism of cows. The pathogenesis of diseases of the gastrointestinal tract may also be a mismatch between the functional load on the digestive organs and their morphological ability (Ozdemirov et al., 2016).

It is well known that proteins are part of all anatomical structures (muscles, cell membranes), carry substances through the blood into cells, precipitate biochemical reactions in the organism, regulate metabolism and retain fluid in blood vessels. Animal proteins are synthesized in the liver from feed amino acids and consist of two main fractions – albumin and globulin. Their optimal level in the blood is provided by both quantitative and qualitative composition of proteins of the general mixed diet.

A special role in the organism of animals is albumin, which are necessary for the synthesis of specific tissue proteins. Normally, the level of albumin in the serum of animals (Tabl. 1) varies slightly and averages 30.0–35.5 g/l. Researches have shown that the concentration of albumin in the serum of experimental heifers was insignificant, as it averaged 22.6 g/l and was slightly lower than normal. The level of albumin in the serum of first heifers was inferior to the lower limit of normal by 13.5% and was, respectively, 26.33 g/l, while exceeding indicate of heifers by 14.2%.

At low levels of albumin in experimental heifers, globulins significantly exceeded the reference value for this indicator. Thus, the serum of this physiological state of animals contained 48.8 g/l of globulins, which exceeded the norm by almost 1.5 times. The concentration globulins of serum during the first lactation of experimental first heifers were at the level of 40.67 g/l, which also significantly exceeded the norm by 13.9%. The globulin fraction of heifer exceeded the index after calving and during lactation by 16.7%.

Albumin and globulin fractions of proteins of serum in cows have some differences in the norm, which is determined by the physiological state of the animals, it is either the first pregnancy or the first lactation.

Compliance of the level of protein supply of the ration to the biological needs of the animal organism is carried out by the level of concentration of total protein in the serum, index of protein and urea. The absolute value of the concentration of albumins or globulins in the serum is less informative than their ratio, which largely characterizes the direction and intensity of protein metabolism. The normal ratio of albumins and globulins in the serum should be 0.6–1.1 units. In Swiss heifers, this ratio was below normal and was 0.46 units. Despite the significant difference in the indicators of albumins and globulins, the protein coefficient in experimental first heifers was satisfactory and averaged 0.65 units. In the conducted researches different indicators of two fractions of protein did not lead to the general disturbance of its value at experimental animals at their different physiological state. In norm total serum protein is in the range of 67–75 g/l. In heifers this indicator was close to the norm and averaged 71.4 and 78 g/l, respectively, and during the first lactation – did not exceed the reference values and averaged 67.0–71.89 g/l. Decreased levels of total protein in the serum (below 60 g/l) occurs with prolonged incomplete feeding and general malnutrition of animals, as well as the development of osteodystrophy, chronic diseases of the gastrointestinal tract, kidneys and liver.

The optimal compliance of the amount of crude protein in the ration with the biological needs of animals is based on the concentration of urea in the serum. It is proved that urea very right shows the concentration of ammonia in the rumen of ruminant's animal. Excess ammonia is absorbed into the blood, enters the liver, where it is converted into urea. The level of urea in combination with concentration albumin and glucose of serum can be used to accurately valuation the balance of the ration at all stages of lactation of cows in terms of energy-protein ratio and to establish a deficiency or excess of crude protein in the dry matter of the ration. A decrease the level of urea indicates a deficiency of crude protein in the ration, and increase with a decrease in the level of albumins and glucose indicates an imbalance in the ration in terms of energy and protein ratio. High concentration of urea at normal values of other biochemical indicators of blood indicates a high degree of assimilation protein of feed (Mayorov & Kozlovskaya, 2015).

Urea in animals is the main end product of nitrogen metabolism. The process of urea synthesis in ruminant's animal takes place in the liver and the wall of the rumen. Excretion of urea from the organism occurs mainly by the kidneys. An increase of urea in the blood (uremia) is observed in renal failure and other kidney diseases, as well as in the feeding of large amounts of green legumes and overdoses of synthetic nitrogenous substances (urea, etc.). Decrease of urea in blood happens at long malnutrition of protein, at disturbance of synthesizing function of a liver. This fact is often observed in cows with hepatic dystrophy as a result of ketosis.

