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The efficiency of haylage use conserved by the pure culture of propionibacteria in black-and-white cattle feeding

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Abstract

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To enrich the diet of black and white cattle with energy and nutrition, we conserved alfalfa haylage with pure cultures of propionibacteria, selected optimal doses of spray material to achieve the maximum conserving effect, and evaluated the effect on interior and productive indicators. The line of research was chosen due to the fact that alfalfa haylage is a high-protein, but difficult to conserve food. To do this, all animals were divided into 4 groups. There were selected control groups fed by haylage without conservatives and experimental groups fed by haylage conserved with propionibacteria. It was found out that in the blood of experimental groups' animals, the proportion of erythrocytes and hemoglobin increased within the regulatory limits, regardless of the season of the year. The analysis of the weighing data of bull calves revealed a steady increase in the growth of those fed by conserved haylage. By the age of 18 months the weight of experimental group bull calves reached 515.2 – 523.0 kg, which is 15.5 – 23.3 kg higher than the control group (3.10-4.66%). A similar pattern has been established when analyzing the milk yield in black-and-white cows. The productivity of experimental groups' animals was 2793.6–2918.5 kg for 120 days of lactation and of control groups' animals was 2678.3 kg. The maximum effect was obtained in the second experimental group, where both young and adult animals got haylage with a conservative intake rate of 4 liters per 1 ton of weight.

Keywords: bulls; cows; propionibacteria; hematological parameters; live weight; milk yield; productivity

Introduction

For the development of the livestock industry, it is necessary to carry out activities aimed at maximizing the genetic potential of cattle productivity, which is impossible to implement without creating a stabile nutritive base and complete cattle feeding (Food safety: the experience of seven countries united their systems of food safety, 2010; Gizatova et al., 2016; Khaziakhmetov et al., 2018; Mironova et al., 2018; Sharipova et al., 2017, 2018; Sedykh et al., 2018 Tagirov et al., 2018;).

Domestic and foreign practice, in matters of preparation and storage of feed, is aimed at the selection of methods for their conserving. In recent years, new and effective means, characterized by low cost, safety and adaptability to use, have been increasingly used (Tagirov & Fisenko, 2017; Kosintsev & Molodkin, 2018).

Alfalfa belongs to the group of high-protein feeds that can enrich the diet with energy and nutrition. Alfalfa has received considerable distribution in the southern Urals. The disadvantages of this crop include the loss of leaf when harvesting hay and the difficulty of conserving it when preparing haylage (Tagirov & Fisenko, 2017; Laptev et al., 2018).

Numerous works of domestic and foreign scientists are devoted to the issues of an adequate choice of feed types, the way of their processing and the study of the relationship between their productivity (Gabitov et al., 2018; Moran & Owen, 1996; Weissbach, 1999; Feldman et al., 2000; Zelepukhin et al., 2000; Kung et al., 2003; Zaynukov et al., 2008; Research Animal Resources, 2009; Mironova et al., 2010; Mazzullo et al., 2014; Kopylova et al., 2016; Tagirov & Fisenko, 2017; Kinsfator & Konnova, 2017; Bagautdinov et al., 2018; Bikchantaev et al., 2018; Dementyev et al., 2018; Fisenko, 2018; Kosintsev & Molodkin, 2018; Laptev et al., 2018; Tagirov et al., 2018).

In this regard, we propose the use of domestic biological starter culture, based on propionibacteria, with the optimal concentration of the spray material when making haylage from the green mass of alfalfa (Kinsfator & Konnovaa, 2017; Laptev et al., 2018).

Material and Methods

Pure culture of propionibacteria (*Bacillus subtilis*) with a content of at least $1 \cdot 10^8$ CFU (colony-forming unit) in 1 ml was purchased under the commercial name "Biotroph" at the "Biotroph" plant (St. Petersburg). Its action is aimed at suppressing microbiological processes and ensuring the conservative effect of plant mass in a short time due to the creation of a barrier to the accumulation of butyric acid and fungal toxins. In addition, *B. subtilis* produces proteases, amylases, amino acids and some polysaccharides, and its enzymes affect sugars and protein of feed, making it more accessible to animals (Bikchantaev et al., 2018).

