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Utilizing Low-Protein Diets to Mitigate Gas Emissions and Foster Environmental Sustainability Impacts on the Physiological Performance of Broiler Chickens

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Abstract— This experiment was conducted at the Poultry Farm of the College of Agriculture, University of Anbar , from 13/9/2025 to 25/10/2025, lasting for 42 days . The study aimed to evaluate the impact of utilizing low-protein diets supplemented with synthetic amino acids on the physiological performance of Ross 308 broiler chickens and their role in promoting environmental sustainability by reducing gas emissions. A total of 192 broiler chicks were used, randomly distributed into three dietary treatments: T1 (control) with standard protein levels (21%, 20%, and 19%) for the starter, grower, and finisher phases, respectively; while protein levels in T2 and T3 were reduced by 1% and 2% , respectively , with amino acid fortification .No statistically meaningful ($P<0.05$) difference was observed for the hematological parameters (Hb, PCV, RBC, WBC) and heterophil/lymphocyte (H/L) ratio and for blood biochemical parameters (total protein, albumin, globulin, glucose, V.LDL, LDL, HDL, Triglyc and Cholesterol). No negative effect was observed for renal parameters (creatinine and uric acid) and liver enzymes (aspartate aminotransferase and alanine aminotransferase (AST and ALT). All these suggest that metabolic and physiological homeostasis was achieved during the experimental period. Therefore, a reduction of dietary crude protein without disturbing the amino acids ratio may provide an alternative way to reduce poultry production costs while also minimizing nitrogen and ammonia excretion without adversely affecting biological efficiency.

Keywords — Broiler Chickens, Gas Emissions, Low-Protein Diets.

INTRODUCTION

The broiler sector is considered one of the most advanced animal production industries, responding effectively to food security demands . However, it faces dual challenges related to environmental sustainability and economic viability (1) . Nutrition represents the cornerstone of production costs, with crude protein emerging as one of the most expensive feed components and a primary factor influencing the commercial balance of poultry farms (2).

The poultry industry relies heavily on soybean meal as a primary protein source , rendering it vulnerable to global price fluctuations (3).Recent studies have demonstrated that adopting a low-protein diet strategy , supplemented with synthetic amino acids , not only contributes to reducing feed costs but also enhances metabolic efficiency by minimizing the energy lost in catabolizing excess nitrogen (4). Furthermore, this strategy promotes intestinal health by reducing the nutritional substrates available for pathogenic bacteria , thereby positively impacting overall productive performance (1).

From an environmental perspective, the excretion of excess nitrogen in droppings poses a direct threat to air and soil quality. Excess nitrogen degrades into ammonia gas (NH_3) , which is a prominent greenhouse gas and a major pollutant within rearing facilities (5). Research confirms that reducing the crude protein percentage in the diet is the most effective tool for mitigating these emissions, a 1% reduction in dietary protein can lead to approximately a 10% decrease in ammonia emissions (6). This approach not only improves the birds environment and reduces the incidence of footpad dermatitis and respiratory infections but also aligns with global standards for sustainable production and the reduction of the carbon footprint of farms (6,5).

To control ammonia levels and emissions in poultry houses , various mitigation strategies have been analyzed , such as litter additives and feed modifications. In addition to reducing emissions and environmental impacts, low-protein diets are crucial for gastrointestinal health. Studies have shown that reducing dietary protein , combined with amino acid supplementation to balance avian requirements, can decrease nitrogen excretion and water consumption , potentially improving excreta quality in terms of moisture content and ammonia concentration (8).

This study aimed to evaluate the impact of utilizing a low-protein diet strategy supplemented with synthetic amino acids as a sustainable alternative to conventional diets. The objective is to transition toward cost-effective diets, minimize environmental damage resulting from fecal ammonia emissions, and ensure the continuity of productive and physiological performance efficiency in broiler chickens, ultimately achieving a sustainable environment.

