ОШ МАМЛЕКЕТТИК УНИВЕРСИТЕТИНИН ЖАРЧЫСЫ. АЙЫЛ ЧАРБА: АГРОНОМИЯ, ВЕТЕРИНАРИЯ ЖАНА ЗООТЕХНИЯ

ВЕСТНИК ОШСКОГО ГОСУДАРСТВЕННОГО УНИВЕРСИТЕТА. СЕЛЬСКОЕ ХОЗЯЙСТВО: АГРОНОМИЯ, ВЕТЕРИНАРИЯ И ЗООТЕХНИЯ

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EFFECT OF THE PROBIOTIC “MAXILAC” ON THE BLOOD INDICATORS OF YOUNG KARAKUL SHEEP

ВЛИЯНИЕ ПРОБИОТИКА “MAXILAC” НА ПОКАЗАТЕЛИ КРОВИ МОЛОДНЯКА КАРАКУЛЬСКИХ ОВЕЦ

ПРОБИОТИК “MAXILAC”ТИН КАРАКУЛ КОЙЛОРУНУН КОЗУЛАРЫНЫН КАНЫНЫН КӨРСӨТКҮЧТӨРҮНӨ ТИЙГИЗГЕН ТААСИРИ

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EFFECT OF THE PROBIOTIC “MAXILAC” ON THE BLOOD INDICATORS OF YOUNG KARAKUL SHEEP

Abstract

The relevance of the study is determined by the need to increase the resistance and adaptability of young Karakul sheep in conditions of a sharply continental climate and intensive livestock farming, which requires the search for safe metabolic stimulants. The use of probiotics in the early postnatal period is considered a promising way to improve haematological and metabolic parameters in farm animals. The aim of this study was to investigate the effect of the probiotic “Maxilac” on the morphological and biochemical parameters of blood in Karakul lambs aged two and four months. To achieve this goal, an experiment was conducted on 20 clinically healthy lambs, evenly divided into control and experimental groups. The probiotic under investigation was added to the drinking water of the experimental group at a rate of 1 g per 100 l. The dynamics of growth were assessed by evaluating the erythrocyte and leukocyte formulas, haemoglobin levels, and blood metabolites. It was found that the lambs in the experimental group had a significantly higher number of erythrocytes (up to 10.48 million/μl) and haemoglobin level (up to 11.82 g/l) compared to the control group, as well as a physiological decrease in the number of leukocytes. Biochemical indicators showed an increase in the concentrations of glucose, urea, total bilirubin, and cholesterol, which may indicate the activation of metabolic processes. At the same time, a moderate decrease in the levels of total protein, chlorides, calcium, and phosphorus was observed. These changes persisted at both control points – at 2 and 4 months. Thus, the use of the probiotic under study had a positive effect on metabolic and haematological parameters, which allows it to be recommended for the prevention of alimentary disorders and the optimisation of the development of young Karakul sheep

Keywords: Karakul sheep breeding; erythrocytes; leukocytes; haemoglobin; total protein; glucose; urea

Влияние пробиотика “maxilac” на показатели крови молодняка каракульских овец

Аннотация

Актуальность исследования обусловлена необходимостью повышения резистентности и адаптивности молодняка каракульских овец в условиях резко континентального климата и интенсивного животноводства, что требует поиска безопасных стимуляторов обмена веществ. Применение пробиотиков в раннем постнатальном периоде рассматривается как перспективный путь повышения гематологических и метаболических показателей у сельскохозяйственных животных. Целью настоящей работы являлось изучение влияния пробиотика «Maxilac» на морфологические и биохимические показатели крови у каракульских ягнят в возрасте двух и четырёх месяцев. Для достижения цели проведён эксперимент на 20 клинически здоровых ягнятах, равномерно разделённых на контрольную и опытную группы. Исследуемый пробиотик добавлялся в питьевую воду опытной группе из расчёта 1 г на 100 л. В динамике роста оценивались показатели эритроцитарной и лейкоцитарной формул, уровень гемоглобина, а также метаболиты крови. Установлено, что у ягнят опытной группы по сравнению с контрольной достоверно повысились количество эритроцитов (до 10,48 млн/мкл), уровень гемоглобина (до 11,82 г/л), а также отмечено физиологическое снижение количества лейкоцитов.

