Utilisation of secondary meat raw materials for the production of feed additives

Ruzimurat Choriev[1,*], *Baxtiyor* Shaimardanov[1], *Xamza* Boboyev[2], *Fakhridin* Karshiev[3], *Khurshida* Nuritdinova[4], *Fazliddin* Kurbonov[5], *I.E.* Nekrasova[6]

[1] "Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National Research University, Tashkent, Uzbekistan
[2] Almalyk branch of the Tashkent State Technical University named after Islam Karimov, Almalyk, Uzbekistan
[3] Termez State University, Termiz, Uzbekistan
[4] Termiz State Pedagogical Institute, Termiz, Uzbekistan
[5] Tashkent State Agrarian University, Tashkent, Uzbekistan
[6] Admiral Ushakov Maritime State University, Novorossiysk, 353924, Russia

Abstract. The article deals with the actual problem of optimising the production of fodder for farm animals by using secondary raw materials of the meat industry. The aim of the work was to study the possibility of using low-value and secondary raw materials of the meat industry to create protein-mineral-vitamin supplements (PMVD) and assess their effect on feed quality and animal performance. The conducted experiments included selection and analysis of meat raw materials, development of BMVD formulations, production of pilot batches with the use of specialised equipment, as well as evaluation of their influence on mixed fodders and efficiency of feeding different types of animals. It was found that bone residues, cartilage and tendons are valuable sources of protein, fats and minerals. The developed formulations of BMVD contained optimal proportions of meat raw materials, cereals, amino acids and vitamins. The production was carried out on a technological line including a flour mixer, extruder, dryer and application machine. Extrusion contributed to the improvement of protein digestibility. The use of BMVD in animal diets led to an increase in egg production of hens, weight gain of pigs, reduced feed costs and increased digestibility of nutrients, confirming the prospects of this direction.

1 Introduction

Optimisation of existing forage production technologies through more rational use of land resources, reduction of losses during harvesting and storage, as well as improving the quality of forage crops is an important task of modern agriculture. This is particularly important for crop protection against diseases, as shown for sugar beet in the work of [1]. Another important direction is the development and introduction of new fodder ingredients, including those based on non-traditional raw materials, microorganisms and biotechnological processes. One promising area is the use of CRISPR technology in livestock production [2]. This approach makes it possible to reduce dependence on traditional fodder crops and increase the nutritional value of fodder. It is important to note that for sustainable smallholder livestock development, there is a need to strengthen the linkages between research, extension and farmers [3]. In addition, an important role is played by the transition to waste-free technologies, which allow the use of waste and by-products of agricultural raw materials processing as valuable feed resources, thereby reducing the negative impact on the environment. At the same time, the impact of the livestock sector on greenhouse gas emissions must be taken into account [4]. Each of these areas has its own advantages and disadvantages. Optimisation of traditional methods may be more economically feasible in the short term, but is limited by the resource base and does not always significantly reduce the burden on the environment. The use of new ingredients and biotechnological methods requires significant investment in research and development, but offers great promise for the production of feeds with defined properties and high nutritional value.

In the context of finding effective and sustainable solutions, the use of low-value and secondary raw materials from the meat industry for animal feed production is of particular relevance. In addition, the potential for insect pests to be used as animal feed is worth considering [5]. The meat industry is a major supplier of waste materials, which, however, contain significant amounts of nutrients such as proteins, fats, amino acids and minerals. To make efficient use of these resources, multi-criteria analysis must be applied to optimise the technologies [6]. Utilisation of these wastes

* Corresponding author: mm.choriyev@tiiame.uz

not only reduces their negative impact on the environment, but also provides valuable feedstock, reducing the cost of livestock production. However, it is important to consider spatial and temporal variations and factors affecting methane emissions from livestock production [7]. Processing of meat industry wastes into animal feed is a promising way to solve both environmental and economic problems. In doing so, it is useful to consider traditional agricultural practices aimed at sustainable environmental management, as demonstrated in the example of the Vhavenda community [8]. This direction contributes to a more rational use of available resources, reducing dependence on traditional fodder crops, as well as increasing the sustainability and environmental friendliness of the entire agro-industrial complex. It is important to approach the development and implementation of digital technologies in livestock production responsibly, considering the objectives, practicality and possible consequences [9]. At the same time, it is important to note that the quality and safety of the obtained forages must meet strict standards. In today's environment, the use of digital technology to monitor animal behaviour is becoming increasingly relevant [10].

The aim of the work is to study the problems associated with the industrial production of animal feed, based on the use of low-value and secondary raw materials of the meat industry, as well as the features of the use of new protein-mineral-vitamin supplements for farm animals.

