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THE EFFECT OF ENZYME PREPARATIONS (PHYTASE, XYLANASE) ON ENERGY METABOLISM IN BROILER CHICKENS

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Abstract:

The efficient utilization of nutrients and optimization of energy metabolism are key factors determining the productivity and economic efficiency of broiler poultry production. This study aimed to evaluate the effect of enzyme preparations, phytase and xylanase, on energy metabolism and energy utilization efficiency in broiler chickens during different growth periods (1-7, 8-16, and 17-28 days). Experimental studies were conducted using control and treatment groups, where broilers in the experimental groups received phytase alone and in combination with xylanase. Metabolizable energy utilization and energy efficiency were analyzed using statistical methods including ANOVA and Student's t-test.

The results showed that the use of phytase improved metabolizable energy utilization by 3.4-4.6%, while the combined use of phytase and xylanase increased this parameter by 6.5-8.9% compared to the control group ($P>0.95$; $P>0.99$). Energy utilization efficiency was also significantly higher in the enzyme-treated groups, reaching 82.1% in the combined enzyme group during the finishing period. The synergistic effect of phytase and xylanase enhanced nutrient digestibility, reduced energy losses, and improved metabolic efficiency.

The findings indicate that enzyme supplementation, especially the combined use of phytase and xylanase, plays an important role in improving energy metabolism, enhancing feed efficiency, and increasing growth performance in broiler chickens. These results provide a scientific basis for the practical use of enzyme preparations in modern poultry nutrition.

Keywords:

Broiler chickens, phytase, xylanase, enzyme preparations, energy metabolism, metabolizable energy, nutrient digestibility, feed efficiency, poultry nutrition, growth performance.

Introduction

The broiler poultry industry is an essential component of ensuring global food security and improving animal productivity worldwide. Increasing feed efficiency, reducing waste, and ensuring healthy growth of poultry are among the most pressing issues at the global level today. According to the Food and Agriculture Organization (FAO, 2022), incomplete digestion of feed nutrients in poultry production results in billions of dollars in feed resources being used inefficiently each year.[4]

At the global level, the loss of phosphorus and protein remains a significant problem, causing not only economic damage but also environmental pollution. In many countries, the use of enzyme preparations is recommended to improve broiler growth performance; in particular, recommendations from the European Union (EU, 2020) and the United States Department of Agriculture (USDA) confirm their effectiveness.[5]

In our region, particularly in Uzbekistan, Kazakhstan, and Kyrgyzstan, low feed efficiency is observed in the broiler industry. Due to the limited use of enzyme preparations, nutrient digestibility decreases by 10–15% (Uzbekistan FAO National Reports, 2023).[4]

Therefore, at the regional level, the following urgent tasks remain Increasing feed efficiency, Enhancing animal productivity, Protecting the environment.

Research Objective:

To scientifically investigate the effects of enzyme preparations (Phytase and Xylanase) on the digestion process, feed efficiency, and growth performance of broiler chickens, and to determine the optimal enzyme combination.

Research Tasks:

1. To determine energy metabolism in the bodies of chicks.

Methods:

- The obtained data were analyzed using Microsoft Excel 2019 and SPSS 25 software.
- Differences between groups were determined using ANOVA (Analysis of Variance).
- Significant differences between groups were evaluated using the Student's t-test at a statistical significance level of $p < 0.05$.
- The coefficient of variation (CV%) was used to assess the dispersion of experimental results.

Experimental Procedure:

1. Day-old chicks were randomly assigned to experimental groups.
2. The feed formulation and enzyme preparations were provided daily in precise amounts.
3. Energy metabolism in the chicks' bodies was determined.

Effect of enzyme preparations (phytase and xylanase) on energy metabolism in broiler chicks

The inclusion of enzyme preparations-phytase and xylanase-in the diet of broiler chicks optimizes energy metabolism by improving nutrient digestibility.