Researches have shown that the level of urea in the serum of heifers averaged 9.24 mmol/l, which is 1.6 times higher than normal. Elevated urea levels indicated the presence in the ration of heifers during the first pregnancy of high digestibility of feed protein. The level of urea in the blood of first heifers corresponded to the reference values and averaged 3.84 mmol/l.

Indicate of serum nitrogen in urea during pregnancy and during the first lactation was practically at the lower limit of norm and averaged 7.30–7.34 mg%.

Table 1 – Dynamics of protein, carbohydrate and lipid metabolism in animals of different physiological state, M ± m

Indicator	Norm	A group of animals	
		Heifer, n = 9	First-heifers, n = 9
Albumins, g/l	30,0–35,5	22,6 ± 1,32	26,3 ± 1,28
Globulins, g/l	30–35	48,8 ± 4,14	40,6 ± 1,63
Protein coefficient, units	0,6–1,1	0,46 ± 0,071	0,65 ± 0,033
Total protein, g/l	67–75	71,4 ± 3,043	67,0 ± 2,303
Urea, mmol/l	2,8–5,8	9,24 ± 5,946	3,84 ± 0,239
Urea nitrogen, mg%	8–14	7,30 ± 0,526	7,34 ± 0,456
Creatinine, μmol/l	45–140	93,25 ± 7,628	67,22 ± 4,594
Glucose, mmol/l	2,50–4,16	2,64 ± 0,193	2,49 ± 0,110
Lipoproteins, mg%	400–800	1219,34 ± 59,026	1056,18 ± 36,586

In the serum of experimental heifers indicate of creatinine was averaged 93.25 μmol/l, which corresponded to the normative value – 45–100 μmol/l. Within the norm, the creatinine was characterized by the blood of experimental first heifers, which averaged 67.22 μmol/l.

Glucose (sugar) – is the main source of energy for animals. It accounts for more than 90% of all low molecular weight carbohydrates. Normal level of blood glucose (40–60 mg% or 2.2–4.0 mmol/l) is maintained in the animal's organism hormonally. Hypoglycemia in animals occurs in ketosis, secondary osteodystrophy, postpartum paresis, some forms of obesity, toxic liver damage and others (Farney et al., 2013). It often occurs in animals as a result of lack of low digestible carbohydrates in feed, the high need of animals for glucose with a highly concentrated type of feeding, with prevalence in the ration of acidic feed.

In ruminants animal, carbohydrate metabolism plays a significant role in determining the level and intensity of other metabolisms. An important indicator of carbohydrate metabolism is the concentration of sugar in the blood – glucose, which is the main source of energy (in addition to glucose, pyruvic and lactic acids are also used). It is the main energy material not only for the brain but also for the parenchyma of the udder of cows. Persistence in the blood is ensured by absorption from the digestive tract, glycogenolysis (breakdown of glycogen to glucose) and glucogenesis (formation of glycogen). With silage and silage-pulp feeding there is a decrease indicator of carbohydrate metabolism. High consumption of glucose by the organism at high levels of concentrated feed (60-70% by nutrients). Insufficient supply of glucose, especially in the first phase of lactation, the organism tries to compensate for energy deficiency by fat, which significantly increases the concentration of cholesterol in the blood and the formation of ketone bodies, which significantly reduces the productivity of cows. The level of glucose in the blood of ruminants animal is low, but quite stable and remains at the level of 2.0–2.7 mmol/l. For maintaining this dynamic balance must to increase of glucose intake during intense lactation, which accompanied by an increase in its entry into the blood. Absorption of glucose from the digestive system occurs in small quantities, and the content is replenished by its synthesis and breakdown of glycogen. This means that the hypoglycemic state (lowering of blood glucose) is adaptive and indicates not only an unsatisfactory level of feeding, but also the deficit of glycogen in the liver. However, to ensure high milk productivity, the organism of cows through a neurohumoral reaction mobilizes not only glycogen from its depot, but also reserve fat and protein in the form of lipoproteins, which leads to the development of hyperketonemia (Gromyko, 2005).