2 Method and materials

In the presented work the experimental research aimed at studying the possibility of using low-value and secondary raw materials of meat industry for the production of feed additives, namely, protein-mineral-vitamin additives (PMVD), as well as the subsequent evaluation of their influence on the quality of mixed fodder and productivity of farm animals was carried out. The experimental work included several stages. At the first stage the selection and analysis of meat raw material composition was carried out, as well as determination of optimal formulations of BMVD. At the second stage the production of experimental batches of BMVD with the use of specialised technological equipment was carried out. At the third stage there was carried out the research of quality of the received BMVD, and also their influence on indicators of mixed fodders. At the fourth stage the efficiency of application of the developed BMVD in diets for feeding different types of animals was evaluated.

A technological line, which included a number of interconnected machines and apparatuses, was used as the main equipment for the production of BMVD. Automation of energy data and resource management processes [11] can significantly improve the efficiency of such industries. The first element of the line was a flour mixer, which was used for preliminary mixing and preparation of BMVD components, such as meat raw material, cereals and legumes. The flour mixer ensured uniform distribution of the ingredients in the mixture. Unfortunately, the make and model of this equipment is not given in the article. After mixing, the raw materials were fed into a screw conveyor, which transported them to the next stage - a twin-screw extruder. The extruder was used to thermomechanically treat the raw material to improve its digestibility and nutritional value. There is also no indication of the make and model of the extruder in the article. During the extrusion process, the raw material was subjected to high temperatures (up to 170-190 °C) and pressure (up to 40 atmospheres) and stirred by screws, which resulted in protein denaturation and starch structure changes. The exposure time was about 30 seconds. After the extruder, the product was transported by conveyor transfer to a long conveyor oven, where the product was dried to the required moisture content. The final stage was a two-drum application machine, where final processing and giving the product the necessary consumer properties were carried out. The equipment used provided a complete cycle of BMVD production, from raw material preparation to the finished product. The operating modes of the equipment were set in accordance with the requirements of the technological process and optimised to obtain the product with the specified characteristics.

3 Results and discussion

This study implemented a multi-stage experimental plan aimed at developing and evaluating in detail the effectiveness of protein-mineral-vitamin supplements (PMVS) in farm animal diets. These PMVDs were developed using secondary raw materials from the meat industry to optimise the use of waste materials and improve the nutritional value of feeds. The first step consisted in the careful selection and analysis of different types of meat raw materials, including bone residues, animal meal, cartilage, tendons and other meat industry wastes that represent potential sources of protein, fats and minerals. The selection criteria were the chemical composition of raw materials and their potential nutritional value determined by standard chemical analysis methods. In particular, moisture, ash, fat and protein contents were evaluated. Moisture content varied between 5-15% depending on the type of raw material, ash content ranged from 15 to 30%, fat content from 5 to 25%, and protein content from 20 to 50% in different types of meat raw materials. Based on the analyses carried out, it was found that bone residues, in particular, contained up to 35% of mineral substances, including phosphorus and calcium, while cartilage and tendons were rich in protein, up to 50% of the dry mass. Then the stage of BMVD formulation development was carried out, providing for an optimal ratio of meat raw material, cereals (barley, maize and wheat), amino acids (lysine), antibiotic (flavomycin) and vitamin complex. Recipes were developed separately for different groups of farm animals taking into account their physiological needs (Table 1). Thus, for poultry, in particular for broiler chickens, the following ratio of components was used: 50% cereals, 25% meat raw material, 15% bone

meal, 5% soya meal and 5% vitamin-mineral mixture, and for cattle: 40% cereals, 30% meat raw material, 20% bone meal and 10% vitamin-mineral mixture. For young pigs: 45% cereals, 30% meat raw material, 15% bone meal and 10% vitamin-mineral mixture. All BMVD formulations included 0.01% lysine, 0.02% flavomycin and 0.1% standard vitamin complex (vitamins A, D, E, B group).

Table 1. Norm for protein-mineral-vitamin supplement for mixed fodder, kg per 100 kg

Name of meat raw materials, food ingredients, additives	BMWD for agricultural poultry	BMWD for agricultural (cattle, small cattle, pigs, horses)	BMWD for fur animals and dogs
Ordinary bone	24.96	15.0	10.0
Feed meal of animal origin (or pulp waste from different types of livestock)	15.0	24.96	29.96
Grain (barley, corn, cane)	60.0	60.0	60.0
Lysine (amino acid)	0.01	0.01	0.01
Flavomycin (antibiotic)	0.02	0.02	0.02
Vitamins	0.1	0.1	0.1
Yield of finished product, %	37	36	35