Universality is achieved by the possibility of conserving raw materials that are difficult to silage and impossible to silage, as well as green mass with moisture of more than 80%.

We started haylage making with daily drying in wind rows of mown green mass on the field to moisture content of about 55%. This type of treatment allows you to create physiological dryness in which the water-holding power of plant cells exceeds the sucking power of microorganisms. The cutting size during grinding was chosen to be no more than 3 cm.

Tractor trailers were used for transporting the chopped silage to the above-ground concrete trenches, forage harvesters for loading them, and bulldozers for leveling and compacting. The compaction of the haylage mass to a density of at least 600 kg/m^3 was carried out round the clock using two K-701 tractors. This technique allowed displacing the air to the best degree, to ensure the optimal temperature regime of making haylage process (37°C) and to prevent self-heating of the feed.

The daily volume of the laid mass was not less than 200 t or about 1 m. The time of filling the trench was within 4 days. The trench was loaded 30 cm above the upper level of the side walls, and 60 cm above the edges along the centerline, to form a two-sloping surface that precludes sediment delay. Filled trenches were covered with freshly cut grass up to 50 cm thick, and to create tightness of 0.20 mm thick polythene glued into the canopy was used. The polythene was covered with a 50-cm straw-layer. There were four trenches in total. The first one had haylage, made according to the traditional technology, the rest trenches had haylage made with propionibacteria in different concentrations of the spray material. The consumption rate of bioconservative is 1 l per 150 t of the green mass. For this, 1 l of the preparation, consisting of propionibacteria, was diluted in 500 l of water. The conserved mass was treated by this spray material embedded in different trenches at the rate of 2, 4 and 6 liters of the spray material per 1 t.

To study the effect of prepared haylage from alfalfa contained conservative and without it on the productivity of bull calves and cows, scientific and economic experience was organized. The place of conducting a research was OOO "Alga" in Chekmagushevsky District of the Republic of Bashkortostan. At first full-aged cows and black-and-white bull calves were selected. The cows were divided into 4 groups of 12 animals each, and of 10 bull calves in each group. As a result, on each class of animals there were formed control and three experimental groups. The diet of cows and bull calves of the experimental groups contained haylage with propionibacteria at a dose of 2, 4 and 6 l of spray material per 1 t of mass, respectively.

For analysis the blood was taken from the jugular vein in cows during fall and winter period, and in the bull calves, during fall and spring period. Studies were performed on an automated hematology analyzer, which allows quantifying the number of erythrocytes, leukocytes and hemoglobin.

The level of milk production was evaluated according to the average daily milk yield, milk yield for 100 and 120 days of lactation. To study the growth of experimental animals, they were weighed monthly in the morning before feeding.

Animals were treated in accordance with the instructions and recommendations of the Russian Regulations, 1987 (Order No.755 on 08.12.1977 by the USSR Ministry of Health), as well as 'The Guide for Care and Use of Laboratory Animals (Institute of Laboratory Animal Resources, Commission on Life Sciences, National Research Council, National Academy Press Washington, D.C. 1996). When conducting research, efforts were made to minimize the suffering of animals and reduce the number of samples used.

Results and Discussion

To establish the effect of conservation in the process of making haylage, we analyzed the blood samples of bull calves and cows according to morphological features. The blood was taken from the jugular vein in the morning at the beginning and end of the experiment. In bull calves, the initial period fell on the fall period and corresponded to the age of 10 months, the final one – on the spring period and 18 months, respectively. It was established that the studied parameters of each class of animals in all seasons of the year were within the normative limits.

At the same time, haylage from alfalfa, made with a different dosage of a biological product based on propionibacteria, had a positive effect on the concentration of erythrocytes and the level of hemoglobin in the blood of all animals (Table 1).

Thus, according to the erythrocyte content, the bull calves of the experimental groups exceeded the control group during fall season by 0.01-0.03*10^{12} per l (0.13-0.39%), during spring season – by 0.19-0.46*10^{12} per l (2.68-6.64%; P < 0.05-0.01); cows during fall period by 0.03-0.08*10^{12} per l (0.46-1.23%), during winter – by 0.08-0.16*10^{12} per l (1.31-2.61%; P < 0.05-0.01).

It should be noted that the content of erythrocytes in the blood of all experimental groups' animals in all seasons of the year was mainly dominated by individuals of the second experimental group.

