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The Use of Spirulina Platensis in Cattle Feeding

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ABSTRACT
The effectiveness of the blue-green alga Spirulina platensis use, separately and along with dispersed peat, during its introduction into the diet of the calves of Holstein breed, is considered in the article. The animals of the 1st and 2nd experimental groups received 10 mg and 15 mg of dry matter (DM) of the defrosted biomass of Spirulina platensis per 1 kg of calves' live weight 1 time per day for 60 days. The young animals of the 3rd experimental group received 15 mg of dry matter of the defrosted biomass of Spirulina platensis per 1 kg of live weight together with 50 ml of the aqueous suspension of dispersed peat 1 time per day. It was found that the studied non-traditional additives not only had a stimulating effect on the growth of young cattle, increasing the average daily and absolute increments in the 1st, 2nd, and 3rd experimental groups of calves at the age of 4 months by 4.57 - 6.79 - 10.94 % in comparison with the control group, but also provided a prolonging effect on the growth of calves in the period from the 2nd to the 6th month by 4.69 - 8.41 - 16.10 %, respectively. Feeding calves using Spirulina platensis separately and in combination with the sorbent contributed to a better digestion of the nutrients of the feed in comparison with the control group. The studied hematological parameters in all groups of experimental animals were within physiological boundaries. The content of erythrocytes, hemoglobin, total protein, albumin fraction and glucose in the blood of calves from experimental groups exceeded the level of the same studied parameters of the control group both in 4 and 6 months of age. In comparison with the control group (16.84 %), the level of production profitability was higher in the 1st and 2nd experimental groups by 1.67 % and 3.61 %, respectively, in the 3rd group the profitability level was higher than in the control group by 7.99 %.

Keywords: Cattle, calves, Spirulina platensis, sorbent, fodder bio-supplement, probiotic

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INTRODUCTION

The State Program for the Development of Agriculture and Regulation of the Markets of Agricultural Products, Raw Materials and Food for 2013-2020 is aimed at ensuring Russia's food independence, including production of meat and milk, as well as increasing the competitiveness of Russian agricultural products in the domestic and foreign markets [12]. In this connection, it is necessary to develop the industrial animal

husbandry everywhere, the key to success of which is the production, preservation and cultivation of healthy young animals, the preservation of the health of adult animals in the conditions of increasing production volumes using natural, environmentally safe fodder and fodder bio-supplements.

Weak feed reserve and insufficiently high quality of feed are one of the reasons for low production indicators in animal husbandry [8, 9, 11]. The problem of providing livestock with domestic high-quality fodders can be solved by using new feed products in the form of probiotics, prebiotics, synbiotics and other feed additives [1, 4, 17, 20, 27]. In animal husbandry and poultry farming, algae of the genera Chlorococcum, Spirogyra, Scenedesmus, Nostoc, Navicula, Nitzschia and others are used as the source of the nutrient complex [13, 16, 21]. One of the used probiotic feed additives is the blue-green alga Spirulina platensis, which is increasingly used in animal husbandry, poultry farming, beekeeping, fish farming, veterinary medicine, etc. [10, 18, 22, 23, 24, 25, 26].

The relevance of research, its scientific and practical interest is due to the need to study the effectiveness of using Spirulina platensis in the form of fodder additive as a growth bio-stimulator for young cattle.

The materials covered in the article are an integral part of the complex scientific research conducted by the FSBEE HE Kursk SAA together with the scientific-production organization (SPO) "Biosolar MSU" and the L.K. Ernst Federal Science Center for Animal Husbandry (agreement on scientific cooperation of 16.01.2017), and are also part of the scientific-research plans for 2010-2015 and 2015-2020.

Experiments on the use of preparations based on alga Spirulina platensis have previously been carried out on laboratory animals, pigs, calves and cows [2, 3, 4, 5, 6, 7, 14, 15], however, the investigated doses by weight of the dry matter of Spirulina platensis were significantly higher.

MATERIALS AND METHODS OF RESEARCH

The experimental part of the work was carried out in the period from 2015 to 2017 in the conditions of agricultural enterprises: educational farm "Znamenskoe" of FSBEE HE Kursk SAA and the branch "Kurchatov sveklovod" of LLC "Kursk-Agro" on the calves of Holstein breed.

In our experiments we used the blue-green alga Spirulina platensis of the greenhouse production from the SPO "Biosolar MSU" located in settlement Ponyri, Kursk Oblast.

