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PRODUCTIVITY AND METABOLISM OF SUBSTANCES IN THE BODY OF BULLS BY OPTIMIZING THEIR PROTEIN NUTRITION

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*The issue of optimizing the protein nutrition of bulls by keeping them in the territory belonging to the III zone of radioactive contamination due to the Chernobyl accident is considered. Experimental studies on young cattle of the Ukrainian black-and-white dairy breed were conducted in the conditions of the physiological yard of the Institute of Agriculture of the Polissya NAAS. For the experiment, 2 groups of experimental animals were formed: Group I (control) - protein deficiency in the diet was provided by feeding 1.02 kg of pea shoots (*Pisum sativum* L.), and in Group II (experimental) - the same amount of field peas (*Pisum sativum*, var *arvense*). Since different types and amounts of feed were used for feeding the bulls, optimization of the nutritional value of the feed rations was carried out monthly. The experimental animals were kept in the same room according to the adopted technology - in stalls on a leash. The feeding and watering regime, microclimate parameters in both groups were the same.*

Optimization of protein nutrition of fattening bulls due to various high-protein feeds has a positive effect on productivity (875-1023 g) and feed conversion (103.0-120.4 MJ), does not have a negative effect on the slaughter qualities of animals. At the same time, the use of field peas compared to peas to ensure the normalized need of young cattle in digestible protein contributed to an increase in the average daily gain of live weight of animals by 16.9% ($P>0.95$) while reducing the expenditure of metabolic energy per unit of gain by 14.5%. The introduction of field peas into the diet of fattening bulls compared to the use of peas contributed to better digestion of dry matter by 0.2% abs., crude protein - 3.9 ($P>0.95$) and fiber - by 0.9% abs. Experimental animals of group II digested crude fat (by 1.4% abs.) and BER (by 0.3% abs.) somewhat worse than their peers of group I. At the same time, the Nitrogen balance in the body was better in the experimental group bulls compared to the control by 2.9%.

Keywords: *bulls, protein nutrition, peas, field peas, productivity, digestibility, Nitrogen balance.*



ПРОДУКТИВНІСТЬ І ОБМІН РЕЧОВИН В ОРГАНІЗМІ БУГАЙЦІВ ЗА ОПТИМІЗАЦІЇ ЇХ ПРОТЕЇНОВОГО ЖИВЛЕННЯ

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*Розглянуто питання щодо оптимізації протеїнового живлення бугайців за їх утримання на території, яка належить до III зони радіоактивного забруднення внаслідок аварії на ЧАЕС. Експериментальні дослідження на молодняку великої рогатої худоби української чорно-рябої молочної породи проводили в умовах фізіологічного двору Інституту сільського господарства Полісся НААН. Для проведення дослідів сформовано 2 групи піддослідних тварин: I група (контрольна) – дефіцит протеїну в раціоні забезпечували за рахунок згодовування 1,02 кг дерті гороху (*Pisum sativum* L.), а в II (дослідній) групі - такої ж кількості пелюшки (польовий горох) (*Pisum sativum*, var *arvense*). Оскільки за годівлі бугайців використовували різні види та кількість кормових засобів, оптимізація поживної цінності кормових раціонів проводилися щомісяця. Піддослідних тварин утримували в одному приміщенні згідно з прийнятою технологією – у стійлах на прив'язі. Режим годівлі та напування, параметри мікроклімату в обох групах були однаковими.*

Оптимізація протеїнового живлення бугайців на відгодівлі за рахунок різних високобілкових кормів позитивно позначається на показниках продуктивності (875-1023 г) та конверсії корму (103,0-120,4 МДж), не має негативного впливу на забійні якості тварин. Водночас використання пелюшки порівняно з горохом для забезпечення нормованої потреби молодняку великої рогатої худоби у перетравному протеїні сприяло підвищенню середньодобових приростів живої маси тварин на 16,9 % ($P>0,95$) за зниження витрат обмінної енергії на одиницю приросту на 14,5 %. Введення пелюшки до раціону бугайців на відгодівлі порівняно з використанням гороху сприяло кращому перетравленню сухої речовини на 0,2 % абс., сирих протеїну – 3,9 ($P>0,95$) і клітковини – на 0,9 % абс. Деяко гірше дослідні тварини II групи відносно ровесників I групи перетравлювали сирий жир (на 1,4 % абс.) та БЕР (на 0,3 % абс.). При цьому баланс Нітрогену в організмі був кращим у бугайців дослідної групи порівняно з контролем на 2,9 %.

