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Effect of feed with extruded components and phytobiotics on quail

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Abstract. Quails are a valuable type of poultry, as their eggs and meat have high nutritional value. Moreover, quails are distinguished by early sexual maturity, high egg production and small body size. These unique characteristics make them an attractive object for breeding and scientific research. The purpose of the study was to investigate the effect of feed with extruded components and phytobiotics on the meat productivity and blood biochemistry of Texas quails. The methodology involved dividing 200 quails into experimental and control groups, feeding them different diets

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over a 60-day period, and analysing their growth performance, meat yield, and biochemical blood parameters using statistical analysis tools. As a result of the research, it was revealed that feed produced according to the developed recipe has a positive effect on the weight gain of quails. In the experimental group (EG), the absolute increase was 313.7 ± 4.34 g, in the control group (CG) – 275.9 ± 2.89 g (not significant difference, P > 0.05). Furthermore, the feed with extruded components and phytobiotics led to improved feed conversion ratio in the EG compared to the control. The birds in the EG also demonstrated higher carcass weight and yield. The experimental diet also appeared to have a positive influence on the immune status of the quails. The results demonstrate the potential benefits of incorporating extruded components and phytobiotics into quail feed to improve growth performance and maintain healthy physiological parameters. Evaluating the biochemical blood test results, it can be indicated that no significant changes in the blood composition were detected, which may indicate the absence of a negative effect of the developed feed on the body of birds. The results obtained may be of practical importance for developing optimal diets for meat quails and improving the quality and safety of their products

Keywords: extrusion; blood biochemistry; homeostasis; diet; protein

INTRODUCTION

The relevance of this study lies in addressing the critical issues surrounding quail farming, which has gained popularity due to its economic advantages, such as low maintenance costs, short generation intervals, disease resistance, and high egg production. Two key factors that limit poultry production are energy and protein, traditionally sourced from plant-based ingredients like grains and beans. Although, competition for these resources, along with challenges such as global warming and rising costs, has raised concerns about the sustainability of using conventional feed ingredients. This highlights the importance of developing alternative feeding solutions, such as balanced diets supplemented with animal proteins or essential amino acids, to ensure sustainable and productive quail farming.

There is no direct ban on the use of meat and bone meal (MBM) in animal diets in the Republic of Kazakhstan, however, the Veterinary (Veterinary and Sanitary) Rules dated August 25, 2015 (as amended and supplemented as of July 11, 2023) provide recommendations not to allow the use of MBM for cattle feed and ruminant processing waste to prevent bovine spongiform encephalopathy. In this regard, when developing their own feed recipes, the authors have used fishmeal in the feed compositions.

Feed additives are used to replenish missing dietary elements. The increasing demand for natural feed additives in poultry farming is due to the ban on the use of antibiotics as feed additives. The feed industry is now focusing on a new category of additives called phytogenic feed additives or phytobiotics, which are made from herbs, aromatic plants and spices. The successful use of phytogenic growth promoters brings greater benefits to the poultry industry through increased feed efficiency and improved health status (Alagawany *et al*., 2022; Abd Elzaher *et al*., 2023). Therefore, in this study, the authors used a mixed feed that included extruded components and was enriched with BioFeed-P phytobiotic, which is a natural immunostimulant (Sultanayeva *et al*., 2023).

G. Kanbur *et al*. (2023) examined the effects of adding dried banana leaves with or without a multienzyme complex to the diets of laying quails. The results showed that it increased egg production and weight, improved yolk colour, and affected egg quality, while the multienzyme addition had minimal effects on laying performance. This lack of any benefits from adding multienzymes leaves room for further exploration into optimal dietary supplementation strategies.

