Milk productivity and quality depending on the composition of the diet

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Abstract. The aim of the research was to study the effect of using wet feed wheat grain harvested with sodium acetate in the diets of lactating cows instead of dried grain on milk productivity and milk quality. The content of crude protein in wheat grain at the natural humidity of the experimental variant was significantly higher than in the grain storage of the control variant prepared by the traditional method of canning - fire drying. The data of the experiment on lactating cows indicated that the inclusion of wet flattened wheat grain with sodium acetate in the diet instead of dried flattened grain had a positive effect on the dairy productivity of cows and milk quality. In comparison with the control group, the advantage of cows of the experimental group in terms of the average daily milk yield was 7.8%, and in terms of fat content by 0.21% and protein by 0.04%. The consumption of energy feed units per 1 kg of natural milk in the control group of cows was 1.02 and in the experimental group - 0.95 and the tested grain fodder – 290 and 269 g. The economic efficiency of milk production in the experimental group increased by 14.5%.

1. Introduction

The expansion of the range of effective feed products makes it possible to more fully realize the genetically determined productivity potential of farm animals, reduce the cost and increase the profitability of production [1, 2, 3].

To a large extent, the implementation of the productive qualities of cattle is facilitated by the peculiarities of the modern technologies used for its maintenance [4, 5]. Dairy productivity and the quality of cow milk also depend on different breeding [6]. At the same time, the productivity and physiological indicators of livestock are significantly influenced by the provision of the completeness of its feeding [7, 8, 9].

It should also be noted that in physiological studies, a great importance is attached to the study of blood composition indicators in animals [10, 11].
The productivity of farm animals is greatly influenced by the energy value of the diets used [12, 13]. Also, when organizing animal feeding, along with other nutrients, their protein nutrition is important [14, 15, 16, 17].

The main indicators of the quality of the feed used are the energy value, their protein nutrition value, the content of mineral elements and vitamins in them. Moreover, in balancing the diets of lactating cows in terms of energy and basic nutrients, great importance is attached to concentrated feeds, and in particular grain fodder. Preservation of grain fodder in a wet state with chemical preparations serves as a progressive and rational way of its preparation and storage. Wet canned grain is better eaten by animals and absorbed after its flattening; therefore, the productive effect of this feed increases.

Chemical canning technology has been developed to preserve grain with high humidity. For example, production tests for preserving of wet grain carried out using propionic acid and carbon ammonium salts have shown their high efficiency. In comparison with thermal drying of grain and active ventilation, energy is consumed during its chemical preservation by 1.5-2 times less [18].

It should be noted that the assessment of the economic component also plays an important role in the production of animal products [19, 20].

At the same time, it is relevant to carry out research on the use of wet grain fodder harvested with a preservative additive - sodium acetate, in dairy cattle breeding.

The purpose of the research was to study the effect of the use of wet feed wheat grain harvested with sodium acetate in diets instead of dried grain of this crop on milk productivity and milk quality of lactating cows.

The objectives of the research were to determine the quality, chemical composition and nutritional value of wet wheat grain prepared with sodium acetate and dried grain of this crop and their influence in a comparative aspect on the productivity and quality of milk of lactating cows, their physiological indicators, economic assessment of milk production.

2. Materials and methods

When performing a laboratory (reconnaissance) experiment, a glass container with a capacity of 1 dm³ was used. In the first container fodder grain was placed for storage – dried wheat with a humidity of 14% (I control variant); in the second container – wheat with a humidity of 25% (II control variant); in the third container – wheat with a humidity of 25% treated with a new preservative – sodium acetate at a dose of 9-10 g per 1 kg of wet grain based on the dry substance of the preservative (III experimental variant). The container was sealed with lids and left for storage.

In the laboratory experiment, the quality indicators of harvested fodder grain were studied using generally accepted methods. The quality of harvested wheat grain was determined by the color, smell, structure of feed particles, the content of protein, calcium, phosphorus. Along with this, biochemical studies were carried out with the determination of acetic, lactic and butyric acids in grain preserved with sodium acetate.

