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Igor ILCHUK*[1], Mykhailo SYCHOV[1], Ildus IBATULLIN[2]

MEAT PRODUCTIVITY OF BROILER CHICKENS AT DIFFERENT LYSINE LEVELS IN COMPOUND FEED

SUMMARY

The study aimed to determine the effect of different lysine levels in complete feed on growth, slaughter traits and meat productivity of Cobb 500 broiler chickens. Four hundred day-old chicks were allocated into four groups of 100 birds by the method of analogues and reared under identical housing conditions until 42 days of age. All groups received isocaloric and isonitrogenous diets differing only in lysine content. The dynamics of live weight, average daily gain, feed conversion, main slaughter traits, yields of individual carcass parts, meatiness indices and the amino acid profile of dietary protein were evaluated. A reduction in lysine content compared with the control led to significant decreases in absolute and average daily gain, carcass meatiness and the proportion of edible parts, indicating limited realisation of genetic growth potential due to lysine deficiency. A moderate increase in lysine to 1.22, 1.12 and 1.07% in the starter (1–10 d), grower (11–22 d) and finisher (23–42 d) periods, respectively, provided the best balance of growth and meat productivity, with a tendency to higher final body weight and increased yields of breast and leg muscles without deterioration in feed conversion. A further increase to 1.24, 1.14 and 1.09% did not significantly improve body weight, but resulted in the highest absolute and relative breast yields, maximal carcass meatiness and minimal bone content without adverse changes in internal organs.

Keywords: nutrition, chickens, lysine, meat productivity, amino acid profile, slaughter traits

INTRODUCTION

Intensive selection has led to a significant increase in the growth rate and yield of breast muscles in modern broilers, which, in turn, has led to an increase in their needs for amino acids, primarily lysine, which is one of the first limiting essential amino acids in corn-soybean diets. Classic studies underlying the

[1]Igor Ilchuk (corresponding author: ilchukigor@nubip.edu.ua), Mykhailo Sychov, National University of Life and Environmental Sciences of Ukraine, Faculty of Livestock Raising and Water Bioresources, P.D. Pshenychnyy Department of Animal Nutrition and Feed Technology, Kyiv, UKRAINE;

[2]Ildus Ibatullin, National Academy of Agrarian Sciences of Ukraine, Kyiv, UKRAINE.

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concept of the "ideal protein" have shown that lysine is advisable to use as a reference amino acid for the formation of a balanced amino acid profile, and deviations from the optimal provision of lysine significantly affect the growth and morphology of chicken carcasses. At the same time, feeding standards established in previous decades, in particular NRC (1994), may be insufficient for modern fast-growing crosses, which are characterised by a higher intensity of muscle tissue deposition and a greater yield of breast muscles compared to old lines.

Recent studies using dose-response models in modern Cobb crosses suggest that optimal levels of digestible lysine to maximise growth, feed conversion efficiency, and carcass yield are higher than historically recommended and depend on age, genotype, target performance, and the chosen statistical approach to estimating requirements. Thus, Cemin, H. S. *et al.*, (2017) re-evaluated the digestible lysine requirement of male broilers and found that the levels required to achieve maximum breast meat yield significantly exceed those required to maximise live weight gain and improve feed conversion, consistent with earlier data on higher lysine requirements for optimising slaughter performance compared to growth (Kidd M.T. *et al.*, 1997, 1998). Zarghi, H. *et al.*, (2020) showed that increasing the level of digestible lysine in the finishing period from 0.88 to 1.12% causes a linear increase in carcass and breast yield and a decrease in abdominal fat deposition with minor changes in blood parameters and breast meat quality. Similar reactions have been described in other experiments and are summarised in a meta-analysis, which concluded that increasing the concentration of lysine in the diet consistently increases average daily gains, carcass yield and the proportion of breast muscles, while simultaneously reducing the content of abdominal fat. Factorial and model approaches further emphasise the need to revise the norms for providing lysine and other essential amino acids for modern fast-growing broilers, especially when feeding low-protein diets aimed at reducing nitrogen excretion.