Carbohydrates are absorbed from the pancreas mainly in the form of volatile fatty acids – acetic, butyric and propionic. The pancreatic hormone insulin promotes the synthesis of glycogen, due to which the level of glucose in the blood decreases. Under the action of the pancreatic hormone glucagon, adrenal hormones adrenaline and glucocorticoids, adrenocorticotropic hormone of the pituitary and thyroxine, glycogen is broken down and increase sugar in blood. In healthy animals with a balanced level of feeding the level of glucose in blood range from 2.50 to 4.16 mmol/l. In Swiss heifers the concentration of glucose was also observed the level of the normative value, where its value did not fall below 2.64 mmol/l. In the experimental first heifers almost within normal limits of blood glucose was, the rate of which did not exceed 2.49 mmol/l.

Lipid metabolism in ruminants animal begins with the breakdown fats of feed, which occurs under the action of lipases of microorganisms. Fatty acids in the liver undergo beta-oxidation and are converted to butyric acid, which can form ketone bodies and acetic acid. Functional activities of the gastrointestinal tract, the level of lipolysis, and the organism sensitivity to insulin determine the state of metabolic processes in animals (Man et al., 2017; (Hoytema van Konijnenburg et al. 2017).

Researches have shown that the concentration of lipoproteins in Swiss first heifers did not fall below 1056.18 mg%, which also exceeded the reference value by 1.32 times. Scientists note that in cows, liver lipidosis can be a result of a negative energy balance (Gerloff, 1986), or associated with the occurrence of prenatal diseases – ketosis, displacement of abomasum to the left, milk fever and placental abruption (Oikawa, 2002).

Additional diagnostic tests for aminotransferase activity are introduced to rule out the effect of health factors. It is known that aminotransferases play an important role in protein, lipid and mineral metabolism of animals. Thus, aspartate and alanine aminotransferases take an active part in nitrogen metabolism, making a connection, through ketoglutaric, oxalic acetic and pyruvic acids, with protein, carbohydrate and fat metabolism. Researches of the blood of experimental heifers showed (Tabl. 2) that the activity of aspartate aminotransferase (AST) is increased, compared to the determined optimal values. The lower reference value of this enzyme is 10 U/l, and the maximum is 50 U/l. At the same time, the activity of AST in Swiss heifers averaged 83.6 U/l, which was 1.67 times higher than the maximum value of the norm.

According to the results of serum researches of experimental heifers, the activity of aspartate aminotransferases (AST) was also 1.48 times higher than normal and averaged 74.11 U/ l. This figure was lower than the indicator of heifers by 12.8%. The level of alanine aminotransferases (ALT) in the blood of experimental heifers almost exactly corresponded to the normative value – 21.2 U/l, and in first heifers this indicator was lower and did not exceed an average of 20.89 U/l. But, these indicators of heifers and first heifers corresponded to norm.

Scientists note (Soboleva, 2011; Mayorov & Kozlovskaya, 2015) that low ALT activity is very infrequent, often with a deficiency of vitamin B6 (pyrodyxin) and with normal values of other biochemical parameters of almost no diagnostic value. The normal value of the de Ritis index ranges from 1.0 to 3.4 units. With the increased activity of AST in experimental animals of two physiological periods, the de Ritis index was also higher than the normative value. However, close to the normative value, this index was in the first heifers and averaged 3.55 units.

