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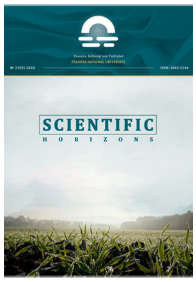

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# The role of microbial enzymes β-glucanase and α-amylase in optimising feed production for poultry

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**Abstract**. With the increase in world population and higher consumption of poultry meat, the need for efficient feed production to ensure high quality and quantity of products is increasing. The main objective of the study was to find out the effect of microbial enzymes β-glucanase and α-amylase on optimising the performance of

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poultry feed. The method of analysis, one-way analysis of variance, chemical analysis and quantitative analysis were used in the study. A review of the work showed that enzyme analysis in the experimental feeds confirmed the determined concentrations of 44, 67 and 88 kN. The treatments significantly reduced body weight gain and feed conversion ratio throughout the evaluation period. The effect was particularly marked at K-110 kcal/kg and enzyme concentrations of 250, 350 and 450 mg/kg. Enzyme supplementation resulted in partial recovery of performance evident at various intervals including 10-17 days, 17-30 days, and 30-37 days. The enzyme supplemented groups showed positive results in body weight gain, especially at K-110 kcal/kg and enzyme concentrations of 250, 350 and 450 mg/kg, compared to the control group. The results emphasised not only the high precision of the study, but also the effectiveness of the enzymes in improving feed utilisation and maintaining bird performance under altered dietary conditions. The study of enzyme complex in feeds is of practical importance to the poultry industry, as it confirms the efficacy of enzyme supplementation in improving feed utilisation and maintaining bird performance under altered diets. The findings provided a basis for optimising diets using specific energy levels and enzyme concentrations, which can lead to improved body weight gain and FCR, promoting more efficient nutrient uptake and reducing productivity losses in birds

**Keywords:** diet; active additives; broilers; productivity; body weight gain; feed conversion ratio

## INTRODUCTION

The study of the use of supplementary enzymes in poultry diets represents an important aspect of modern science and agriculture. The results of the research conducted in recent years show a significant increase in interest in this topic. The increased need for research lies in the problems of determining the optimum conditions for the use of supplementary enzymes, selection of the most effective types of enzymes and their ratio in diets. It is also important to study the possible negative effects or limitations of using certain enzymes in order to prevent possible health problems in poultry. According to N.T. Rashidova and A. Fayziyeva (2023), the use of supplemental enzymes in poultry diets can significantly improve digestive efficiency and nutrient absorption. The authors note the increased relevance in today's emerging market and increased competition, where efficient poultry production plays a key role. According to the assessment of Z. Alimkulo *et al.* (2022) and also A. Temirbekova *et al.* (2023), research on this topic has important practical implications for agricultural enterprises and farmers. Understanding which types of enzymes have the best effect on digestive processes in poultry allows optimising diets and increasing poultry performance, which ultimately affects the economic outcome of the farm.

The Food and Agriculture Organization of the United Nations states that microbial enzymes such as β-glucanase and α-amylase play a key role in optimising poultry feed production, as they aid in efficient digestion and nutrient absorption. The intervention of these enzymes in feed additives helps to improve nutrient availability, increase bird productivity, and reduce feed intake (Smits *et al.*, 2021). In their research, A. Mendybayeva *et al.* (2023) concluded that α-amylase and β-glucanase, assist in the breakdown of complex carbohydrates such as starch and beta-glucans which may be difficult for birds to digest. This improves the digestibility of the feed, making it more suitable for efficient energy utilisation. In addition, the authors note that the efficient breakdown of complex carbohydrates into simpler forms such as sugars and simple polysaccharides helps to improve feed intake efficiency. This is especially important for birds that frequently receive cereals in their diet.

Meanwhile, K. Mogilev *et al.* (2023) state that α-amylase and β-glucanase can help to overcome anti-nutrients such as phytates and other compounds that may reduce mineral absorption. This is especially important in diets with high grain content. The authors also note improved digestion and nutrient absorption, which are directly linked to improved bird performance. This can be in the form of faster growth, increased egg production (for laying hens) or improved body weight gain. In their work, M. Kurmanbayeva *et al.* (2023) noted the benefits of using β-glucanase in poultry feed. Among the positive aspects, the authors noted improved absorption of energy and other nutrients from the feed, which may lead to increased bird productivity, improved feed conversion and reduced digestive stress on the bird's digestive system. The results of a study by S.S. Muminova *et al.* (2023) show the role of α-amylase in the breakdown of complex carbohydrates, such as starch, into simple sugars. The authors observed an increase in energy availability from grain feeds, improved starch digestibility, reduced digestive load and increased feed intake efficiency. Since most cereals used in poultry feed contain starch, the addition of α-amylase helps improve the breakdown of starch into simpler forms that are more easily digested by the birds' bodies.