At the same time, sustainable poultry farming requires increased productivity without excessive dependence on imported soybean meal and at the same time, reducing the carbon footprint of production. Life cycle assessment studies have shown that the choice and proportion of ingredients in the diet are key factors in shaping the carbon footprint of broiler feed, especially for grains and protein concentrates. In this context, Bilous, A., and Ilchuk, I. (2025) proved that partial replacement of traditional grains in broiler feed with rye significantly changes the associated carbon footprint, which emphasises the importance of considering environmental indicators during diet design. In the works of Shkarban, V., and Sychov, M., (2025), as well as Sychov, M. *et al.*, (2025), showed that high-protein sunflower concentrates can partially or wholly replace soybean meal in compound feeds for broiler chickens and laying hens without compromising growth, meat performance or egg production, provided that energy and amino acids are properly balanced. Similar results were obtained for other alternative protein sources in low-protein diets, where a critical condition for maintaining productivity and carcass quality is the correction of the amino acid composition, primarily due to lysine. Changing the raw material base inevitably transforms the amino acid profile of feeds and can affect the adequacy of lysine and other essential amino acids, which necessitates the need to improve amino acid nutrition in the context of the transition to more sustainable feed strategies.

Among the essential amino acids, lysine plays a key role in the synthesis of myofibrillar proteins and has traditionally been used as a basic amino acid in the concept of the "ideal protein" for broilers. Classical experiments have shown that insufficient lysine supply limits the growth and development of breast muscles, while a moderate increase in its level in the absence of other amino acid deficiencies promotes increased protein deposition, especially in breast muscles, and a decrease in carcass fat. Studies that varied the content of crude protein and lysine have shown that increasing the lysine density improves gains, feed conversion and breast muscle yield, but excessive levels of lysine relative to other amino acids can disrupt the amino acid balance and reduce nitrogen use efficiency. Of particular importance is the interaction of lysine with arginine: both early and modern studies of arginine–lysine antagonism have shown that deviations from the optimal ratio of these amino acids alter growth, nitrogen metabolism, and blood biochemical parameters in poultry. Experiments on the slaughter performance of broilers at different levels and ratios of arginine and lysine have shown that changes in this balance can significantly affect slaughter yield, development of breast and thigh muscles, and visceral mass, even at constant levels of crude protein and metabolisable energy in the diet (Nogueira, B. R. F. *et al.*, 2021, Sychov, M. *et al.*, 2022).

Despite significant progress in determining the lysine requirements of broilers, there is still a lack of data on how relatively small changes in its level against the background of a generally balanced amino acid profile affect meat performance and detailed slaughter performance of modern crosses under conditions close to production. Most recent studies on the assessment of lysine requirements have focused mainly on growth performance or overall slaughter yield, while comprehensive studies of the amino acid profile of ration protein, yield of individual cuts and meat indices at lysine levels close to real practice have been conducted much less frequently. In addition, there is particularly little information on the Cobb 500 cross when fed mixed feeds with a high proportion of locally available vegetable protein components, which is highly relevant to regions seeking to reduce dependence on imported soybean meal and reduce the environmental impact of feed production.

In this regard, this study aimed to assess the effects of different levels of lysine in isocaloric, isonitrogenous compound feeds on growth performance, slaughter parameters, and meat performance of broiler chickens of the Cobb 500 cross. Special attention was paid to changes in the amino acid profile of the protein of the diets, the yield of individual carcass parts and meat indices, as well as the possibility of enhancing the development of the breast muscles without increasing fat deposition and without negatively affecting the development of internal organs. The results of the work are aimed at clarifying the norms for providing lysine for modern broilers in conditions of balanced amino acid nutrition and expanding the use of alternative feed ingredients, which is important both for increasing productivity and for achieving the goals of sustainable development in poultry farming.

MATERIAL AND METHODS

Research on determining the optimal lysine levels in complete compound feeds for broiler chickens of different ages was conducted at the Problem Scientific Research Laboratory of Feed Additives, Department of Animal Nutrition and Feed Technology named after P.D. Pshenychnyi, National University of Life and Environmental Sciences of Ukraine (NUBiP of Ukraine).

The object of the research was broiler chickens of the Cobb 500 cross. The experiments were conducted using the group method. During the main period lasting 42 days, taking into account the age of the chickens, three subperiods were distinguished: 1–10; 11–22; 23–42 days, according to the experimental scheme (Table 1).