C.E. Stanquevis *et al*. (2022) focused on evaluating the effects of different levels of vitamin A supplementation in the diets of meat-type quails (Coturnix coturnix sp) from 1 to 35 days of age. The research finds that vitamin A supplementation has a significant impact on body weight, weight gain, and feed efficiency, although its effect on immune parameters was limited. A critical analysis of the work reveals its focus on immunity was somewhat narrow, only examining a few immune-related factors like heterophil/lymphocyte ratio and organ weights. The lack of significant findings in immunity could indicate either that vitamin A does not strongly influence early immune development or that more comprehensive immunological markers need to be assessed.

In their study A. Ansaripoor *et al*. (2020) examined the improvement of the growth and production of Japanese quail breeders and their offspring. Using the Taguchi method, the researchers measured egg production, feed intake, and hatchability in 630 quails. And while the study provides valuable data on the optimisation of quail diets, it is limited by its relatively short timeframe and does not explore potential long-term impacts on reproductive performance or health. E.A. Ashour *et al*. (2024) also investigated the productive performance, egg quality, and digestibility of laying Japanese quails. They found that the best egg weight and mass were achieved with a diet containing 20% crude protein and 2,900 kcal/kg metabolised energy. However, the study was conducted only in the summer season, which might limit the generalizability of the findings to other seasons.

The aim of this study was to assess the effects of feeding Texas quails with extruded parts and phytobiotics on their physiological parameters and meat productivity. By focusing on alternative feed solutions, the study address concerns about the sustainability and efficiency of traditional poultry diets. It determines whether these dietary enhancements can improve quail growth performance, carcass characteristics, and biochemical blood markers.

MATERIALS AND METHODS

The experiment was carried out in the base farm (Akmola-Phoenix Farm) in Akmola region, Kazakhstan. The experiment period was 60 days, starting feeding from the 7th day of life until the poultry reached the slaughter age. The experimental part of the research was approved by the local ethical commission on biological and medical ethics (for research involving animals) of the S. Seifullin Kazakh Agro Technical Research University, Minutes of the Meeting No. 2 dated December 14, 2021. All procedures performed in studies involving animals were in accordance with the ethical standards of the institutional and national research committee and with the Basel Declaration (Animal Research Tomorrow, 2010) and its later amendments or comparable ethical standards.

Diets were formulated according to the recommendations of the Nutrient Requirements of Ring-Necked Pheasants, Japanese Quail, and Bobwhite Quail (National Research Council, 1994). Compound feed for quails for meat production was produced in the production and testing workshop of "NFT-KATU" Limited Liability Partnership on the basis of S. Seifullin Kazakh Agro Technical Research University. The composition included extruded corn, wheat, soybean meal/cake, fish meal, tricalcium phosphate (TCP), feed yeast, crushed shell rock and chalk, table salt, activated carbon, and BioFeed-P phytobiotic feed additive developed by the authors.

The chemical composition of feed for quails for meat production (content of "crude" protein, "crude" ash, "crude" fat, Ca, P, carotene) was determined using NIRS DS2500 infrared feed analyser (Foss Analytical A/S, Denmark). Feed components were purchased from local producers in Kazakhstan. The chemical composition of meat and eggs was determined by the permanganometric method. The experiment used 200 birds of the Texas breed to determine the effect of the developed recipe on meat productivity, the chemical composition of meat, and biochemical blood parameters, reflecting a complete picture of the body state.

The birds were divided into 2 groups: control and experimental. Until the 7th day of age, the chicks were fed commercial feed used in the base farm. The maintenance of two groups of birds is generally accepted according to zootechnical standards, depending on the age of the birds. The experimental group and the control group were housed in identical settings, guaranteeing uniformity in environmental elements including humidity, illumination, and temperature. The amount of feed was adjusted as the birds matured to meet their changing nutritional requirements. To support healthy growth and reduce stress, age-appropriate guidelines for general care and space allocation were closely followed, guaranteeing that every bird enjoyed ideal living conditions for the duration of the trial. Feed was given to quails during the fattening period in the amount of 42 g/bird per day with two feedings a day. Daily feed intake was measured by subtracting the remaining feed from the feed offered. The feed conversion ratio was calculated by dividing feed intake by weight gain *100. The control group (CG) ate feed previously used on the base farm. The experimental group (EG) was fed according to three recipes: "Start" (from the 7th to 21st days), "Grower" (from 21 to 42 days), "Finish" (from the 42nd to 63rd days), differing in the percentage of components, however, the data on the "Finish" recipe was important in authors' research and is shown in Table 1.