However, research lacks better data on dynamic changes in poultry growth and experiments with different concentrations of the microbial enzymes β-glucanase and α-amylase. Based on the above, the aim of the study was to analyse the effectiveness of supplementary enzymes in poultry diets to improve digestion and nutrient absorption. In particular, investigating the role of microbial enzymes such as α-amylase and β-glucanase in improving digestion, studying their positive contribution in the breakdown of complex carbohydrates and overcoming anti-nutrients.

## MATERIALS AND METHODS

Various methods were applied to solve the problems and to collect the necessary information to analyse the effects of protein additives in the production of meat products. Analysis method, one-way analysis of variance method, chemical analysis and quantitative analysis were used in the research. The method of analysis was applied to search for information resources and analytical processing of data in the research context of the selected topic. This enabled to identify patterns and study the dynamics of poultry development with microbial enzymes such as β-glucanase and α-amylase. The information for the study was derived from the data obtained from the experiments conducted by D. Shalginbaeyv *et al.* (2022) in agro-combinat "Astana" (Astana), A.T. Abylgazinova *et al.* (2023) in "KazAgroFood" (Pavlodar) and A.K. Saken *et al.* (2021) in "Altyn Taraz" company (Taraz city) of the Republic of Kazakhstan. Each of the researchers used the same methodology for rearing, preparation for slaughter, as well as slaughtering itself and analysing performance. This meant formulating diets based on soya and maize meal with careful consideration of nutrient and energy requirements of birds. The calculations made ensured that the birds' requirements were met or even exceeded, except for the total energy score. The diets were supplemented with an enzyme complex with a reduction of 120 kcal IEE/kg with the addition of 250 (U-110-250), 350 (U-110-350) and 450 (U-110-450) mg/kg of exogenous α-amylase+β-glucanase.

Data were analysed using one-way analysis of variance using SAS 9.3 procedure. The significance level was set at 7% and mean differences were identified using Tukey's test for statistically significant model effect (Nanda *et al.*, 2021). Linear and quadratic effects of decreasing imaginary metabolic energy (energy absorption ratio) were investigated for diets without enzyme supplementation. Calculated values of imaginary exchangeable energy (IEE) for body weight gain (BWG) and feed productivity ratio (FPR) at each level of enzyme addition allowed estimation of additional improvements in IEE with the enzyme complex at different points on the curve. Regression equations were fit and solved for the amount of energy intake and additional amylase intake (based on estimated data) in relation to specific variables. This was performed using both quadratic and linear models. The enzyme analogy estimation performed in this study followed the methodology outlined in the work by M.T. Hasan *et al.* (2023), where the equivalence of phosphorus released from phytase was evaluated. Poultry productivity was estimated using weekly measurements of BWG, feed intake (FI) and feed conversion ratio (FCR) corrected for dead weight of birds aged 1 to 45 days. Abdominal fat was weighed separately. Carcass yield was estimated considering the weight of the animal, while parts of meat for sale and abdominal fat were measured as a percentage of the total carcass weight. All sampling was conducted in accordance with the European Convention for the Protection of Pet Animals (1987) and the Universal Declaration on Animal Welfare (2007).

## RESULTS

The widespread adoption in commercial practice of the use of exogenous enzymes in broiler diets has only recently occurred, although research on this topic has been ongoing for several decades. The practical use of phytase in broiler diets is now being successfully applied on commercial poultry farms, but the use of enzymes targeting other substrates remains less common. However, this trend is rapidly changing due to the increasing cost of ingredients, especially those that provide energy and have market linkages to biofuels. In the works of D. Shalginbaeyv *et al.* (2022) and also A.T. Abylgazinova *et al.* (2023), the compliance of α-amylase and β-glucanase concentrations with expectations in experimental feeds was confirmed by enzyme complex analysis. The set values were: 45, 65 and 85 kN units of α-amylase/kg; actually, recorded values: 44, 67 and 88 kN of α-amylase/kg, respectively. Exposure to treatment affected BWG ($p < 0.01$) and FCR ($p < 0.01$) in birds for all weeks evaluated, with a loss of productivity due to reduced IEE. However, a partial recovery of productivity due to enzyme supplementation was noted (Table 1).