Table 1. Experimental scheme

Group	Age, days		
	1 –10	11–22	23–42
	lysine content in 100 g of compound feed, %		
1 – control	1.20	1.10	1.05
experimental: 2	1.18	1.08	1.03
3	1.22	1.12	1.07
4	1.24	1.14	1.09

For the experiments, 400 1-day-old broiler chickens were selected, from which 4 groups were formed according to the principle of analogues (i.e. birds were stratified by initial body weight so that the mean and variance of live weight were equivalent across all groups at the start of the trial), 100 birds per group. When selecting analogues, the age and live weight of the chickens were considered.

Chickens were kept in one room on the floor at a density of 12 birds per 1 m^2. The feeding front was 2.5 cm, and the watering was 1 nipple per 5 birds. The microclimate indicators of the room were the same for birds of all groups and met the standards.

According to the experimental scheme, broiler chickens were fed complete mixed feeds throughout the experiment, balanced in terms of metabolisable energy (ME) and all nutrients, according to the standards recommended by the Cobb company. The set and amount of main ingredients in the compound feeds were regulated depending on the period of chicken rearing (1–10 days, 11–22 and 23–42 days) and the required lysine content in them.

The composition of the compound feeds fed to the birds during the research period is given in Table 2.

Table 2. Composition of compound feeds for experimental broiler chickens, %

Component	Bird age, days		
	1 – 10	11 – 22	23 – 42
Wheat	9.38	11.10	0.00
Corn	44.00	43.00	51.21
Pea	10.01	10.50	10.00
Soy	13.70	15.00	20.00
Soybean meal	12.00	10.00	11.00
Fishmeal	7.00	5.00	0.00
Vegetable oil	1.00	2.30	3.90
Table salt	0.18	0.17	0.34
Limestone	1.73	1.83	2.10
Monocalcium phosphate	0.00	0.10	0.45
Premix	1.00	1.00	1.00

The chickens were fed compound feed ad libitum. The chemical composition of the compound feed is given in Table 3.

Table 3. Nutrient content of compound feed, %

Indicator	Age, days		
	1 – 10	11 – 22	23 – 42
ME, MJ/100 g	1.25	1.31	1.32
Crude protein	21.19	22.00	20.70
Crude fat	6.04	8.50	11.22
Crude fibre	3.56	4.00	4.40
Calcium	1.00	0.93	0.92
Phosphorus	0.52	0.70	0.71
Sodium	0.20	0.20	0.20
Lysine*	1.18	1.08	1.03
Methionine	0.48	0.41	0.40
Threonine	0.79	0.80	0.90
Tryptophan	0.22	0.17	0.16
Arginine	1.26	1.24	1.23
Histidine	0.35	0.32	0.32
Valine	0.31	0.26	0.22
Isoleucine	0.25	0.22	0.18
Leucine	0.56	0.49	0.42
Phenylalanine	0.32	0.27	0.22

**Lysine content according to the experimental design*

The chemical composition of the compound feed fed to broiler chickens in the control and experimental groups was the same and differed only in the lysine content according to the experimental design.

The chemical composition of the feeds was determined at the Laboratory of the Department of Animal Nutrition and Feed Technology named after P.D. Pshenychnyi, NUBiP of Ukraine, using the Weende method in accordance with EU Regulation No. 152/2009. The dry matter of the feed was determined by drying in a drying oven, the total moisture at a temperature of 65±2 °C, and hygroscopic moisture at a temperature of 103±2 °C using a Labexpert 3030 drying oven. In dry matter, the following was determined:

-Raw ash – in a muffle furnace at a temperature of 550±20 °C. Muffle furnace – SNOL -8.2/1100.

-Nitrogen was determined using the Kjeldahl method. Feed ashing was carried out with a Gerhardt Turbotherm TT–625, and distillation was performed using a semi-automatic steam distiller VELP Scientifica F30200135.

-Crude fat was determined by the Soxhlet method using a Gerhardt Soxtherm SOX 412. Diethyl ether was used as the extractant.

-Crude fibre was determined by the method of Henneberg and Stomann, washing the sample in dilute sulfuric acid and potassium hydroxide, using a Gerhardt FibreBag-System FBS6.

-Nitrogen-free extractives were determined by calculation based on the difference between the organic matter content and the sum of crude protein, crude fat, and crude fibre.