Ключові слова: бугайці, протеїнове живлення, горох, пелюшка, продуктивність, перетравність, баланс Нітрогену.

Introduction. The problem of feed protein was and remains the main one in organizing full-fledged feeding of farm animals. The deficit of digestible protein in the diets of ruminants is 15-30%, while the production of livestock products decreases by 20-35%, and the cost and consumption of feed increase by 1.5 times (Razumovskyi N.P., Bogdanovych D.M., 2019; Huuskonen A., Joki-Tokola E., 2010). Under such conditions, the search for opportunities to increase the level of protein supply of animals through the use of protein-rich feeds acquires particular importance and is relevant in industrial animal husbandry (Kandyba V. M. et al., 2015; Osmane B. et al., 2017).

According to foreign authors (David L.S. et al., 2024; Volpelli L.A. et al., 2012), grain legumes are a complete source of protein, amino acids and energy, and they can be used as a replacement for soybean meal in animal and poultry feeds, as soybean meal is



becoming scarce and expensive. In addition, the use of legume feeds reduces dependence on fossil-based nitrogen fertilizers and imported protein concentrates, improves carbon sequestration and diversifies crop rotations, thereby improving the economics and sustainability of dairy farming (Räisänen S.E. et al., 2023; Watson C.A. et al., 2018).

An important reserve for replenishing the protein deficiency in animal diets in Polesie can be the use of peas, chickpeas, fodder beans, vetches, and narrow-leaved lupine (alkaloid-free) (Savchuk I.M. et al., 2022; Savchenko Yu.I. et al., 2013). Pea grain is a highly valuable legume that is a source of dry matter, energy, and other nutrients for ruminants (Johnston D.J. et al., 2019). According to reports by domestic researchers (Sloboda O.M., Sloboda L.Ya., 2010; Savchenko Yu.I. et al., 2007), chickpea grain is also a highly nutritious feed for domestic animals, it contains about 18% of digestible protein, which is better than cereal protein in terms of amino acid composition. According to the authors (Halmemies-Beauchet-Filleau A. et al., 2018; Savchenko Y.I. et al., 2014), peas and chickpeas may be attractive alternative substitutes for “high-protein” feed ingredients, as well as cereals in ruminant diets due to their relatively high crude protein content and starch concentration. This is also supported by the findings presented in the review by Rungruangmaitree R. and Jiraungkoorskul W. (2017), which highlighted the health benefits of legume seeds and confirmed the antibacterial, antidiabetic, antifungal, anti-inflammatory, antioxidant and anticarcinogenic effects of pea seeds.

According to the authors (Osmane B. et al., 2017), when dairy cows were fed diets containing beans and peas, the fat and protein content in milk significantly increased, and the total amount of amino acids increased in bulk milk samples. In addition, the addition of field peas to fattening cows that consumed hay from medium-quality grasses increased the overall gain in live weight (Soto-Navarro S.A. et al., 2012). As a protein supplement for feeding beef cattle, the authors (Anderson V. et al., 2007) recommend including field pea grain in an amount of 15 to 30% of the diet (dry matter basis). According to their data, the inclusion of at least 10% of field pea grain in the finishing diet improved the tenderness and juiciness of beef, without affecting the properties of the carcass.

Foreign researchers (Degola L., Jonkus D., 2018; Hanczakowska E. et al., 2019) did not show a negative impact of the use of legume seeds in pig feeding on meat quality. On the contrary, Hanczakowska E. and Świątkiewicz M. (2014) and Sirtori F. et al. (2015) in their studies note a positive impact of feed mixtures containing legume seeds on the quality indicators of pork. Taking into account the results of studies presented by many authors (Prandini A. et al., 2011; Sońta M. et al., 2021) on the use of legume grains in feeding animals for fattening and their various effects on the quality of livestock products, continued research in this regard seems quite justified.

