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EFFICACY OF A LOW PROTEIN FEEDSTUFF IN FEEDING DAIRY CATTLE

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This study experimentally proved the effectiveness of using a low-protein feed preparation in feeding dairy cows. The research was conducted for 53 days in the experimental farm «Gontarivka» of the Livestock Farming Institute of the National Academy of Agrarian Sciences of Ukraine on dairy cows of the Ukrainian Black-and-White dairy breed. A control and experimental group of cows was formed by the method of pair wise analogues, with 22 animals in each group by age, milk production, number and lactation period. All animals were clinically healthy, and no animals dropped out of the study during the experiment. The housing conditions, feeding and watering regimes, and microclimate parameters during the study were identical between the groups of experimental animals. The working hypothesis of the research was to find a way to increase the milk production of cows using a low-protein feed preparation. The feed preparation was produced by processing animal feed - extruded meat and bone meal with the addition of grain filler, it is characterized by a high content of amino acids. The feed preparation was fed in the diet of cows of the experimental group by replacing 2 kg of sunflower meal and compared with the performance of cows of the control group. It was found that cows that consumed a diet containing a low-protein feed preparation produced 1713 kg of milk over 53 days of the experiment, or 1.48 kg of milk per cow per day. The milk of the experimental cows also had a 0.05% higher fat content and 0.11% higher protein content. In terms of basic fat content (3.4%), the milk yield of the experimental group cows was 3.06 kg higher. The profit from the production of 1 kg of milk when using a low-protein feed preparation in the cow's diet was 0.48 UAH higher, and the level of profitability was 4.9% higher.

Keywords: dairy cattle, feeding, ration, low-protein feed drug, milk production, profitability



ЕФЕКТИВНІСТЬ КОРМІВ З НИЗЬКИМ ВМІСТОМ БІЛКА У ГОДІВЛІ МОЛОЧНОЇ ХУДОБИ

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Дослідженнями експериментально доведено ефективність використання низькобілкового кормового препарату в годівлі молочних корів. Дослідження проводили впродовж 53 днів на базі дослідного господарства «Гонтарівка» Інституту тваринництва Національної академії аграрних наук України на молочних коровах української чорно-рябої молочної породи. Контрольна та дослідна групи корів були сформовані методом парних аналогів, по 22 тварини в кожній групі за віком, надоем молока, кількістю та періодом лактації. Всі тварини були клінічно здоровими, і жодна тварина не вибула з дослідження під час експерименту. Умови утримання, режими годівлі та напування, а також параметри мікроклімату під час дослідження були однаковими для груп дослідних тварин. Робочою гіпотезою дослідження було знайти спосіб збільшити надої молока корів за допомогою низькобілкового кормового препарату. Кормовий препарат був виготовлений шляхом переробки кормів для тварин - екструдованого м'ясо-кісткового борошна з додаванням зернового наповнювача, він характеризується високим вмістом амінокислот. Кормовий препарат вводили в раціон корів експериментальної групи, замінюючи 2 кг соняшникового шроту, і порівнювали з продуктивністю корів контрольної групи. Було встановлено, що корови, які споживали раціон, що містив низькобілковий кормовий препарат, за 53 дні експерименту дали 1713 кг молока, або 1,48 кг молока на корову на добу. Молоко експериментальних корів також мало на 0,05% вищий вміст жиру і на 0,11% вищий вміст білка. За базовим вмістом жиру (3,4%) надої корів експериментальної групи були вищими на 3,06 кг. Прибуток від виробництва 1 кг молока при використанні низькобілкового кормового препарату в раціоні корів був вищим на 0,48 грн, а рівень рентабельності — на 4,9%.

Ключові слова: молочна худоба, годівля, раціон, низькобілковий кормовий препарат, виробництво молока, рентабельність.