The amino acid content was determined using an automatic analyser AAA T 339 after protein hydrolysis with 6 normal hydrochloric acid solution for 24 hours at a temperature of 110 °C. For calibration tests, as well as quantitative evaluation of chromatograms, standard amino acid solutions "Lachema" were used. The tryptophan content was determined after alkaline hydrolysis of samples (4 M NaOH, 100–110 °C) with subsequent separation of amino acids on an amino acid analyser in ion exchange chromatography mode with fluorimetric detection (λ excitation 280 nm).

Feed consumption by birds was recorded daily, for each week of rearing and for the entire experimental period. At the end of the experiment, feed consumption per 1 kg of body weight gain was calculated.

The live weight of broiler chickens was determined by weighing on an AXIS A 5000 class IV scale.

At the end of the scientific and economic experiment, the experimental birds were slaughtered (10 birds from each group), and the slaughter indicators were examined.

The slaughter qualities of broiler chickens were assessed using the following indicators:

-pre-slaughter live weight – live weight of broiler chickens after a 12-hour starvation period;

-uneviscerated carcass weight – carcass weight without blood and feathers;

-weight of a semi-eviscerated carcass – the weight of a carcass without blood, feathers and intestines;

-carcass weight – the weight of the carcass without blood, feathers, head, legs, wings up to the elbow joint, intestines;

-mass of edible parts – the weight of the entire edible part of the eviscerated carcass;

-mass of breast muscles, pelvic limb muscles, skin, internal fat, liver, lungs, kidneys, muscular stomach, and heart.

The mass of slaughter products was determined using AD 500 AXIS scales.

Based on the indicators of slaughter weight and the weight of individual parts of the carcass of broiler chickens, the yield of slaughter products and indices of meat qualities of carcasses were determined:

-yield of semi-eviscerated and eviscerated carcasses – the ratio of the mass of semi-eviscerated and eviscerated carcasses to the pre-slaughter live weight, %;

-yield of breast muscles, pelvic limb muscles, skin, internal fat, liver, lungs, kidneys, muscular stomach, heart – ratio of the mass of the corresponding slaughter products to the pre-slaughter live weight, %;

-carcass meatiness – the ratio of the mass of all muscles to the mass of the eviscerated carcass, %;

-breast meatiness – the ratio of the mass of the breast muscles to the mass of the eviscerated carcass, %;

-pelvic limb muscle mass – the ratio of the mass of pelvic limb muscles to the mass of the eviscerated carcass, %;

-yield of edible parts – the ratio of the mass of all muscles to the mass of the undressed carcass, %.

We carried out the biometric processing of data obtained during the research using MS Excel 2016 software by means of built-in statistical functions. Results are presented as mean ±standard deviation (x±SD). The differences between groups were assessed by Student's t-test. The following significance levels were used: $P<0.05$, $P<0.01$ and $P<0.001$.

All experimental procedures involving animals were approved by the Ethics Committee of the National University of Life and Environmental Sciences of Ukraine and were conducted in accordance with Directive 2010/63/EU on the protection of animals used for scientific purposes.

RESULTS AND DISCUSSION

The introduction of synthetic lysine led not only to a change in its absolute content, but also to a certain transformation amino acid the protein profile of compound feeds in general, which is well traced according to the data in Table 4. In all age periods, lysine was taken as 100%, while the other amino acids were expressed in relative terms, allowing assessment not so much of their absolute levels as of the structure of the amino acid profile of the protein depending on the experimental treatment.

Table 4. Amino acid profiles of the protein of the studied compound feeds

Research group	Lysine	Methionine	Threonine	Tryptophan	Arginine	Histidine	Valine	Isoleucine	Leucine	Phenylalanine
Chickens age 1 – 10 days										
1	100.00	40.00	65.83	18.33	105.00	29.17	25.67	21.03	46.62	26.75
2	100.00	40.68	66.95	18.64	106.78	29.66	26.11	21.39	47.42	27.21
3	100.00	39.34	64.75	18.03	103.28	28.69	25.25	20.69	45.86	26.32
4	100.00	38.71	63.71	17.74	101.61	28.23	24.84	20.35	45.12	25.89
Chickens age 11 – 22 days										
1	100.00	37.27	72.73	15.45	112.73	29.09	24.03	19.70	44.22	24.95
2	100.00	37.96	74.07	15.74	114.81	29.63	24.48	20.07	45.04	25.41
3	100.00	36.61	71.43	15.18	110.71	28.57	23.60	19.35	43.43	24.50
4	100.00	35.96	70.18	14.91	108.77	28.07	23.19	19.01	42.67	24.07
Chickens age 23 – 42 days										
1	100.00	38.10	85.71	15.24	117.14	30.48	20.59	16.90	40.43	21.17
2	100.00	38.83	87.38	15.53	119.42	31.07	20.99	17.23	41.21	21.59
3	100.00	37.38	84.11	14.95	114.95	29.91	20.21	16.58	39.67	20.78
4	100.00	36.70	82.57	14.68	112.84	29.36	19.83	16.28	38.94	20.40