The mechanism of phytase action involves the hydrolysis of phytic acid present in feed, converting bound phosphorus into its available form.[2] This enhances the absorption of protein, starch, and mineral substances, reduces phosphorus deficiency required for ATP synthesis, and consequently increases metabolizable energy values and improves feed utilization efficiency.[1]

The mechanism of xylanase action is based on the degradation of non-starch polysaccharides (NSP), which reduces intestinal viscosity, enhances enzymatic digestion of nutrients, improves starch and fat utilization, and stabilizes intestinal microflora, thereby contributing to the formation of additional energy sources.[3]

Based on the above-mentioned information, our study investigated the effects of these enzymes on energy metabolism in broiler chicks. The composition of broiler chick diets by feeding phases is presented in Tables 1, 2, and 3.

Table 1. Diet Composition for Broiler Chicks (1-7 Days of Age)

Indicator	Value
Metabolizable energy, MJ/kg	12,1
Crude protein, %	22,5
Crude fat, %	5,2
Crude fiber, %	3,8
Calcium, %	1,05
Total phosphorus, %	0,72
Lysine, %	1,32
Methionine + Cystine, %	0,95

Table 2. Diet Composition for Broiler Chicks (8-16 Days of Age)

Indicator	Value
Metabolizable energy, MJ/kg	12,6
Crude protein, %	21,0
Crude fat, %	5,8
Crude fiber, %	4,1
Calcium, %	0,95
Total phosphorus, %	0,68
Lysine, %	1,20
Methionine + Cystine, %	0,87

Table 3.Diet Composition for Broiler Chicks (17-28 Days of Age)

Indicator	Value
Metabolizable energy, MJ/kg	13,2
Crude protein, %	19,2
Crude fat, %	6,4
Crude fiber, %	4,3
Calcium, %	0,88
Total phosphorus, %	0,64
Lysine, %	1,05
Methionine + Cystine, %	0,78

In the study, the diet formulated for broiler chicks was differentiated according to age periods and developed with consideration of their physiological growth characteristics, metabolic intensity, and productivity indicators.

The diet designed for the 1–7 day period was enriched with high biological value protein and essential amino acids. At this stage, metabolizable energy was 12.1 MJ/kg, while crude protein accounted for 22.5%. The relatively high levels of lysine (1.32%) and methionine + cystine (0.95%) ensure intensive tissue differentiation and muscle fiber formation in chicks. The comparatively elevated levels of calcium (1.05%) and total phosphorus (0.72%) support the initial mineralization processes of the skeletal system. The primary objective during this period is to accelerate structural growth.

In the 8–16 day period, metabolizable energy was increased to 12.6 MJ/kg, while crude protein was reduced to 21.0%. At this stage, the energy-to-protein ratio is optimized to ensure maximum growth rate. Increasing crude fat content to 5.8% enhances the energy density of the diet. Mineral levels (Ca – 0.95%, P – 0.68%) were slightly reduced, as the initial skeletal formation phase is largely completed and rapid body weight gain becomes the priority.

In the subsequent growth phase, metabolizable energy was increased to 13.2 MJ/kg, while crude protein was reduced to 19.2%. Raising crude fat content to 6.4% strengthens energy supply. Maintaining lysine (1.05%) and methionine + cystine (0.78%) at physiologically adequate levels ensures the final development of muscle mass. Calcium and phosphorus levels, at 0.88% and 0.64% respectively, provide an age-appropriate balance of mineral metabolism.

Table 4 Effect of enzyme preparations on energy metabolism in broiler chicks (1-7 days of age)

Group	Metabolizable Energy Utilization, %		Energy Use Efficiency, %	
	X±Sx	Cv,%	X±Sx	Cv,%
Control	72,4 ± 0,68	2,15	68,2 ± 0,74	2,43
I Experimental (Phytase)	75,8 ± 0,71*	2,08	72,6 ± 0,69*	2,19
II Experimental (Phytase + Xylanase)	78,9 ± 0,64**	1,94	75,9 ± 0,66**	2,01

*P>0,95; **P>0,99

Note:* – Significant difference compared to the control group (P > 0.95)

** – Highly significant difference compared to the control group (P > 0.99)

Table 4 presents the changes in metabolizable energy utilization and energy efficiency in 1–7 day-old broiler chicks when enzyme preparations were applied. The results were evaluated statistically at significance levels (*P > 0.95; **P > 0.99).