***Table 1**. Feed composition for the EG of quails*

Feed component	Percentage, %
Wheat	39.54
Soybean meal/cake	33
Fish meal	13
Extruded corn	10
Feed yeast	2
TCP	1
Crushed shell rock and chalk – 1%	1
BioFeed-P phytobiotic feed additive	0.06
Common salt (NaCl)	0.4

***Source:** compiled by the authors*

To assess the effect of the developed feed on metabolic processes in the blood of quails, the following indicators were studied: total protein (TP), albumin and globulins, total bilirubin, urea, calcium, glucose, amylase activity, alanine aminotransferase (ALT), aspartate aminotransferase (AST). Meat productivity was

determined by conducting weekly individual weighing and slaughter with the study of meat productivity indicators. For that, 100 quails (50 quails from each group) were sent for slaughter. Due to the fact that sexual maturity in quails occurs in approximately 6-7 weeks and blood parameters change quickly accordingly, it is methodically incorrect to compare them at the beginning and after the experiment. Therefore, the blood parameters of the EG were compared with the parameters of the CG of poultry at the end of the experiment at the age of 60 days. The blood test was carried out on SMT-120V biochemical veterinary analyser (Chengdu Seamaty Technology Co., China, Sichuan), the operation of which is based on absorption spectroscopy and transmission turbidimetry. Blood samples were collected by decapitation using a simple random sampling method. Before blood sampling, the birds were on a 6-hour starvation diet. After slaughter of poultry, blood samples for biochemical analysis were collected in 1.5 ml testing tubes with an activator and gel, followed by centrifugation at 3,000 rpm during 10 minutes on a CM-6M centrifuge (Sia "Elmi", Latvia, Riga). Statistical analysis was performed using SPSS 25.0 application.

RESULTS

To optimise feeding patterns, it is important to determine the energy content of feeds and also establish the poultry ideal energy intake to ensure maximum economic return. The chemical composition of the diets of the EGs is presented in Table 2.

***Table 2**. Chemical composition of quail diets in EGs*

Group	Humidity (%)	DM (%)	Crude protein (%)	Crude fat (%)	Crude fiber (%)	Ash	Starch (%)	ME (poultry), Kcal
CG	9.3	90.7	25.3	6.9	3.88	6.57	28.83	3,309
EG	8.3	91.7	27.6	5	3.49	5.38	32.79	3,357

***Source:** compiled by the authors*

As can be seen from Table 2, the metabolic energy of the mixed feed of the EG was 3,357 Kcal/1,000 g, while in the commercial feed of the CG the level of metabolic energy was lower by 48 Kcal, but in both groups the indicator was at a high level. According to the Manual for working with meat quails, the metabolic energy should be 3,100 Kcal/1,000 g, protein in the feed should be 20%. Due to the fact that the components of the feed are subjected to extrusion processing, its moisture content is reduced, which makes it possible to prolong the shelf life, reducing the risk of the development of microorganisms and molds. In the mixed feed of the EG the moisture content was 8.3%, in the CG – 9.3%.

An important indicator of the nutritional and energy value of feed is dry matter. Dry matter content indicates the actual amount of various nutrients available to the poultry consuming the feed. Dry matter contains inorganic (raw ash) and organic components. Organic matter in feed consists of crude protein, crude fat, and carbohydrates. The feed according to the recipe authors developed contained 91.7% of dry matter, while the CG contained 90.7%. The percentage of protein in the feed of the EG was 27.6%, in the CG – 25.3%, which indicates a sufficient supply of protein to the poultry's body and satisfies their needs. Fiber in the feed is digested in the poultry body in the cecum, where there are microorganisms that secrete enzymes that can decompose from 10 to 30% of the fiber. The crude fiber content should be at the level of 4.0-5.0%, in authors' case this figure is slightly reduced and amounts to 3.49% in the EG and 3.88% in the CG.