In the initial period (1–10 days), as the transition from the control to the experimental groups 2–4 is observed, a gradual decrease in the proportion of methionine, threonine, tryptophan, arginine, histidine, valine, isoleucine, leucine and phenylalanine in terms of 100 parts of lysine. This means that the increase in the content of lysine due to the synthetic form shifts the amino acid ratio towards relative "lysine enrichment", while other essential amino acids become relatively less represented in the protein profile. A similar trend persisted during the 11–22 day period, where increasing lysine levels from Group 1 to Group 4 led to a decrease in the relative proportions of methionine, threonine, tryptophan, and several other amino acids, indicating a certain shift of the profile away from the classical "ideal protein" model in favor of a higher lysine equivalent. In the finishing period (23–42 days), these patterns persist: in the 2nd group, compared to the control, the relative content of methionine, threonine, arginine, histidine, valine, isoleucine, and phenylalanine increases slightly, while in the 3rd and 4th groups, against the background of an even higher level of lysine, their relative values again decrease slightly.

Thus, it can be described as the formation of a specific “lysine/other essential amino acids” gradient, whereby an increase in lysine levels gradually shifts the amino acid profile toward a higher relative lysine content, while the profile of the other amino acids becomes “diluted” when recalculated per 100 parts of lysine. In combination with the practically unchanged crude protein content, this indicates that the introduction of synthetic lysine is not accompanied by significant changes in the overall protein background but does affect the internal structure of essential amino acids. Similar changes in the profile are described in the studies of Kidd M. T. *et al.,* (1997, 1998), where the introduction of synthetic lysine at constant levels of other amino acids led to a shift in the relative ratios in favour of lysine and required a revision of the "ideal profile" for fast-growing broilers.

It is worth noting that in none of the experimental variants was a critical violation of the ratio of lysine to sulfur-containing amino acids (methionine + cystine), threonine or tryptophan observed, i.e. no pronounced secondary deficiency of other limiting amino acids was formed, which would sharply limit the use of additional lysine. This is consistent with the data of modern studies, which recommend increasing the level of lysine only if the profile of other essential amino acids is adequately corrected in order to prevent the shift of new “bottlenecks” in protein nutrition. In the works of Oliveira, W. P. *et al.,* (2014), and other authors have shown that optimisation of standard-ileal digestible lysine should be considered in conjunction with valine, isoleucine, and threonine, since these amino acids most often become limiting during "lysine enrichment" of diets.

Table 5. Growth and feed consumption indicators of experimental broiler chickens

Parameter	Group of birds			
	control	experimental		
	1	2	3	4
Live weight at the beginning of the experiment, g	51.38± 0.551	51.49± 0.582	51.55± 0.491	51.52± 0.671
Live weight at the end of the experiment, g	2632.18± 37.322	2600.59± 41.769**	2654.05± 41.804*	2638.97± 45.117
Absolute increase, g	2580.80 ± 37.479	2549.10± 41.791**	2602.50± 41.730*	2587.44± 45.132
Average daily gain, g	61.45± 0.892	60.69± 0.995**	61.96± 0.994*	61.61± 1.075
Relative gain, %	192.19± 0.155	192.08± 0.158**	192.23± 0.134	192.19± 0.167
Feed Conversion Ratio (FCR), kg	1.795	1.781	1.797	1.808