The introduction of the optimum dose of dispersed peat in an amount of 50 ml per head per day to the scheme of studies is based on the results of studies by the scientists of the FSBEE HE Kursk SAA to identify the optimal dose of a water solution of a sorbent that was carried out earlier on the Holstein breed calves from the branch "Kurchatov sveklovod" of LLC "Kursk-Agro" [19].

Four groups of 10 calves were formed. Animals was selected according to the pairs-analogues method, taking into account age, live weight and health status. The main period of the experiment was carried out at the age of calves from 2 to 4 months. From 4 to 6 months of young cattle life, the study was conducted in the form of observations.

Feeding calves up to 2 months were the same and were carried out according to the scheme adopted in the farm for pedigree heifers, according to the norms of the Russian Academy of Agricultural Sciences, taking into account the receipt of 650-700 g of average daily body weight gain. Feeding before the 4-month-old age was three-fold, and then two-fold. In the age period from 2 to 4 months, the calves of the 1st and 2nd test groups, in addition to the main diet, were fed a feed additive in the form of the pre-thawed biomass of Spirulina platensis with 10 and 15 mg of dry matter (DM) per 1 kg of calves' live weight, respectively. In the diet of the calves from the 3rd test group, 15 mg of Spirulina platensis (DM / kg of calves' live weight) were entered together with 50 ml per head of an aqueous suspension of dispersed peat. The calves of the control group continued to receive only the main food ration. The measured amount of additives was diluted in 1 liter of drinking water and was distributed to each animal using feeding bottle before giving the main feed. In addition, control group received 1 liter of drinking water during this period. In the age period from 4 to 6 months, the calves of all the experimental groups received the basic diet again.

The obtained results of the studies are reliable due to the application of classical methods, as well as conducting experiment on sufficient number of livestock. The digital factual material of the experimental data is processed by the method of variation statistics, and the level of the reliable difference between the groups of the studied features is established using the Student's t-test.

RESULTS OF STUDY

Calves, the live weight of which at the age of 2 months was 72.09 - 73.34 kg / head, were selected for the experiment. Individual monthly

control weighing allowed to establish the dynamics of accumulation of calves' live weight, to track the intensity of absolute and average daily increments.

Feeding of unconventional feed additives had a positive effect on the formation of live weight in the calves of experimental groups (Table 1). At the age of 4 months, the changes of the considered indicator in the 1st experimental group slightly exceeded the value of the control variant and were at the level of 1.28 % (1.41 kg/head). In calves of the 2nd experimental group, the dynamics of live weight was higher than the control variant by 3.16 % (3.48 kg/head). The live weight of the young animals of the 3rd experimental group increased in comparison with the control variant by 3.45 % or 3.80 kg / head (P≥0.99).

Table 1 . Dynamics of the live weight of calves during the experiment, kg

Indicator	Group			
	control	1 experimental	2 experimental	3 experimental
at the age of 2 months	72.43±1.49	72.11±1.03	73.34±1.23	72.09±0.84
% to the control group	100	99.56	101.26	99.53
at the age of 4 months	110.26±0.94	111.67±0.54	113.74±1.50	114.06±0.28**
% to the control group	100	101.28	103.16	103.45
at the age of 6 months	144.72±0.98	147.79±0.55*	151.71±0.92***	156.02±0.57***
% to the control group	100	102.12	104.83	107.81

*P≥0,95; **P≥0,99; ***P≥0,999

At 6 months of age, the weight gain in the calves of the 1st experimental group was 2.12% (147.79 kg/head versus 144.72 kg/head in the control variant). The body weight of the animals from the 2nd experimental group reached 151.71 kg/head, which is 4.83 % higher than the control variant. The simultaneous use of Spirulina platensis with the sorbent led to the most pronounced effect of increasing the energy of growth during the feeding of calves of the 3rd experimental group. The animals of this group surpassed the analogues of the control group by 7.81 % or by 11.30 kg/head. (P≥0.999).

At the age of 4 months, the greatest absolute increment (41.97 kg) with a significant difference (P≥0.99) was observed in the calves of the 3rd experimental group who received Spirulina platensis together with the sorbent, which is 10.94 % more than the control variant (37.83 kg). The weight gain in the first and second experimental groups of calves was expressed as 4.57 % and 6.79 % (39.56 kg and 40.40 kg) in relation to the control variant (Table 2).