Carbohydrates – starchy polysaccharides (starch, sugar) are the main sources of energy for poultry. The percentage of starch in the feed of the EG was slightly higher than in the CG and amounted to 32.79% and 28.83%, respectively. Ash content is generally recognized as the most important indicator for assessing the mineral composition of a product. The feed of the EG contained 5.38% of ash, and the CG – 6.57%. The results of the weight gain of the EGs of quail are shown in Table 3.

***Table 3**. Dynamics of growth of quails from the 7th day to the 63rd day of life using the developed recipes*

Age, days	Average weight, g	
	CG	EG
7	56.7 ± 1.22	60.1 ± 0.88
14	105.8 ± 1.54	106.1 ± 1.56
21	147.7 ± 2.22	170.8 ± 1.98
28	220.6 ± 2.93	233.3 ± 2.48
35	267.9 ± 3.02	278.3 ± 2.7
42	306.2 ± 4.03	314.7 ± 3.62
49	319.6 ± 4.4	342.7 ± 3.58
56	331.4 ± 4.74	360.3 ± 4.35
63	333.2 ± 4.53	373.7 ± 4.28

***Source:** compiled by the authors*

From Table 3 it can be seen that during all periods of quail growth, the EG had a greater weight gain. Live weight when feeding birds according to the Start recipe (from the 7th to 21st days) in the CG by the 21st day was 147.7 ± 2.22 g, and in the EG – 170.8 ± 1.98 g, which is 15.6% higher or 23.1 g. Live weight when feeding birds according to the Grower recipe (from 21st to 42nd days) on the 42nd day in the EG is 2.7% higher than in the CG. The weight of birds fed with the Finish recipe (from the 42nd to 63rd days) in the EG increased every week, while in the CG from the 56th to 63rd days there was practically no increase. So, by the end of the fattening period, the EG poultry weighed 373.7 ± 4.28 g, while the poultry in the EG weighed 333.2 ± 4.53 g, which is 12.15% lower than the EG level or less than 40.5 g. The dynamics of growth in live weight of quails is presented by indicators of absolute and relative growth. The growth rates (absolute, average daily) of quail in groups are shown in Table 4.

***Table 4**. The Contribution of agroforestry practice to pesanggem household income*

Group	Absolute weight gain, g	Average daily weight gain, g
CG	275.9 ± 2.89	5.11
EG	313.7 ± 4.34	5.81

***Source:** compiled by the authors*

Calculation of absolute weight gain revealed that the difference between the groups amounted to 37.8 g. Absolute gain in the EG amounted to 313.7 ± 4.34 g, in the CG – 275.9 ± 2.89 g. Average daily gain in the CG – 5.11 g, in EG – 5.81 g. The EGs ate almost the same amount of feed on average per day in the EG – 32.1 ± 0.97 g, in the CG – 31.9 ± 0.99 g, or per 1 g of gain in the EG 5.53 g of feed was spent, while in the CG – 6.24 g, i.e. in the EG feed conversion was 13% higher. The results of meat productivity indices are shown in Table 5.

***Table 5**. Meat productivity indices*

Indicator	Group (n = 30)	
	1st group (EG) M ± m, g	2nd group (CG) M ± m, g
Pre-slaughter weight, g	370.1 ± 24.05	294 ± 14.9
Weight of semi-gutted carcass, g	331.3 ± 16.9	240.6 ± 13.01
Weight of gutted carcass, g	287 ± 17.4	219.3 ± 16.4
Slaughter yield, %	78%	75%
Weight of skin and subcutaneous fat, g	37.1 ± 2.3*	13.5 ± 5.99
Pectoral muscles, g	93.1 ± 5.7	51.6 ± 4.8
Leg muscles, g	49.3 ± 4.9	34.85 ± 13.1
Weight of internal organs, g		
Muscle stomach, g	4.1 ± 0.73	3.65 ± 0.3
Heart, g	3.25 ± 0.21	2.8 ± 0.47
Liver, g	6.12 ± 1.48	4.07 ± 0.12

