Sorghum as a substitute for corn in poultry feed

Mirshod Kurbonov, and *Rauf* Khaitov*

Bukhara Engineering-Technological Institute, Bukhara, Uzbekistan

Abstract. The article substantiates the expediency of using sorghum grain (seeds) as a substitute for corn in feed for poultry. The aim of the study was to develop a recipe and technology for the preparation of compound feed of increased nutritional value for birds using sorghum grain subjected to IR - processing. Examples of its impact on grain quality and its biological value are considered. The physical principles of operation of this technology and the properties of the applied method are analyzed. It was found that protein digestibility and attack by its enzymes increased from 82.3 to 89.8%. The results of a comparative zootechnical assessment of the quality of feed without sorghum and with the replacement of 47.0% of corn with this raw material are presented. The economic efficiency from the use of the proposed composition of feed for chickens and the profitability of its production have been established.

1 Introduction

Agriculture is the largest sector of the economy of Uzbekistan, and plays an important role in ensuring the economic and social stability of the Republic of Uzbekistan. As the leading agricultural sector in Uzbekistan, the livestock sector produces approximately 40.7% of the agricultural output produced in the country. In recent years, the poultry industry has been developing especially intensively in all regions of the country, which is an important factor in meeting the needs of the population in high-quality and affordable poultry products of domestic production.

At the same time, there are a number of problems that impede the further accelerated development of this sphere of agriculture, the introduction of modern technologies, the modernization of production processes and the expansion of exports of finished poultry products. In particular, the work on creating a fodder base for poultry farming and the production of import-substituting feed has not been set up at the proper level.

The rapidly developing poultry meat industry will need compound feed, because the constant growth of the population on the planet entails an increase in the need for protein productsAnd the increase in the volume of the poultry industry only by increasing the rate of production of compound feed is a dead end, since it implies the use of ever new areas under crops. As a result, the main task of scientists and poultry farmers in the field of feeding is to search for new types of raw materials that can significantly increase the use of nutrients in poultry feed, while maintaining or possibly increasing the productivity and quality of the products obtained.

* Corresponding author: xaitov66@mail.ru

At present, fodder crops are needed that would have high productivity, good adaptation to the soil and climatic conditions of the region, high manufacturability in the preparation of various types of feed from them, and at the same time solve the problem of feed protein [1].

According to the Ministry of Agriculture and Water Resources about 50.0% of land in Uzbekistan is currently subject to salinization. At the same time, the acute shortage of water resources for irrigating sown areas in many regions of our country is forcing farmers to use drought-resistant crops for cultivation which during a period of moisture deficiency produce a sufficient yield of high quality [2]. The cultivation of corn in such conditions does not provide the planned harvest, therefore the zoning of drought-resistant grain crops is currently one of the main tasks for the development of agriculture in the republic.

In this aspect, sorghum deserves attention, which is included in the top of the most profitable crops in terms of margin, as it does not require large expenditures on fertilizers and plant protection products. The culture adapts well to rapidly changing climate conditions and saves fresh water reserves thanks to a well-developed root system. In the southern and southeastern arid and semi-arid regions sorghum produces high grain yields, superior to other crops in its ability to develop at elevated temperatures and is a good alternative to corn. Sorghum consumes 300 parts of water to form a unit of dry matter (corn - 338, wheat - 515, barley - 534, oats - 600, sunflower - 895). The amount of water required for the swelling of sorghum seeds is 35% of the total weight of the seeds (for corn - 40%, wheat - 60%). It is advisable to grow sorghum in areas where the average annual rainfall does not exceed 350 mm. For successful cultivation of corn, 350-400 mm is required [3, 4].

2 Methods

The aim of the study was to develop a recipe and technology for the preparation of compound feed of increased nutritional value for birds using sorghum grain subjected to IR - processing.

The experimental part of the work was carried out in the laboratories of the Department of Food Technology of the Bukhara Engineering-Technological Institute. The objects of the study were grain (seeds) of sorghum and corn of local varieties. Compound feed was prepared without sorghum (control) and with the appropriate replacement of the prescription amount of corn for sorghum.