An important role in reactions by differentiation and growth of cells, absorption of nutrients, and reabsorption of fats and carbohydrates in the small intestinal mucous membrane is played by the enzyme alkaline phosphatase (Soboleva, 2011; Mayorov & Kozlovskaya, 2015). This enzyme in the blood of experimental

Table 2 – Dynamics of transaminases and serum carotene of heifers, M ± m

Indicator	Norm	A group of animals	
		Heifers, n = 9	Heifers, n = 9
AST, U/l	10–50	83,6 ± 7,922	74,11 ± 4,863
ALT, U/l	10–40	21,0 ± 2,739	20,89 ± 1,806
De Ritis Index (AST/ALT), units	1,0–3,4	3,98 ± 0,256	3,55 ± 0,412
Alkaline phosphatase, U/l	20–150	82,4 ± 19,564	65,44 ± 12,389
Carotene, μg%	275–965	422,8 ± 57,921	350,3 ± 52,963

Table 3 – The main bio-essential elements of the serum of heifers, M ± m

Indicator	Norm	A group of animals	
		Heifers, n = 9	First heifers, n = 9
Calcium, mmol/l	2,43–3,10	1,88 ± 0,037	1,99 ± 0,131
Inorganic phosphorus, mmol/l	1,45–1,94	1,38 ± 0,049	1,53 ± 0,114
Ca/P, units	1,2–1,6	1,36 ± 0,037	1,30 ± 0,078
Copper, μg%	80–120	–	81,03 ± 3,019
Zinc, μg%	100–150	–	109,15 ± 5,322
Cobalt, μg%	5–10	–	10,23 ± 0,448

heifers was within the norm, which ranging from 20 to 150 U/l, and averaged 82.4 U/l. Lower this value was found in Swiss first heifers, in which it did not exceed 65.44 U/l.

Vitamin metabolism increases the level of productivity and reproductive function of ruminants animal. Deficit of vitamins in the organism leads to profound metabolic disorders and diseases – beriberi and hypovitaminosis. Levels of carotene and vitamin A in serum are used to assess the supply of vitamins to the organism of cows at the expense of feed. The level of carotene in the blood of animals normally fluctuates significantly and is in the range of 275–965 μg%. Researches have shown that the feed mixture is sufficiently provided with provitamins, so the level of carotene in Swiss heifers, in this physiological period, averaged 422.8 μg%, which was 17.2% more in period after calving during the first lactation, where its value was an average of 350.3 μg%.

Minerals play an important role in the prevention of metabolic disorders during the first pregnancy and lactation. Deficiency, excess, or violation of the ratio of biologically active elements is the cause of nutritional diseases, disorders reproduction function and metabolic processes (Rodionova & Panfilova, 2004; Arieli et al., 2008). At the same time, not only the productivity of animals decreases, but also the quality of products deteriorates. Macro- and micronutrients should enter the organism in optimal amounts and ratios and in strict accordance with the needs of animals, taking into account their bioavailability (Radostits et al., 2000; Taylor et al., 2009).

Scientists note a close connection between mineral, protein, carbohydrate, lipid and vitamin metabolism. For violation of one of them there is a change of another. Providing heifers and lactating first heifers with a sufficient amount of macro- and microelements in the ration help to preserve their health. In animals, minerals are represented by salts and biocomplexes that break down and form again. Vitamin D and calcium promote the activation of cellulosolytic bacteria in the rumen and reduce the time of fiber breakdown. The organism needs of cows for calcium is 45–100 g per day (Table 3). Biochemical analysis of the blood of experimental animals showed that the level of calcium is below its maximum level. Sufficient minerals in the blood of experimental heifers are very important because the organism have a fetus. The conducted biochemical analysis of the blood of heifers showed that the concentration of calcium is insufficient and is 1.88 mmol/l, which is 1.29 times lower than the established norm and in first heifers with a content of 1.9 mmol/l – 1.22 times. It is known that calcium metabolism is associated with phosphorus metabolism, and the optimal ratio of calcium and phosphorus is 2:1. Phosphorus in animals is found in the skeleton and muscles and is required for normal protein, fat and carbohydrate metabolism (Gromyko, 2005).

Experimental animals did not have a high concentration of inorganic phosphorus in the blood, which was at the limit and slightly inferior to the reference value, which is 1.45–1.94 mmol/l. Below the normative value of inorganic phosphorus was observed in the blood of Brown Swiss heifers, which showed 1.38 mmol/l, and in the first heifers it was more by 9.8% and was 1.53 mmol/l, which corresponded to the reference value.