MATERIALS AND MTHODS

Experimental Design and Management

This experiment was conducted at the Poultry Research Station, Faculty of Agriculture, University of Anbar, from 13/9/2025 to 25/10/2025, spanning a total duration of 42 days . A total of 192 onedayold Ross 308 broiler chicks , with an initial average weight of approximately 42 g , were utilized in this study . The birds were housed in three enclosed facilities , each partitioned into four replicates. Isolation between replicates was maintained using wire mesh (B.R.C.) fencing to ensure group segregation while maintaining environmental homogeneity. Each experimental unit measured 1.5 m2 (1 m width × 1.5 m length). The chicks were reared in floor pens under standardized management conditions, including regulated heating, lighting, ventilation , and ad libitum access to feed and water throughout the experimental period.

Chicks were randomly assigned to three dietary treatments , with four replicates per treatment (16 chicks per replicate) , totaling 64 birds per treatment . The lighting program was implemented according to the (9), providing 23 hours of light and 1 hour of darkness from day 1 to day 6. From day 7 until day 42 , a continuous schedule of 20 hours of light and 4 hours of darkness was maintained . Optimal environmental conditions , including heating , cooling , ventilation , and humidity , were strictly provided . Heating was managed via gas brooders , commencing at 36°C and gradually reduced by 2°C per week until reaching 22°C by day 42. Ventilation was facilitated through windows equipped with fans and extractors, utilized as required, while wood shavings were employed as bedding material at a depth of 5–6 cm.

Feed was provided to the chicks ad libitum immediately upon their arrival at the rearing facilities . For each replicate , a plastic tray with a diameter of 38 cm was initially used ,which was replaced at 10 days of age with hanging feeders of 45 cm in diameter . These feeders were gradually adjusted upward as the birds aged to remain at the level of the birds' backs. Dietary raw materials were sourced from local markets, and the experimental diets were manually formulated within the facility for each growth phase according to Table (1). Water was also provided ad libitum from the first day and throughout the duration of the experiment , supplied via 4.5-liter inverted plastic drinkers across all facilities.

The experiment comprised three dietary treatments that varied in their crude protein (CP) levels as follows: the first treatment (Control) involved birds fed a standard diet containing 21% , 20% , and 19% CP during the starter , grower , and finisher phases , respectively . The second treatment consisted of birds fed diets with 20% , 19% , and 18% CP across the same respective phases, while the third treatment included diets containing 19% , 18% , and 17% CP.

Blood Sampling and Laboratory Analysis

At the end of the experimental period (day 42) ,blood samples were collected from the right jugular vein of each bird into tubes labeled with the sample number . The tubes contained no anticoagulant to allow for serum separation . Samples were centrifuged at 3000 rpm for 15 minutes to separate the serum for laboratory analysis, which was then stored at (20°C-) until further processing.

Glucose concentration was determined enzymatically according to (10) Total protein was measured following (11), and albumin according to (12), while globulin valueswere calculated by subtracting albumin from total protein as per (12). Regarding the lipid profile , total cholesterol was estimated according to (13), triglycerides following (14), and high-density lipoprotein (HDL) according to (15). Low-density lipoprotein (LDL) concentration was mathematically calculated using the equation by (16). Renal function efficiency was determined by estimating creatinine according to (17) and uric acid according to (18). Enzymatic activities of AST and ALT were measured based on (19). Hematological parameters included the measurement of packed cell volume (PCV%) according to (20) and hemoglobin (Hb) concentration using the Sahli method . Total red blood cell (RBC) and white blood cell (WBC) counts were performed following the methodology of (21), followed by a differential WBC count and calculation of the H/L ratio as per (22).

Statistical Analysis

Data were statistically analyzed using a Completely Randomized Design (CRD) within the General Linear Model (GLM) procedure to evaluate the effects of the experimental treatments, utilizing the (23). statistical software package. Significant differences between the arithmetic means of the studied parameters were determined using (24) . Statistical significance was declared at probability levels of ($P<0.05$).

Table 1. Composition of Starter, Grower, and Finisher Diets Used in the Experiment and Their Calculated Chemical Composition.