***Table 1**. Effect of gradual reduction of imaginary metabolisable energy in broiler diets with or without the addition of α-amylase+β-glucanase complex from days 1 to 40*

| Procedures, kcal/kg | Addition of enzymes, mg/kg | BWG, g | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1-10 days | 10-17 days | 17-30 days | 30-37 days | 37-45 days | 1-40 days |
| Control group | - | 116 | 289 | 518 | 661 | 846 | 3,137 |
| K-55 | - | 117 | 279 | 511 | 638 | 841 | 3,099 |
| K-85 | - | 115 | 285 | 507 | 641 | 832 | 3,065 |
| K-110 | - | 116 | 287 | 502 | 635 | 828 | 3,049 |
| K-110 | 250 | 124 | 288 | 514 | 636 | 838 | 3,111 |

*Table 1. Continued*

| Procedures, kcal/kg | Addition of enzymes, mg/kg | BWG, g | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1-10 days | 10-17 days | 17-30 days | 30-37 days | 37-45 days | 1-40 days |
| K-110 | 350 | 124 | 293 | 515 | 639 | 832 | 3,118 |
| K-110 | 450 | 127 | 296 | 514 | 643 | 853 | 3,121 |
| p-value | | 0.0399 | 0.0043 | 0.0223 | 0.0167 | 0.0369 | 0.0093 |
| Procedures, kcal/kg | Addition of enzymes, mg/kg | Feed consumption, g | | | | | |
| | | 1-10 days | 10-17 days | 17-30 days | 30-37 days | 37-45 days | 1-40 days |
| Control group | - | 129 | 401 | 731 | 1.059 | 1.389 | 4,048 |
| K-55 | - | 133 | 398 | 743 | 1.066 | 1.384 | 3,874 |
| K-85 | - | 124 | 406 | 731 | 1.048 | 1.382 | 3,654 |
| K-110 | - | 127 | 405 | 718 | 1.047 | 1.385 | 3,777 |
| K-110 | 250 | 129 | 400 | 742 | 1.066 | 1.4 | 3,714 |
| K-110 | 350 | 133 | 409 | 736 | 1.061 | 1.395 | 3,689 |
| K-110 | 450 | 134 | 404 | 730 | 1.06 | 1.395 | 3,632 |
| p-value | | 0.3501 | 0.2099 | 0.5811 | 0.9854 | 0.8592 | 0.9899 |
| Procedures, kcal/kg | Addition of enzymes, mg/kg | Feed conversion ratio | | | | | |
| | | 1-10 days | 10-17 days | 17-30 days | 30-37 days | 37-45 days | 1-40 days |
| Control group | - | 1.079 | 1.341 | 1.387 | 1.622 | 1.647 | 1.599 |
| K-55 | - | 1.117 | 1.402 | 1.437 | 1.667 | 1.658 | 1.638 |
| K-85 | - | 1.091 | 1.4 | 1.439 | 1.657 | 1.668 | 1.644 |
| K-110 | - | 1.12 | 1.388 | 1.4341 | 1.665 | 1.678 | 1.645 |
| K-110 | 250 | 1.101 | 1.394 | 1.437 | 1.669 | 1.675 | 1.647 |
| K-110 | 350 | 1.099 | 1.379 | 1.428 | 1.668 | 1.671 | 1.634 |
| K-110 | 450 | 1.077 | 1.361 | 1.424 | 1.655 | 1.662 | 1.629 |
| p-value | | 0.0051 | 0.000099 | 0.000099 | 0.0005 | 0.0053 | 0.0151 |

***Source:*** *compiled by the authors based on D. Shalginbaeyv et al. (2022), A.T. Abylgazinova et al. (2023), A.K. Saken et al. (2021)*

The table shows the effects of different enzyme and energy levels in broiler chicken diets on live weight gain, feed intake and feed conversion ratio at different age intervals. Seven treatment groups, including a control group (K) and six diet variants with different enzyme concentrations and energy levels, participated in the experiment. Regarding body weight gain, as noted by D. Shalginbaeyv *et al*. (2022), the results show differences depending on the treatment at different age intervals (1-10 days, 10-17 days). In general, it appears that increasing enzyme levels, especially in groups with K-110 kcal/kg intake and enzyme concentrations of 250, 350 and 450 mg/kg, has a positive effect on body weight gain compared to the control group. Significant differences in BWG were observed between 10-17 days, 17-30 days, and 30-37 days, suggesting that enzyme supplementation may influence the early stages of growth. The table also presents feed intake data, indicating that there were no significant differences between treatments. Feed intake values are relatively similar between treatment groups, suggesting that changes in body weight gain are not related to differences in feed intake.

Treatments significantly affected feed conversion ratio, a key indicator for assessing feed utilisation efficiency. Lower FCR values were generally observed in groups with higher enzyme concentrations, especially in groups with K-110 kcal/kg at enzyme levels of 250 mg/kg and 350 mg/kg. This suggests that these treatments are more efficient in converting feed to body weight, reflecting increased feed utilisation efficiency (Abylgazinova *et al.*, 2023). Thus, the table shows the effect of enzyme supplementation and energy level on broiler chicken performance. Higher enzyme concentrations, especially in the group with K-110 kcal/kg, have a positive effect on body weight gain and feed conversion efficiency at certain growth stages. These results have implications for optimising broiler diets to improve growth performance and feed utilisation in poultry production.