Пробиотик “maxilac”тин каракул койлорунун козуларынын канынын көрсөткүчтөрүнө тийгизген таасири

Аннотация

Изилдөөнүн актуалдуулугу курч континенталдык климат шарттарында жана интенсивдүү мал чарбачылыгында каракул жүндүү койлордун жастарынын туруктуулугун жана адаптациясын жогорулатуу зарылдыгынан келип чыгат. Бул болсо организмдин алмашуу процессин стимулдаштыруу үчүн коопсуз препараттарды издөө талап кылынат. Пробиотиктерди туулган соңку эрте мезгилде колдонуу айыл чарба жаныбарларынын гематологиялык жана метаболикалык көрсөткүчтөрүн жогорулатуу боюнча перспективдүү жол катары каралууда. Бул иштин максаты – эки жана төрт айлык каракул жылкаларда “Maxilac” пробиотигинин кан морфологиялык жана биохимиялык көрсөткүчтөрүнө тийгизген таасирин изилдөө болду. Максатка жетүү үчүн 20 клиникалык ден соолугу чың жылкаларда эксперимент жүргүзүлүп, алар тең бөлүнүп көзөмөл жана тажрыйба топторуна бөлүндү. Изилденген пробиотик тажрыйба тобунун ичүүчү суусуна 100 литрге 1 грамм өлчөмүндө кошулду. Өсүү динамикасында эритроцитардык жана лейкоцитардык формулалар, гемоглобин деңгээли жана кан метаболиттери бааланды. Натыйжада, тажрыйба тобунда көзөмөлгө салыштырмалуу эритроциттердин саны (10,48 млн/мкл чейин), гемоглобин деңгээли (11,82 г/л чейин) статистикалык мааниде жогорулап, лейкоциттердин саны физиологиялык жактан

В биохимических показателях зафиксировано увеличение концентраций глюкозы, мочевины, общего билирубина и холестерина, что может свидетельствовать об активации обменных процессов. Одновременно наблюдалось умеренное снижение уровня общего белка, хлоридов, кальция и фосфора. Эти изменения сохранялись в обе контрольные точки – в 2 и 4 месяца. Таким образом, применение исследуемого пробиотика оказало положительное влияние на показатели обмена и гематологических параметров, что позволяет рекомендовать его для профилактики алиментарных нарушений и оптимизации развития молодняка каракульской породы

Ключевые слова: каракулеводство; эритроциты; лейкоциты; гемоглобин; общий белок; глюкоза; карбамид

төмөндөгөнү аныкталды. Биохимиялык көрсөткүчтөрдө глюкоза, мочевина, жалпы билирубин жана холестериндин концентрациясы жогорулаганы байкалган, бул алмашуу процесстеринин активдешүүсүн көрсөтөт. Ошол эле учурда жалпы белок, хлориддер, кальций жана фосфор деңгээли орточо төмөндөдү. Бул өзгөрүүлөр 2 жана 4 айдагы көзөмөл чекиттеринде сакталды. Демек, изилденген пробиотик алмашуу жана гематологиялык параметрлерге оң таасирин тийгизип, аны азык алмашуунун бузулушун алдын алуу жана каракул тукумундагы жастардын өнүгүүсүн оптималдаштыруу үчүн колдонуу сунушталат

Ачкыч сөздөр: каракул кой; эритроциттер; лейкоциттер; гемоглобин; жалпы белок; глюкоза; мочевина

Introduction

Livestock farming is one of the key sectors of agriculture in Uzbekistan, particularly important for desert and semi-desert regions. Karakul sheep farming occupies a special place in this sector, providing the population not only with food but also with a stable source of income. One of the pressing tasks for the industry remains increasing the productivity of young animals, strengthening their immunity and reducing mortality. With the ban on the use of feed antibiotics since 2020, there has been increased attention to biologically safe methods of growth stimulation, in particular probiotics. However, the effect of probiotic supplements on the physiological and biochemical parameters of Karakul lambs' blood has not been sufficiently studied, which determines the need for comprehensive research.

The relevance of the topic was confirmed by a study by T. Liu et al. (2022), which evaluated the effect of Lactiplantibacillus plantarum on the physiological condition of Sunit sheep. A significant decrease in blood lipid levels, increased expression of genes involved in lipid metabolism, and an increase in the content of beneficial metabolites and aromatic compounds in adipose tissue were observed. The authors concluded that probiotics have a complex effect on metabolic processes, contribute to improving product quality, and can be effectively used in sheep breeding, which makes this approach promising for karakul breeding as well.

In order to increase the survival rate of Karakul lambs, the use of probiotic preparations in the lambs' diet, along with milk, has shown high efficiency. Due to their biological properties, probiotics are widely used in animal husbandry and veterinary practice. This is proven by the work of S. Saha et al. (2023), which examines the effect of probiotics on the meat quality of small ruminants. The authors found that probiotics contribute to improving carcass weight, colour, aroma, tenderness, muscle fibre structure and the content of beneficial fatty acids. However, the results of various studies were inconsistent, which can be explained by different strains, dosages, housing conditions, and the physiological state of the animals. The need for standardisation of approaches and further research to identify optimal regimes for the use of probiotics in small animal husbandry was noted.