Table 2 . Changes in the increment of the live weight of calves by age

Indicator	Group			
	control	1 experimental	2 experimental	3 experimental
from 2 to 4 months				
Absolute increment, kg	37.83±0.92	39.56±0.61	40.40±0.87	41.97±0.84**
Average daily increment, g	630.50±0.51	659.33±0.72***	673.33±1.08***	699.50±0.47***
% to the control group	100	104.57	106.79	110.94
Relative increment,%	41.41	43.05	43.19	45.09
Coefficient of growth	1.52	1.55	1.55	1.58
from 4 to 6 months				
Absolute increment, kg	34.46±0.74	36.12±0.94	37.97±0.52**	41.96±0.57***
Average daily increment, g	574.33±0.88	602.00±1.10***	632.83±0.67***	699.33±0.83***
% to the control group	100	104.82	110.19	121.76
Relative increment,%	27.03	27.84	28.61	30.63
Coefficient of growth	1.31	1.32	1.33	1.38
for the period from 2 to 6 months				
Absolute increment, kg	72.29	75.68	78.37	83.93
Average daily increment, g	602.42	630.67	653.08	699.42
% to the control group	100	104.69	108.41	116.10
Relative increment,%	66.58	68.83	69.65	73.59
Coefficient of growth	2.00	2.05	2.07	2.16

*P≥0,95; **P≥0,99; ***P≥0,999

The results of the experiment obtained at the age of 6 months showed that the greatest absolute increment in the live weight of calves was obtained in calves of the 3rd experimental group and amounted to 41.96 kg, which is 7.50 kg (21.76 %) more than in the control group of

calves (P ≥ 0.999). The increments in the live weight of calves in the 1st experimental (36.12 kg) and 2nd experimental (37.97 kg) groups remained lower than in the 3rd experimental group by 5.84 and 3.99 kg, however, they were higher than the control variant by 4.82 and 10.19 % respectively. The relative increment was calculated according to the S. Brody formula and showed that the maximum energy of growth, the intensity of the growth processes, the higher growth rate of the experimental calves was localized in the 3rd experimental group.

As a result of the conducted studies, it was revealed that for 4 months of the experiment (the period from 2 to 6 months) the absolute and average daily increments of the 1st experimental group were higher than the control variant by 3.39 kg and 28.25 g respectively (4.69 %). The difference in the live weight increment of the calves from the 2nd experimental and control groups increased slightly and amounted to 6.08 kg and 50.66 g (8.41 %). The best result was obtained in the 3rd experimental group - in comparison with the control variant, the increment increased by 16.10 % (11.64 kg and 97.00 g).

As a result of the analysis of the chemical composition of feeds, the amount of nutrients consumed by animals during the experiment was determined, and the digestibility ratios of nutrients were calculated. It was revealed that feeding to calves of blue-green alga Spirulina platensis in combination with sorbent promoted better digestion of feed nutrients.

Calves that consumed the blue-green alga Spirulina platensis in combination with the sorbent in the basic diet composition were in a predominant position relative to the other groups of animals, as the preparation had a beneficial effect on the consumption, absorption of nitrogen and the degree of its use. Thus, heifers of 2nd and 3rd experimental groups were more intensely used the received nitrogen (by 6.78 and 9.12 %) than the analogues of the control group (25.26 %). In animals of the 1st experimental group, the result was less by 4.61 % in comparison with the control variant. The identical dependence is also traced in the indicator of the use of nitrogen from digested.

The most favorable balance of calcium was formed in the animals of the 3rd experimental group - 13.45 g. In calves of the 2nd and 1st experimental groups, the values of this indicator were obtained at the level of 12.84 and 12.30 g, which is 12.63 % and 7.89 % more than in the animals of the control group (11.40 g). The results of the studies indicate an increase in the use of calcium taken with fodder in the experimental calves of 1st and 2nd experimental groups by 3.20 – 4.71 % compared with the control variant, the value of which was 46.14 %. Feeding calves according to the scheme of the third experimental group is most effective, since the amount of calcium used from the feeds among the variants of the experiment is the most pronounced – 52.81 %.

Significant deposition of phosphorus is recorded in the body of animals from the 3rd experimental group - 4.88 g, which is 1.13 g more than in the control group. The balance of the 1st and 2nd experimental groups is set above the control group by 0.40 and 0.89 g respectively. Calves of the 1st experimental group used phosphorus more efficiently compared with the control variant by 3.23 %. Calves of the 2nd and 3rd experimental groups also used phosphorus more efficiently compared with the control variant by 7.13 and 8.91 % respectively.