The purpose of the research is to establish the productive and slaughter qualities of bulls, the digestibility of nutrients and the balance of Nitrogen in the body when using various high-protein feeds in animal diets - peas and field peas.

Materials and methods of research. For the research, bulls of the Ukrainian black-and-white dairy breed were used, which were kept in the conditions of the physiological yard of the Institute of Agriculture of the Polissya NAAS. For the accuracy of the experiments, two separate groups of animals were formed, which were kept on a leash. The formation of experimental groups was carried out using the balanced group method according to the methodological provisions of Ibatullin I. and Zhukorsky O. (2017). The selection and comparison of animals for testing lasted 31 days. After the end of the comparative period, 10 animals with similar indicators were selected for each group of experimental bulls. The study was conducted in the village of Grozyne, Korosten district, Zhytomyr region, which belongs to the territory with a density of radioactive



contamination up to 185 kBq/m² (zone III). The duration of the experimental period is 122 days.

The experimental bulls were fed twice - in the morning and in the evening. The animals had free access to automatic water troughs throughout the day.

According to the main study design, during the experiment, young cattle of the control group were fed with farm ration feed, which included cereal hay, cereal-legume hay, fodder beet, grain mixture, pea husks and table salt. Pea husks were replaced with diaper husks for the animals of the experimental group. The deficiency of trace elements in the diet was ensured by introducing copper and zinc sulfate, cobalt chloride and potassium iodide into its composition.

Diets formed in accordance with modern detailed feeding standards and taking into account the actual composition and nutritional value of feed, fully provide the animal body with energy and make it possible to fully reveal the genetic potential in terms of their productivity (Ibatullin I.I. et al., 2016).

Against the background of scientific and economic research, in accordance with generally accepted methods in zootechnics (Ibatullin I.I., Zhukorsky O.M., 2017), a balance experiment was conducted to determine the influence of the studied factors on the digestibility of nutrients in feed rations and the assimilation of Nitrogen in the body of bulls. For the exchange experiment, three animals were selected from each group, which were kept in individual cages on a leash. The duration of the preparatory period was 10 days, the main (accounting) period was 7 days. During the research period, individual records of feed consumed and excreted feces and urine were kept, with the selection of average samples for analysis.

Before taking the average sample, feces were well mixed and taken in an amount of 10%, placed in glass jars with ground lids, while for its preservation, a 5% solution of hydrochloric acid was added at the rate of 10 ml per 100 g of feces, as well as a few drops of chloroform.

After weighing, urine was filtered and placed in jars with ground lids, taking an average sample in an amount of 5%, and for its preservation, a 10% solution of hydrochloric acid was added at the rate of 5 ml per 100 g of urine and 1-2 ml of thymol. After weighing the feed residues, an average sample (10%) was taken and placed in a glass jar with ground lids, where a few drops of chloroform were added for preservation.

All average samples were stored until laboratory tests at a temperature of 5-70 °C.

The nutritional value of the rations was determined based on the chemical analysis of individual feeds and their residues. Zoochemical analysis of feeds was carried out according to generally accepted methods in the laboratory of agrochemical research, environmental safety of lands and product quality of the Institute of Agriculture of Polissya NAAS (Kostenko V. M. et al., 2008; Vlizlo V. V. et al., 2012). A portion of feeds, their residues, feces, urine was dried in a drying oven to an air-dry state at a temperature of 60-65 °C and the initial moisture was determined. Then, by drying the air-dry portion in a drying oven to a constant mass at a temperature of 100-105 °C, hygroscopic moisture was investigated. Total moisture was determined by calculation.