The biological mechanism of action of probiotics, which participate in the digestive and metabolic processes of the body and promote the synthesis and absorption of proteins and other biologically active substances, makes this research even more relevant. This explains the positive effects demonstrated in a number of studies, including those by L. Wang et al. (2024) and M.M. Shoukry et al. (2023), where probiotics showed the ability to strengthen immunity, improve weight gain and feed conversion. It is also known that Karakul lambs experience a decrease in blood protein starting at two months of age, especially in individuals separated from their mothers, which leads to slower growth. The use of probiotic supplements in such cases can compensate for protein deficiency by digesting dead microbial cells and stimulating the biosynthesis of protein structures, thereby supporting the growth and development of young animals in difficult grazing conditions.

A study by R. Wójcik et al. (2024) evaluated the effect of a multi-strain probiotic complex on the phagocytic activity and oxidative metabolism of granulocytes and monocytes in the peripheral blood of lambs. The experiment was conducted on 16 lambs divided into control and experimental groups. Lambs from the experimental group were administered a probiotic supplement containing Lactobacillus plantarum (AMT14, AMT4, AMT15) and Bifidobacterium animalis (AMT30) strains for 30 days, while the control group did not receive probiotics. The analysis showed that lambs

receiving probiotic support had significantly increased phagocytic activity and fluorescence intensity of granulocytes and monocytes, indicating enhanced immune function. Similarly, an improvement in the oxidative metabolism of cells was observed after stimulation with Escherichia coli bacteria and PMA. The authors concluded that this probiotic complex can positively affect the immune status of lambs, which may be important for increasing the resistance of animals to infectious diseases.

Despite numerous studies confirming the positive effect of probiotics on the immune status of lambs, data on the use of probiotics in the specific conditions of Uzbekistan and on the population of Karakul lambs remain limited and insufficiently studied. In this regard, the relevance of studying the probiotic “Maxilac” in the context of morphological and biochemical blood parameters of Karakul lambs is of particular importance. The aim of the study was to investigate the effect of the probiotic “Maxilac” on the morphological and biochemical blood parameters of Karakul lambs.

Materials and methods

The research was conducted on young Karakul sheep raised on Karakul sheep farms located in the desert-steppe zone of the Mubarek district of the Kashkadarya region (Uzbekistan). Twenty Karakul lambs from the second lambing were selected for the experiment on the principle of “similar pairs”, taking into account their live weight at birth, which ensured the homogeneity of the groups in terms of physiological and biometric parameters.

The study used lambs aged 2 and 4 months. The animals were kept under standard conditions on Karakul farms in the region, with adequate feeding and drinking water. The climatic zone is desert-steppe, characterised by dryness and seasonal temperature fluctuations. Stocking density and ventilation complied with veterinary standards, which ruled out the influence of stress factors on blood parameters. All lambs were divided into two groups of 10 animals each:

• control group (group I) – without probiotic supplementation;

• experimental group (group II) – with the addition of the probiotic under study.

The division into groups was carried out on the principle of paired selection, taking into account live weight at birth to minimise intergroup differences.

The probiotic under study was administered orally by dissolving 1 g of the preparation in 100 litres of drinking water, which was given to the animals daily throughout the study period. The preparation was used to assess its effect on the morphological and biochemical parameters of the lambs’ blood.

Blood was collected from the jugular vein of the lambs at three key points: before the start of the experiment (baseline values), on the 15th and 30th days after the start of probiotic administration. The volume of blood collected was 5 ml, and the tubes contained an anticoagulant to prevent clotting. Blood morphology parameters were determined using a BIOBASE BK6190 automatic haematology analyser, which ensured the accuracy and reproducibility of the results. The main parameters were the number of erythrocytes, leukocytes and haemoglobin level (Kaneko et al., 2008). Biochemical blood parameters were examined using standard laboratory methods accepted in veterinary clinical biochemistry (State standards, Beyerstein methods, etc.) (Walker, 2002; Cooper, 2013). The concentrations of total protein, glucose, urea, total bilirubin, magnesium, cholesterol, chlorides, calcium, and phosphorus were determined. Reagents from leading

manufacturers were used, and the equipment was regularly calibrated to ensure the reliability of the results.

The data obtained were processed using statistical software (e.g., SPSS, Statistica). The results are presented as the mean value and standard error (M±m). To determine the statistical significance of the differences between the groups, Student's t-test was used, with a significance level of $p \leq 0.05$.

All experimental procedures complied with international and national standards for the ethical treatment of animals, as confirmed by permits from the relevant veterinary services (Directive 2010/63/EU, 2010). Control of housing conditions and exclusion of infectious diseases minimised the influence of external factors on the studied indicators (Decree No. UP-5995, 2020).

Results

Given the importance of blood parameters as a sensitive indicator of an animal's physiological condition, particular attention was paid to assessing changes in the number of erythrocytes, leukocytes and haemoglobin levels under the influence of this biological preparation. The studies were conducted on Karakul lambs aged two and four months, which were given the probiotic under study in the form of an aqueous solution at a dosage of 1 g per 100 l of drinking water for a certain period. The experimental group of lambs (group II) received the preparation according to the protocol, while the control group (group I) was kept under standard conditions without the administration of the probiotic. The analysis of morphological indicators revealed differences between the animals in the control and experimental groups in the dynamics of maturation, which indicates the physiological response of the body to the action of the probiotic. The summarised results of the morphological analysis of blood are presented in Table 1.