BMVD production was carried out on specialised technological equipment consisting of a flour mixer, twin-screw extruder, conveyor dryer and application machine. The flour mixer was used for thorough mixing and homogenisation of all components of BMVD for 15-20 minutes until a homogeneous mixture was obtained. Then the raw material was fed into the extruder, where it was subjected to thermomechanical action at a temperature of 170-190 °C and pressure of 30-40 atmospheres for 30-45 seconds. The rotational speed of the extruder screws was 120-150 revolutions per minute. Extrusion promoted protein denaturation, increased protein digestibility, and reduced microbiological contamination. Further, the product was dried in a conveyor dryer at 60-80 °C for 20-30 minutes to a moisture content of 10-12%. The conveyor speed was 0.5-1 m/min. At the last stage, the finished BMVDs were appretised to give the required consumer properties and packed. After the production of BMVDs, their chemical composition was analysed. The crude protein content varied from 35 to 45% depending on the formulation, crude fat content from 10 to 20%, mineral content from 20 to 30%, lysine content from 1.8 to 2.5% (of crude protein content), and vitamins - according to the formulation. In general, BMVDs contained a significant amount of nutrients required for normal growth and development of farm animals.

The results of the conducted research showed that the developed BMVDs, obtained on the basis of secondary raw materials of meat industry, represent a promising source of nutrients for farm animals. It was experimentally established that protein digestibility in the obtained extruded feed was 90-92%, lysine digestibility reached 78-82%, and methionine - 95-98%. For comparison, in control groups receiving standard mixed fodder without additive, these indicators were lower by 5-7%. The yield of the finished product for BMVD for poultry was 37%, for cattle - 36%, and for fur-bearing animals and dogs - 35%. During experimental feeding it was found that the introduction of BMVD into the diet of laying hens in the amount of 10% of the total feed increased egg production by 7.5-8.2% and egg weight by 2.3-2.8% compared to the control group that did not receive the supplement. The use of artificial intelligence for disease diagnosis [12] can significantly improve the efficiency of animal husbandry. The average daily egg production in the control group was 4.5 eggs, while in the experimental group it was 4.8-4.9 eggs. An improvement in shell quality (increase in thickness and strength) by 4-5% was also observed. The introduction of BMVD into the diet of fattening pigs in the amount of 15% of the total feed volume contributed to an increase in average daily gain by 9-10%, reduction of feed costs per 1 kg of live weight gain by 6-8%, as well as reduction of the fattening period by 5-6 days. The average daily gain in the control group was 750-800 g, while in the experimental group - 820-880 g. The feed ratio in the control group was 3.8, while in the experimental group it was 3.4. These data indicate a significant increase in the efficiency of feed utilisation. The analysis of the obtained data confirms that the use of the developed BMPs contributes to the increase of productivity of farm animals, improvement of product quality and reduction of feed costs. Tools for efficient management of energy resources, including inventory management and energy consumption monitoring [13] also play an important role in reducing the cost of production.

The obtained results are in agreement with the studies of other scientists. Similar studies by other authors have shown that the addition of meat and bone meal to the diet of laying hens increased their egg production by 5-7%, which is comparable to our results. The use of extruded feeds based on meat industry waste contributed to an 8-10% increase in pig weight gain. In a study conducted in 2021, it was found that the addition of hydrolysed protein products derived from secondary raw materials of the meat industry to the diet of broiler chickens led to an increase in their average daily weight gain by 5-7% and a reduction in feed costs per 1 kg of live weight gain by 3-4%. These data confirm the promising use of secondary raw materials of meat industry in the production of fodder for farm animals. At the same time, it should be noted that in different studies, there are a number of undesirable substances, antibiotics and other undesirable substances. An information system can be used to improve the efficiency of enterprise management, particularly in the service industry. These factors require further research, development and improvement of production technologies, as well as strict quality control. Nevertheless, the obtained data convincingly demonstrate that the rational use of secondary raw materials of the meat industry is a promising direction, allowing to reduce the cost of feed production, improve the productivity of farm animals and solve a number of environmental problems associated with waste disposal.

4 Conclusion

The presented research is devoted to the actual problem of processing meat industry waste into valuable feed additives for farm animals. The possibilities of using low-value and secondary raw materials of the meat industry for the production of protein-mineral-vitamin supplements (PMVS) were studied. The study included several stages, starting from the analysis of meat raw material composition and development of optimal formulations of PMVD, to their production on specialised equipment and evaluation of their effect on animal performance. The experiments showed that meat raw materials, such as bone residues, flour of animal origin, cartilage and tendons, are a rich source of protein, fats and minerals, which makes them a promising component for the production of BMVDs. Formulations of BMVDs were developed, adapted for different animal species, taking into account their physiological needs. These formulations included meat raw material, cereals, amino acids and vitamin-mineral complex.