Experimental and control samples were prepared from the same batches of raw materials. All types of raw materials met the requirements of relevant standards. The quality of raw materials was evaluated according to modern generally accepted organoleptic (sensory) and physicochemical methods of analysis, described in the relevant standards and methodological guidelines.

3 Results and discussion

Sorghum (lat. Sorghum) is a genus of annual and perennial herbaceous plants of the Cereals or Bluegrass family (Poaceae), is characterized by thermophilicity, very drought resistance, salt resistance, and a high degree of adaptation to various soils [5].

One of the features of sorghum is C4 photosynthesis which is also characteristic of corn. This mechanism increases the efficiency of photosynthetic processes in the plant even under conditions of drought and elevated temperatures [6,7].

In Uzbekistan using the methods of hybridization and individual-mass selection such sorghum varieties as Karlik of Uzbekistan (zoned for grain), Tashkent Belozernoye (zoned for grain and silage), Uzbekskoye -18 (zoned for grain and silage), Uzbekskoe - 5 (zoned for stubble sowing on irrigated lands for grain and silage), Chilyaki local improved (zoned for grain and silage), Kantlik dzhugara (zoned for silage).

The study used grain (seeds) sorghum Chilyaki local improved. This sorghum variety was bred by mass selection from a natural hybrid population of the Chilyaki type. The plant is medium-sized - 220 - 270 cm, grain yield depending on growing conditions ranges from 66.9 to 77.5 centners / ha. The grain is relatively large, the weight of 1000 grains is from 20 to 30 g. The endosperm of the weight of the grain is 83-85%, the germ is 7-10%, the shells (flower, fruit, seed) - 7-8%.

In Uzbekistan mainly corn of the Uzbekskaya-100 variety is grown bred by the method of individual selection from the Imeretinsky hybrid variety. The plant is tall - 280 - 365 cm, the grain yield depending on the growing conditions ranges from 53.8 to 59.3 centners / ha. Weight of 1000 grains from 229 to 358 g.

A comparative analysis of the studied grain of corn and sorghum is given in tables 1-3.

Table 1. Comparative chemical composition of corn and sorghum.

Indicators	Meaning of indicators, %		±Δ, %
	Corn	Sorghum	
Water	13.8±0.4	13.0±0.5	-
Crude protein	10.3±0.5	11.8±0.2	+14.6
Raw fat	4.5±0.1	4.3±0.2	- 4.4
Crude fiber	3.6±0.3	3.9±0.3	+ 8.3
Raw ash	1.5±0.1	1.7±0.3	+ 13.3
Protein extractables	66.3±0.7	65.3±0.9	- 1.5

A comparative analysis of the chemical composition of corn and sorghum grains showed that the content of crude protein in sorghum is 14.6%, crude fiber - by 8.3% and crude ash - by 13.3% higher than similar values in corn grain. По остальным показателям не выявлены принципиальные различия. It is well known that an important indicator of the biological value of feed protein is its amino acid composition. Relatively high concentrations of amino acids are required to ensure high bird growth and productivity. The amino acid composition for essential amino acids and the amino acid score (abbr. AAS) of corn and sorghum proteins are presented in Table 2.

Table 2. Amino acid composition of corn and sorghum.

Amino acid	Protein by FAO/WHO, in g/100 g of protein	Mass fraction of amino acids in grain			
		corn		sorghum	
		g/100 g of protein	AAS, %	g/100 g of protein	AAS, %
Valine	5.0	4.2	84	4.0	80
Leucine	7.0	11.0	157	10.8	154
Isoleucine	4.0	3.8	95	3.5	87
Lysine	5.5	2.9	53	3.0	54
Methionine + cystine	3.5	3.7	106	3.3	94
Threonine	4.0	2.8	70	2.7	67
Phenylalanine + Tyrosine	6.0	8.9	148	8.5	142
Tryptophan	1.0	1.2	120	1.0	100
Total:	36.0	38.5	-	36.8	-

Analysis of the amino acid composition of the proteins of the studied raw materials did not reveal fundamental differences in their quantitative composition. It has been established that the limiting amino acids in corn protein are valine, isoleucine, lysine and threonine, in sorghum protein the same amino acids except for methionine and cystine.