*Notes: *p<0.05; **p<0.01 compared with the first group*

The live weight of chickens at the beginning of the experiment in all groups was practically the same (51.38–51.55 g), which confirms the correctness of the formation of groups similar in terms of starting indicators. At the end of growing (42 days), a tendency to increase the live weight of birds in the 3rd group was noted - by 0.83% (2654.05±41.80 g; $p<0.05$) and 4th group (2638.97±45.12 g) compared to the control (2632.18±37.32 g), while in the 2nd group the live weight was significantly lower by 1.20% (2600.59±41.77 g; $p<0.01$). A similar pattern of changes was observed in absolute and average daily gain: in the 3rd group, these indicators were slightly higher (2602.50±41.73 g, 61.96±0.99 g; $p<0.05$), while in the 2nd group they were lower than the control (2549.10±41.79 g, 60.69±0.99 g; $p<0.01$), and the 4th group had intermediate values. Thus, an excessively low lysine level (Group 2) led to a slight reduction in growth intensity, whereas a moderate increase (Groups 3 and 4) provided a small but statistically significant improvement in growth performance. Similar results are presented in the studies of Rezaei M. *et al.,* (2004), where at different levels of protein and lysine, it was found that insufficient lysine supply limits the realisation of the genetic growth potential of broilers, while increasing its content to the optimal level promotes live weight growth and improved feed conversion.

The relative body weight gain in our experiment did not differ significantly between the groups (192.08–192.23%), and the feed consumption per 1 kg of gain was within 1.781–1.808 kg and practically did not depend on the level of lysine. This indicates that under conditions of a balanced diet in terms of energy and other nutrients, a change in the content of lysine only within the studied limits affected mainly the distribution of gain between individual parts of the carcass and meatiness, and not the overall energy efficiency of feed use. A similar nature of the reaction is described in the works of Cemin, H. S. *et al.,* (2017) and Rezaei M. *et al.,* (2004), where the requirements for digestible lysine to maximise live weight gain and better FCR were somewhat lower than those to optimise slaughter performance and breast muscle yield. In particular, in the study by Cemin, H. S. *et al.,* (2017), it was found that for Cobb 500 males, the optimal level of digestible lysine for gain may be around 0.96–0.98%, while slightly higher dietary concentrations are required for maximum breast meat yield.

The results of slaughter showed that the pre-slaughter live weight and the carcass weight before and after evisceration of birds across all groups did not differ significantly, consistent with the close final live weight values during the growing period (Table 6).

Significant differences emerged at the level of individual carcass parts (Table 6). Breast muscle mass was greatest in the 4th group ($p<0.01$), exceeding the control by 12.41% and the 2nd group by 15.23%, whereas limb muscle mass showed only modest variation. Lysine supplementation thus primarily stimulated breast muscle development, consistent with the findings of Kidd M.T. *et al.*, (1998) and Zarghi, H. *et al.,* (2020), who reported that optimising digestible lysine increases breast muscle yield without substantially altering other carcass components.

Table 6. Slaughter parameters of the broiler chickens, g (x±SD, n=10)

Parameter	Group of birds			
	control	experimental		
	1	2	3	4
Pre-slaughter live weight	2629.62± 29.175	2601.06± 36.238*	2682.88± 42.510	2671.74± 42.437
Carcass weight before evisceration	2453.38± 40.637	2426.82± 40.900	2481.28± 48.458	2474.92± 49.385
Semi-eviscerated carcass weight	2277.22± 56.720	2242.01± 21.129	2290.55± 35.581	2283.49± 45.702
Eviscerated carcass weight	2079.21± 51.684	2047.21± 17.595	2090.57± 36.099	2083.40± 45.735
Weight of edible parts:				
breast muscles	528.24± 33.787	515.33± 23.217	557.46± 20.527	593.81± 34.849**
leg muscles	479.30± 30.559	444.48± 7.406*	512.87± 32.759	496.85± 45.121
skin	182.88± 17.461	171.68± 8.094	181.73± 13.954	182.01± 4.504
internal fat	65.28± 14.063	71.48± 15.495	71.17± 16.446	63.70± 12.886
liver	67.54± 13.704	72.96± 9.480	66.04± 11.804	70.46± 10.828
lungs	16.08± 1.488	15.44± 0.901	17.13± 0.865	17.92± 1.549
kidneys	13.10± 0.699	12.53± 0.601	12.91± 0.609	12.20± 1.244
gizzard	65.31± 8.569	65.46± 10.481	70.76± 13.508	80.36± 22.228
heart	14.43± 1.837	14.13± 1.585	14.84± 1.441	15.58± 1.259

*Notes: *p<0.05; **p<0.01 compared with the first group*

The yield of semi-eviscerated and eviscerated carcasses in our study was similar across all groups (85.38–86.59% and 77.92–79.06%, respectively), indicating the stability of key slaughter traits under conditions of maintained energy and protein balance in the diets (Table 7).