Analysis of seasonal dynamics showed that the fall period was characterized by a higher concentration of erythrocytes. Thus, in the bull calves of the control group, this parameter decreased by 0.70*10^{12} per l (10.03%) by the spring period; of the experimental group – by 0.55*10^{12} per l (7.68%); 0.26*10^{12} per l (3.49%) and 0.31*10^{12} per l (4.20%). During winter period in comparison with fall period cows had by 0.37*10^{12} per l (5.99%) less red blood cells in the control group; in the first experimental group by 0.32*10^{12} per l (5.16%); in the second experimental group by 0.29*10^{12} per l (4.62%) and third experimental group by 0.32*10^{12} per l (5.07%).

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An increase in hemoglobin content is noted in the blood of bull calves and cows fed by conserved haylage. So, in the blood of bull calves of the first, second and third experimental groups compared with the control groups, the studied parameter was higher during the fall period: by 0.08 g/l (0.06%); 0.04 g/l (0.03%) and 0.07 g/l (0.06%), during winter period by 1.03 g/l (0.80%); 3.23 g/l (2.52%) and 2.79 g/l (2.18%). In cows, this increase during fall period was 2.42

Table 1. Blood morphological composition

Parameters	Season	Group			
		Control	Experimental		
			I	II	III
Bull calves					
Erythrocytes 10^{12}/l	fall	7.68±0.07	7.71±0.15	7.70±0.11	7.69±0.13
	spring	6.98±0.02	7.16±0.09*	7.44±0.14**	7.38±0.12**
Leukocytes 10^{9}/l	fall	7.09±0.04	7.10±0.05	7.08±0.09	7.11±0.07
	spring	7.02±0.02	7.14±0.09	7.17±0.37	7.13±0.08
Hemoglobin gr/l	fall	123.13±0.46	123.21±0.39	123.17±0.50	123.20±0.77
	spring	128.04±1.38	129.07±1.21	131.27±0.88	130.83±0.19
Cows					
Erythrocytes 10^{12}/l	fall	6.49±0.08	6.52±0.05	6.57±0.03	6.56±0.04
	winter	6.12±0.01	6.20±0.01**	6.28±0.07*	6.24±0.03*
Leukocytes 10^{9}/l	fall	6.39±0.07	6.41±0.03	6.44±0.02	6.43±0.01
	winter	6.84±0.07	6.87±0.03	6.98±0.04	6.94±0.04
Hemoglobin gr/l	fall	113.25±0.81	115.67±0.45*	118.71±0.26**	118.17±0.60**
	winter	85.56±0.52	87.25±0.92**	89.53±0.52**	89.16±0.62**

Remark: * P < 0.05; ** P < 0.01; *** P < 0.001

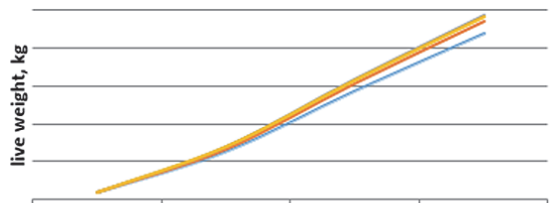
g/l (2.14%; P < 0.05); 5.46 g/l (4.82%; P < 0.01) and 4.92 g/l (4.34%; P < 0.01), during winter period was 1.69 g/l (1, 98%; P < 0.01); 3.97 g/l (4.64%; P < 0.01) and 3.60 g/l (4.21%; P < 0.01).

We associate the pattern of increase in hemoglobin level and erythrocyte concentration in the blood of experimental groups' animals with an increase of redox processes intensity in their bodies.

It is important to note the effect of the season on changes in the morphological parameters of the blood, which are characterized by the influence of environmental conditions. Thus, the spring period is more favorable in terms of conditions of animal welfare and feeding. During this period, metabolic processes in the body of young animals are activated and cause a higher level of productive qualities.

The content of leukocytes characterizes the immunological reactivity of the organism; therefore, high blood levels of leukocytes during the winter period in cows and a decrease in the level of bull calves during the spring period are caused by the manifestation of their body protective function due to changing environmental conditions.