In addition to the amino acid composition, an important indicator of the biological value of a protein is the degree of its digestibility, that is digestibility. The digestibility of a dietary protein is an important indicator of biological value, i.e. directly related to protein digestibility. In this regard, a promising direction for improving the quality of raw materials for feed production is the task of introducing innovations in the physical methods of its processing. Particularly promising for the task is the use of infrared (abbr. IR) irradiation of grain which has significant advantages over traditional heating methods.

The method of infrared irradiation, which is one of the promising physical methods of processing products, is increasingly used in such technological processes as drying, roasting, pasteurization, grain disinsection, and contributes not only to the intensification of the process, but also to the improvement of the quality of processed products [8]. When heated the protein undergoes denaturation changes, which lead to a significant increase in the rate of hydrolysis by proteinases. Therefore, it is necessary to analyze the degree of protein digestibility [9].

In order to increase the availability of protein, sorghum grain was subjected to IR-treatment in a laboratory setting. As generators of IR radiation were used emitters of the KGT-220-1000 type, the maximum emissivity of which is in the wavelength range of 0.8-1.2 μm. Sorghum grain was exposed to infrared radiation with an incident flux density of 10-12 kW/m2 in the wavelength range from 0.8 to 2.0 μm without "explosion" of the grain for 120-150 seconds.

The heat treatment process begins with the fact that infrared radiation is generated by halogen lamps, which then passes through a layer of material, being converted into thermal energy. It heats the material, evaporating moisture from it. Such a technological scheme provides a constant thickness of the grain layer along the height of the apparatus. As a result, the thickness of the layer is equal to the width of the gap formed by the perforated cylinder and the rotating disks. Therefore, the heating process proceeds evenly and efficiently [10]. At the same time the flower films and the shell of the grain did not burn.

The effect of IR-treatment of sorghum grain on the change in the fractional composition of the protein, its digestibility and its attack by trypsin, which belongs to the group of digestive enzymes was studied.

The results of the study are presented in Table 3.

Table 3. Influence of IR treatment on the fractional composition of sorghum protein.

Sample	Mass fraction of the protein, %	Fractional composition of the protein, % of DM in protein			
		Albumins	Globulins	Prolamins	Glutelins
Before processing	10.41	10.2	27.6	17.2	45.0
After IR processing	10.38	9.1	25.7	18.7	50.3

Analysis of the obtained results showed that the mass fraction of protein in sorghum grain did not change. At the same time was established a decrease in the amount and a certain loss of solubility of such globular proteins as albumins and globulins by 10.8 and 6.9%, respectively. The content of alkali-soluble fractions slightly increases by 8.7 and 11.8%, respectively. The glutelin fraction of the protein dominates. The loss of solubility is due to denaturation changes during IR treatment of grain.

It was found that protein digestibility and attack by its enzymes increased from 82.3 to 89.8%. Thus IR-treatment of grain leads to the production of protein with a high digestibility coefficient.

Research carried out by V.A. Glebov in the team, using the example of barley grain, showed that IR treatment causes mechanical and chemical degradation of starch with the formation of highly digestible dextrins [11]. The volume of "exploded" barley at a moisture content of 10.0-14.0% and an incident radiation flux density of 22 kW/m^2 increases by 1.5 times; an increase in the initial moisture content above 14.0%, as well as its decrease below 10.0% causes a decrease in the increase in the volume of the grain. Thus, the higher the degree of swelling of the grain which reduces the density and increases the absorption of water, the higher the degree of starch attack by amylolytic enzymes which as a result contributes to an increase in its digestibility.

According to some researchers, the method of IR processing makes it possible to almost completely preserve vitamins and biologically active substances and the natural organoleptic properties of raw materials.

The method of IR processing allows to significantly reduce the content of microflora in the processed raw materials, which increases the shelf life of the finished product [12-14].

In accordance with the above recommendations, the recipe was optimized for laying hens aged 24-45 weeks. Together with the leading specialists of Buxoroparranda JSC (Bukhara, Uzbekistan), a compound feed composition for chickens was developed, intended for the prevention and treatment of non-infectious diarrhea. In this product, 47.0% of corn grain was replaced by IR-treated sorghum grain of compound feed with the addition of 3.0% of the total amount of pomegranate pomace raw materials. The optimization results are presented in Table 4.

Table 4. Recipe composition of compound feed for chickens.