As soya meal contains minimal amounts, the main source of starch in the diets used by the farms for the study was maize. The proportion of starch in diets with a reduced IEE of 135 kcal/kg increased from 29.7% in the pre-starter diets to 44.5% in the finishing diets. The improvement in productivity was particularly marked with increasing age of birds, indicating a greater impact of adding the enzyme complex to diets with higher starch content, as shown in Table 1. Starch digestibility, which was investigated in this study, showed improved BWG and FCR in the enzyme supplemented birds as starch became a more significant part of their daily intake. This emphasises that the addition of $\alpha$-amylase to the enzyme complex promotes starch digestion and increased availability of glucose, which is used as energy.

Despite the generally high starch digestibility in birds, the digestibility of maize starch in the terminal tubular intestine was only 85% and did not increase with chick age. Resistant starch that avoids digestion in the small intestine may provide an opportunity to utilize exogenous α-amylase (Yadav & Jha, 2019). A.T. Abylgazinova *et al*. (2023) noted that the different treatments have no effect on the total carcass yield and marketable part of the carcass. Nevertheless, it is worth noting a significant reduction in the proportion of fat in the abdominal part of the carcass in birds fed the K-110-450 diet compared to the group fed the K-110 programme (1.55% compared to 1.88%; $p < 0.0347$). Importantly, all other treatment options were intermediate in this parameter (Table 2).

***Table 2**. Effect of gradual reduction of apparent metabolizable energy and addition of α-amylase + β-glucanase complex on the yield of carcass, abdominal fat, and marketable cuts in broilers from days 1 to 40 (%)*

| Procedures, kcal/kg | Addition of enzymes, mg/kg | Bran | Abdominal fat | Fillet | Hip | Wings |
|---|---|---|---|---|---|---|
| Control group | - | 76.8% | 1.79% | 32.1% | 33.1% | 11.1% |
| K-55 | - | 76.6% | 1.75% | 31.7% | 32.7% | 11.2% |
| K-85 | - | 76.5% | 1.87% | 32.3% | 32.4% | 11.3% |
| K-110 | - | 76.8% | 1.87% | 31.9% | 31.4% | 11.3% |
| K-110 | 250 | 78.7% | 1.81% | 32.4% | 31.4% | 11.2% |
| K-110 | 350 | 78.7% | 1.82% | 31.9% | 31.6% | 11.3% |
| K-110 | 450 | 78.5% | 1.68% | 31.7% | 31.7% | 11.3% |
| p-value | | 0.8601 | 0.0352 | 0.3412 | 0.5543 | 0.2349 |

***Source:** compiled by the authors based on D. Shalginbaeyv et al. (2022), A.T. Abylgazinova et al. (2023), A.K. Saken et al. (2021)*

A.K. Saken *et al*. (2021), interpret this result as a potential effect of the C-110-450 diet on the biochemical composition of broiler carcasses, especially with respect to abdominal fat content. The data presented highlight the importance of considering diet composition when formulating dietary programmes for broilers to optimize their metabolic parameters and meat quality characteristics. A variety of interpretations have been proposed to explain the improvements achieved when exogenous carbohydrazines are introduced into poultry diets, and these interpretations are not always related to a more intensive degradation of the target substrate of these enzymes. A more efficient breakdown of starch, and hence increased digestibility of this substance, can be seen when metabolised energy is increased when broilers are fed corn-soybean diets supplemented with amylases.

The use of α-amylase in combination with other enzymes such as beta-glucanase and xylanase resulted in an increase in metabolised energy content in corn-soy-based broiler diets and improved digestibility of all amino acids in the club intestine (Bakare *et al.*, 2021). In a study by D. Shalginbaeyv *et al*. (2022), field performance on diets with reduced energy and addition of α-amylase-β-glucanase complex also improved, although it did not fully compensate for the productivity losses caused by a 120 kcal/kg reduction in the diet for 40 days. The enzyme complex includes α-amylase and β-glucanase. The β-glucan content of the corn-soya diets was low, approximately 0.2% in corn and 0.4% in soya meal. Although the improvements are probably due to the effect of α-amylase on starch, since its content exceeds that of β-glucans, the influence of the latter cannot be excluded either. It is generally believed that β-glucans have a negative effect on chicken performance due to their viscosity, and they are considered as an important anti-nutritional component in diets with barley, wheat, or rye. Despite the low content of β-glucans (8.1% in barley, 0.6% in wheat and 0.9% in rye), their negative effects on poultry performance are proportionally high (Moran & Bedford, 2022). Consequently, even considering their small proportions compared to other cereals, the impact of β-glucanase on maize-soya diets may be notable.