Component	T1 Starter (1–14 d)	T1 Grower (15–28 d)	T1 Finisher (29–42 d)	T2 Starter (1–14 d)	T2 Grower (15–28 d)	T2 Finisher (29–42 d)	T3 Starter (1–14 d)	T3 Grower (15–28 d)	T3 Finisher (29–42 d)
Yellow corn	53.8	55.8	57.8	55.8	57.8	60.8	57.8	60.8	63.8
Soybean meal (44%)	28	26	24	26	24	23	24	23	20
Protein concentrate	5	5	5	5	5	3	5	3	3
Wheat bran	5	5	5	5	5	5	5	5	5
Vegetable oil	4	4	4	4	4	4	4	4	4
Dicalcium phosphate	2	2	2	2	2	2	2	2	2
Limestone	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Salt (NaCl)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Methionine + Lysine	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Premix	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100	100	100	100	100
Parameter	T1 Starter	T1 Grower	T1 Finisher	T2 Starter	T2 Grower	T2 Finisher	T3 Starter	T3 Grower	T3 Finisher
Metabolizable energy (kcal/kg)	3050	3082	3120	3082	3120	3188	3120	3188	3210
Crude protein (%)	21.2	20.38	19.1	20.38	19.1	18.07	19.1	18.07	17
Crude fat (%)	2.62	2.69	2.72	2.69	2.72	2.74	2.72	2.74	2.95
Crude fiber (%)	2.75	2.67	2.64	2.67	2.64	2.62	2.64	2.62	2.54
Calcium (%)	0.85	0.77	0.72	0.77	0.72	0.67	0.72	0.67	0.66
Available phosphorus (%)	0.68	0.75	0.6	0.75	0.6	0.56	0.6	0.56	0.55
Lysine (%)	1.35	1.3	1.25	1.3	1.25	1.2	1.25	1.2	1.06
Methionine (%)	0.65	0.63	0.62	0.63	0.62	0.61	0.62	0.61	0.58
Cystine (%)	0.38	0.36	0.35	0.36	0.35	0.34	0.35	0.34	0.31
Methionine + Cystine (%)	1.03	1	0.97	1	0.97	0.96	0.97	0.96	0.9

RESULT AND DISCUSSION

Results in Table (2) showed no significant effects were observed ($P \leq 0.05$) for all treatments in Hb, WBC , RBC , H/L ratio & PCV% .

Table 2. Impact of Using Low-Protein Diets on Mitigating Gas Emissions and Promoting Environmental Sustainability, and Their Effect on the Physiological Performance and Hematological Parameters of Broiler Chickens.

Type of examination	Treatments			Level of Significance
	T1	T2	T3	
H/L%	0.730 ± 0.235	0.742 ± 0.194	0.427 ± 0.035	N.S
RBC	2.85 ± 0.377	2.97 ± 0.256	3.27 ± 0.2015	N.S
WBC	23.5 ± 4.06	28.6 ± 2.53	24.2 ± 2.390	N.S
Hb	9.67 ± 0.980	9.90 ± 0.660	10.7 ± 0.462	N.S
PCV %	30.0 ± 2.94	30.7 ± 2.28	32.7 ± 1.10	N.S
NS: Indicates no significant differences among treatments at a significance level of (P ≤ 0.05).				

Results in Table (3) show that no significant effects were observed ($P > 0.05$) among all experimental treatments (T1, T2, and T3) for all biochemical parameters studied, including total protein, albumin, globulin, glucose, creatinine, and uric acid concentrations. Furthermore, the lipid profile indicators (Cholesterol, Triglycerides, HDL, LDL, and VLDL) did not show any significant differences ($P > 0.05$) between the control group and the low-protein diet treatments.

Table 3. Impact of Using Low-Protein Diets on Mitigating Gas Emissions and Promoting Environmental Sustainability, and Their Effect on the Physiological Performance and Biochemical Blood Parameters of Broiler Chickens .