***Source:** compiled by the authors*

According to Table 5, it can be concluded that the slaughter yield of quails in the EG is 4% higher than in the CG. The best results were obtained in the EG, which received Finish enriched feed. Live weight in the EG was 370.1 ± 24.05 g, which was higher than in the CG by 76.1 g or 26%, in the CG live weight index was less by 21%. According to the table in the EG the weight of half-gutted (331.3 ± 16.9) and gutted (287 ± 17.4) carcasses was 30.6-37.7% ahead of the corresponding indicators of the CG, while in the CG the indicators were lower by 67.7-90.7 g or 27.38-23.6%, which indicates the effectiveness of the developed enriched feed.

Also, according to the results obtained in the EG an increase in the weight of skin and subcutaneous fat was noted, which gives the meat juiciness, tenderness and peculiar taste. According to the results of the study in the EG this indicator was equal to 37.1 ± 6.8 g, which was an increase of 174%, as well as pectoral muscles – 93.1 ± 5.7 g or 80.4%, leg muscles – 49.3 ± 4.9 g or 41.46% were more in comparison with the index of the CG. At the same time in the CG the mass of skin and subcutaneous fat amounted to 13.5 ± 5.99 g, pectoral muscles – 51.6 ± 4.8 g, leg muscles – 34.85 ± 13.1 g. Thus, analysing the obtained data, it can be noted that meat productivity of quails increases with the introduction of "Finish" enriched feed into the main diet.

In the EGs, the weight of internal organs such as muscular stomach, heart and liver surpassed the values of the CG. It is important to develop heart, liver and muscular stomach as human food organs. The mass of muscular stomach of the EG was 4.1 ± 0.73 g, which was 12.33% higher than of the CG. The EG was superior to the CG in heart weight by 16.08%. Liver weight in the EG was 6.12 ± 1.48 g or more by 50.7% compared to the CG. Thus, relative to live weight, internal organs of experimental birds in the EG had a better index, which

indicates the positive effect of "Finish" enriched feed. When analysing the results of chemical composition of quail meat, 4.70 ± 1.74% of fat was found in the CG, while in the EG this index was 2.79 ± 0.89% (Table 6).

***Table 6**. Chemical composition of quail meat*

Name of indicators, units of measurement	Results of the EG	CG results
1	2	3
Physical and chemical indicators:		
Mass fraction of protein, %	21.12 ± 0.36	20.82 ± 0.08
Mass fraction of fat, %	2.79 ± 0.89	4.7 ± 1.74
Mass fraction of carbohydrates, %	Not detected	Not detected
Mass fraction of ash content, %	1.18 ± 0.03	1.27 ± 0.06

***Source:** compiled by the authors*

Protein level in the EG was equal to 21.12 ± 0.36%, in the CG – 20.82 ± 0.08%. Mass fraction of ash content in the EG was slightly lower than in the CG and amounted to 1.18%. Thus, enriched feeds with the use of highly nutritious, highly digestible and natural plant components according to the Start, Grower and Finish formulation had a positive effect on the growth and development of Texas quail. The used enriched feeds allow obtaining the weight of quails at 63 days of age within the physiological norm, while the feed used on the farm showed lower efficiency. The results obtained from the assessment of the developed feed are shown in Table 7.