Physiological studies found that the balance of calcium and phosphorus in all the groups of the experiment was positive. The ratio of calcium and phosphorus in the experimental animals was in the range of 1.28 - 1.43: 1.0. However, the mineral substances received with the feed were better used by calves, who received a complex fodder additive as part of the diet.

The studied hematological parameters in all the experimental calves at the age of 4 and 6 months did not exceed the limits of physiological boundaries (Table 3).

Table 3 . Hematologic indicators of experimental calves, ($\bar{X} \pm S\bar{x}$, n = 4)

Indicator	Group			
	control	1 experimental	2 experimental	3 experimental
age 4 months				
Erythrocytes, 10^{12} / l	6.13±0.25	6.24±0.19	6.51±0.23	6.72±0.21
Leucocytes, 10^{9} / l	9.26±0.53	7.64±0.27*	7.59±0.31*	6.21±0.44**
Hemoglobin, g / l	103.8±1.8	107.9±2.4	113.7±1.7**	117.6±1.5**
Total protein, g / l	72.31±0.74	75.38±0.99*	75.84±0.76**	77.92±1.08**
Albumins, %	41.70±0.68	42.81±0.54	43.39±0.95	45.78±0.41**
Glucose, mmol / l	2.31±0.18	2.44±0.31	2.73±0.11	3.08±0.23*
age 6 months				
Erythrocytes, 10^{12} / l	6.74±0.19	6.84±0.13	6.93±0.23	6.96±0.19

Leucocytes, 10^9 / l	10.37±0.59	9.54±0.72	9.71±0.49	8.53±0.44*
Hemoglobin, g / l	110.2±1.6	111.3±0.8	114.7±1.4	119.1±1.3**
Total protein, g / l	72.36±0.49	74.03±0.72	74.95±0.56**	76.84±0.84**
Albumins, %	45.69±0.53	45.70±0.37	46.98±0.69	47.54±0.27*
Glucose, mmol / l	2.91±0.11	2.96±0.17	3.04±0.12	3.26±0.09*

*P≥0,95; **P≥0,99; ***P≥0,999

In comparison with the control group, the content of red blood cells (4 months) in the 1st and 2nd experimental groups increased by 1.79 % and by 6.20 % respectively. The greatest content of the studied indicator was observed in the blood of the calves of the 3rd experimental group - by 9.62 % more than in the blood of the control group calves. In 6-month-old calves, the trend of increasing the studied index between the groups has been preserved. Compared to the control variant, the erythrocytes content in the calves' blood in the experimental groups increased: by 1.48 % in the 1st group; by 2.82 % in the 2nd experimental group and by 3.26 % in the calves of the 3rd experimental group.

Compared with the control, the content of leukocytes in the blood of the calves of experimental groups decreased by age. In calves of the 3rd test group, at the age of 4 months, the white blood cell count decreased by 32.94 % (P≥0.99), and at the age of 6 months - by 17.74 % (P≥0, 95) in comparison with the control variant. A slightly smaller difference in indicators at the age of 4 months was fixed between the control variant and the 1st and 2nd experimental groups at P≥0.95 - 17.49 % and 18.03 %, while at the semiannual age it was 8.00 % and 6.36 % respectively.

The content of hemoglobin in the blood increased in experimental animals with age. Besides, the increase of hemoglobin in calves of the 4-month age from the 1st experimental group was higher by 4.1 g / l (3.95%) than in the control group (103.8 g / l). The hemoglobin level in the calves of the 2nd experimental group was also higher than the control group level by 9.9 g / l or 9.54 % (P≥0.99). The best result at this age was established in the calves of the 3rd experimental group, which exceeded the control group at P≥ 0.99 by 13.8 g / l (13.29 %). A high content of hemoglobin at the age of 6 months was noted in the calves of the 3rd experimental group (119.1 g / l), which is 8.9 g / l (8.08 %) higher than the control variant. The intermediate position between the control variant and the 3rd experimental group was occupied by the blood analysis results of the calves from the 1st and 2nd experimental groups.

The total protein content in the blood serum of the calves from control group at the age of 4 months was 72.31 g / l. The studied indicator in the calves of the 1st and 2nd experimental groups was higher than the control variant by 3.07 and 3.53 g / l, or 4.25 and 4.88%, respectively. The calves of the 3rd experimental group are characterized by the highest result (77.92 g / l), which exceeded the control variant by 5.61 g / l (7.76 %). During analysis the blood serum of 6-month-old calves, it was established that the greatest content of total protein was found in calves of the 3rd experimental group (76.84 g / l), which is more than the control variant by 4.48 g / l or 6.19 % (P ≥ 0.99). The indicators of calves from the 1st and 2nd test groups occupied an intermediate position, but the results were higher than the control variant by 2.31% and 3.58%, respectively.