For the scientific and economic experiment, feed grain was prepared according to the scheme presented in the Table 1.

| Variant | Fodder crop | Features of the variants |
|---------|-------------|--------------------------|
| I       | Winter wheat (grain) | Control – dried grain |
| II      | -//-        | Treated with sodium acetate in an amount of 10 kg per 1 ton of wet grain per dry preservative substance |

The wet wheat grain delivered to the current from the combine was immediately treated with sodium acetate at the prescribed dose. The processed grain was sent to the storage (warehouse). The grain mound of processed wheat was covered with a gas-impermeable material (polyethylene wrap). The condition of the grain treated with the preservative was monitored. To prevent moisture condensation, grain aeration and storage ventilation were periodically carried out (II experimental variant).
Dried wheat grain was stored in the same warehouse (I control variant).

Two groups of lactating cows with 8 heads each were formed for the research. Cows were selected into groups according to the principle of pairs of analogues, taking into account the breed, age, live weight, lactation by count, productivity for previous lactation, calving and insemination time, average daily milk yield and fat content in it. Scientific and economic experience was conducted on full-aged animals (3-5 lactation) with an average live weight of 590 kg.

The scientific and economic experiment on lactating cows was carried out for 150 days. In the preliminary period of the experiment, lasting 20 days, the similarity of the composition of the selected animals in groups was checked. At the same time, the animals of both groups were fed a basic diet using dried fodder flattened grain. In the transition period of the experiment, lasting 10 days, cows of the I control group were given a basic diet using dried flattened grain fodder, and the II experimental group was given a basic diet, which included wet flattened grain with sodium acetate instead of dried grain (habituation). During the main period of the experiment, lasting 90 days, the cows of the I group were fed a basic diet using dried fodder flattened grain, and the II group - the basic diet, which included wet fodder flattened grain with sodium acetate instead of dried grain. In the final period of the experiment, lasting 30 days, cows of the II experimental group were transferred to the basic diet using fodder dried flattened grain.

During the research work, the animals of both groups were under the same conditions of maintenance and care. Milking of cows was carried out twice a day. During the experiment, the indicators of dairy productivity of cows were studied every week with an assessment of the quality of milk produced from each animal.

Against the background of scientific and economic experience, physiological studies were conducted to study the digestibility and use of nutrients in diets for 3 animals from each compared group. Control over the physiological state of cows was performed by studying hematological parameters in 5 animals from each group at the beginning and at the end of the experiment.

The economic efficiency in the comparative aspect when using dried feed grain and wet grain harvested with the addition of a preservative additive - sodium acetate in the diets was determined by the actual costs of preparing feed and producing livestock products.

3. Results and discussion

Sodium acetate used as a preservative is a by-product of chemical production, which is a powdery substance of white color with a yellowish tinge, practically odorless. This product is characterized by the following chemical composition, wt.%: dry matter of sodium acetate - 56-58, admixture of polytetramethylene ethylene glycol - 0.2-2 and water - the rest. It contains crystalline hydrate water, stable during storage for a year, safe to handle. Sodium salt of acetic acid - sodium acetate is environmentally friendly.

Acetic acid is a natural metabolite. In the rumen of the cow's stomach, it is formed up to 1-1.5 kg or more per day, which contributes to the formation of energy in the body [21].

After two months of storage of feed wheat grain, a glass container was opened and its organoleptic evaluation, biochemical and chemical analysis was performed. Organoleptic evaluation of the quality indicators of harvested feed grain of all variants was carried out on a commission basis. The studies found that in the II control variant, grain with a moisture content of 25%, harvested without preservative, became moldy after storage. It had more than 50% of spoiled grain with a brown color and a musty smell, unsuitable for feeding. According to the studied indicators, in the I control variant, the dried grain with a moisture content of 14% and in the III experimental variant, the grain with a moisture content of 25%, harvested with a preservative - sodium acetate, was evaluated as benign. In the two above-mentioned variants, the grain was characterized by a marketable appearance, structure, had no mold and a sharp moldy smell.

An objective assessment of the quality of the grain under study was performed according to laboratory studies (Table 2).
Table 2. Chemical composition of feed grain, %.

| Indicator           | I control (dried) | III experimental (wet grain with sodium acetate) |
|---------------------|-------------------|--------------------------------------------------|
| Crude protein       | 11.5              | 12.5                                             |
| Phosphorus          | 0.30              | 0.27                                             |
| Calcium             | 0.04              | 0.11                                             |
| Organic acid content: |                 |                                                  |
| acetic acid         | -                 | 0.14                                             |
| dairy               | -                 | 1.88                                             |
| oil                 | -                 | 0.03                                             |

As a result of the research, it was revealed that in wet feed grain preserved with sodium acetate, there was an optimal accumulation of organic acids. The mechanism of the preservative action of sodium acetate (sodium salt of acetic acid) is that it suppresses and inhibits enzymes due to acidification of the feedstock. It should be noted that in the I control variant, with the traditional method of grain conservation – fire drying, the protein content decreases, compared with the III experimental variant, with chemical canning of wet grain, by 1.0% (absolute). At the same time, a cheap preservative, sodium acetate, was used for canning, which allows preserving the nutritional value of wet feed grain.