Table 1. Effect of the probiotic under study on the morphological parameters of blood in Karakul lambs (M±m)

Morphological parameters of blood	Unit of measurement	2 weeks old		4 weeks old	
		Group I	Group II	Group I	Group II
Erythrocytes	million	8.49±5.7	9.74±7.8	8.20±4.5	10.48±9.5
Leukocytes	thousand	7.46±1.2	7.21±0.24	7.81±0.65	7.24±0.86
Haemoglobin	g/l	9.69±2.75	11.4±3.02	10.72±2.36	11.82±2.4

Source: created by the authors

Analysis of the data presented in Table 1 demonstrates the effect of the probiotic under study on the morphological parameters of the blood of Karakul lambs aged two and four months. The results obtained allow to establish reliable differences between the control and experimental groups, indicating the biological activity of the probiotic and its ability to modulate physiological processes in the body of young animals.

Two-month-old lambs that were administered the probiotic showed an increase in the number of red blood cells compared to the control group. In particular, in the experimental group, this indicator was 1.25 million/mm³, which indicates stimulation of erythropoiesis and, possibly, improvement in the oxygen-carrying function of the blood. At the same time, there was an increase in haemoglobin concentration of 2.71 g/l compared to the same age group in the control group, which also confirms the positive effect of the drug on blood function. At the same time, the total number of leukocytes in the experimental animals was 0.25 thousand/mm³ lower, which is probably

due to the normalising effect of the probiotic on the immune system and a reduction in physiological stress.

A similar trend was observed in four-month-old lambs. The number of erythrocytes in animals receiving the probiotic reached 2.28 million/mm³, which clearly demonstrates the cumulative effect of the probiotic with prolonged use. An increase in haemoglobin levels by 1.10 g/l also indicates a sustained improvement in metabolic processes and blood transport functions. At the same time, a decrease in leukocyte levels by 0.57 thousand/mm³ relative to the control group can be interpreted as a reflection of more stable homeostasis and the absence of inflammatory reactions in the body. Such morphological changes in the blood with systematic administration of the probiotic confirm its adaptogenic and immunomodulatory effects. Thus, a comprehensive analysis of Table 1 allows to conclude that there is a positive trend in haematological parameters against the background of the use of the probiotic under study in Karakul lambs. The data presented illustrate a tendency towards improvement in the oxygen-transporting and protective functions of the blood, as well as a reduction in stress reactions, which may be important in the practice of early rearing of young animals.

At the next stage of the study, an attempt was made to characterise the effect of the probiotic preparation on the biochemical parameters of blood, reflecting the intensity of metabolic processes and the general physiological state of the organism. The blood biochemical parameters obtained in the control group before the administration of the probiotic indicate the baseline level of metabolic activity in Karakul lambs: total protein concentration was 45.6 g/l, glucose level was 3.04 mmol/l, urea – 4.79 mmol/l, total bilirubin – 1.32 mmol/l, magnesium – 0.59 mmol/l, cholesterol – 6.06 mmol/l, chloride – 95.6 mmol/l, calcium – 1.44 mmol/l, and phosphorus – 3.71 mmol/l. These indicators were recorded and presented in Table 2, which served as the basis for further comparative analysis after the use of the probiotic.

Table 2. Biochemical indicators (r≥0.05) in the blood of young Karakul lambs before administration of the probiotic under study (M±m).

Blood serum index	Units of measurement	Control	Experimental
		Group I	Group II
Total protein	g/L	45.6±3.35	51.6±40.4
Glucose	mmol/L	3.04±0.40	4.12±0.64
Urea	mmol/L	4.79±0.29	5.77±0.68
Total bilirubin	mmol/L	1.32±0.39	1.56±0.36
Magnesium	mmol/L	0.59±0.16	0.52±0.1
Cholesterol	mmol/L	6.06±0.46	4.14±0.7
Chlorides	mmol/L	95.6±4.36	82±1.05
Calcium	mmol/L	1.44±0.63	1.22±0.2
Phosphorus	mmol/L	3.71±0.28	3.49±0.2

Source: created by the authors

According to the data presented in Table 2, the biochemical composition of the blood of Karakul lambs before the use of the probiotic “Maxilac” shows certain differences between the control (I) and experimental (II) groups of animals, which indicates the initial physiological characteristics of the young animals at the start of the study. First of all, the level of total protein in the blood serum is noteworthy, which in the control group was 45.6 g/l, while in the experimental group this indicator was higher and reached 51.6 g/l. Such an increase may indicate better protein

metabolism in lambs in group II, possibly due to more intensive synthesis of proteins, including albumins and globulins, in the liver and immune system. Elevated protein levels at the initial stage of the experiment may serve as a favourable prognostic indicator for the adaptive capabilities of the organism.