The degree of conservatives' impact when making haylage from alfalfa was analyzed according to the level of productive qualities. For this, the bull calves of all experimental groups were weighed by age periods of 10, 12, 15, and 18 months. The results showed that bull calves grew and developed normally during the entire observation period (Fig. 1).



	10	12	15	18
control	289.8	343.7	423.9	499.7
I	289.0	346.2	433.2	515.2
II	289.4	349.8	439.0	523.0
III	288.9	349.2	437.0	520.4

Age, months

Fig. 1. Live weight dynamics of experimental bull calves, kg

The initial weighing stage showed that the bull calves of all groups had almost the same live weight with a difference of 0.1-0.9 kg. The intergroup differences in the yearling weight were showed up slightly, which can be explained by the short consumption time of the tested feed. So, the difference in favor of bull calves consuming conserved haylage was 2.50-6.10 kg (0.73-1.77%).

At the age of 15 months the difference in live weight of the young bulls of experimental groups over control has become more pronounced. The live weight of the young bulls of first experimental group was 9.34 kg higher (2.20%); of the second experimental group was 15.14 kg (3.57%; P < 0.05) and of third experimental group was 13.14 kg (3.10%; P < 0.05).

The final stage of weighing showed the maximum intergroup difference in favor of experimental groups. At the age of 18 months, the young bulls of the experimental groups exceeded the bulls from control ones in live weight by 15.51–23.31 kg (3.10–4.66%; P < 0.05–0.01).

The highest results of productive qualities throughout the entire observation period were demonstrated by young bulls of the second experimental group. It is enough to note that in 18 months their live weight was higher than that of the first and third experimental groups by 7.80 kg (1.51%) and 2.60 kg (0.50%), respectively. Thus, it is advisable to conserve the haylage making process based on propionibacteria with a concentration of the spray material of 4 l/t of laid mass.

We supplemented the efficiency of using a bio-conservative with a propionate culture during haylage making process of alfalfa by studying the milk productivity of black-and-white cows during 120 days of lactation (Fig. 2).

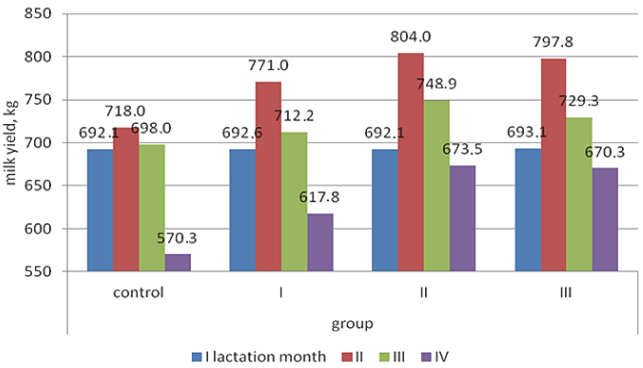


Fig. 2. Cows' milk yields on lactation months, kg

The first month of lactation did not reveal any intergroup differences in milk yield. The difference was in the range of 0.51-1.03 kg (0.07-0.15%). During the second month of lactation, cows of all analyzed groups demonstrated the highest level of productive qualities. At the same time, the best indicators were in animals fed by haylage, subjected to conservation by different doses of the spray material of the preparation based on propionibacteria.

Cows of the first experimental group were leading over the control group by 53.00 kg (7.38%); the second experimental group by 86.00 kg (7.98%) and the third experimental group by 79.75 kg (11.11%) with a significant difference (P < 0.01-0.001).

The third and fourth month of lactation was accompanied by a decrease in the value of the studied indicator, and in cows of all experimental groups. So, this decrease in individuals of the control group cows in the period from the second to the third month was 19.98 kg (2.86%); experimental groups – 58.77 kg (8.25%); 55.09 kg (7.36%) and 68.47 kg (9.39%); from third to fourth – 127.77 kg (22.41%); 94.48 kg (15.29%); 75.41 kg (11.20%) and 59.03 kg (8.81%), respectively.

It should be noted that intergroup differences in milk yield both in the third and fourth month of lactation remained in favor of the individuals of the experimental groups cows. It is enough to note that in the third month, the superiority of cows from the experimental groups over the control group cows was 14.21-50.89 kg (2.04-7.29%; $P < 0.01$-0.001), and in the fourth – 47.50-103, 25 kg (8.33-18.11%; $P < 0.001$).