An analysis of the world's existing dairy cattle feeding standards indicates the need to improve the level of energy and protein nutrition in view of climate change. Nitrogen exchange in the rumen of ruminants is the most important factor in increasing nitrogen utilization efficiency (Oldham, 1984; Tamminga, 1992). As protein production increases, the need for storage per unit of protein production decreases. This approach seems complicated, given farmers' efforts to minimize ration costs. The most important step forward is to adapt the feed and nitrogen requirements changing the nutrition system from crude protein content due to the rumen available nitrogen and the availability of rumen undegradable protein (RUP) (Holder, 2012).

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It is well known that degradable protein nitrogen in the rumen and the ammonia cycle in the animal's body are the two main sources of nitrogen consumption by microorganisms (Huntington et al., 2006), so the amount of degradable protein is one of the most effective sources for microbial growth and increased nitrogen utilization efficiency (Fig. 1).

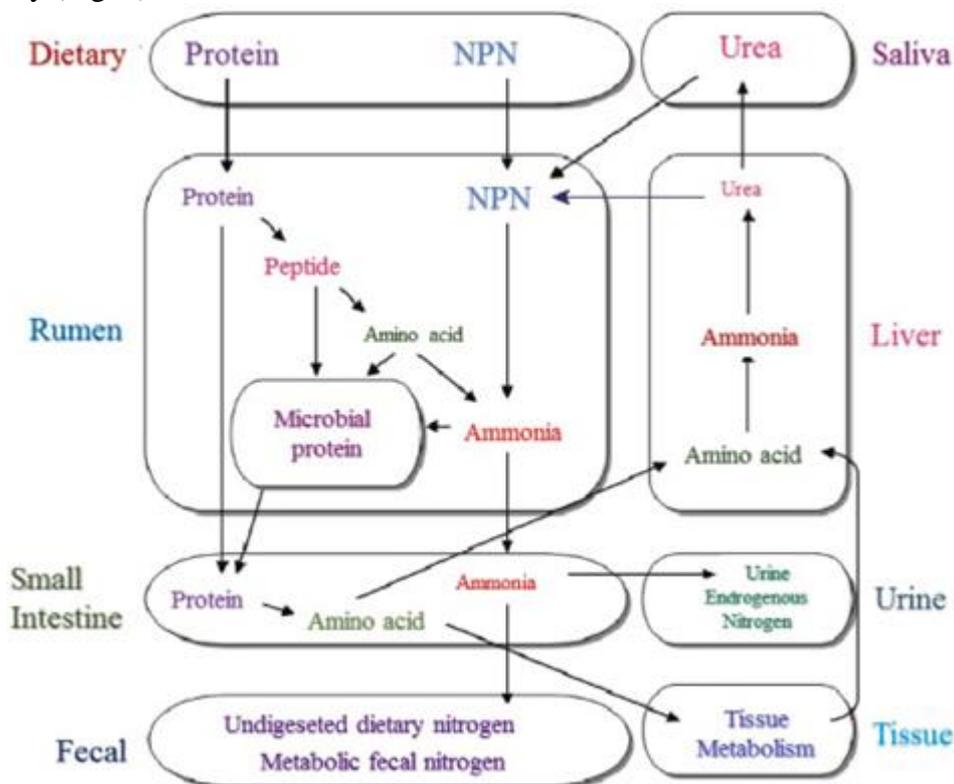


Fig. 1. A model of the metabolism of nitrogen in the rumen (Leng & Nolan, 1984)

In most modern protein nutrition systems, when determining the protein requirements of animals, the amount of protein synthesized in the rumen and broken down in the small intestine is not taken into account when determining the protein requirement. In other words, the total protein requirement of ruminants is defined as the sum of the breakdown and non-breakdown portions in the rumen. This approach to optimizing the protein nutrition of highly productive animals is based on providing the animal body with readily soluble nitrogen compounds of feed protein and non-protein sources of nitrogen, which is replenished through the proteolysis of microbial protein and feed protein. One of the most promising ways to achieve this goal is to determine the optimal ratio of energy and protein in the diets of growing stock and normalize the intake of nutrients in the body of animals under conditions of changing ambient temperature, which can significantly affect productivity regardless of climatic conditions.