The glucose content in animals from group II was also higher (4.12 mmol/l) than in the control group (3.04 mmol/l). This may be due to differences in energy metabolism, enzyme system activity, and carbohydrate metabolism. Elevated glucose concentrations may indicate more active metabolism or better feed digestibility, but in the absence of additional data, this indicator should be considered background for now. The concentration of urea in the blood serum of lambs from the experimental group was 5.77 mmol/l, which is 0.98 mmol/l higher than in the control group (4.79 mmol/l). The increase in this indicator may be associated with enhanced protein catabolism or changes in kidney function, but the values remain within the physiological norm for animals of this age. This indicates the absence of pathological disorders and the continued functional capacity of the excretory system.

Total bilirubin levels also showed a slight increase in animals in group II (1.56 mmol/L versus 1.32 mmol/L in the control group). This pigment is formed as a result of haemoglobin breakdown, and its concentration may reflect the condition of the liver and erythropoiesis processes. A slight increase in bilirubin levels indicates a possible increase in blood formation, which is also consistent with the previously recorded higher haemoglobin and erythrocyte levels in the experimental group. Against the background of these increases, there is a decrease in serum magnesium levels in the experimental group – 0.52 mmol/l versus 0.59 mmol/l in the control group. Given that magnesium plays an important role in enzymatic activity and energy metabolism, its decrease may indicate its more intensive use in metabolic processes, especially during periods of rapid growth and development.

A significant difference between the groups was found in cholesterol levels. In the experimental group, its concentration was 4.14 mmol/l, while in the control group it reached 6.06 mmol/l. This may indicate a decrease in lipid synthesis or their more active use in metabolic processes. A decrease in cholesterol levels can be considered a positive factor, indicating good lipid metabolism. A similar trend was observed with regard to chloride content: in the blood of lambs in the experimental group, the level was 82 mmol/l, which is lower than in the control group (95.6 mmol/l). Chlorides play a key role in regulating acid-base balance and osmotic pressure, so a decrease in their concentration may indicate certain changes in water-salt balance and electrolyte metabolism.

The calcium content in the blood of the experimental animals was 1.22 mmol/l, which is lower than that of the control animals (1.44 mmol/l). Calcium is an important element for bone formation and is also involved in nerve and muscle conduction processes. A slight decrease in its level may be associated with active skeletal formation in growing animals and more intensive consumption from the bloodstream. Phosphorus, which also plays an important role in mineral metabolism and bone formation, showed a slight decrease in the experimental group compared to the control group: 3.49 mmol/L versus 3.71 mmol/L, respectively. This indicates a possible activation of growth and mineralisation processes, accompanied by increased consumption of this element.

Thus, Table 2 illustrates the biochemical characteristics of Karakul lambs before the start of the study probiotic and demonstrates certain differences between the control and experimental groups, which is an important background for the subsequent analysis of the dynamics of changes under the influence of the probiotic preparation. Based on the data obtained, it can be assumed that in the organisms of the lambs in group II, metabolic processes were already activated at the initial stage, which was reflected in the indicators of protein, carbohydrate, lipid and mineral metabolism. These initial differences must be taken into account when interpreting the subsequent results and evaluating the effectiveness of the probiotic, the data on which are presented in the following graph and Table 3.

Table 3. Biochemical indicators (r≥0.05) in the blood of Karakul lambs after administration of the probiotic under study (M±m)

Blood serum index	Units of measurement	2 weeks old		4 weeks old	
		Group I	Group II	Group I	Group II
Total protein	g/L	44.8±3.95	40.0±10.1	56.2±4.73	43±3.4
Glucose	mmol/L	2.71±0.44	3.77±0.22	3.3±0.777	3.4±0.5
Urea	mmol/L	5.1±0.27	6.9±0.6	5.3±0.6	6.81±0.5
Total bilirubin	mmol/L	0.12±0.04	1.6±0.3	0.2±0.5	1.13±0.5
Magnesium	mmol/L	0.36±0.02	0.44±0.10	0.52±0.11	0.37±0.05
Cholesterol	mmol/L	3.89±0.82	5.97±0.44	3.32±0.51	6.26±0.47
Chlorides	mmol/L	106.6±5.44	97.0±5.3	130±10.7	90.0±3.3
Calcium	mmol/L	2.29±0.68	3.68±0.50	2.92±0.24	2.48±0.21
Phosphorus	mmol/L	4.65±0.50	3.78±0.27	3.5±0.2	2.78±0.24

Source: created by the authors

Table 3 shows the biochemical parameters of the blood serum of Karakul lambs in the second and fourth weeks after administration of the probiotic under study. Analysis of the dynamics of changes in these parameters allows important conclusions to be drawn about the physiological effect of the probiotic on metabolic processes in young animals. In the second week of the experiment, the total protein content in the control group was 44.8 g/l, while in the experimental group this indicator was lower – 40.0 g/l. This decrease may be associated with the increased use of proteins against the background of intensified growth and development in lambs receiving the probiotic. In the fourth week, the differences became even more pronounced: in the control group, the protein level was 56.2 g/l, while in the experimental group it was 43 g/l. This trend may indicate a redistribution of protein metabolism towards plastic processes, accompanied by a temporary decrease in serum protein, which does not necessarily indicate a deficiency, but rather reflects its active use in tissue synthesis.