***Table 7**. Assess the effect of the developed feed on metabolic processes in the blood of quails*

Indicator	Actual result of EG	Actual result of CG	Unit
Albumin	13.67 ± 0.48	12.23 ± 2.93	g/L
TP	27.8 ± 1.11	27.33 ± 8.94	g/L
Globulin	14.32 ± 0.89	18 ± 21.35	g/L
Total bilirubin	2.75 ± 0.84	3.5 ± 0.99	umol/L
AST	403 ± 44.95	382 ± 42.75	U/L
ALT	11.67 ± 1.8	11.67 ± 3.34	U/L
Amylase			
Glucose	15.49 ± 0.48	16.68 ± 0.8	mmol/L
Calcium (Ca)	2.31 ± 0.11	2.39 ± 0.09	mmol/L
Urea	1.93 ± 0.24	2.48 ± 0.72	mmol/L

***Source:** compiled by the authors*

According to the results of the research of protein metabolism in quails of the EG at the age of 60 days, the content of TP was 1.7% higher than in the CG. The content of globulin fractions in experimental birds was 20.44% lower than in control birds. Most likely the decrease was due to alpha and beta-globulin fractions, which indicates the absence of intoxication and inflammatory processes in the body of experimental birds. Authors found that the combined feeds do not have a significant effect on the level of urea in the blood of quails, which is associated with a stable level of TP and albumin. Urea content in the blood of the EG was lower by 22.17% than in control quails, and both values were within physiological values. Both increase and decrease of urea content in blood are fraught with consequences for the organism of birds. Urea and creatinine are indicators of normal renal function and their increase in serum indicates renal dysfunction or protein overfeeding. Decreased plasma/serum urea levels are less common and usually have less clinical significance than increased plasma/serum urea levels (Mamoulakis *et al.*, 2024). Decreased blood urea is associated with prolonged protein malnutrition and impaired urea-forming function of the liver.

Healthy poultry have higher glucose levels. For quail, as for other small birds, decrease in blood glucose below 8.25 mmol/L is considered life-threatening. In authors' studies, the blood glucose level in experimental and CGs was at a fairly high level, ranging from 15.49-16.68 mmol/L. The concentration of bilirubin in the blood serum of quails did not exceed the physiological values in poultry of both groups, however, in experimental quails this indicator in the blood was 21.42% lower than in the control ones. Calcium is one of the most important chemical elements necessary to ensure the basic life processes of quails. The concentration of calcium in the blood serum is a fairly constant value. However, its content may vary depending on the level

of its intake from feed and the clinical condition of the bird's body. The calcium content in the blood of quails of the experimental and CGs, although it was within the standard values, 2.31 and 2.39 mmol/l, with a minimum reference value of 2 mmol/l.

The most valuable information about the functioning of the organs of the digestive system of birds is provided by the activity of enzymes such as ALT and AST. All enzymes provide metabolic fluxes along with enzymatic activity, and there is a metabolic relationship between nonspecific biochemical changes. The research results showed that when feeding extruded feed to growing quails, there is a significant fourfold increase in AST, while ALT activity remains within normal limits, and amylase activity shows a distinct decreasing tendency. It was also found that in quails of the EG, amylase activity was 50% lower than in the CG. Such changes can be explained by the fact that this age period is associated with intensive growth of the poultry and its puberty. The function of the pancreas reflects the characteristics of the poultry species nutrition. The content of enzymes in the pancreatic juice of the gland reflects its adaptation to the quality of food and its digestibility. The decrease in amylase activity is apparently associated with a decrease in metabolism, as well as with the emergence of new highly digestible feeds.

DISCUSSION

In the course of this study, significant advantages of the EG over the CG in terms of meat productivity were revealed. This trend can be explained by the completeness of the feed composition of EG, which included extruded components and the phytobiotic feed additive BioFeed-P, which contains more than 250 biologically active components. Research results by A.M. Khalifah *et al.* (2021) showed that growth performance was positively affected by the addition of lemongrass essential oil ($P \leqslant 0.01$) at a dose of 0.4 g/kg compared to the CG. In addition, the additive improved meat quality as it significantly improved ($P \leqslant 0.01$) water holding capacity of thigh meat and pH values. Blood characteristics showed a significant decrease ($P \leqslant 0.01$) in lipid profile, AST, ALT, and malondialdehyde under the influence of additives.