No	Raw materials	Input restrictions, min-max, %	Quantity, % (kg)	
			control	*experience*
1	Wheat	0.0 – 60.0	40.0	40.0
2	Corn	0.0 – 60.0	17.0	9.0
3	Soybean meal	0.0 – 20.0	10.0	10.0
4	sunflower meal	0.0 – 20.0	15.0	15.0
5	Sunflower oil	0.0 – 5.0	3.0	3.0
6	limestone flour	0.0 – 7.0	10.0	9.0
7	Feed monocalcium phosphate	0.0 – 5.0	1.0	1.0
8	Wheat bran	0.0 – 6.0	3.0	-
9	Sorghum	0.0 – 60.0	-	8.0
10	Pomegranate pomace	0.0 – 3.0	-	3.0
11	Adsorbent «Globofix»	0.0 – 0.5	0.1	0.1
12	Salt	0.0 – 0.3	0.3	0.3
13	Vitamin and mineral premix «MegaMix»	0.0 – 1.0	0.1	0.1
14	Salmokil 60 C	0.0 – 0.2	0.2	0.2
15	L-lysine mono chlorohydrate	0.0 –0.2	0.15	0.15
16	DL - methionine	0.0 –0.5	0.15	0.15
	Total		***100.00***	***100.00***

Testing the effectiveness of the use of compound feeds with the introduction of sorghum grain (seeds) subjected to IR treatment and pomegranate pomace into the formulation was carried out by JSC "Buxoroparranda" on hens of the Loman Brown cross. Zootechnical assessment of the effectiveness of the use of new components in the diet of chickens was carried out according to the following indicators: the cost of feed per 1 laying hen and the production of 10 eggs. The results of the study are presented in table 5.

Table 5. Zootechnical characteristics of chickens.

Indicator	**The value of indicators in the group**	
	control	***experience***
Average livestock, head.	30	30
Compound feed costs per 1 laying hen for the accounting period, kg	44.2	42.8
Feed costs for the production of 10 eggs, kg	1.30	1.26

From the data in Table 5 it follows that the use of experimental compound feed made it possible to reduce the cost of compound feed per 1 laying hen for the accounting period by 1.3%, for the production of 10 eggs - 3.1% relative to the control group.

It has been established that the eggs of the control group of laying hens belong to the first category of eggs (from 56.0 to 64.9 g), the experimental group - to the selective category of eggs (from 65.0 to 74.9 g) and meet the requirements of GOST 31654-2012. A comparative analysis of the fractional composition of eggs showed that in the experimental group, the egg weight increased by 2.2%, yolk - by 3.4% and protein - by 2.5% relative to control samples. At the same time, a decrease in the content of the shell in the experimental variants was established by an average of 2.7%.

In addition to zootechnical assessment and the effectiveness of the antidiarrheal activity of therapeutic and prophylactic compound feed for chickens, the increase in live weight of experimental animals was studied For this, 30 white outbred rats weighing 110-120 g were used, followed by division into groups of 6 animals each. The age of the animals at the beginning of the experiment was 40 days. The results of the study are presented in table 6.

Table 6. Increase in live weight of experimental animals observed in the experiment after 3 days of the experiment.

Group	**Live weight of experimental animals**	
	Initial, in gr.	**Final (after 3 days), in gr.**
Intact	162.33±8.29	162.33±7.55
Control (regular food)	155.67±17.73	155.66 ±10.78
Experimental (1000 mg/kg)	175.33±7.62	184.33±19.26

It was found that in the intact and control groups, the weight of the animals did not increase, while when feeding the animals with antidiarrheal compound feed, the live weight of the experimental animals had a significant tendency to increase.

The calculation of the cost of compound feed for two variants of recipes showed that the cost of production of a prototype is lower than the control one by 53165 soums per 1 ton of products. At the same time, the selling price of 1 ton of finished products is reduced by 51374.2 soums when comparing the indicators of a prototype to a control one. Due to the reduction of material costs and the cost of production, the profit of products in the amount of 20398.6 soums per 1 ton of finished feed increases. The production of feed for chickens according to the recommended recipe and technology is more efficient compared to the control recipe option, as the profitability of products and the profitability of material costs increase.