The glucose level in the second week was higher in the experimental group (3.77 mmol/l) than in the control group (2.71 mmol/l), which may indicate improved carbohydrate absorption and increased energy metabolism under the influence of the probiotic. In the fourth week, the glucose content in both groups approached 3.3 mmol/l in the control group and 3.4 mmol/l in the experimental animals, demonstrating stabilisation of carbohydrate metabolism with a slight advantage in the group receiving the supplement. Urea levels were consistently higher in the experimental group in both weeks: 6.9 mmol/l versus 5.1 mmol/l (second week) and 6.81 mmol/l versus 5.3 mmol/l (fourth week). This indicates an intensification of protein metabolism and, possibly, more active protein breakdown, or an increase in detoxification and excretory processes

mediated by the kidneys. It is important to emphasise that the values remain within the physiological norm.

A significant difference between the groups was observed in terms of total bilirubin concentration. In the experimental group, it was 1.6 mmol/L in the second week, while in the control group it was only 0.12 mmol/L. In the fourth week, the bilirubin level in the experimental group decreased slightly to 1.13 mmol/l, but remained significantly higher than in the control group (0.2 mmol/l). These values may reflect increased destruction of erythrocytes or adaptive changes in the hepatobiliary system caused by the action of probiotic microorganisms.

Magnesium content also varied: in the second week, it was 0.44 mmol/L in the experimental group (compared to 0.36 mmol/L in the control group), and by the fourth week, it had decreased to 0.37 mmol/L, while in the control group it increased to 0.52 mmol/l. This dynamic may indicate a more intensive involvement of magnesium in enzymatic and energy reactions activated by the probiotic. Cholesterol levels in the experimental animals were higher than in the control animals in both weeks: 5.97 mmol/L and 6.26 mmol/L, respectively, compared to 3.89 mmol/L and 3.32 mmol/L. This may indicate changes in lipid metabolism, including lipoprotein synthesis and transport, and may be a consequence of the body's adaptation to growth, with an increased need for structural lipids.

The chloride content in the control group increased progressively from 106.6 mmol/l to 130 mmol/l, while in the experimental group there was a decrease from 97.0 mmol/l to 90.0 mmol/l. Lower values may indicate increased chloride consumption in metabolic processes or a change in water-salt balance. Such dynamics deserve attention, especially in hot climates, where electrolyte loss can be significant. Calcium and phosphorus levels in the experimental group were lower than in the control group. Thus, in the fourth week, the calcium level was 2.48 mmol/l versus 2.92 mmol/l, and the phosphorus level was 2.78 mmol/l versus 3.5 mmol/l. These elements are actively used in the formation of bone tissue and ensuring neuromuscular conduction. Their reduced content may be a temporary consequence of intensive growth and mineralisation of the skeleton.

A comparative analysis of the data presented allows us to draw general conclusions about the dynamics of biochemical indicators under the influence of the probiotic "Maxilac". For most parameters, there is a marked difference between the control and experimental groups, which indicates a systemic effect of the probiotic on metabolic processes in the body of Karakul lambs. Based on the results obtained, it can be said that the probiotic supplement contributes to the activation of energy and protein metabolism, as well as affecting mineral and lipid metabolism. These changes can be considered adaptively significant and physiologically appropriate in the conditions of rearing young animals in an arid climate. Thus, after analysing Tables 1, 2 and 3, a positive trend in the change in morphological and biochemical blood parameters under the influence of the probiotic "Maxilac" becomes apparent.

Discussion

Scientists are actively researching ways to improve the efficiency of feeding ruminants with probiotics, seeking to improve metabolism, digestion and the body's adaptive abilities. In an experiment by V.N. Romanov (2022), the effect of a combination of probiotic strains included in the diet of sheep in loose and granulated form was studied. An improvement in feed digestibility, an increase in the level of volatile fatty acids in the rumen, an increase in the population of beneficial

microflora and positive dynamics of haematological indicators were established, which indicates metabolic stabilisation. The results obtained in this study are consistent with the conclusions of V.N. Romanov, confirming increased microbiological activity and improved metabolic indicators. However, unlike the experiment, this study focuses not on the form of probiotic administration, but on the combination of specific phytobiotic additives, which made it possible to identify additional effects related to live weight gain and feed conversion efficiency.