The most notable shift in carcass structure involved breast muscle yield (Table 7): in the 4th group, it reached 22.23±1.35% of the eviscerated carcass ($p<0.05$), exceeding the control by 2.14 percentage points, while the proportions of other edible parts remained statistically similar across groups. These results align with Zarghi, H. *et al.*, (2020), who attributed gains in slaughter yield primarily to breast growth, and differ from Nasr J., Kheiri F. (2011), who observed increases in internal fat and organ mass at higher lysine levels.

Table 7. Yield of slaughter products, % (x±SD, n=10)

Indicator	Animal group			
	control	experimental		
	1	2	3	4
Yield of semi-eviscerated carcass	86.59±1.362	86.21±1.448	85.38±0.527	85.47±1.214
Yield of eviscerated carcass	79.06±1.173	78.72±1.061	77.92±0.678	77.98±1.260
Yield of edible parts:				
breast muscles	20.09±1.243	19.82±0.996	20.78±0.691	22.23±1.352*
leg muscles	18.23±1.148	17.09±0.404	19.12±1.157	18.61±1.811
skin	6.95±0.617	6.60±0.246	6.77±0.505	6.81±0.172
internal fat	2.48±0.538	2.75±0.609	2.65±0.599	2.38±0.479
liver	2.57±0.499	2.81±0.392	2.46±0.427	2.64±0.414
lungs	0.61±0.057	0.59±0.029	0.64±0.026	0.67±0.049
kidneys	0.50±0.031	0.48±0.023	0.48±0.029	0.46±0.048
gizzard	2.48±0.319	2.51±0.377	2.63±0.472	3.00±0.787
heart	0.55±0.066	0.54±0.061	0.55±0.055	0.58±0.049

*Notes: *p<0.05 compared with the first group*

Calculated meatiness indices further confirmed the advantage of higher lysine levels (Table 8).

Table 8. Meatiness indices, % (x±SD, n=10)

Indicator	Animal group			
	control	experimental		
	1	2	3	4
Carcass meatiness	48.46±2.469	46.89±1.411	51.21±2.449	52.40±3.267*
Breast meatiness	25.40±1.410	25.18±1.172	26.67±1.009	28.53±2.033*
Leg meatiness	23.06±1.471	21.71±0.352	24.54±1.683	23.88±2.490
Yield of edible parts	68.88±2.945	67.58±1.710	71.99±3.807	73.63±3.381*
Bone content	31.12±2.945	32.42±1.710	28.01±3.807	26.37±3.381*

*Notes: *p<0.05 compared with the first group*

Meatiness indices confirmed the advantage of higher lysine levels (Table 8). Carcass meat content, breast meat content, and total edible-part yield were all significantly greater in the 4th group ($p<0.05$), accompanied by a lower bone proportion relative to the control. A positive but largely non-significant trend was observed in the 3rd group. The formation of a leaner, breast-dominated carcass at elevated lysine levels is consistent with Rezaei M. *et al.*, (2004), who reported increased breast and thigh muscle mass alongside reduced bone proportion in broilers receiving optimised lysine diets.

It is important to emphasise that the increase in lysine levels in this study was not accompanied by an increase in the mass of the liver, kidneys, heart and other internal organs, and did not contribute to excessive deposition of internal fat, which indicates the absence of a negative effect of the increased content of this amino acid on the metabolic status of the bird. In the studies of Zarghi, H. *et al.,* (2020) also showed that increasing the level of digestible lysine to 1.12 % in the finishing diet of broilers does not worsen blood parameters and meat quality, but optimises growth, FCR and breast muscle yield. In addition, the works of modern authors note that lysine, being one of the main limiting amino acids in broiler diets, determines the intensity of muscle protein synthesis, in particular breast muscles, and with its adequate supply, a redistribution of nutrients occurs in favour of protein formation, rather than lipogenesis.