Broilers have been successfully adapted to starch-based diets as a result. However, the high feed intake of modern fast-growing broilers may create physiological constraints to starch digestion, leaving some dietary starch undigested and available for interaction with additional amylase. Table 3 shows that BWG and FCR responded linearly to the reduction in IEE in diets without enzyme supplementation ($p < 0.02$). At the same time, no effect on feed intake was detected in the weekly dynamics.

***Table 3**. Regression equations for body weight gain and feed conversion ratio in response to a decrease in imaginary metabolisable energy and relative estimates of the equivalence of IEE with the addition of an α-amylase + β-glucanase complex to broiler feeds from days 1 to 40*

| Components | Regression equation | Determination coefficient | p-value | Bioequivalence (mg/kg) | | |
|---|---|---|---|---|---|---|
| | | | | 250 | 350 | 450 |
| BWG, g | | | | | | |
| 1-10 days | A=-0.00003b+0.1193 | 0.2962 | 0.0065 | 7 | 7 | 7 |
| 10-17 days | A=-0.00009b+0.3002 | 0.2889 | 0.0076 | 10 | 9 | 66 |

*Table 3. Continued*

| Components | Regression equation | Determination coefficient | p-value | Bioequivalence (mg/kg) | | |
|---|---|---|---|---|---|---|
| | | | | 250 | 350 | 450 |
| 17-30 days | A=-0.00020b+0.5356 | 0.3111 | 0.0003 | 56 | 59 | 61 |
| 30-37 days | A=-0.00009b+0.3152 | 0.2167 | 0.0031 | 96 | 86 | 99 |
| 37-45 days | A=-0.00011b+0.2846 | 0.1148 | 0.0297 | 49 | 67 | 69 |
| 1-45 days A=-0.00091b+3.2746 | | 0.4378 | 0.0002 | 41 | 48 | 57 |
| FCR | | | | | | |
| 1-10 days | A=0.00024b+1.0785 | 0.2279 | 0.0354 | 49 | 41 | 62 |
| 10-17 days | A=0.00052b+1.2498 | 0.3137 | 0.0003 | 26 | 69 | 97 |
| 17-30 days | A=0.00055b+1.3888 | 0.4754 | 0.0002 | 67 | 83 | 92 |
| 30-37 days | A=0.00029b+1.7368 | 0.1843 | 0.0067 | 99 | 129 | 153 |
| 37-45 days | A=0.00034b+1.9161 | 0.0994 | 0.0507 | 20 | 55 | 57 |
| 1-45 days | A=0.00043b+1.6146 | 0.2903 | 0.0004 | 61 | 78 | 101 |

***Source:*** *compiled by the authors based on D. Shalginbaeyv et al. (2022), A.T. Abylgazinova et al. (2023), A.K. Saken et al. (2021)*

Table 3 presents the calculation of apparent metabolisable energy based on body weight gain and FCR data from broiler chickens subjected to different levels of enzyme supplementation. These results are then compared with the responses of birds whose diets had reduced apparent metabolisable energy and which received no enzyme supplementation. The calculated values of apparent metabolisable energy show variability across age intervals and enzyme concentrations in the feed, with the lowest values observed in the first week and the highest values in the fourth week of the observation period.

The conditional values of metabolised energy reflect the metabolic efficiency of the birds in utilising the provided feed for growth. The age-related changes emphasize the dynamic nature of energy utilisation patterns of birds as they progress through different developmental stages. The first week, characterised by lower conditional metabolisable energy values, may indicate a period of adjustment and adaptation to feeding conditions. Importantly, the mean values of the conditional apparent metabolised energy of the enzyme complex show weekly fluctuations, highlighting the influence of both age and enzyme concentration on the metabolic processes of broiler chickens. Notably, as the birds matured and reached the fourth week of age, there was a significant increase in conditional AME values, indicating an increased capacity for energy utilisation.

Over the entire observation period, conditional estimates of metabolised energy as stated by A.T. Abylgazinova *et al.* (2023) and A.K. Saken *et al.* (2021), show a positive correlation with increasing enzyme concentration in the feed. Specifically, the addition of 250, 350 and 450 mg/kg of enzyme complex was associated with corresponding conditional IEE values of 42, 48 and 59 kcal for body weight gain and 61, 79 and 102 kcal IEE/kg for feed conversion ratio. These results highlight the potential usefulness of enzyme supplementation for optimising energy utilisation and growth of broiler chickens. Linear corrections for BWG and FCR obtained from the beginning to the end of the study when birds were fed different concentrations of enzymes in the diet are presented on Figures 1 and 2. No effect of treatment was found on mortality, which was an overall mean of 4.15%.