One of the most important tasks of dairy farming is to increase milk production while reducing the protein content of the diet, as the protein component is the highest cost of the diet (Chase & Fortina, 2023). It has been proven that overloading dairy cows' diets leads to a decrease in milk production due to the negative efficiency of milk nitrogen (Fadul-Pacheco et al., 2017; Niazifar et al., 2024). In addition, the rationing of protein levels in the diet is associated with the need to reduce greenhouse gas emissions. It has been proven (Schrade et al., 2023) that reducing crude protein in the diet can reduce the emission of ammonia NH_3 and nitrous oxide (H_2O) by dairy cattle. Environmental



legislation in the European Union aims to reduce the amount of nitrogen released into the atmosphere. Nitrogen losses due to the consumption of excessive undigestible protein in the diet are excreted in livestock excreta, which leads to ammonia emissions into the atmosphere and economic losses. For example, one of the leaders in milk production in Europe, the Netherlands, plans to reduce nitrogen emissions by 26% by 2030 and 50% by 2035 (Bannink et al, 2024). One of the ways to achieve this goal, along with improving technological solutions for livestock housing (Çinar et al. 2023; Ruiz-González et al. 2024; Vitaliano et al. 2024) and excreta processing, is to increase the efficiency of nitrogen absorption by cows through feeding (Lu et al. 2024).

Action to change the global livestock feed market is urgent, and future research should focus on quantifying the synergies and trade-offs between sustainable protein solutions (Pexas et al. 2023). In the United States, over the past 20 years, there has been a downward trend in nitrogen intake (by 10.8%) by dairy cattle, while milk yields have increased by 40% and total nitrogen excretion from manure has decreased by 8.1% (Chase 2023).

A study of the effect of crude protein in the diet of Holstein-Friesian dairy cows (Katongole & Yan 2020) showed that with increasing crude protein in the diet, the level of protein and urea in milk (141, 151, 177 and 210 g of crude protein per 1 kg of dry matter) increased, as well as the excretion of nitrogen in manure and urine, while the nitrogen efficiency of milk decreased. It was shown (Chowdhury et al. 2023) that feeding dairy cows with a lower protein content did not affect milk production, but improved their nitrogen utilization efficiency.

The priority of the agricultural and livestock sector should be to replace soy and other protein crops in livestock feed with alternative feeds (Song et al. 2021). This also makes sense in the sense that soybeans are significantly affected by climate change in the direction of global warming and their yields are declining (Schauberger et al. 2017, Li 2023).

The analysis of information sources was the basis for choosing the research goal – to determine the effectiveness of a low-protein feed drug in feeding dairy cattle.

Materials and methods of research. The research was conducted for 53 days in the experimental farm «Gontarivka» of the Livestock Farming Institute of the National Academy of Agrarian Sciences of Ukraine on dairy cows of the Ukrainian Black-and-White dairy breed. A control and experimental group of cows was formed by the method of pair wise analogues, with 22 animals in each group by age, milk production, number and lactation period. All animals were clinically healthy, and no animals dropped out of the study during the experiment. The housing conditions, feeding and watering regimes, and microclimate parameters during the study were identical between the groups of experimental animals. The working hypothesis of the research was to find a way to increase the milk production of cows using a low-protein feed preparation.

Cows were fed nutritionally balanced diets twice a day. The diets for the experimental cows were normalised based on an average daily milk yield of 22-25 kg per cow. The diets of cows in the control and experimental groups differed in that instead of 2 kg of sunflower meal, cows in the experimental group received 2 kg of a low-protein feed preparation. The feed preparation was produced by processing animal feed (extruded meat and bone meal with the addition of grain filler) and is characterised by a high content of amino acids. 1 kg of the test product contained 0.89 kg of dry matter, including 328.4 g of crude protein and 13.3 MJ of metabolic energy. After the first control milking (before the inclusion of the feed preparation in the diet), a levelling period of 15 days was carried out while the animals got used to the group, adapted to the conditions of housing, feeding



regime and rations. The experimental drug was administered gradually, in a controlled manner, in equal proportions each day before the experiment.