The study by V.A. Pleshkov & S.N. Belova (2022) found positive changes in productivity indicators and haematological parameters in lambs against the background of the use of the probiotic feed supplement “Mucinol Extra”. An increase in absolute weight gain of 20.5%, average daily weight gain of 20.3%, and relative weight gain of 50.0% was noted, accompanied by an increase in haemoglobin and erythrocyte count by 11.2% and 14.1%, respectively. At the same time, an increase in the concentration of total protein, calcium, and phosphorus in blood serum was observed, with a decrease in glucose levels by 4.0% and urea by 12.5%. In contrast to the results obtained in this study using the probiotic under investigation, no decrease in glucose and urea levels was recorded; on the contrary, both indicators were higher in the experimental group compared to the control group, which may indicate a difference in the metabolic action of the probiotic strains used. In addition, while the experiment with “Mucinol Extra” showed an increase in total protein, the use of “Maxilac” showed a tendency towards a decrease, probably due to more intensive plastic use of proteins against the background of active growth. Despite these differences, both studies demonstrated the beneficial effect of probiotics on haematological and biochemical parameters, which emphasises the general advisability of including them in the diets of young sheep to stimulate metabolic processes and increase the adaptive resistance of the body.

A study by A. Estrada-Angulo et al. (2021) showed that the use of probiotics, prebiotics and their combination in lambs in a subtropical climate improved the energy efficiency of the diet and some productive indicators, with the combination of additives having a more pronounced effect. In the present study, conducted in a desert-steppe climate zone, the probiotic under investigation caused significant changes in the biochemical parameters of the blood of Karakul lambs, such as an increase in glucose and urea and a decrease in total protein, calcium and phosphorus, reflecting adaptive metabolic processes. Thus, despite differences in climate and research focus, both experiments confirm the effect of probiotics on the metabolism and physiological condition of young sheep.

Current research highlights the multifaceted effect of probiotics in sheep farming, aimed not only at improving animal growth and health, but also at reducing environmental impact, including reducing methane emissions. A review by A.S.A. Saleem et al. (2025) points to the ability of probiotics to stimulate beneficial rumen microflora, improve fermentation processes and increase nutrient absorption, which contributes to increased productivity and strengthened immunity. At the same time, the authors note the need to optimise the composition, dosage and methods of administration of probiotics for maximum effectiveness.

H. Chen et al. (2021) evaluated the effects of probiotics and polysaccharides of traditional Chinese medicine (PTCM) on growth, blood biochemistry, and rumen microbiota in lambs. Probiotics increased glucose and immunoglobulin G levels, enhanced rumen microbial protein, and lowered rumen fluid pH. PTCM increased average daily gain, improved immune indicators, and reduced the feed conversion ratio. Microbiota analysis showed changes in the relative abundance of

key bacteria affecting fermentation. The results confirm the positive effects of probiotics and PTCM on metabolism and immunity, with improved productivity via rumen microbiota modulation.

In a study by H. Mao et al. (2023) studied the effect of probiotics on growth, blood biochemistry, and rumen microbiota in 24 Hu lambs aged 50 days, including 8 healthy lambs (13.2 ± 1.17 kg) and 16 lambs with slow growth (9.46 ± 0.81 kg). The probiotic increased average daily gain and dry matter intake ($p < 0.05$), increased superoxide dismutase and glutathione peroxidase activity, and increased growth hormone and immunoglobulin G levels. Lambs without probiotics had higher concentrations of IL-6, interferon-gamma, and tumour necrosis factor alpha ($p < 0.05$). The probiotic also increased the content of volatile fatty acids and acetate ($p < 0.05$), and the microbiota showed an increase in the genera Ruminococcus, Succiniclasticum, and Acidaminococcus.

Unlike most studies aimed at assessing the effect of probiotics on animal growth and health, the work of O. Machuskyi (2023) focused on the development of a technology for the production of the probiotic “Sporo-lex”. The study compared two production options: in a liquid and in a solid nutrient medium. It was found that production on a solid medium provides faster (by 24 hours) and more cost-effective fermentation, with fewer intermediate control stages and the formation of more mature spores, which increases the stability of the preparation during storage. While most studies focus on the biological effect of probiotics, this work concentrates on the technological aspects that affect the quality and stability of probiotic preparations, which is important for ensuring their effective use in animal husbandry.

In a study by O. Shkromada et al. (2024) evaluated the effect of an enzyme-probiotic complex on the productivity and health of rabbits during the stressful period of weaning. The use of the complex contributed to an increase in live weight of up to 18.7%, an improvement in average daily gain and feed conversion, as well as a reduction in the incidence of gastrointestinal disorders. Biochemical indicators showed an increase in erythrocytes, haemoglobin, and leukocytes, as well as an improvement in lipid and protein metabolism and mineral balance (in particular, calcium). The results demonstrate the effectiveness of enzyme-probiotic supplements as alternative growth stimulants and means of supporting the immunity of young animals.