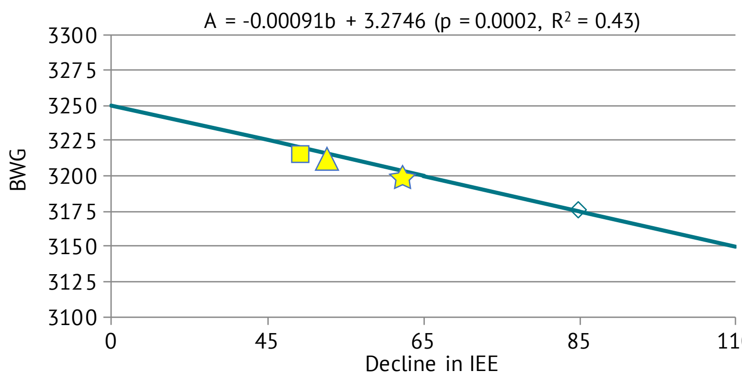


***Figure 1***. *Body weight gain of broilers fed AME diets supplemented or not with α-amylase+β-glucanase complex from day 1 to day 40, g*

***Note:*** *square – 250 mg α-amylase + β-glucanase; triangle – 350 mg α-amylase + β-glucanase; star – 450 mg α-amylase + β-glucanase*

***Source:*** *compiled by the authors based on D. Shalginbaeyv et al. (2022), A.T. Abylgazinova et al. (2023), A.K. Saken et al. (2021)*

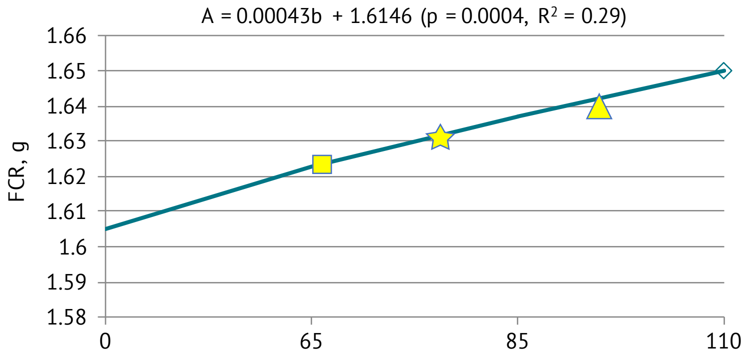


***Figure 2**. FCR values for broilers fed diets containing progressively lower apparent metabolisable energy levels, with or without α-amylase+β-glucanase complex supplementation, from day 1 to day 40*
***Source:** compiled by the authors based on D. Shalginbaeyv et al. (2022), A.T. Abylgazinova et al. (2023), A.K. Saken et al. (2021)*

Exposure of complex substrates containing different types of molecules, after partial or complete degradation by an enzyme, may provide access to other enzymes that would otherwise be unable to interact with the original substrate. The concept of degradation of a new matrix is often invoked to explain these improvements. Some plant nutrients, such as starch and protein, are retained within insoluble cell walls (sometimes referred to as the cage effect), preventing poultry from accessing these nutrients. In addition, soluble fibres dissolve in the intestine, forming viscous gels that trap nutrients and slow the rate of etching and passage of feed through the intestine (Boukid *et al*., 2023).

The use of different enzyme combinations under a wide range of conditions and with a variety of feed compositions has demonstrated improved broiler performance. The results of this study highlight that the addition of α-amylase-β-glucanase complex to diets may represent a promising alternative in the field of supplementation that can potentially optimize the efficient energy utilisation of broiler birds. This discovery emphasises the importance of finding innovative solutions to improve broiler feed efficiency. Supplementation of an enzyme complex such as α-amylase-β-glucanase may be an effective way to optimize the nutritional process and improve overall bird performance.

## DISCUSSION

In conjunction with the global trend of optimising poultry feed production, microbial enzymes such as β-glucanase and α-amylase are gaining importance, attracting attention and wide application. The increasing world population and improved living standards in different regions are accompanied by an increase in meat and egg consumption, thus presenting the livestock industry with an urgent challenge to improve poultry productivity. In the context of this challenge, there is a growing trend towards more efficient feeding as producers seek to optimize the use of feed resources to reduce costs and increase overall productivity (Voronetska & Yurchuk, 2023). The use of microbial enzymes such as β-glucanase and α-amylase stands out as one of the promising optimisation methods in this field. This approach represents not only a cost-saving strategy, but also an important component of a sustainable development strategy in the face of increasing demands for food resources (Daneshmand *et al*., 2023). The results of studies on the role of microbial enzymes in poultry feed production show positive effects on various parameters, which opens new perspectives in improving feed efficiency and poultry productivity.