According to the data obtained in the laboratory experiment, wet wheat grain prepared with the use of sodium salt of acetic acid - sodium acetate at a dose of 10 g/kg of wet grain per dry substance of the preservative has a better quality than dried grain. Therefore, when conducting scientific and economic experience, this method of canning was adopted when harvesting wet feed grain.

In the scientific and economic experiment, after 2 months of storage of feed grain, average samples were selected to assess its quality according to organoleptic indicators and the results of chemical analysis.

Organoleptic assessment of harvested grain was carried out by commission. In general, according to organoleptic indicators, the grain of both harvesting variants was evaluated as high-quality. In the compared variants, the wheat was of normal color and had no mold and moldy smell.

An objective assessment of the quality of the prepared grain fodder was obtained on the basis of zootechnical analysis data (Table 3).

The results obtained indicate that the content of dry and organic matter in the fodder flattened wheat grain of the experimental variant at natural humidity was lower compared to the control. This is explained by the fact that the preparation of feed wheat of the control variant was produced by the traditional method of preserving grain - fire drying, and wheat was used for the preparation of feed grain of the experimental variant without preliminary drying (with higher humidity). Due to the same reason, compared with the experimental version, the content of fiber and nitrogen-free extractives in the wheat grain in the control was higher. This had a definite effect on the general (energy) nutritional value of the prepared grain fodder. In terms of energy nutrition value, the wheat of the control variant slightly exceeded the experimental variant.

The treatment of wet grain fodder with a preservative preparation (sodium acetate) had a positive effect on the quality of the harvested feed. The content of crude protein in wheat grain at the natural humidity of the experimental version was significantly higher than in the control group. In terms of fat content, the compared variants of grain harvesting had no differences.

As in the laboratory experiment, in the harvested grain of the experimental variant, a greater accumulation of lactic acid was noted, a lesser accumulation of acetic acid and a minimum accumulation of butyric acid. Wheat of the experimental variant had a pH of 4.0. Preservative - sodium acetate (sodium salt of acetic acid) has fungicidal and bactericidal properties. Due to its introduction, the grain is acidified to the optimal pH value and conditions are created that are disastrous for microorganisms that
contribute to mold formation and spoilage of unprocessed grain. After treatment with sodium acetate, it does not heat up, does not mold and does not germinate.

Table 3. Chemical composition and nutritional value of feed grain at natural humidity.

| Indicator                        | Grain feed variants |
|----------------------------------|---------------------|
|                                  | I control           | II experimental   |
| Total moisture, %                | 13.90               | 24.80             |
| Dry matter, %                    | 86.10               | 75.20             |
| Organic matter, %                | 84.20               | 73.50             |
| Crude protein, %                 | 11.72               | 12.45             |
| Crude fat, %                     | 1.98                | 1.98              |
| Crude fiber, %                   | 4.0                 | 2.91              |
| Crude ash, %                     | 1.90                | 1.70              |
| Nitrogen-free extractive substances, % | 66.50               | 56.16             |

It is contained in 1 kg of grain fodder:

- energy feed units, EFU: 1.14, 1.0
- exchange energy, MJ: 11.41, 10.04
- digestible protein, g: 98.45, 104.58
- calcium, g: 1.74, 1.60
- phosphorus, g: 3.31, 2.89
- sugar, g: 19.5, 16.5

*1 EFU = 10 MJ of exchange energy.

However, for a more full view of the quality of the harvested grain fodder, the results of the chemical composition of wheat at natural humidity were recalculated to an absolutely dry matter (Table 4).

Table 4. Chemical composition of flattened grain in terms of absolutely dry matter, %.

| Показатель                        | Variants for harvesting grain fodder |                  |
|-----------------------------------|-------------------------------------|------------------|
|                                  | I control (dried)                   | II experimental (with sodium acetate) |
| Dry matter                        | 86.10                               | 75.20            |
| Dry matter content of feed:       |                                     |                  |
| crude protein                     | 13.61                               | 16.55            |
| crude fat                         | 2.30                                | 2.63             |
| crude fiber                       | 4.65                                | 3.87             |
| nitrogen-free extractive substances | 77.23                           | 74.69            |
| crude ash                         | 2.21                                | 2.26             |
| Sugar content, g/kg               | 22.70                               | 22.0             |

In comparison with the control, the dry matter of the wheat grain of the experimental variant contained more crude protein by 2.94% and crude fat by 0.33%. The compared grain fodder variants differed slightly in the content of nitrogen-free extractives and sugars.

