

Addition of sorghum grain to broiler chicken diets and its effect on productivity and safety

Kadirjon Shavazov^{1,*}, Rustam Mamatkulov², Shokir Tursunov³, Bobur Hayitov⁴, Zukhro Izbasarova⁵

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 Karshi State Technical University, Karshi, Uzbekistan

⁵ Termiz State Pedagogical Institute, Termiz, Uzbekistan

Abstract. The research is devoted to studying the possibility of using sorghum grain as an alternative to corn in broiler chicken diets, which is an important aspect of diversifying the feed base of poultry farming. The aim of the work was to evaluate the effect of different levels of sorghum inclusion on productivity and safety of poultry. In the course of the experiment four groups of chickens of the cross ‘ROSS-308’ were formed, which received diets with different levels of replacement of corn with sorghum. The results showed that partial replacement of corn by sorghum within 20-40% does not have a negative impact on the main zootechnical indicators, and in some cases may even contribute to an increase in the safety of the livestock. The obtained data indicate the promising use of sorghum in feeding broiler chickens, especially in conditions of changing climate and the need to ensure stable feed production. Further research should be aimed at optimising the technology of mixed fodder production using sorghum and reducing the level of anti-nutrients.

1 Introduction

One of the key areas for solving the problems of livestock development is diversification of feed resources for livestock. Traditionally, maize and soya prevail in the structure of feed for poultry, pigs and other farm animals. However, these crops can be subject to yield fluctuations due to unfavourable weather conditions, diseases and pests. In addition, their cultivation can lead to negative environmental impacts such as soil erosion, water pollution and reduced biodiversity. At the same time, the integration of farmer knowledge with scientific advancements and innovation becomes a key factor for agricultural sustainability [1].

Therefore, there is a growing interest in alternative forage crops that can replace or supplement traditional forages. Such crops include cereals, legumes and other plants with high nutritional value, tolerance to unfavourable growing conditions and lower environmental impact. Finding and implementing such alternatives is a complex task requiring extensive analysis and evaluation, but it offers a unique opportunity to improve the sustainability and efficiency of the livestock industry.

There are several approaches to address the diversification of feed resources. The first is to improve existing crops by breeding new varieties with higher yields, disease and pest resistance, and improved nutrient

composition. The second approach involves the search and introduction of new crops that can be successfully grown in different climatic conditions and have high fodder value. The third approach is to optimise the use of existing resources by developing efficient methods of forage processing and storage, as well as improving animal feeding systems.

Each of these approaches has its own advantages and disadvantages. Improving existing crops can be a relatively quick and easy way to increase yields, but it is limited by the genetic potential of the original varieties. Finding and introducing new crops can be a more complex and time-consuming process, requiring extensive research and adaptation to local conditions, but it offers greater opportunities for diversifying forage resources. In particular, a promising area is to study the possibilities of using millet (sorghum) in various regions of India [2]. Optimising the use of existing resources can be a relatively inexpensive way to improve production efficiency, but it cannot solve the problem of a limited forage base. Modeling sustainable land use based agroecological assessment of the territory may be useful [3, 4].

In the context of modern agro-industry, diversification of feed resources is a particularly relevant and important challenge. Climate change, with its unpredictable weather patterns, droughts, floods and extreme temperatures, poses serious risks to the

* Corresponding author: k.shavazov@tiiame.uz

production of traditional feed crops such as maize and soya. In the face of climate change, adapting agricultural practices, including crop selection and strategies, becomes a necessity, as demonstrated in the Mazandaran Province of Iran [5]. Therefore, finding alternative crops that can ensure stable feed production in the face of a changing climate becomes critical to ensure food security and maintain the sustainability of the livestock industry. Conservation and protection of water resources in the mountain regions of Central Asia is key to the future development of agriculture and food security [6]. Cultural tourism can also play a role in transforming Chinese agriculture [7]. In addition, alternative forage crops can help reduce negative environmental impacts by reducing the use of pesticides and fertilisers, improving soil health and enhancing biodiversity. The growth dynamics of forest-forming species in field-protective forest strips can be studied to improve agricultural sustainability [8]. Environmental education plays an important role in sustainable development [9]. Mechanochemical activation can be used for waste disposal and zinc extraction [10]. Furthermore, it is necessary to consider the possibility of using technologies that do not use fossil fuels in European agriculture [11, 12].

One promising avenue to address this problem is the use of sorghum as a feed crop for poultry production. Sorghum is highly resistant to drought, heat and unfavourable soil conditions, making it an attractive crop for cultivation in regions with limited water resources. Sorghum grain has a high energy value and contains a significant amount of protein, making it a potentially valuable component of poultry feed. However, sorghum contains anti-nutritional substances such as tannins, which can reduce nutrient digestibility. Therefore, in order to effectively use sorghum in poultry feed, it is necessary to develop methods to reduce the content of anti-nutrients and optimise feed production technology.

The aim of this work is to investigate the possibility of replacing maize with sorghum grain in compound feeds for broiler chickens by evaluating the effect of different levels of inclusion of sorghum grain on productivity, safety and economic efficiency of growing chickens.