The study of the albumin fraction of the calf blood protein at 4 months of age showed an increase by 4.08 % (P≥0.99) in the 3rd experimental group compared to the control group. The result of the calves from the 1st and 2nd experimental groups was higher than the control variant by 1.11 % and by 1.69 %, respectively.

A slightly less pronounced trend for this indicator was found in 6 months old calves. Thus, in the calves of the 3rd experimental group, the highest content of albumins was found – 47.54 %, which is 1.85 % higher (P≥0.95) than in the control group. In this case, the difference between the control and the 1st experimental group was not observed. The content of albumins in the blood of calves from the 2nd experimental group was greater by 1.29 % than in the control variant.

At the age of 4 months, the glucose content of the calves from the control group and the 1st experimental group was the smallest and amounted to 2.31 and 2.44 mmol / l. Somewhat higher than the control variant, the level of glucose was in the calves of the 2nd experimental group, where the difference in indices was 0.42 mmol / l or 18.18 %. In calves of the 3rd experimental group, the glucose content in the blood was greatest - 3.08 mmol / l, which is 33.33 % higher than the control variant. At the age of six months, the dependence of the indicator between the groups remained unchanged. The smallest amount of glucose in the blood was found in the control and 1st experimental groups of calves (2.91-2.96 mmol /

l). The studied indicator in the blood of calves from the 2nd experimental group was higher than the control group by 0.13 mmol / l (4.47 %). The difference between the control group and the 3rd experimental group was 0.35 mmol / l (12.03%).

The economic efficiency analysis of the use of the studied feed additives in the diet of experimental animals up to 6 months of age showed that the cost of 1 kg of increment in the live weight of the calves from the control group was 171.32 rub / kg, which is 1.41% higher than the indicators of the 1st experimental group and 2.99% higher than in 2nd experimental group. The prevailing situation was formed by the 3rd experimental group, here the cost of production was cheaper than the control variant by 6.40%. With the same selling price of 1 kg of live weight, the profit in the 3rd experimental group was 33421.00 rubles, which is higher than the control option at 12566.39 rubles. The values of the 1st and 2nd experimental groups also turned out to be above the control group by 2808.13 and 5773.98 rubles, respectively. The level of profitability of production in the 3rd experimental group was 24.83 %, which is higher than in the control group by 7.99 %. The difference between the control and the 1st and 2nd experimental groups was 1.67 % and 3.61 %, respectively.

CONCLUSION

1. It was established that the introduction of Spirulina platensis into the basic diet separately and together with the sorbent did not adversely affect the body of the experimental animals.
2. Non-traditional supplements added to diets not only increased the average daily and absolute increments in the 1st, 2nd, and 3rd experimental groups of calves at the age of 4 months by 4.57 – 6.79 – 10.94 % compared to the control group, but also had a prolonging effect on the growth of animals in the period from the 2nd to the 6th month at 4.69 – 8.41 – 16.10 %, respectively.
3. Introduction to the main diet of calves of 10 and 15 mg dry matter of blue-green alga Spirulina platensis biomass per 1 kg of the live weight of calf, as well as 15 mg of dry matter of Spirulina platensis biomass in combination with sorbent had the most pronounced stimulating effect on metabolism during the period of intensive growth of animal's organs. Feeding calves in conjunction with the main diet of a complex additive based on Spirulina platensis with a sorbent promoted better digestibility of the feed nutrients. It was found that the balance of calcium and phosphorus in all the groups of the experiment was positive. However, the minerals coming in with the feed were better used by calves that received Spirulina platensis as part of the diet. Calves, taking with the main diet of Spirulina platensis in combination with peat, showed the best result in comparison with other experimental groups.
4. By the content of erythrocytes, hemoglobin, total protein, albumin fraction and glucose, experimental groups with both 4 and 6 months old calves were superior to the control variant. The studied hematological parameters in all experimental animals did not go beyond the limits of physiological boundaries.
5. Growing young cattle with an introduction to the main diet of Spirulina platensis biomass in a dose of 10 and 15 mg of DM per 1 kg of live weight for 60 days is economically justified, as the level of profitability compared to the control group is higher by 1.67 % and 3.61 %.

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