In Swiss heifers the ratio of calcium and inorganic phosphorus in the blood did not exceed 1.36 units, and in first heifers – 1.30 units. First heifers were provided with a sufficient amount of copper in the feed. In the serum of lactating cows, the copper content corresponded to the normative value – an average of 81.03 μg%.

Increasing the reproductive function of lactating cows is provided by a sufficient amount in the rations of zinc and cobalt. The content of zinc in the blood of experimental first heifers almost corresponded to the lower value of the norm and averaged 109.15 μg%. The level of cobalt in the blood of experimental first heifers slightly exceeded the upper normative value for this element, and averaged 10.23 μg%.

Thus, metabolic homeostasis in the first pregnancy is naturally dynamic and corresponds to the level of physiological processes of the organism and the provision of vital nutrients of the general-mixed ration. The metabolic homeostasis of first heifers is in a tense state, which is determined by the first lactation function and adaptation to the harsh conditions of the industrial complex.

The normal level of protein, carbohydrate, lipid, vitamin and mineral metabolism in first heifers provided their maximum

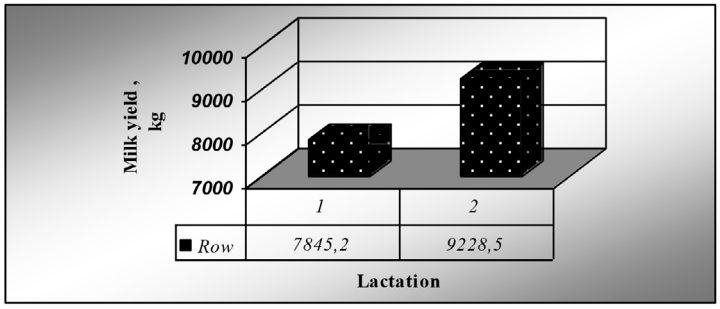

Fig. 1. The level of milk productivity of first heifers (n = 75)
Notes: 1 – milk fat, kg; 2 – milk protein, kg.

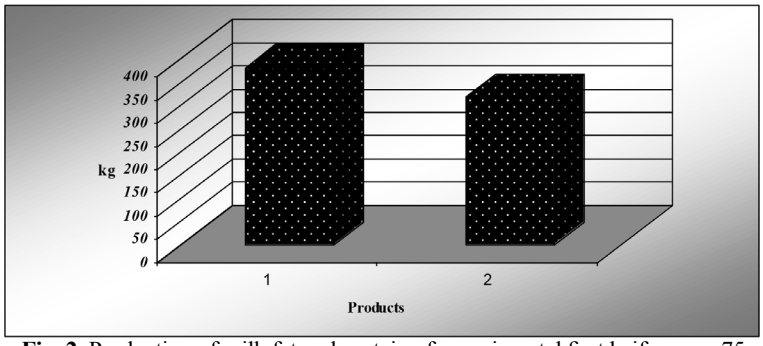

Fig. 2. Production of milk fat and protein of experimental first heifers, n = 75
Notes: 1 – milk fat, kg; 2 – milk protein, kg.

productivity. The level of milk productivity of experimental cows was high, although the researches included young animals of the first lactation, which had to adapt not only to the specialty of the industrial complex, but also to the first lactogenesis and lactopoiesis. Feed intake and nutrient also depended on the condition of cows, whether they were catabolic (Zachut et al., 2013; Zachut, 2015) or anabolic processes (Contreras et al., 2015; 2016), which affects the synthetic processes in the udder.

Swiss first heifers were high productive (Fig. 1), because during the entire lactation period they secreted an average of 9 228.5 ± 45.61 kg of milk. In terms of standard lactation (10 months), the level of milk productivity averaged 7 845.2 ± 25.34 kg, which characterizes Swiss animals of the dairy type.

The milk of first heifers was characterized by high quality indicators, at which the mass fraction of fat was at the level of 4.15%, and protein – 3.45%. The high level of milk productivity of animals and the mass share of its main components provided a high level of their production (Fig. 2). During the lactation period, first heifers secreted 383.1 kg of milk fat and 318.8 kg of milk protein.