Type of examination	Unit	Treatments			Level of Significance
		T1	T2	T3	
Globulin concentration	g/dL	1.75 ± 0.138	1.55 ± 0.134	1.69 ± 0.192	N.S
Albumin concentration	g/dL	1.47 ± 0.21	1.45 ± 0.111	1.54 ± 0.143	N.S
Total protein concentration	g/dL	3.23 ± 0.334	3.01 ± 0.210	3.24 ± 0.333	N.S
Glucose concentration	mg/dL	185 ± 5.98	177 ± 2.61	180 ± 1.47	N.S
V.LDL	mg/dL	1.63± 17.8	16.5± 1.027	16.6 ± 0.572	N.S
LDL	mg/dL	55.2 ± 6.51	51.2 ± 5.68	73.04 ± 9.85	N.S
HDL	mg/dL	63.0 ± 6.02	64.5 ± 5.33	77.2 ± 3.42	N.S
Triglyc.	mg/dL	89.1 ± 8.17	82.8 ± 5.13	83.2 ± 2.86	N.S
Cholesterol	mg/dL	136 ± 11.7	132 ± 10.7	166 ± 12.5	N.S
Creatinine	mg/dL	0.360 ± 0.076	0.360 ± 0.069	0.320 ± 0.073	N.S
UricAcid	mg/dL	5.40 ± 0.947	4.55 ± 0.542	4.10 ± 0.256	N.S
NS: Indicates no significant differences among treatments at a significance level of (P ≤ 0.05).					

The results in Table (4) show the liver enzymes in blood serum at the end of the experiment, where no significant effects were observed ($P \leq 0.05$) for all experimental treatments.

Table 4. Impact of Using Low-Protein Diets on Mitigating Gas Emissions and Promoting Environmental Sustainability, and Their Effect on the Physiological Performance and Hematological Parameters of Broiler Chickens.

Type of examination	Unit	Treatments			Level of Significance
		T1	T2	T3	
AST	U/L	34.1 ± 1.33	31.7 ± 2.28	34.9 ± 2.18	N.S
ALT	U/L	13.7 ± 1.93	14.3 ± 0.964	12.4 ± 2.11	N.S
NS: Indicates no significant differences among treatments at a significance level of (P ≤ 0.05).					

The results presented in the table indicate a remarkable stability in the physiological and metabolic status of the birds , as no significant differences ($P > 0.05$) were observed between the control group and the treatments fed low-protein diets across all studied biochemical and hematological parameters . The stability of total protein , albumin , globulin , and glucose concentrations in the serum is attributed to the high capacity of the birds to maintain metabolic homeostasis when dietary crude protein levels are reduced, provided that the precise requirements for essential amino acids are met . This is consistent with the findings of (1), who emphasized that poultry do not have a quantitative requirement for crude protein per se , but rather for a balanced profile of amino acids that support physiological pathways and internal organ development. Furthermore , the stability of glucose concentration serves as evidence of efficient energy metabolism and the lack of reliance on protein catabolism pathways for energy production (gluconeogenesis), which aligns with the review by (4), regarding production sustainability in low-protein diets.

On the other hand , the non-significant effect on creatinine and uric acid concentrations reflects the integrity of renal functions and the absence of metabolic stress resulting from excessive nitrogenous by-products. This result is in agreement with (25,26), who reported that low-protein diets based on amino acid balancing maintain blood parameters within normal physiological ranges . Additionally, this strategy plays a crucial role in reducing ammonia and nitrogen emissions , as highlighted by (3,7).Regarding the lipid profile , the stability of cholesterol , triglycerides ,HDL , and LDL , along with the maintenance of liver enzyme activities (AST and ALT) within normal levels , confirms that reducing dietary protein did not lead to lipid metabolism disorders or hepatic tissue damage , supporting the conclusions of (2,27). Finally , the consistency of hematological parameters (Hb , PCV , RBC and WBC) and the stability of the H/L ratio (Heterophil/Lymphocyte ratio) serve as critical indicators that the birds were not under nutritional stress . this proves the health and immune efficiency of Ross 308 broilers under current experimental conditions , confirming the success of the low-protein strategy in achieving a balance between physiological efficiency and environmental sustainability.

CONCLUSION

The study concludes that reducing dietary crude protein levels in broiler diets (by 1–2%) while balancing essential amino acid requirements is an effective strategy for maintaining the physiological stability and metabolic homeostasis of the birds without adverse effects on liver and kidney functions. Moreover, this approach holds great potential for promoting environmental sustainability by contributing to the reduction of ammonia and nitrogen excretion, as birds maintained a healthier metabolic state. This strategy also provides an economic advantage by lowering production costs through the optimized use of expensive protein sources.

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N/A

Conflict of Interest

The authors declare no conflict of interest.

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