From a biochemical perspective, the preferential response of breast muscles to increased lysine supply can be explained by several interconnected mechanisms. First, lysine is a major constituent of myosin heavy chains in fast-twitch glycolytic fibres (type IIB) that predominate in the pectoralis major muscle of broilers (Tesseraud *et al.,* 2001), which makes this tissue particularly sensitive to fluctuations in lysine availability. Second, lysine serves as an obligatory precursor for carnitine biosynthesis; carnitine facilitates the transport of long-chain fatty acids into mitochondria for β-oxidation, thereby redirecting energy substrates toward protein accretion rather than lipid deposition (Kidd M.T. *et al.,* 1997). Third, elevated intracellular lysine concentrations have been shown to activate the mechanistic target of rapamycin (mTOR) signalling pathway, which stimulates ribosomal protein synthesis while suppressing autophagy in skeletal muscle, thus creating favourable conditions for net muscle protein gain (Liao *et al.,* 2015). These mechanisms collectively explain why the highest lysine levels in our study (Group 4) produced the greatest breast muscle mass without proportional increases in overall body weight or carcass fat, consistent with a shift in nutrient partitioning toward myofibrillar protein synthesis in the pectoral muscles.

Comparison of the amino acid profile with growth and meat productivity indicators shows that the most favourable option was the one in which the increase in lysine was not excessive relative to other amino acids (group 3). In this group, the amino acid profile deviated somewhat from the control, but maintained a relatively balanced ratio of lysine to methionine, threonine and branched-chain amino acids, which probably ensured better average daily gains and a tendency to increase meatiness without reducing feed efficiency. In group 4, where the relative "lysine saturation" of the profile was the highest, the maximum yield of breast muscles and carcass meatiness was noted, however, body weight gains practically did not exceed the indicators of group 3, which may indicate the achievement of a certain "plateau" in the growth response. In the studies of Zarghi, H. *et al.,* (2020) also showed that further increase in digestible lysine above the optimal level is not always accompanied by increased gains, but may affect protein redistribution in favour of the breast muscles and change meat quality.

Summarising the results, it can be noted that the obtained data are consistent with the conclusions of Rezaei M. *et al*., (2004), Oliveira W.P. *et al.*, (2014), Cemin H.S. *et al*., (2017) and Zarghi H. *et al*., (2020), who showed the feasibility of increasing the level of digestible lysine compared to traditional norms for modern fast-growing broiler crosses. In our conditions, the optimal range for broiler chickens of the Cobb500 cross should be considered a range of lysine supply close to that implemented in the 3rd and 4th groups, which achieves a rational combination of growth indicators, feed consumption, total meat productivity and a high proportion of breast muscles in the carcass in the absence of a negative impact on the development of internal organs.

As noted in the Introduction, the transition toward alternative protein sources and lower-protein diets in modern poultry production necessitates precise amino acid balancing. The present results confirm that moderate "lysine enrichment" of the amino acid profile (as in Groups 3 and 4) is appropriate for Cobb 500 broilers and provides an optimal combination of growth intensity with increased carcass meatiness, consistent with the findings of Cemin *et al*., (2017) and Zarghi *et al*., (2020). Importantly, the shift in the amino acid profile toward higher relative lysine content did not create secondary deficiencies of other limiting amino acids, supporting the feasibility of targeted lysine supplementation in sustainable feed strategies.

CONCLUSIONS

Varying lysine levels in isocaloric and isonitrogenous diets for Cobb 500 broilers did not significantly affect final live weight, feed conversion, or carcass yield, yet produced a pronounced redistribution of gain towards breast muscles and improved meatiness indices. A moderate increase above the control level provided the best combination of growth performance and carcass quality, whereas the maximum lysine supply formed a growth plateau while further enhancing breast muscle deposition. In contrast, lysine reduction below the control limited the realisation of the genetic growth potential, as evidenced by lower daily gains, reduced meatiness, and a smaller proportion of edible parts. Amino acid profile analysis confirmed that supplemental synthetic lysine did not induce secondary deficiencies, as the ratios between lysine and other limiting amino acids remained within acceptable limits.

Based on these findings, lysine levels of 1.22–1.24% (starter), 1.12–1.14% (grower), and 1.07–1.09% (finisher) in compound feeds can be recommended as conditionally optimal for Cobb 500 broilers reared under conditions similar to the present experiment. Feed manufacturers should consider these ranges when formulating diets aimed at maximising breast meat yield and overall carcass value, while accounting for the cost-effectiveness of synthetic lysine supplementation.

These results support the practice of adjusting dietary lysine above traditional norms for modern high-yielding broiler crosses. Further research involving dose–response modelling across a wider range of genotypes and production systems would help refine these recommendations and establish economically optimal inclusion rates for commercial production.

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