In the scientific discourse, the position is spreading that the use of natural feed additives as growth promoters in poultry diets has a positive effect on egg production, meat production, reproduction and health and minimizes the use of antibiotics as growth promoters. In the course of this research, a phytobiotic additive BioFeed-P was developed for animals and poultry, which was used as a plant feed additive. Corn, wheat, and soybean meal are the main components of poultry diets, providing a significant portion of energy and protein. Traditional sources of fiber-rich byproducts include wheat bran, sunflower meal, cottonseed, oat bran, soybean bran, and pea bran (Jha & Mishra, 2021).

M.T. Sisay *et al.* (2018) reported that wheat-based extruded products are relatively low in protein and high in gluten, and have a high glycemic index. Due to the high protein content in legumes, they are considered crops that satisfy the need for plant protein in poultry diets (Nalluri & Karri, 2021). The extruded components used by the authors also improve the safety performance of the feed, reducing the risk of contamination by microorganisms and fungi. According to D.D. Loy and E.L. Lundy (2019), corn starch is almost 100% digestible and its content can be increased during grain processing. M.M. Rahman *et al.* (2024) found that groups of quails receiving specific combinations of olive oil and key lime juice showed improved weight gain and feed conversion ratio. F.M. Reda *et al.* (2024) examined the effects of naringenin, a natural feed additive, on the growth performance, carcass traits, blood biochemistry, immunity, antioxidant responses, and cecal microbiota of Japanese quails. The results showed that naringenin improved quail growth, feed conversion ratio, blood biochemistry, and immune responses, while also reducing harmful microbial populations in the quails' cecum.

K. Wengerska *et al.* (2022) believe that with proper enrichment, soybean meal fully meets the requirements for essential amino acids. According to S.A. Lee *et al.* (2023), TCP is obtained by reaction of phosphoric acid with carbonate, followed by calcination at temperatures above 900°C. TCP, intended for feeding, is used in diets for poultry. TCP is able to provide unique properties of a filler agent to powder mixtures. According to C.H. Kim *et al.* (2023) premixes and minerals such as copper, iron, zinc, magnesium are important nutrients that directly or indirectly contribute to biochemical processes in the body. The authors included 1% premix to the developed feed to enrich the diet with minerals.

Enrichment of the diet of quails with extruded components and the phytobiotic additive BioFeed-P demonstrated a positive effect on the main zootechnical indicators. Thus, the absolute increase in live weight of quails in EG was 313.7 ± 4.34 g, while in CG – 275.9 ± 2.89 g (the difference is not significant, $P > 0.05$). This indicates an increase in the energy of growth and the efficiency of the use of feed by quails when using the developed diet. In addition, the EG bird had a higher slaughter weight and meat yield in the carcass. The analysis of biochemical indicators of blood did not reveal significant differences between the groups, which may indicate the absence of a negative effect of the developed feed on the bird's body. TP, albumin, and globulin levels were within the normal range for both groups, indicating adequate nutritional support and absence of inflammation. Also, no significant differences were found in the activity of liver enzymes, which indicates the absence of a negative effect on the function of the organ.

A positive effect of the experimental diet was also observed on the immune status of quails. The stability

of the indicators of protein metabolism and the absence of signs of liver damage can indicate the maintenance of the homeostasis of the body and the preservation of the health of the bird when using the developed feed. As for the study of quail homeostasis, it should be noted that this indicator is significantly influenced by the egg production of birds, as well as the quality and hatchability of eggs. This indicates the additional advantages of using extruded components and phytobiotic additives in feeding meat quails and the need to involve them in the development of optimal schemes for increasing productivity and product quality. The results obtained by the authors regarding the use of extruded components in diets in combination with a phytobiotic feed additive are consistent with the above data of foreign authors, and the authors consider their use in the production of compound feed for quail to be promising.