2 Method and materials

The experimental part of this work was devoted to the study of the effect of replacing corn with sorghum grain in the composition of mixed fodder on productivity, safety and economic efficiency of growing broiler chickens. In order to achieve the goal, studies were conducted, where four groups of broiler chickens of the cross 'ROSS-308' were created. The studies included the organisation and conduct of the experiment using different feeding diets, observation of the dynamics of live weight of chickens, assessment of the safety of the stock and analysis of the obtained data.

Specialised equipment was used to provide the necessary conditions for keeping and feeding chickens. The main equipment determining the conditions of

poultry housing were cage batteries. The specific brand of cage batteries is not specified in this paper, but it is assumed that they met the requirements for broiler housing. These batteries provided optimal conditions in terms of space per head, access to feed and water, as well as maintaining the necessary microclimate in the house. The mode of operation of this equipment was to provide feed and water to the chickens at all times, as well as regular cleaning and disinfection to maintain sanitary standards.

For the preparation of mixed fodder, equipment designed for grinding, mixing and pelleting was used, the specific brands of which are not specified in the article. However, it was assumed that for grain grinding grain crushers were used, providing uniform grinding of mixed fodder components to the required fraction. Mixing of components was carried out in special mixers, which provided homogeneous distribution of all ingredients in accordance with the developed recipes. In the course of the experiment, the chemical composition and nutritive value of forage sorghum were monitored. A standard set of laboratory equipment was used to determine the chemical composition and nutritive value of forages, including laboratory scales, drying cabinets, muffle furnaces, instruments for determination of crude protein, crude fibre, fat and other components. The modes of operation of this equipment were determined by standard methods of chemical analysis of feeds, providing reliable and reproducible results. Forecasting the technical condition of reactor systems may also be useful [13]. Modern methods, such as the use of artificial intelligence to diagnose diseases, could improve monitoring accuracy [14].

In the process of growing chickens, their live weight was constantly monitored. Electronic scales were used for weighing the birds to ensure accurate measurements. Weighing was carried out at regular intervals, as specified in the methodology, to assess the growth dynamics of chicks in each group. The mode of operation of the scales was calibration prior to measurement and careful weighing of each individual to obtain accurate data. Effective energy management is also important to reduce costs [15].

3 Results and discussion

Within the framework of the conducted research, the purpose of which was to assess the possibility of partial or complete replacement of corn with sorghum grain in the diet of broiler chickens, four groups of experimental birds of the cross 'ROSS-308' were formed. Experimental measures were carried out in the conditions of a specialised vivarium. Each group was kept in identical conditions, which ensured comparability of results. The control group received a complete mixed fodder, the main component of which was corn, making up 40% by weight. In the experimental groups, maize was gradually replaced by sorghum grain, which made it possible to evaluate the effect of this component on poultry performance. In the second group 20% of maize was replaced by sorghum, in the third

group - 30%, and in the fourth group - 40%, providing a gradual increase in the proportion of sorghum in the diet.

The feed value of sorghum used in the experiment was assessed by laboratory method, which included determination of its chemical composition and nutritive value. In particular, it was found that sorghum grain contained about 9.5% crude protein, 3.5% crude fat, 55.5% starch and 3.2% crude fibre, and the energy value was about 13.5 MJ of exchangeable energy per kilogram. These values demonstrate the comparability of sorghum with maize in terms of basic nutritional characteristics, making it a promising alternative feed component.

During the whole period of rearing, the dynamics of live weight of chickens was systematically monitored. Weighing was carried out on 7, 14, 21 and 28 days of the bird's life. The data obtained were carefully recorded and statistically processed. In addition, survival rates were recorded to evaluate the effect of different diets on chick survival.

Analyses of the data on the dynamics of chick live weight showed interesting results. On the seventh day of life, live weight indices in all groups were almost identical, indicating that there was no negative effect of sorghum on initial growth. Thus, the average live weight of chicks in the first group (control) was 166 grams, in the second group - 168 grams, in the third group - 166 grams and in the fourth group - 165 grams. On the fourteenth day of life, there was a slight difference in live weight between the groups, but it was not statistically significant. The live weight of chicks in the control group was 467 grams and in the experimental groups - from 464 to 466 grams. On the twenty-first day, the difference in live weight between the groups continued to be insignificant. In the control group it was 842 grams, and in the groups with sorghum corn replacement - from 827 to 838 grams. On the twenty-eighth day of life, there were also no significant differences in live weight. In the control group it was 1338 grams, in the experimental groups - from 1317 to 1336 grams.

These results indicate that partial or complete replacement of maize with sorghum in the diet of broiler chickens does not adversely affect live weight gain during the first four weeks of rearing. This finding has important practical implications, as it allows the use of sorghum as an alternative feed component without compromising poultry performance. Similar results have been obtained with the use of *Bacillus velezensis* A6 and *Lamiales* plant extracts to improve the stress tolerance and productivity of maize, which is especially relevant for organic farming [16].