The feeding scheme for the experimental cows is presented below (Table 1).

Table 1

Feeding pattern of experimental cows

Feed by type	Cow groups	
	control (n=22)	experimental (n=22)
	Amount of feed in the daily diet, kg	
Corn silage	16,0	16,0
Alfalfa haylage	10,0	10,0
Wheat straw	1,0	1,0
Crushed corn	3,0	3,0
Shredded wheat	1,3	1,3
Crushed barley	1,3	1,3
Sunflower meal	3,4	1,4
Low protein feed drug	0,0	2,0

The results were processed and analysed at the Testing Centre of the Livestock Farming Institute of the National Academy of Agrarian Sciences of Ukraine, accredited by the National Accreditation Agency of Ukraine, in accordance with the requirements of State standard of Ukraine (SSTU) ISO/IEC 17025:2006.

Prior to the experiment, the chemical composition and nutritional value of the diets used in the experimental animals were determined.

The moisture content of the feed and feed preparation was determined according to SSTU ISO 6496:2005, the content of dry matter (DM), nitrogen-free extractives and metabolic energy was determined by calculation. The crude ash content was determined according to SSTU ISO 5984-2004. The crude fat content was determined according to GOST 13496.15-97. The content of total nitrogen and crude protein was determined according to SSTU ISO 5983-2003. Crude fibre content was determined according to the IT NAAS 7:19 standard (SSTU ISO 6865-2004 MOD). The calcium and phosphorus content was determined according to IT NAAS 4:19 and 1:18 standards, respectively. The solubility and digestibility of crude protein were determined according to SSTU 8570-2015. The ratio of sugar and starch, as well as the ratio of calcium and phosphorus, was determined by the calculation method. The total energy content (*TEC*) was determined by the formula:

$$TE = 0,239 \times CP + 0,0398 \times CF + 0,0201 \times CFib + 0,0175 \times NFE$$

explanation: TE - Total energy, MJ; CP - Crude protein, g; C - Crude fat, g; CFib - Crude fibre, g; NFE - Nitrogen-free extractives, g.

The metabolic energy content was determined by the formula:

$$ME = 0,0312 \times DCF + 0,0147 \times (DOM - DF - DCF) + 0,00234 \times CP,$$

explanation: ME - metabolic energy, MJ; DCF – digestible crude fibre, g; DOM – digestible organic matter, g; DF – digestible fat, g; CP - crude protein, g.

The rumen nitrogen balance (*RNB*) was determined by the formula:

$$RNB = \frac{CP - DP}{6,25},$$



explanation: BAR - rumen nitrogen balance, g; CP - crude protein, g; DP - digestible protein, g.

The digestible protein (*DP*) content was determined by the formula:

$$DP = \frac{11,93 - 6,82 \times IP}{CP} \times ME + 1,03 \times IP,$$

explanation: AP - assimilated protein, g; IP - indigestible protein, g; CP - crude protein, g; ME - metabolic energy, MJ.

The indigestible protein (*IP*) content was determined by the formula:

$$IP = \frac{CP \times IP(\%)}{100},$$

explanation: IP – indigestible protein, %; CP – crude protein, g.

The content of energy-protein units (*EPU*) was determined by the formula:

$$EPU = \frac{MJ + 10 \times P}{2},$$

explanation: EPU – Number of energy-protein units in 1 centner of feed; MJ – Amount of MJ in 1 centner of feed; P – Protein content in 1 centner of feed.

Net lactation energy (*NEL*) was calculated using the formula:

$$NEL = 0,6 \times \left(1 + 0,04 \times \frac{ME}{TE \times 100 - 57} \right) \times ME,$$

explanation: NEL – Net energy of lactation, MJ; ME – Metabolic energy; TE – Total energy.

Control milking was carried out twice a day - in the morning and in the evening, a total of 7 control milking sessions were carried out during the experiment. Milk samples were collected in sterile containers with a broad-spectrum preservative using a probe, in proportion to the first and second milking in accordance with the requirements of SSTU ISO 707:2002 Milk and milk products, instructions for sampling (ISO 707:1997, IDT). Samples were delivered to the laboratory on the same day.