CONCLUSIONS

As a result of the conducted research, the specifics of the use of extruded components in quail diets were analysed in order to increase meat productivity. The basis of the study was the problem of antibiotic resistance, in particular, effective ways of replacing antimicrobial agents with safe natural herbal alternatives were considered. It has been established that they can be phytobiotics that have similar properties, without having a negative effect on the bird's body, and, on the contrary, stimulating metabolic processes. The results obtained during the research confirm the high efficiency of the use of extruded components and the phytobiotic additive BioFeed-P in quail diets for the meat sector. Poultry feeding according to the specially developed "Start", "Growth" and "Finish" recipes ensured an increase in live weight indicators, better slaughter characteristics and quality indicators of meat compared to the CG.

It was established that the introduction of extruded components and phytobiotics into the compound feed contributed to a significant increase in the absolute and average daily weight gain of the quails of the EG. In addition, the poultry of the EG had a higher slaughter weight by 26%, a higher yield of semi-eviscerated and gutted carcasses by 30.6-37.7%, a greater mass of skin, subcutaneous fat, pectoral and tender muscles compared to the CG. The analysis of biochemical blood parameters conducted during the study did not reveal significant deviations from the norm, which indicated the absence of a negative effect of the developed compound feed on the physiological state of the bird. At the same time, a decrease in amylase activity was observed, which is probably associated with a decrease in the intensity of metabolism against the background of the use of easily digestible feed components. In general, the results obtained in this study prove the expediency of using extruded components and phytobiotic additives in feeding quails of the meat production sector to increase their productivity, preserve health and improve the quality of meat products. The obtained data can be used in the development of complete balanced diets for industrial quail breeding. Further research is required to better understand the mechanisms underlying these changes and determine homeostasis for quail. Additional studies could also explore the impact of the experimental diet on egg production, quality and hatchability.

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CONFLICT OF INTEREST

None.

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Вплив комбікорму з екструдованими компонентами та фітобіотиками на організм перепелів

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Анотація. Перепели є цінним видом домашньої птиці, оскільки їхні яйця та м'ясо мають високу поживну цінність. Крім того, перепели відрізняються ранньою статевою зрілістю, високою несучістю і невеликими розмірами тіла. Ці унікальні характеристики роблять їх привабливим об'єктом для селекції та наукових досліджень. Метою роботи було дослідити вплив комбікорму з екструдованими компонентами та фітобіотиками на м'ясну продуктивність і біохімічні показники крові техаських перепелів. Методологія дослідження передбачала розподіл 200 перепелів на дослідну та контрольну групи, згодовування їм різних раціонів протягом 60 днів та аналіз показників росту, м'ясної продуктивності та біохімічних показників крові за допомогою інструментів статистичного аналізу. У результаті досліджень було виявлено, що комбікорм, виготовлений за розробленою рецептурою, позитивно впливає на приріст маси тіла перепелів. У дослідній групі (ЕГ) абсолютний приріст склав 313,7 ± 4,34 г, у контрольній групі (КГ) – 275,9 ± 2,89 г (різниця не вірогідна, P > 0,05). Крім того, комбікорм з екструдованими компонентами та фітобіотиками призвів до покращення коефіцієнту конверсії корму в ЕГ порівняно з контролем. Птахи в ЕГ також продемонстрували вищу масу тушки та виходи. Експериментальний раціон також позитивно вплинув на імунний статус перепелів. Отримані результати демонструють потенційні переваги включення екструдованих компонентів та фітобіотиків у корм перепелів для покращення показників росту та підтримання здорових фізіологічних параметрів. Оцінюючи результати біохімічного аналізу крові, можна зазначити, що суттєвих змін у складі крові не виявлено, що може свідчити про відсутність негативного впливу розробленого комбікорму на організм птиці. Отримані результати можуть мати практичне значення для розробки оптимальних раціонів для м'ясних перепелів та підвищення якості і безпечності їх продукції

Ключові слова: екструзія; біохімія крові; гомеостаз; дієта; білок