Metabolizable energy utilization in the control group was 72.4 ± 0.68%. In the first experimental group (Phytase), this value increased to 75.8 ± 0.71%, which is 3.4% higher than the control (P > 0.95). In the second experimental group (Phytase + Xylanase), it reached 78.9 ± 0.64%, showing a 6.5% increase compared to the control group (P > 0.99). This improvement is attributed to the enzymes breaking down complex feed compounds, enhancing the biological

availability of energy. Notably, a synergistic effect was observed when the enzyme combination was applied.

Energy efficiency in the control group was 68.2 ± 0.74%. Application of Phytase increased this parameter to 72.6 ± 0.69%, 4.4% higher than the control (P > 0.95). In the Phytase + Xylanase group, energy efficiency reached 75.9 ± 0.66%, 7.7% higher than the control (P > 0.99). This indicates more effective utilization of energy for both plastic (growth-related) and metabolic needs.

The coefficient of variation (Cv) ranged from 1.94% to 2.43% across all groups, demonstrating the consistency of the experimental data and low within-group variability.

During the 1–7 day period, the use of enzyme preparations, particularly the combination of Phytase and Xylanase, significantly increased metabolizable energy utilization, improved energy efficiency, reduced energy losses, and supported intensive metabolic processes in young chicks. These results indicate that the combined use of enzymes is especially effective in optimizing energy metabolism, providing high biological performance during the initial growth stage, which is crucial for the intensive growth and future productivity of broiler chicks.

Table 5 Effect of enzyme preparations on energy metabolism in broiler chicks (8-16 days of age)

Group	Metabolizable Energy Utilization, %		Energy Use Efficiency, %	
	X±Sx	Cv,%	X±Sx	Cv,%
Control	74,1 ± 0,72	2,21	70,5 ± 0,77	2,34
I Experimental (Phytase)	78,6 ± 0,69*	2,03	74,8 ± 0,71*	2,12
II Experimental (Phytase + Xylanase)	82,3 ± 0,66**	1,88	78,9 ± 0,68**	1,97

*P>0,95; **P>0,99

Note:* – Significant difference compared to the control group (P > 0.95)

** – Highly significant difference compared to the control group (P > 0.99)

Based on the data presented in Table 5, it can be stated that the changes in metabolizable energy utilization and energy use efficiency in 8–16-day-old broiler chicks under the application of enzyme preparations were evaluated. The results were assessed according to statistical significance levels (*P > 0.95; *P > 0.99).

The metabolizable energy utilization in the control group amounted to 74.1 ± 0.72%. In Experimental Group I (Phytase), this indicator reached 78.6 ± 0.69%, which was 4.5% higher compared to the control group (P > 0.95). In Experimental Group II (Phytase + Xylanase), it reached 82.3 ± 0.66%, showing an 8.2% increase compared to the control group (P > 0.99). The obtained results indicate that enzyme preparations enhance the digestibility of complex polysaccharides and phytate compounds in the feed, thereby increasing the level of energy utilization. Notably, a synergistic effect was observed in the enzyme combination, where metabolizable energy utilization reached the highest level.

Regarding energy use efficiency, the control group demonstrated a value of 70.5 ± 0.77%. When phytase was applied, this indicator increased to 74.8 ± 0.71%, which was 4.3% higher than the control group (P > 0.95). In the Phytase + Xylanase combination group, the value reached 78.9 ± 0.68%, representing an 8.4% increase compared to the control group (P > 0.99). This indicator reflects the efficient allocation of energy for plastic processes and growth requirements in the organism. Under the influence of enzymes, improved nutrient digestibility led to reduced energy losses.

In all groups, the coefficient of variation (Cv) ranged from 1.88% to 2.34%, indicating the stability of the results and low intra-group variability. This confirms the reliability of the experimental data.

During the 8–16-day period, especially under the combined application of phytase and xylanase, the following effects were observed: A significant increase in metabolizable energy utilization, Improved energy use efficiency, Reduced energy loss, Activation of metabolic processes during the intensive growth phase.