The physical and technological properties of milk were studied in accordance with SSTU 8009:2015. The biochemical parameters of milk were determined in a certified laboratory for the assessment of the quality of livestock products. The mass fraction of fat, protein, protein (casein + whey proteins), lactose, and dry matter was determined by the express method of infrared spectrometry (SSTU 8396:2015, 2017). The freezing point of milk was determined by the conduct metric express method (SSTU 7671:2014, 2015), and the somatic cell content was determined by the express method of flow cytometry (SSTU 7672:2014, 2015).

The first control milking was carried out before the start of the experiment. After the first control milking of cows and the formation of experimental groups, a levelling period of 15 days was carried out, when the animals got used to each other, adapted to the conditions of detention and feeding ration. The studied feed preparation was introduced into the diet of cows of the experimental group gradually, in equal proportions, after each feeding the condition of the animals was monitored and the actual amount of feed intake by cows of both groups was recorded.



The biometric processing of the obtained digital material was carried out by the method of variation statistics, taking into account the Student's criterion. The standard computer mathematical and statistical program *Microsoft Excel* was used to assess the reliability of the results obtained: arithmetic means (M), error of the arithmetic mean ($\pm m$) and the probability of the difference between the studied arithmetic means (p). Changes between values in the experimental groups were considered significant at $p \leq 0.05$.

All experimental studies were carried out in accordance with modern methodological approaches, requirements and standards (SSTU ISO/IEC 17025:2019, 2021), Directive 2010/63/EU (2010) and the Procedure for Conducting Animal Testing in Research Institutions (Law of Ukraine No. 249, 2012). The experiments were performed in accordance with the provisions of the European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes (1986).

Research results. The results of the analyses and calculations of the chemical composition and nutritional value of the diets of the control and experimental groups of dairy cows are given below (Table 2).

Table 2

Chemical composition and nutritional value of diets of experimental animals

Indicators	Groups of cows		Reference values
	control	experimental	
Moisture content of the diet (%)	46,87	47,0	50-55
Content: dry matter (kg)	19,18	19,13	16,26
dry matter per 100 kg of live weight of cow(kg)	2,74	2,73	2,71
Exchange energy (MJ)	215	220	-
Exchangeable energy in dry matter (MJ)	11,51	11,19	11,00
Content: crude protein (g)	3060	3017	
crude protein in dry matter (%)	15,77	15,95	16,00
crude fat in dry matter (%)	4,73	3,08	4,00
crude fibre in dry matter (%)	18,55	19,03	18,00
sugar in dry matter (%)	3,31	3,81	10,06
starch in dry matter (%)	29,88	24,13	15,33
Ratio of sugar and starch to digestible protein	2,57	3,07	2,22
Calcium and phosphorus ratio	1,20	1,28	1,44
Nitrogen balance in the rumen	0,97	0,07	0-10
Cationic and anionic balance	180,33	186,23	200-400
Contents in dry matter (%)			
Crude protein	15,95	15,77	16,00
Protein that is broken down in the rumen	76,30	75,60	65-70
Protein that is not broken down in the rumen	24,38	25,10	30-45
Crude fat	3,08	4,73	4,00
Crude fibre	19,03	18,55	18,00
Metabolic energy	11,19	11,51	11,0
Sugar	3,81	3,31	10,06
Starch	24,13	29,88	15,33
Net lactation energy	6,9	14,3	-
Energy-protein units (EPU)	10,3	10,6	8,08-10,5



During the main experimental period, all animals of the control and experimental groups consumed the prescribed diet in full. No changes in health status were observed both visually and according to the veterinarian.

It was found that during the 53 days of the accounting period, the animals of the experimental group outperformed the analogues of the control group in terms of milk production (Table 3).