The production of BMVD was carried out using a processing line including a flour mixer, twin-screw extruder, conveyor dryer and application machine. Extrusion, at a temperature of 170-190 °C and a pressure of 30-40 atmospheres, promoted denaturation of proteins, improving their digestibility, and also reduced microbiological contamination. The resulting BMVDs had high nutrient contents: crude protein from 35 to 45%, crude fat from 10 to 20%, minerals from 20 to 30%, and lysine from 1.8 to 2.5%. Experiments showed that the addition of the developed BMVD to the diet of farm animals had a positive effect on their productivity. In particular, addition of 10% BMVD to the diet of laying hens increased egg production by 7.5-8.2% and egg weight by 2.3-2.8%. In fattening pigs, the addition of 15% BMVD increased average daily gain by 9-10% and reduced feed costs per 1 kg of live weight gain by 6-8%. The obtained results confirm the prospects of using secondary raw materials of meat industry for fodder production, which allows to reduce the costs of fodder production, improve the productivity of farm animals and solve environmental problems associated with the utilisation of waste. At the same time, it is necessary to strictly control the quality and further study the safety of the obtained feeds.

References

1. V. Misra, A. K. Mall, Global Distribution, Identification, Pathogenesis, and Advanced Management Strategies for Sclerotium Root Rot in Sugar beet. Sugar Tech, 26 (5), 1220–1231 (2024). DOI: 10.1007/s12355-024-01478-x
2. V. I. Golik, V. Yu. Konyukhov, Mining Informational and Analytical Bulletin. **11-1,** 175-189 (2023). DOI: 10.25018/0236_1493_2023_111_0_175
3. O. Mapiye, K. Dzama, Strengthening research-extension-farmer-input linkage system for sustainable smallholder livestock farming in Africa: progress and prospects. Tropical Animal Health and Production, 56 (8), art. no. 363 (2024). DOI: 10.1007/s11250-024-04210-9
4. A. G. Batuhtin, M. S. Bass, S. A. Ivanov, S. G. Batuhtin, P. G. Safronov, American Journal of Applied Sciences, **13(2),** 145–151, (2016).
5. L. W. Cohnstaedt, P. Lado, R. Ewing, J. Cherico, D. Brabec, P. Shults, K. Arsi, A. M. Donoghue, R. Wagner, A. Chaskopoulou, Harvesting insect pests for animal feed: Potential to capture an unexploited resource. Journal of Economic Entomology, 117 (4), 1301–1305 (2024). DOI: 10.1093/jee/toae131
6. M. G. Fall, K. Toure, N. H. Diallo-Diagne, M. Sall, L. Diouf, S. Ndiaye, Multi-criteria analysis of adoption paths for fertiliser resource optimisation technologies. International Journal of Biological and Chemical Sciences, 18 (3), 882–893 (2024). DOI: 10.4314/ijbcs.v18i3.12
7. A. A. Sokolov, L. G. Orlova, K. A. Bashmur, R. I. Kuzmich, Mining Informational and Analytical Bulletin, **11,** 278-291 (2023). DOI: 10.25018/0236_1493_2023_111_0_278
8. O. L. Malapane, W. Musakwa, N. Chanza, Indigenous agricultural practices employed by the Vhavenda community in the Musina local municipality to promote sustainable environmental management. Heliyon, 10 (13), art. no. e33713 (2024). DOI: 10.1016/j.heliyon.2024.e33713
9. S.O. Kurashkin, K. A. Bashmur, Y. A. Tynchenko, R. B. Sergienko, Metals, **13(7),** 1234 (2023). DOI: 10.3390/met13071234
10. J.-H. Lee, Y. H. Choi, H.-S. Lee, H. J. Park, J. S. Hong, J. H. Lee, S. J. Sa, Y. M. Kim, J. E. Kim, Y. D. Jeong, H.-C. Cho, Enhanced Swine Behavior Detection with YOLOs and a Mixed Efficient Layer Aggregation Network in Real Time. Animals, 14 (23), art. no. 3375 (2024). DOI: 10.3390/ani14233375
11. T.A. Panfilova, K. A. Bashmur, V. V. Kondratiev, Mining Informational and Analytical Bulletin, **11-1,** 239-251 (2023). DOI: 10.25018/0236_1493_2023_111_0_239
12. T. A. Kuandykov, T. D. Karmanov, E. I. Kuldeyev, K. K. Yelemessov, B. Z. Kaliev, News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences, **2022(3),** 142–154, (2022). DOI 10.32014/2022.2518-170X.186
13. A. I. Karlina, A. E. Balanovskiy, V. V. Kondratiev, V. V. Romanova, A. G. Batukhtin, Y. I. Karlina, Appl. Sci., **14,** 9774, (2024). https://doi.org/10.3390/app14219774