The results demonstrate that the combined application of enzymes is highly effective in optimizing energy metabolism in broiler chicks and is biologically and economically justified during the second phase of growth.

Table 6 Effect of enzyme preparations on energy metabolism in broiler chicks (17–28 days of age)

Group	Metabolizable Energy Utilization, %		Energy Use Efficiency, %	
	X±Sx	Cv,%	X±Sx	Cv,%
Control	76,8 ± 0,75	2,27	73,2 ± 0,81	2,41
I Experimental (Phytase)	81,4 ± 0,72*	2,05	77,6 ± 0,74*	2,16
II Experimental (Phytase + Xylanase)	85,7 ± 0,69**	1,91	82,1 ± 0,71**	2,02

*P>0,95; **P>0,99

Note:* – Significant difference compared to the control group (P > 0.95)

** – Highly significant difference compared to the control group (P > 0.99)

From the data presented in Table 6, it can be observed that the changes in metabolizable energy utilization and energy use efficiency in 17–28-day-old broiler chicks under the application of enzyme preparations were evaluated. The results were assessed according to statistical significance levels (*P > 0.95; *P > 0.99).

Metabolizable energy utilization in the control group amounted to 76.8 ± 0.75%. In Experimental Group I (Phytase), this indicator reached 81.4 ± 0.72%, which was 4.6% higher than in the control group (P > 0.95). In Experimental Group II (Phytase + Xylanase), it reached 85.7 ± 0.69%, representing an 8.9% increase compared to the control group (P > 0.99). These results indicate that the application of enzyme preparations enhances the breakdown of complex feed compounds, thereby significantly increasing the intestinal absorption of energy nutrients. In particular, when enzymes were applied in combination, a synergistic effect was observed, and metabolizable energy utilization reached its highest level.

Regarding energy use efficiency, the control group showed a value of 73.2 ± 0.81%. With phytase supplementation, this indicator increased to 77.6 ± 0.74%, which was 4.4% higher than the control group ($P > 0.95$). In the Phytase + Xylanase combination group, it reached 82.1 ± 0.71%, showing an 8.9% increase compared to the control group ($P > 0.99$). This reflects the more efficient utilization of energy for plastic processes (muscle tissue synthesis) and metabolic energy requirements. Due to improved nutrient digestibility under the influence of enzymes, energy losses were reduced.

In all groups, the coefficient of variation (Cv) ranged between 1.91% and 2.41%, indicating the stability of the experimental results and low intra-group variability. This confirms the statistical reliability of the data.

During the 17–28-day period, especially when phytase and xylanase were applied in combination, the following effects were observed. A significant increase in metabolizable energy utilization, Improved energy use efficiency, Optimization of energy metabolism processes, A higher level of energy resource utilization during the intensive growth phase.

The results demonstrate that the combined application of enzyme preparations effectively regulates energy metabolism in broiler chicks even during the final growth stage and provides a scientific basis for improved productivity indicators.

In conclusion, the results of the conducted scientific experiments showed that the use of enzyme preparations had a significant positive effect on energy metabolism parameters in broiler chicks. In particular, during the starter period, metabolizable energy utilization in the control group was 72.4%, whereas it reached 75.8% in Experimental Group I (Phytase) and 78.9% in Experimental Group II (Phytase + Xylanase).

A similar trend was observed during the grower and finisher periods. Especially in Experimental Group II, energy utilization reached 82.3% and 85.7%, respectively, which was 8.2–8.9% higher than in the control group ($P > 0.99$). This can be explained by the ability of xylanase to improve nutrient digestibility through the breakdown of non-starch polysaccharides (NSPs).

Energy use efficiency was also higher in the enzyme-supplemented groups. In Experimental Group II, this indicator reached 82.1% during the finisher period, which was 8.9% higher than in the control group ($P > 0.99$).

The obtained results indicate that phytase improves energy metabolism by hydrolyzing phosphorus bound in phytate form, while xylanase enhances energy utilization by breaking down NSP components in the feed. The highest levels of energy metabolism and energy use efficiency were observed in Experimental Group II, where phytase and xylanase were applied in combination.

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