In addition, the following were determined in the studied material: total Nitrogen – by the classical Kjeldahl method; crude fiber – by Henneberg and Stoman; crude fat – by the method of extraction of an absolutely dry sample in a Soxhlet apparatus; crude ash – by combustion in a muffle furnace at a temperature of 500–600°C; Calcium – by the trilonometric method using fluorexon; Phosphorus – by the photolorimetric method; crude protein, nitrogen-free extractives (BER), metabolic energy – by calculation; digestible protein, sugar, starch, trace elements, vitamins – according to reference data (Bomko V. S. et al., 2010). Nutrient digestibility was calculated by the difference between



nutrients that entered the animal body with feed and their amount excreted with feces. Nitrogen balance in the body of bulls was calculated as the difference between the amount of substances consumed from feed and their excretion with feces and urine.

Live weight of bulls was determined by individual weighing before morning feeding at the beginning and end of each experimental period and monthly, and payment for food feed by live weight gain was calculated (based on the expenditure of metabolic energy per unit of production in animals of the control and experimental groups).

To assess meat qualities, a control slaughter of animals was carried out - 3 heads from each group, the live weight of which corresponded to the average indicators in the groups, using the technology adopted at meat processing enterprises. The weight of a paired carcass and internal fat, slaughter indicators were calculated by dividing the weight of a paired carcass by the live weight after starvation.

The results of the studies were processed by standard methods of variational statistics using POM and computer programs for statistical processing Microsoft Excel were used. The levels of statistical significance (reliability) in the tables were indicated using letter superscripts in the following correspondence: * $P > 0.95$; ** $P > 0.99$; *** $P > 0.999$ (Ruban S.Yu. et al., 2020).

During the experimental studies, all biotic requirements for animals were observed, which correspond to the Law of Ukraine "On the Protection of Animals from Cruelty" dated 03/28/2006 and the "European Convention for the Protection of Vertebrate Animals" dated 11/13/1987, the Order of the Minister of Education and Science, Youth and Sports of Ukraine dated 03/01/2012 No. 249, registered in the Ministry of Justice of Ukraine on March 16, 2012 under No. 416/20729 on the "Procedure for Conducting Experiments and Experiments on Animals by Scientific Institutions (European..., 1986; Order of the Ministry of Education..., 2012).

Research results. A characteristic feature of young animals is their ability to grow and increase live weight. The increase in body weight of young animals is influenced by the fullness of feeding. The productive effect of the feeding factors studied is usually assessed primarily by the parameters of growth and development of animals, the consumption of feed nutrients and energy per unit of growth.

The results of the studies showed that under the same conditions of feeding and keeping animals, bulls, depending on the type of protein feed in the diet, had different live weights at the end of the experiment (Table 1). At the beginning of the studies, the live weight of the experimental animals ranged from 277.8 kg to 281.7 kg in terms of groups. The intergroup difference in this indicator was insignificant and amounted to 1.0% in favor of bulls of the I (control) group. The use of field peas in the grain mixture for fattening young cattle of the II group led to an increase in their live weight at the end of the experiment to 403.6 kg, which is 18.0 kg more than the indicator of peers of the I group with a significant intergroup difference ($P > 0.95$).

By optimizing the protein nutrition of bulls at the expense of various high-protein feeds, a high intensity of their growth was obtained. Thus, this indicator when using peas for feeding animals was 875 g, field peas - 1023 g. Young cattle of the II (experimental) group in terms of average daily live weight gains exceeded their peers from the I (control) group by 148 g, or by 16.9% with a significant difference ($P > 0.95$). The expenditure of metabolic energy and digestible protein per 1 kg of live weight gain varied within 103.0-120.5 MJ and 818-957 g, respectively. These indicators in bulls of the II group compared to their peers in the I group were lower by 14.5%.



Table 1

Live weight gain of fattening bulls and metabolic energy expenditure per 1 kg of gain (n=10; M ± m)

Indicators	Groups	
	control (I)	experimental (II)
Live weight, kg: at the beginning of the experiment	281,7 ± 4,71	278,8 ± 3,32
at the end of the experiment	388,5 ± 3,44	403,6 ± 4,10*
Live weight gain: absolute, kg	106,8 ± 4,51	124,8 ± 4,47*
average daily, g	875 ± 34	1023 ± 33*
+ or – to control: g	-	+148
%	-	+16,9
Nutrient consumption per 1 kg of live weight gain:		
- metabolizable energy, MJ	120,5	103,0
- - digestible protein, g	957	818

Note: *P > 0.95.