Among the cows consuming conserved haylage, the best productivity is noted in the second experimental group. The level of milk yield per 100 days of lactation in cows of the control group was 2260.20 kg; the first experienced group was 2340.60 kg; the second experimental group was 2424.60 kg and the third experimental group was 2398.9 kg. Thus, the superiority of cows of the three experimental groups over the control groups was 80.39-164.43 kg (3.56-7.27%; $P < 0.01$-0.001).

For 120 days of lactation, the productivity of cows in the control group reached 2678.34 kg, which is lower than that of experimental groups by 115.22 kg (4.30%; $P < 0.01$); 240.14 kg (8.97%; $P < 0.001$) and 212.04 kg (7.92%; $P < 0.001$), respectively.

The intensification of the domestic livestock industry will be possible only with the improvement of the livestock feeding system. Particular attention should be paid to the preparation of high-protein feed that can enrich the diet with energy and nutritional value. Alfalfa, which meets the above requirements, is widely spread in the zone of the Southern Urals. The main disadvantage of this crop is the reduction of nutrients and metabolic energy when making hay due to the leaves loss, which takes up to 50% of the plant mass. Harvesting alfalfa in the form of haylage will reduce the leaves mass loss up to 15% (Tagirov & Fisenko, 2017; Laptev et al., 2018).

We offer to preserve the high quality of haylage from alfalfa, which has a hard conserving property, through the use of a new biological conservative based on propionibacteria, and developed by the "Biotroph" plant specialists. The objectives of our research were to determine the optimal dose of the spray material per 1 t of green mass and to establish the effect of conserved food on the interior and productive indicators of black-and-white cattle.

In solution of this problem special attention is paid to conservatives of green fodder, which can simultaneously enrich the feed with certain substances and increase their nutritional value, which ultimately will have a positive effect on the efficiency of nutrient use and animal productivity. The effectiveness of their application is demonstrated by the work of a number of authors (Zelepukhin et al., 2000; Kopylova et al., 2016; Fisenko, 2018; Tagirov et al., 2018).

The use of a biological conservative in the making of haylage contributed to the optimization of the morphological composition of the cows and young bulls' blood of experimental groups. In the course of research, an increase in the number of erythrocytes and hemoglobin in animals consuming canned haylage was noted, which is a positive factor indicating a high level of metabolic processes in the body of black-and-white cattle (Feldman et al., 2000; Research Animal Resource, 2009). According to the leukocytes content, the opposite pattern was noted, which is consistent with the data (Fisenko, 2018).

The use of bio-conservative green mass of alfalfa allowed to increase meat and dairy productivity, which can be explained by an increase in the nutritional value of haylage and better utilization of nutrients.

Analysis of the obtained data showed that the results of our research are consistent with the work, which established the relationship between productivity, the correct choice of feed means and the way of their processing (Moran & Owen, 1996; Weissbach, 1999; Feldman et al., 2000; Kung et al., 2003; Zaynukov et al., 2008; Mironova et al., 2010; Mazzullo et al., 2014; Bagautdinov et al., 2018; Dementyev et al., 2018).

Conclusions

Our data indicate that the change in hematological parameters to the average limits of the physiological norm and the increase in meat and milk productivity of black-and-white cattle occur due to changes in the feeding conditions of animals. At the same time, the use of biological conservative based on propionibacteria in a dose of 2-6 l of spray material per 1 t of mass during the process of haylage of alfalfa contributes to:

- an increase in the concentration of erythrocytes in the young bulls' blood in fall by 0.13-0.39%, in spring by 2.68-6.64%; in cows' blood in fall by 0.46-1.23%, in winter by 1.31-2.61%; hemoglobin in bulls by 0.03-0.06% and 0.80-2.52%; in cows, by 2.14-4.82% and 1.98-4.64%;
- achievement of body weight by the age of 18 months 515.2-523.0 kg;
- an increase in milk yield in 120 days of lactation to 2793.6-2918.5 kg.

To increase the productivity of farm animals, haylage from alfalfa, prepared with the participation of a pure culture of propionibacteria at a dose of a spray material of 4 l per 1 t of stock, should be included in the diet of cows and bulls.

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