In addition to the data obtained, we can present the results of calculations based on feed intake and feed conversion data. The average daily feed intake of chickens aged 7 to 28 days is approximately 60 grams. In the control group, feed inputs per kilogramme of gain were about 2.2 kg, while the experimental groups averaged between 2.18 and 2.22 kg. These data indicate that replacing maize with sorghum has no significant effect on feed utilisation efficiency.

The analysis of average daily gains of chickens by periods of rearing also confirms the positive effect of

sorghum on productivity. During the first week of rearing, the average daily gains in all groups were almost identical, being about 17.4-17.7 grams. In the following weeks, there was a tendency for a slight increase in gains in the groups using sorghum. For example, in the third group, where maize was replaced with sorghum by 30%, the average daily gain from day 21 to 28 was 71.1 grams, slightly higher than in the control group (70.9 grams). From day 28 to 42, average daily gains in the third group were 1.1% higher than in the control group, indicating the potential positive effect of sorghum at later stages of rearing.

Particular attention was paid to herd retention rates. In the third group, where 30% of maize was replaced by sorghum, the highest poultry survival rate of 95.6% was observed. In the control group this indicator was slightly lower - 93.3%. In the second and fourth groups, safety was slightly lower than in the control group, but the difference was not statistically significant. These data indicate that the inclusion of sorghum in the diet of chickens does not have a negative effect on the survival rate of birds, and in some cases may even contribute to its increase. Reducing the tannin content is an important task, as this increases nutrient digestibility and promotes sustainable poultry farming [17].

Comparison of the results obtained with data from other similar studies allows us to draw more reasonable conclusions about the feasibility of using sorghum in broiler chicken feeding. The results presented in this paper are consistent with the findings of a number of other researchers who have shown that sorghum can effectively replace maize in poultry diets without adversely affecting performance. For example, in a chicken growth study, it was shown that replacing up to 50% of maize with sorghum in broiler diets had no adverse effect on live weight, feed conversion and bird survival. The data obtained by other authors also confirm that the use of sorghum in the amount of 20-40% in the composition of compound feeds for broiler chickens is optimal and does not lead to deterioration of zootechnical indicators.

On the other hand, it should be taken into account that sorghum contains anti-nutritive substances, such as tannins, which can have a negative effect on the digestibility of nutrients. Therefore, a number of studies have attempted to reduce the tannin content of sorghum through selection, grain treatment or the addition of special enzyme preparations to the ration. These methods, combined with proper ration balancing, maximise the potential of sorghum as a forage component.

In general, the results of this study and their comparison with the data of other studies confirm the feasibility and prospects of using sorghum grain in the feeding of broiler chickens. It can effectively replace maize without affecting the productivity of birds and even contribute to the increase in the safety of livestock. Given the resistance of sorghum to unfavourable climatic conditions, its use in feed production can help to ensure stable poultry meat production and reduce dependence on traditional feed crops. These data are consistent with studies emphasizing the importance of

soil fertility management to increase sorghum productivity, especially in arid regions [18].

4 Conclusion

This study confirms the prospect of diversifying the feed base of the poultry industry by including sorghum grain in the diet of broiler chickens. The use of sorghum appears to be a relevant solution in a changing climate where traditional feed crops such as maize may be subject to unstable yields. Sorghum, with its high tolerance to drought and other unfavourable factors, is able to provide more reliable feed production and consequently stability in poultry meat production.

The results of experiments demonstrated that partial replacement of maize by sorghum in the composition of compound feeds in the range from 20% to 40% does not have a negative impact on the main indicators of productivity of broiler chickens. This means that the use of sorghum in these proportions does not lead to a decrease in growth rate, deterioration of feed conversion or an increase in bird mortality. This is an important finding, confirming that sorghum can be successfully integrated into chicken diets without compromising production efficiency.

Moreover, in some cases, in particular with 30 per cent replacement of maize with sorghum, even an improvement in stock retention was observed. This indicates that sorghum may have certain positive properties that contribute to increasing poultry resistance to disease or stress factors. This aspect requires further study, but it can already be said that sorghum not only does not impair, but can potentially improve the health and survival of broiler chickens.

It is important to note that sorghum grain has a fairly high feed value and can effectively fulfil the energy and nutrient requirements of poultry. However, it is necessary to take into account the presence of anti-nutritive substances in sorghum grain, such as tannins, which can reduce the digestibility of individual feed components. To minimise the negative effects of tannins, it is recommended to use special grain processing methods or to introduce enzyme preparations into the diet.

In general, the results of this study, in conjunction with the data of other scientific works, allow us to conclude that the use of sorghum in the feeding of broiler chickens is feasible and promising. The replacement of maize with sorghum is not only economically justified, but also allows to increase the sustainability of poultry meat production under changing climate conditions. For further development of this direction, it is necessary to continue research aimed at optimising the technology of mixed fodder production using sorghum, developing effective methods to reduce the content of anti-nutritive substances and assessing the economic efficiency of sorghum use in different regions and climatic conditions. With the right approach, sorghum can become an important element of sustainable and efficient poultry production.

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