The observed weight gain of hens is an important indicator of the effectiveness of microbial enzyme administration (Szeląg-Sikora *et al*., 2024). Such results are in line with the findings of authors A.A. Nascimento *et al*. (2023), who also observed a positive effect on poultry growth when such enzymes were used. In this study, the inclusion of feed bard (DDGS) in the diet resulted in a significant increase in body weight. It is emphasised that the study revealed an increase in feed intake due to the introduction of DDGS in the diet. In addition, the authors note that DDGS significantly increased the palatability of the diet. The results suggest that DDGS contributes to increased weight gain not so much through favourable digestion and absorption of nutrients, but by increasing the palatability of the feed. This is supported by similar digestive enzyme activity, nutrient absorption levels and overall performance of the feed without DDGS supplementation.

The study confirms increased feed digestibility and energy metabolism efficiency with microbial enzymes. These results are in agreement with the study of scientists A. Daneshmand *et al*. (2023) who emphasised that enzymes promote better polysaccharide breakdown and nutrient digestibility, resulting in improved energy efficiency. The authors stated that enzymes can also improve the absorption of proteins, fats, vitamins, and minerals. This occurs by breaking down the cellular structures of plant material and activating processes that promote better absorption of nutrients in the gastrointestinal tract. Similar results are provided by P.E. Rupolo *et al*. (2023), in their work. In it, the authors concluded that microbial enzymes have a positive effect on the function of the gastrointestinal tract, giving it a higher efficiency in digestion and assimilation of food. This process results in a shorter residence time of feed in the body, which in turn reduces nutrient losses and increases overall energy efficiency.

Studies conducted by N.K. Morgan *et al.* (2021) confirm the effects of microbial enzymes in stimulating the microbiota. In their research, the authors found that microbial enzymes exhibit the ability to create favourable conditions for the growth of beneficial bacteria in the gut, thereby contributing to an improved microbiotic balance. This important aspect of the observed effects of microbial enzymes has the potential to improve feed processing efficiency and nutrient absorption. The results obtained by J. Chauhan *et al.* (2023), highlight that the use of microbial enzymes can not only stimulate the microbiota, but also contribute significantly to the optimisation of physiological processes in the digestive system. Creating favourable conditions for the development of beneficial microorganisms represents an important mechanism to improve the overall health and digestive efficiency of birds (Daskalova *et al.*, 2023). These findings provide additional scientific justification for considering microbial enzymes as a promising component in optimising poultry nutrition.

Increased productivity is related to feed conversion efficiency, which means that poultry produce more meat or eggs with the same or even less feed intake (Sychov *et al.*, 2024). This aspect becomes extremely important in the context of high feed costs in industrial poultry production. The work of scientists P. Gulizia *et al.* (2023), also highlights the improvement in feed conversion when microbial enzymes are used, which confirms the importance of this factor in overall productivity. The authors argue that increased productivity also has a direct impact on the economic efficiency of poultry production. Reducing feed costs while increasing yields can significantly improve profitability of production. This is an important aspect to attract the attention of industrialised enterprises and farms. Meanwhile, C. Liu *et al.* (2022) note environmental benefits in the use of microbial enzymes. The authors note that increased productivity accompanied by more efficient feed utilisation may also have positive environmental aspects. Reduced feed intake results in a reduced need for agricultural inputs, which helps to reduce environmental impacts and supports the sustainability of poultry production. These findings emphasize the importance of considering microbial enzymes not only as a tool to increase productivity, but also as a strategy that can promote environmental sustainability in agriculture. Optimising the use of feed resources not only improves the economic performance of production, but also contributes significantly to reducing the negative impact of human activities on the natural environment (Turmagambetova *et al.*, 2015).

The observed improvement of the conditional equivalent after the first week of feeding is of interest. The initial deterioration of the conditioned equivalent in the first week may be due to adaptation of the organism to the new type of feed and activation of enzymes, which takes time to optimize their action. Subsequent improvement in this indicator suggests that the birds' digestive system is successfully adapting to the use of microbial enzymes, which in turn leads to increased efficiency of feed digestion and optimisation of energy balance (Montayeva *et al.*, 2023). Similar dynamics were also identified by researchers L. Bornaei *et al.* (2022), who suggested that enzyme activation during the initial phase of feeding may take time to reach optimal efficiency. The results showed a temporary deterioration in equivalence during the initial period of enzyme administration, followed by a gradual improvement with increasing duration of use. The authors attributed this to the gradual adaptation of the birds to the new biological processes induced by microbial enzyme administration. This indicates the importance of long-term studies to better understand the temporal aspects of the effects of microbial enzymes on birds.