Table 3

Indicators of milk productivity and economic efficiency of the studied feed preparation

Economic efficiency indicators	Groups of cows		Difference between the experimental and control groups (+/-)
	control	experimental	
Total milk yield for 53 days of the experiment (kg)	23507,0	25220,0	+1713,0
Average daily milk yield per 1 cow (kg)	20,16±1,37	21,64±1,09	+1,48
Fat content in milk (%)	4,08±0,05	4,13±0,03	+0,05
Protein content in milk (%)	3,35±0,03	3,46±0,04	+0,11
Total milk production in terms of basic fat content (3.4 %) (kg)	28208,4	30634,9	+2426,5
Average daily milk yield in terms of basic fat (3.4 %) (kg)	24,19	26,29	+2,10
Expenses for 53 days of the experiment for all studied cows (UAH)	159240,62	165770,22	+6529,6
Costs for 53 days of the experiment per 1 cow (UAH)	7238,21	7535,01	+296,8
Feed costs per 1 day (UAH)	95,85	102,45	+6,60
Selling price of 1 litre of base milk (UAH)	11,0	11,0	-
Estimated cost of 1 kg of milk (UAH)	6,77	6,57	-0,2
Revenue from the sale of milk of basic fat content for 53 days of the experiment (UAH)	295842,51	335351,82	+35509,31
Profit from milk production for 53 days of the experiment (UAH)	136601,89	169581,60	+32979,71
Profit per 1 cow per day (UAH)	117,15	145,44	+28,28
Profit on production of 1 kg of milk of basic fat content (UAH)	5,08	5,56	+0,48
Profitability (%)	62,5	67,4	+4,9

It was found that the average daily productivity of natural milk in cows of the experimental group was 1.47 kg higher, fat content – by 0.22%, protein – by 0.24%. In terms of basic fat content, the milk yield of the experimental group cows was 3.06 kg higher. The cows of the experimental group produced 1713 kg more milk than the experimental group during 53 days of the experiment.

The calculations of economic efficiency showed that due to the higher cost of the diet containing the experimental feed preparation on a low-protein basis, the total cost of



milk production from experimental cows was higher. However, due to the higher quantity of milk produced and higher fat content, the cost per kg of milk was 0.2 UAH lower and the cost per kg of milk of basic fat content was 0.48 UAH lower than in the control group. Accordingly, the profit per cow in the experimental group was 28.28 UAH higher than in the control group. The profitability of milk production with the use of a low-protein feed preparation in the diet of cows is 4.9% higher than with the use of sunflower meal.

Discussion. The results obtained on the effect of crude protein in the diet of dairy cows are confirmed by other researchers. Thus, a study on Holstein cows (Katongole & Yan 2020) showed that with an increase in crude protein content in the diet, the level of protein and urea in milk (141, 151, 177 and 210 g of crude protein per 1 kg of dry matter) increased, as did nitrogen excretion in manure and urine, while nitrogen utilization efficiency in milk decreased. It has been shown (Chowdhury et al. 2023) that feeding dairy cows feed with a lower protein content did not affect milk production but improved nitrogen utilization efficiency.

The priority for the agricultural and livestock sector should be to replace soybeans and other protein crops in animal feed with alternative feeds (Song et al. 2021). This also makes sense given that soybeans are significantly affected by climate change in the direction of global warming, and their yields are declining (Schauberger et al. 2017, Li 2023).

Thus, the effectiveness of using a low-protein feed preparation in feeding dairy cows by partially replacing sunflower meal with it has been proven.

Conclusion. The effectiveness of using a low-protein feed preparation produced by processing animal feed (extruded meat and bone meal with the addition of grain filler) in feeding dairy cows was experimentally proven. In particular, during 53 days of the experiment, cows consuming a diet containing the experimental feed preparation produced 1713 kg more milk than cows in the control group. The cows in the experimental group had a higher daily milk yield of 1.48 kg, fat content of 0.05%, and protein content of 0.11%. Profit from the production of 1 kg of milk with the use of a low-protein feed preparation in the diet of cows is 0.48 UAH higher, the level of profitability is 4.9% higher.

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