Thus, previously obtained data in laboratory experience are confirmed by the results of scientific and economic experience. The use of sodium acetate as a preservative makes it possible to harvest feed grain without preliminary drying, which was provided for by the purpose of the research.

The milk productivity of lactating cows was studied when using wet feed wheat grain preserved with sodium acetate in the diets in scientific and economic experience. The composition and quantity of succulent and coarse feeds in the diets of cows of both groups was the same. Animals of both groups were given the same amount of cereal concentrates. The difference in the rations was that the cereal concentrates were of different harvesting technologies. On average, during the experiment period, the
daily ration of cows in the compared groups included leguminous hay - 4.4 kg, corn silage - 28.4 kg, legume haylage - 4.0 kg, feed molasses - 1.0 kg. At the same time, the animals of the I control group were fed 5.2 kg of dried flattened wheat grain prepared by the traditional method of preserving it - fire drying, and the II experimental group - 5.2 kg of wet flattened wheat grain harvested with a preservative - sodium acetate (a by-product of the chemical industry) at a dose of 10 kg per 1 ton of wet grain based on the dry matter of the preservative. To meet the needs of cows in mineral elements and vitamins in the diets, the necessary feed additives were used. In the diet of cows of the I control group, the content of energy feed units was 19.1, exchange energy - 191.2 MJ, dry matter - 18.47 kg, and the II experimental group - respectively 18.4, 184.2 MJ, 17.91 kg. Crude protein in the diet of animals of the I group contained 2366.3 g and the II group - 2404.2 g, digestible protein – 1617.7 and 1649.6 g, respectively, crude fiber – 3633.0 and 3576.3 g, starch – 3032.4 and 2954.4 g, sugars – 1163.5 and 1148.0 g, crude fat – 473.5 and 473.5 g, calcium – 179.7 and 179.0 g, phosphorus – 77.3 and 75.1 g, carotene – 923 and 925 mg.

During the period of the experiment, cows of the II experimental group differed in higher consumption of feed (with the exception of grain cereal concentrates and feed molasses) and nutritional substances of the diets. So, in comparison with the I control group, per 1 animal in the II experimental group, more dry matter was consumed by 18.0 kg (1.14%), crude protein – by 12.35 kg (6.10%), digestible protein – 8.56 kg (6.17%), sugars – 1.25 kg (1.23%), crude fat – 1.92 kg (4.76%), calcium – 0.86 kg (5.71%), carotene – by 4.95 g (6.40%). At the same time, the difference in the consumption of energy feed units, exchange energy, starch and phosphorus between the compared groups was insignificant.

The obtained results of the performed studies indicate that the inclusion in the diet of wet flattened wheat grain harvested with sodium acetate, instead of dried flattened grain of the same crop, positively affected the dairy productivity of cows and milk quality (Table 5).

Table 5. Dairy productivity of cows in the main period of the experiment, kg.

| Indicator                        | Groups of animals   |          |
|----------------------------------|---------------------|----------|
|                                  | I control           | II experimental |
| Average daily milk yield of natural milk | 17.90 ± 0.43        | 19.30 ± 0.50* |
| % to control                     | 100                 | 107.8    |
| Average content in milk, %:      |                     |          |
| fat                              | 3.77 ± 0.04         | 3.98 ± 0.03*** |
| protein                          | 3.30 ± 0.03         | 3.34 ± 0.05 |

*P < 0.05, ***P < 0.001.

So, during the main period of scientific and economic experience in terms of average daily milk yield of natural milk, the advantage of cows of the II experimental group, in comparison with analogues of the I control group, was 1.40 kg (7.8%; P > 0.95).

Fat and protein content are important indicators in characterizing the quality of milk. These indicators in animals of the II experimental group were higher than in the I control group, respectively, by 0.21 (P > 0.999) and 0.04 absolute percent.