Summarising the above, the results of the study on the role of the microbial enzymes β-glucanase and α-amylase in poultry feed production provide valuable information for optimising poultry production. The observed positive changes in hen weight, feed digestion, conditioned equivalent, and performance confirm the significance of introducing these enzymes into feed rations. The results obtained not only confirm previous studies, but also indicate the need for a more in-depth study of temporal aspects and interactions with microflora. These findings may provide a basis for the development of new strategies in poultry production to improve animal performance and resilience to changes in feed conditions. In the long term, understanding these mechanisms may provide impetus for the development of innovative solutions in agriculture, balanced in terms of economic efficiency and eco-sustainability.

## CONCLUSIONS

The analysis of the enzyme complex in the experimental feeds confirmed that the concentrations of α-amylase and β-glucanase were as expected. The developed values were 45, 65 and 85 kN of α-amylase/kg and the actual values were 44, 67 and 88 kN, respectively. This indicates the high accuracy of the study in supporting the stated objectives. The effect of the treatment significantly affected the productivity of the birds. There were statistically significant decreases in both body weight gain (BWG index, $p < 0.01$) and feed conversion ratio (FCR index, $p < 0.01$) throughout the weeks evaluated. These productivity losses were associated with a reduction in energy in the diet, resulting in a decrease in IEE (expressed in kcal). Enzyme supplementation resulted in a partial recovery of productivity. The effectiveness of this recovery is emphasised by data on weight gain and conversion ratio. For example, significant differences in body weight gain (BWG) were observed between 10-17 days, 17-30 days and 30-37 days, where enzyme supplemented groups, especially at K-110 kcal/kg and enzyme concentrations of 250, 350 and 450 mg/kg, showed positive results compared to the control group.

It was found that the treatments significantly affected the feed conversion ratio (FCR). Lower FCR values were recorded in the groups with higher enzyme concentrations, especially at K-110 kcal/kg and enzyme levels of 250 mg/kg and 350 mg/kg. These results indicate an increase in feed utilisation efficiency in the groups with enzyme supplementation. Based on the results of this study, the following recommendations for optimising broiler chicken performance are proposed: the introduction of enzyme supplements, especially α-amylase-β-glucanase complex, is a promising approach to improve bird performance. It is recommended to consider the inclusion of such additives in diets, especially under reduced energy conditions. It is recommended that the concentration of enzymes in diets should be tuned for age-specific performance, which may help to maximize feed utilisation efficiency at different growth stages. Further research is recommended to determine the optimum enzyme concentrations in diets that maximize the positive effects on growth and feed conversion efficiency. The results emphasize the importance of starch treatment and effects on the fat component of the carcass. Further investigation of the effects of enzymes on these parameters and possible adjustments in rations is recommended.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

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## Роль мікробних ферментів β-глюканази та α-амілази в оптимізації виробництва кормів для птиці

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**Анотація**. Зі збільшенням чисельності населення планети та зростанням споживання м'яса птиці зростає потреба в ефективному кормовиробництві для забезпечення високої якості та кількості продукції. Основна мета дослідження полягала в тому, щоб з'ясувати вплив мікробних ферментів β-глюканази та α-амілази на оптимізацію продуктивності комбікормів для птиці. У дослідженні використовували метод аналізу, однофакторний дисперсійний аналіз, хімічний аналіз та кількісний аналіз. Огляд роботи показав, що аналіз ферменту в експериментальних кормах підтвердив визначені концентрації 44, 67 і 88 кН. Обробка значно знизила приріст живої маси та коефіцієнт перетворення корму протягом усього періоду оцінки. Ефект був особливо помітним при К-110 ккал/кг і концентраціях ферменту 250, 350 і 450 мг/кг. Додавання ферментів призвело до часткового відновлення продуктивності, що було помітно через різні проміжки часу, включаючи 10-17 днів, 17-30 днів та 30-37 днів. Групи, які отримували ферментну добавку, показали позитивні результати у збільшенні маси тіла, особливо при К-110 ккал/кг і концентрації ферменту 250, 350 і 450 мг/кг, порівняно з контрольною групою. Результати підкреслили не тільки високу точність дослідження, але й ефективність ферментів у покращенні використання корму та підтримці продуктивності птиці в умовах зміненого раціону. Дослідження ферментного комплексу в кормах має практичне значення для птахівничої галузі, оскільки підтверджує ефективність ферментних добавок у покращенні використання корму та підтримці продуктивності птиці при зміні раціонів. Отримані результати є основою для оптимізації раціонів з використанням певних рівнів енергії та концентрацій ферментів, що може призвести до покращення приросту живої маси та КПК, сприяючи більш ефективному засвоєнню поживних речовин та зменшенню втрат продуктивності птиці

**Ключові слова:** раціон; активні добавки; бройлери; продуктивність; приріст живої маси; коефіцієнт конверсії корму