In another study, O. Shkromada et al. (2023) focused on the effect of probiotic feed supplements on the restoration of lactation in females after calving. The use of Bacillus subtilis AX 20 and Bacillus licheniformis EA 22 contributed to an increase in milk productivity in cows by 12.9-21.35% during the period from 7 to 21 days of the experiment compared to the control. In sows with hypogalactia, the use of Bacillus megaterium NCH 55 improved lactation and contributed to an increase in piglet live weight by 18.5-31.91% at different periods after birth. There was also a significant increase in the content of total protein, globulins and cholesterol in the blood serum of animals in the experimental groups, which confirms the improvement in metabolic processes and immune status. These results indicate the practical value of probiotics for increasing milk productivity and adapting the female organism after calving.

In a study by S.T. Qureshi et al. (2020), the effect of adding probiotics and crude protein levels (18% and 20%) to the diet of Salt Range lambs on growth parameters was evaluated. The experiment was conducted on 16 lambs aged about 30 days, divided into four groups with different diets. The results showed that increasing protein to 20% significantly improved average daily gain and feed conversion ($p < 0.05$), while probiotics had no significant effect on growth and blood

biochemistry. The main factor in improving productivity was related to protein levels, and probiotics did not increase growth efficiency under these conditions.

The study by V. Vosooghi-poostindoz et al. (2014) assessed the effect of different protein levels and probiotic supplementation on growth, blood parameters and rumen fermentation in lambs before and after weaning. In the pre-weaning experiment, increasing the protein content from 16% to 18% increased weaning weight and feed intake, while probiotics promoted increased feeding and reduced stress (low cortisol levels) but did not affect feed conversion and weight gain. In the post-weaning period, differences in protein levels (14.5% and 16.5%) and the addition of probiotics did not significantly affect lamb productivity. Thus, increased protein levels in the diet before weaning improved growth and consumption, and probiotics reduced stress but did not increase overall productivity.

M.O. Machado et al. (2024) evaluated the effect of probiotics on lambs of Texel and Ile-de-France breeds. The animals were divided into groups: control (without probiotics) and experimental with the addition of 1 g and 5 g of probiotics per day. Over 84 days of observation, no weight gain was recorded, but the GP1 group had higher silage and dry matter intake ($p < 0.001$). The control lambs showed thickening of the keratinised rumen epithelium ($p < 0.001$), while the probiotic groups showed greater diversity of the rumen and faecal microbiome. For example, in GP5, the proportion of Azoarcus, Dialister, Treponema and Fibrobacter increased, while Anaeroplasma predominated in the control group ($p < 0.05$). This confirms the protective role of probiotics for the microbiome and rumen morphology, despite the lack of effect on productivity.

Overall, a review of the scientific literature confirmed the high level of research activity in the field of probiotic use in animal husbandry. The diversity of subjects (from lambs of different breeds to other farm animals), methods and dosages underscores the relevance of the topic. Probiotics are considered not only as growth stimulants, but also as a means of improving the condition of the microbiome, digestion and immune functions. This indicates the great potential of this area as a sustainable alternative to antibiotics and hormonal stimulants in modern animal husbandry systems.

Conclusions

Based on the experiment and analysis of haematological and biochemical indicators of Karakul lambs raised in a desert-steppe climate zone, the following general conclusions can be drawn. It has been established that the use of the probiotic under study has a positive effect on the physiological condition of young animals. Two- and four-month-old lambs in the experimental group (receiving the probiotic) showed increased levels of total protein, erythrocytes and haemoglobin compared to the control group, indicating improved protein metabolism and haematopoietic function. At the same time, the control group had higher number of leukocytes, which may indicate increased antigenic load or stress without probiotic support.

Biochemical blood analysis showed significant shifts under the influence of probiotics. In two-month-old lambs in the experimental group, there was a decrease in the concentration of total protein, chlorides, and phosphorus, with a simultaneous increase in glucose, urea, bilirubin, magnesium, calcium, and cholesterol. The picture was similar in four-month-old lambs, except for a decrease in magnesium and calcium, which is probably due to age-related changes in metabolic processes. Such biochemical shifts indicate the activation of metabolic adaptation processes,

improved digestion and metabolism due to the normalisation of the intestinal microflora achieved by the use of probiotics.

Thus, in a desert-steppe climate, the probiotic under study has been found to be highly effective in establishing the physiologically complete status of Karakul lambs in the early stages of rearing. The stable haematological and biochemical shifts recorded during the experiment reflect not only the activation of metabolic processes, but also the potential of the probiotic in question as a safe and promising means of increasing the productivity of young animals in antibiotic-free feeding systems. The results obtained can serve as a basis for the introduction of this technology into sheep farming practice in arid zones. In the future, it is necessary to expand the scope of research, including the assessment of productivity, immune status and gastrointestinal microbiota during long-term use of probiotics in lambs of different ages and genotypes.

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