During the main period of the experiment (90 days), the average yield of natural milk from each cow of the I control group was 1611.0 kg and the II experimental group - 1737.0 kg. At the same time, more milk by 126.0 kg (7.8%) received from each cow of the II group in comparison with analogues of the I group.

At the same time, the average daily milk yield in terms of basic fat content (3.4%) was 19.85 in cows of the I control group, and in the II experimental group – 22.59 kg. Hence, the animals of the experimental group had an average daily milk yield of basic fat content higher by 2.74 kg (13.8%) than the control analogues.
According to the results obtained in the experiment, cows of the compared groups had differences in indicators of feed costs for the production of a unit of production. Thus, the consumption of energy feed units per 1 kg of natural milk in the I control group of cows was 1.02 and in the II experimental group - 0.95, and the tested grain fodder - 290 and 269 g, respectively.

In physiological studies on the digestibility and use of nutrients of diets by lactating cows of the compared groups, higher studied indicators were revealed in the experimental group, compared with analogues from the control. Indicators of morphological and biochemical composition of blood in animals in the compared groups were within the physiological norm.

Upon completion of the research, an assessment of the economic efficiency of milk production was carried out using wet flattened wheat grain (with sodium acetate) as part of the main diet instead of dried flattened grain of this crop. During the 90 days of the main period of scientific and economic experience, an average of 1786.5 kg of milk was milked per cow in the I control group and 2033.1 kg of milk with a basic fat content of 3.4% in the II experimental group. According to this indicator, the II group of cows had an advantage with a difference of 246.6 kg (13.8%). The performed calculations showed that the cost of milk produced, minus additional costs, on average per animal was 53250.0 rubles in the I control group and 60961.0 rubles in the II experimental group.

The economic efficiency (net income) from the introduction of wet wheat grain harvested with sodium acetate into the diets of lactating cows per 1 animal in the II experimental group was 7711.0 rubles, which is 14.5% more compared to the I control group.

Thus, in order to increase the economic efficiency of milk production, it is advisable to prepare wet wheat grains with sodium acetate and include lactating cows in the diets.

4. Conclusion
As in the laboratory experiment, in the scientific and economic experience in the harvested grain of the experimental variant with sodium acetate, a greater accumulation of lactic acid was revealed, a lesser accumulation of acetic acid and a minimum accumulation of butyric acid. Due to the introduction of sodium salt of acetic acid into the wheat of the experimental variant, the grain is acidified to an optimal pH value of 4.0 and conditions are created that are disastrous for microorganisms that contribute to mold and spoilage of unprocessed grain. After treatment with sodium acetate, it does not heat up, does not mold and does not germinate.

In the scientific and economic experience, after 2 months of storage of feed grain, according to organoleptic indicators, the wheat of both harvesting variants was assessed as high-quality, had a normal color and did not have mold and mildew smell. Studies of the chemical composition showed that the treatment of the experimental variant of wet grain fodder with a preservative preparation (sodium acetate) had a positive effect on the quality of the prepared feed. The content of crude protein in wheat grain at natural humidity of the II experimental variant was significantly higher than in the grain storage of the I control variant, prepared by the traditional method of preserving grain - fire drying. In terms of fat content, the compared grain variants had no differences.

Recalculation of the results of the chemical composition of wheat at natural humidity to an absolutely dry matter gave a more full view of the quality of the harvested grain fodder. In comparison with the control, the dry matter of the wheat grain of the experimental variant contained more crude protein by 2.94% and crude fat by 0.33%. The compared grain fodder variants differed slightly in the content of nitrogen-free extractives and sugars. The use of sodium acetate as a preservative makes it possible to harvest feed grain without prior drying.

The inclusion in the diet of wet flattened wheat grain harvested with sodium acetate, instead of dried flattened grain of this crop, positively affected the dairy productivity of cows and the quality of milk. According to the average daily milk yield of natural milk, the advantage of cows of the II experimental group, in comparison with analogues of the I control group, was 7.8%. The results of the quality of the milk produced indicated that the fat and protein content of the animals of the II experimental group was higher than in the I control group, respectively, by 0.21 and 0.04 absolute percent.
The best indicators of milk production efficiency with the use of wet flattened wheat grain (with sodium acetate) as part of the main diet instead of dried flattened grain of this crop have been established. The consumption of energy feed units per 1 kg of natural milk was 1.02 in the I control group of cows and 0.95 in the II experimental group, and the tested grain fodder – 290 and 269 g, respectively. The economic efficiency of milk production in the experimental group was 14.5% higher compared to the control group.

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