4 Conclusion

As a result of the research, it was found that the use of the proposed compound feed composition had a positive effect on the zootechnical and physiological parameters of chickens, which characterizes the use of sorghum subjected to IR - processing of grain (seeds) as a substitute for corn in feed for farm birds, as a stimulator of the availability of basic nutrients, before all protein. The recommended modes of this heat treatment of sorghum are: wavelength range 0.8-1.2 µm, incident flux density 10-12 kW/m^2, treatment duration 120-150 seconds.

The use of this compound feed had a positive effect on feed conversion and increased egg production of chickens. The involvement of non-traditional types of plant raw materials and methods of heat treatment in the production of compound feed for poultry is a promising and relevant scientific area of research, which is of practical importance in terms of providing the population with basic food. This determines the implementation of the priority directions of the state development strategy in the field of food security, the economic component in terms of reducing the cost of production by reducing the cost of production and consumption of animal feed. The expansion of the areas of application of salt- and drought-resistant grain crops, in particular sorghum, will significantly expand the sown areas through the rational use of arid zones and improve the ecological situation in a region with a dry and hot climate. The expediency of using sorghum grain (seeds) subjected to IR treatment and secondary vegetable raw materials, in this case, pomegranate pomace, as part of the compound feed has been confirmed. When using this method of heat treatment of grain, the heating time and energy costs are significantly reduced.

Thus, the production of compound feed according to the proposed recipe is economically beneficial for manufacturers due to the reduction of material costs, other things being equal, the increase in the profitability of products in general and the attractiveness of the price for potential buyers.

References

1. A. N. Astakhov S. I. Kononenko I. S. Kononenko, Corn and sorghum **5**, 13-14 (2009)
2. A. Sh. Azizov, *Selection of optimal varieties of saxar sorghum for the production of bioethanol in the conditions of Uzbekistan,* The current state of the path of innovative development of the agricultural sector on the example of Agroholding "Baiserke-Agro" (2017)
3. Sorghum is a substitute for corn when there is a lack of moisture (2022). http://ikar.ru/articles/264.html (accessed 20.02.2022)
4. V. S. Plaksina, A. N. Astashov, Yu. V. Bochkareva et al, Successes of modern natural sciences **12**, 36-41(2020). https://natural-sciences.ru/ru/article/view?id=37534 (date of access: 02/23/2023)
5. E. N. Efremova, Bulletin of the Altai State Agrarian University **3(113)**, 125-129 (2014)
6. N. Barakaev, O. Mirzaev, B. Toirov, A. Alimov, Journal of Physics: Conference Seriesthis link is disabled **1889(2)**, 022061 (2021)
7. N. R. Barakaev, J. M. Kurbanov, A. O. Uzaydullaev, A. X. Gafforov, IOP Conference Series: Earth and Environmental Sciencethis link is disabled **848(1)**, 012024 (2021)
8. R. A. Khaitov, IOP Publishing Journal of Physics: Conference Series **2388** 012132 (2022)
9. G. G. Babaev, P. M. Matyakubova, L. N. Nasimkhanov Young scientist **14(118)**, 116-118 (2016). https://moluch.ru/archive/118/32597/ (date of access: 02/28/2022)

10. T. V. Zaletova, *Influence of types of pre-treatment on the quality of dried apples: author*. dis. … cand. s.-x. Sciences: 05.18.01 (Michurinsk-naukograd, 2013), 24
11. V. A. Glebov, Yu. R. Kirakosyan, S. V. Zverev et al, *The use of infrared radiation for the processing of grain components of compound feed.* Scientific and technical achievements and best practices in the bakery industry. Information collection (VNPO Zernoprodukt, M., 1990) **1**, 17-24
12. O. I. Kvasenkov, V. B. Pento, Patent 2090075 Russian Federation, IPC 6 A23B7/02. Method for the production of dried supplies from fruit and berry raw materials, applicant and patent holder All-Russian Scientific Research Institute. No. 95116461/13; dec. 09/19/95; publ. 09/20/97, 4
13. R. A. Khaitov, Geliotekhnika **5**, 39-41 (1998)
14. Mirshod T. Kurbonov, Tamara I. Atamuratova, Journal of Pharmaceutical Negative Results, 4346-4352 (2022)