Brown Swiss first heifers were characterized by satisfactory indicators of reproductive function. The reproductive ability was at the level of 0.87, and the insemination index did not exceed 2.83 units. For one fertilization were required almost three artificial inseminations.

The low efficiency of artificial insemination in first heifers formed a long period from calving to fertilization (Fig. 3). The service period of first heifers averaged 134.0 ± 3.37 days, which is 1.6 times higher than the technologically established norm at the level of 85 days. Excessive intensification with high-energy feed of one function in animals, in this case lactogenic, adversely affects the reproductive organs. Many scientists think (Butler, 1989; Silvia, 1998; Pryce et al., 2004) that cows have an antagonism between high milk productivity and reproductive function. As noted by Bello et al. (2013), such a connection is not always evident.

According to the technology of exploitation of cows at the industrial complex, their start-up to the dry period is carried out on the 235th day of pregnancy. According to the duration of the service period and lactation during pregnancy, the duration of the lactation period in first heifers are averaged 376.4 ± 1.84 days, which is 1.23 times higher than standard lactation. Animals were characterized by some infertile period, the average value of which was 92.0 ± 3.37 days.

Thus, the reproductive function of Brown Swiss first heifers is satisfactory, the service period lasts 140 days in conditions of intensive exploitation of animals during long-term economic use, and reduces the number of calving, significantly reduces the cost of treatment of diseases after calving.

Conclusions

The biochemical parameters of the serum of Swiss animals during their first pregnancy and first lactation are dynamic, which characterizes the different physiological state of the cows, and its provision of nutrients from the general mixed ration.

The level of albumin in the blood of heifers and first heifers is lower than normal, and the globulin fraction of the protein is above the reference value. The level of globulins in heifers is higher than the first heifers. In heifers, the ratio of albumins and globulins is lower than normal, and in first heifers – corresponds to normal. The serum of heifers and first heifers had satisfactory indicators of total protein, urea and urea nitrogen, which indicated a balanced energy-protein ratio of the ration, which ensured a normal state of protein metabolism. The serum creatinine and glucose of animals during the first pregnancy and the first lactation correspond to the reference values, which characterized the high level of feeding and sufficient accumulated glycogen.

The concentration of lipoproteins in the serum of heifers and first heifers was higher than normal. The balance of protein nutrition

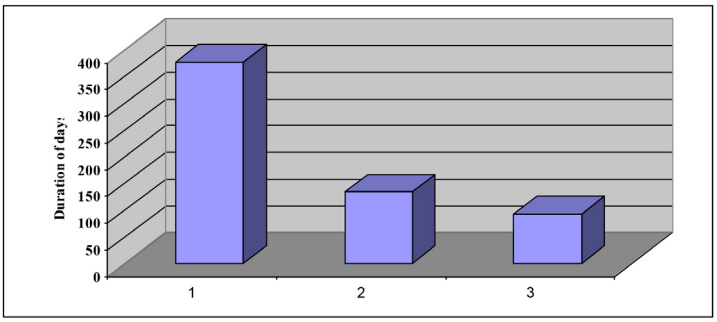

Fig. 3. Duration of lactation, service period and infertility in first heifers, n = 75
Notes: 1 – lactation, days; 2 – service period, days; 3 – infertility, days.

was indicated by the activity of aminotransferases. AST activity in heifers and first heifers was higher than normal and ALT activity was almost normal, as was the enzyme alkaline phosphatase. The animals of the two physiological periods had lower levels of calcium and phosphorus in their blood than norm, and their ratio was close to normal. The blood of the first heifers contained sufficient copper, zinc and cobalt.

The normal state of protein, carbohydrate, lipid, vitamin and mineral metabolism during the first pregnancy and the first lactation was provided by complete general-mixed rations. The high level of productivity of first heifers inhibited their reproductive function. Therefore, their insemination index increased, and a long service period contributed to the occurrence of a period of infertility and loss of calf.

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