Based on the obtained research results, it can be concluded that balancing the rations for digestible protein at the expense of diaper compared to peas during fattening of bulls in the Polissya zone of Ukraine has a positive effect on their growth rate and feed conversion.

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The meat productivity of young cattle is determined by the genotype, level and quality of feeding, and production technology. The main criteria for its assessment are pre-slaughter live weight, carcass weight and yield, slaughter weight and slaughter yield. The obtained results indicate good slaughter qualities of the experimental animals, while no significant intergroup differences were found in carcass weight and yield and slaughter yield (Table 2). The pre-slaughter live weight of young cattle ranged from 399.3 kg (group I) to 406.3 kg (group II). According to this indicator, the animals of the experimental group exceeded their peers of the control group by 7.0 kg, or by 1.7% with an insignificant difference (P<0.95). Against the background of a greater pre-slaughter live weight of bulls of group II relative to analogues of group I, the carcass yield did not differ significantly - 51.8-52.5%. The slaughter yield varied from 53.6 to 54.3% and is characteristic of fattening young animals of the Ukrainian black-and-white dairy breed. In animals of group II (experimental) the slaughter yield was 0.7% abs. higher than in the control.



Table 2

Slaughter qualities of experimental bulls (n = 3; M ± m)

Indicators	Groups	
	control (I)	control (I)
Pre-slaughter live weight, kg	399,3 ± 5,78	406,3 ± 1,81
Weight of paired carcass, kg	206,8 ± 9,32	213,3 ± 4,19
Carcass yield, %	51,8 ± 1,97	52,5 ± 0,78
Weight of internal fat, kg	7,4 ± 0,80	7,4 ± 0,69
Fat yield, %	1,85 ± 0,19	1,82 ± 0,17
Slaughter weight, kg	214,2 ± 10,11	220,7 ± 4,49
Slaughter yield, %	53,6 ± 2,22	54,3 ± 0,93

Analysis of the results of the balance experiment showed that the digestibility of nutrients in the diets of bulls of both groups was at a sufficiently high level (Table 3).

Table 3

Digestibility of nutrients in the diet of bulls, % (n=3; M ± m) (n=3; M ± m)

Nutrients	Groups	
	control (I)	control (I)
Dry matter	74,2 ± 1,42	74,4 ± 0,89
Crude protein	59,3 ± 0,38	63,2 ± 0,93*
Crude fat	53,5 ± 2,80	52,1 ± 1,33
Crude fiber	70,2 ± 1,78	71,1 ± 1,72
nitrogen-free extractive substances	83,7 ± 1,82	83,4 ± 1,19

Note. *P > 0,95.

After analyzing the results of the research, it can be stated that the digestibility coefficients of feed nutrients in the body of the experimental bulls were within the range typical for this live weight of animals, and did not significantly differ between the groups, with the exception of crude protein. The digestibility of crude protein in the body of animals of the experimental group, which were fed diaper rags as part of the diet, was significantly higher compared to the peers of the control group by 3.9% abs. (P > 0.95).

In complex metabolic processes, one of the main places belongs to protein metabolism, the main indicator of which is the balance of Nitrogen in the body of animals. The study of the balance of Nitrogen in animals has both scientific and practical significance, and with the use of new feed - even more so. Balance is one of the factors characterizing the biological value of feed and is the main indicator of the degree of use of nitrogenous substances of feed by animals, allows us to give a fairly objective assessment of metabolic processes associated with the transformation and synthesis of proteins in the body.

The results of the experiment on the use of Nitrogen from feed rations in the body of fattening bulls, under the influence of the studied factors, are presented in Table 4. The analysis of the physiological experiment shows that the balance of Nitrogen in the body of young cattle of both experimental groups was positive and was at a sufficient level to meet physiological needs. At the same time, some intergroup differences in the excretion of Nitrogen with feces and urine were established, which significantly affected the efficiency of the use of digested Nitrogen in the body of animals. It was found that with the feces of bulls of group I, a greater amount of Nitrogen was excreted than in analogues from group II by 3.51% abs.



Table 4

**Average daily balance of Nitrogen in the body of experimental animals, g/head.
(n=3; M ± m)**

Indicators	Groups	
	control (I)	control (I)
Intaken with feed	240,62	235,22
Excreted with feces	88,21 ± 1,50	77,98 ± 3,96
% of intake	36,66	33,15
Digested	152,41 ± 1,50	157,24 ± 3,96
Excreted with urine	24,59 ± 2,54	25,72 ± 2,53
% of intake	10,22	10,93
Total excretion	112,80 ± 1,90	103,70 ± 1,94*
Deposited in the body	127,82 ± 1,90	131,52 ± 1,94
Absorbed, %: of intake	53,12 ± 1,20	55,91 ± 1,24
of digested	83,87 ± 1,69	83,64 ± 1,36

Note. *P > 0,95.

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According to the results of the research, it was found that in young cattle of group II (experimental), the grain mixture of which included of field peas, the average daily excretion of Nitrogen with urine was the largest - 25.72 g, which is 10.93% of the intake. As a result, the animals of the experimental group excreted 9.10 g/head/day less nitrogen with feces and urine than the same-sex animals of the control group (P > 0.95). Therefore, in the body of bulls of group II, nitrogen deposition was 131.52 g/head/day, or was 2.89% higher than the indicators of analogues from group I (P < 0.95). In addition, the introduction of field peas into the feed rations increased nitrogen absorption in young cattle of the experimental group compared to the control by 2.79% abs. Nitrogen absorption from digested food between animals of both groups did not differ significantly and was 83.64-83.87%.

Discussion. *Pisum sativum* L., known as green peas, dry peas or field peas, is an important legume crop that is a source of proteins, vitamins, minerals and biologically active compounds that are beneficial to human health (Fahmi R. et al., 2019). Peas are cultivated in almost all countries of the world and are considered an integral part of the human diet (Han X. et al., 2023). The largest producer of peas in the world is Canada, followed by China, Russia and India (Raghunathan R. et al., 2017).

The energy nutritional value of 1 kg of pea grain is 11.2 MJ of metabolic energy with a content of 192-195 g of digestible protein, 12.7-14.2 - lysine, 4.3-5.5 - methionine with cystine, 2.0 - tryptophan, 2.0-2.5 - calcium and 3.5-4.3 g of phosphorus (Gnoevy V.I. et al., 2009; Ge J. et al., 2020). Higher growth intensity indicators and nitrogen balance in the body of bulls of group II compared to their peers of group I can be explained by a slightly better provision of their diets with protein and its better amino acid composition. The content of essential amino acids in the diet feed can serve as one of the indicators of the overall quality of protein.

At the same time, according to the authors (Shi L. et al., 2018; Hugman J. et al.,



2021), peas contain, albeit in small quantities, anti-nutrients (trypsin inhibitors, tannins, lectins, and phytic acid). Therefore, when pea grains are fed to animals without prior preparation and in significant quantities, protein digestibility decreases and growth slows down (Wu D.-T. et al., 2023), which is consistent with the results of the conducted studies. In addition, according to reports by domestic and foreign authors, in ruminants, an increase in the amount of tannins above a certain level suppresses the rumen microflora, which negatively affects their use of feed nutrients (Savchenko Y.I. et al., 2014; Ge G. Et al., 2021).

Conclusions.

1. The use of field peas in the feed rations of bulls for fattening compared to peas to ensure the normalized need for digestible protein in the conditions of Polissya, Ukraine significantly increases the average daily gain in live weight (by 16.9%) and reduces the expenditure of metabolic energy per unit of gain (by 14.5%), without significant intergroup differences in slaughter indicators.

2. Optimization of protein nutrition of animals by introducing of field peas into the ration had a positive effect on the digestibility of crude protein in the body of bulls of the experimental group, which turned out to be significantly higher compared to the peers of the control group by 3.9% abs. ($P > 0.95$). Nitrogen deposition in the body of young cattle of group II was 131.52 g/head/day, or was higher than the indicator of analogues from group I by 2.89% ($P < 0.95$).

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