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# Optimizing Broiler Performance: Lowering Dietary Protein with Amino Acids Supplementation and Protease Enhancement

**Mamdouh O. Abd-Elsamee[1], Hany M.R. Elsherif[1], Mohamed S.S.S. Aldeep[1] and Ahmed Samy[2]**

[1]*Animal Production Department, Faculty of Agriculture, Cairo University, Giza, Egypt,*

[2]*Department of Animal Production, National Research Centre, 12622, Giza, Egypt.*

**Abstract**

THIS study conducted to investigate how the addition of amino acids and proteolytic enzymes can compensate for the reduced protein content in broiler diets. The 420-day-old male chicks (Arbor Acres) were assigned into seven treatment groups. Seven diets were prepared to cover all the nutrient needs except crude protein, T1 crude protein (CP) according to the strain guide requirements (control), T2-T4 gave 2% minus of CP than the control diet with the addition of amino acids to get the recommendation levels or protease enzyme or mixture of them, respectively. T5-T7 gave 4% minus of CP than the control diet with the addition of amino acids to get the recommendation levels or protease enzyme or mixture of them, respectively. Productive performance, carcass characteristics, thyroid hormones, blood proteins, liver and kidney functions, intestinal morphology and economic efficiency were be measured. The results indicated that the addition of a sufficient amount of amino acids, or adding protease enzyme, or adding both to diets low in protein percentage, whether with a deficiency of 2% or 4%, compensated for this decrease and produced results that were comparable to the control group also enhancing the overall feed conversion ratio. No significant differences (P>0.05) were seen between all treatments in carcass characteristics, thyroid hormones, blood proteins, kidney and liver functions and intestinal histomorphological parameters. These data imply that adding necessary amino acids in in amounts that meet nutritional needs or using protease enzymes or a combination can lower broiler feed crude protein by up to 4%.

**Keywords:** Amino acids; Blood biochemical parameters; Broilers; Crude protein; Protease enzymes; Thyroid hormones.

## Introduction

Since broiler chicks are the greatest source of protein for human consumption, there is a higher need for animal protein sources as a result of population growth [1]. Since crude protein (CP) is the major element needed for optimal growth and development, 70% of the costs related to producing broilers are spent on creating diets that are mostly protein-based [2]. Researchers looked for approaches to lower feeding costs in light of global economic issues and feed component supply [3-6]. Consequently, improving the efficiency of broiler feeding. In order to build protein for appropriate growth, dietary amino acids are necessary [7]. The first limiting amino acid is methionine. Additionally, skeletal muscle and feather growth and development depend on lysine and threonine [8]. Where, owing to the massive amounts of excreta produced during the raising of broilers, which include a significant quantity of nitrogen (N) that is transformed into ammonia and may have an adverse effect on the land, water, and air due to the possibility for overfeeding, acidity, and ecotoxicity [9]. Changes in feed's nutritional composition can consequently have a substantial impact on the environment, the need for producing protein sources such soybean meal, and the environment's ability to utilize nutrients [10]. The performance, feed efficiency, and meat characteristics of broilers fed low CP diets prepared with sufficient dietary amounts of AA were shown to be comparable [11]. More noticeable decreases in dietary CP might be possible, though, when the remaining proteinogenic amino acids become more widely available commercially [2]. Additionally, the addition of the protease enzyme to the broiler diets increased the digestibility of the crude protein, which led to a greater fall in the inclusion levels of soybean meal and a higher decrease in dietary CP [12-13]. Due to the availability of these non-bound amino acids and protease enzymes, considerable reductions in the amount of dietary CP and soybean meal in

*Corresponding authors: Ahmed Samy, E-mail: Asamy1@yahoo.com, Tel.: 01225778184
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broiler diets are already possible, even if this topic seems to be relatively new [14].

Finding out how adding amino acids and proteolytic enzymes can make up for the lower protein content in chicken diets is the aim of this study.

## Material and Methods

The Poultry Nutrition Research Unit (PNRU) of Cairo University's Agriculture College and National Research Centre in Egypt carried out this investigation.

Finding out how adding amino acids, protease enzyme, or both would impact the percentage of crude protein levels and the productivity of broiler chicks from 1 to 35 days of age, together with certain physiological indicators, was the aim of the chick growth experiment.

Seven treatment groups were created from the 420 day-old male chicks (Arbor Acres) (7 groups × 6 replicates x 10 chicks each). With the exception of crude protein, seven diets were created to meet the nutritional requirements of Arbor Acres chicks, T1 crude protein (CP) according to the strain guide requirements (control), T2-T4 gave 2% minus of CP than the control diet with the addition of amino acids to get the recommendation levels or protease enzyme or mixture of them, respectively. T5-T7 gave 4% minus of CP than the control diet with the addition of amino acids to get the recommendation levels or protease enzyme or mixture of them, respectively. Table 1, 2 and 3 shows the composition of all experimental diets throughout various periods.

The initial weights of the chicks in each replicate were quite similar, weighing about 42g. The experimental diets were given to the chicks during the starter (1–10 days), grower (10–26 days), and finisher (26–35 days) periods while they were being raised in a warm environment. The chicks had free reign to eat and drink. A vaccination schedule against New Castle, IB, IBD, and avian flu was followed during the experiment.

The chicks were weighed after an overnight fast, and the amount of feed that each replicate consumed each day was noted (FI). The feed conversion ratio (FCR=FI/WG) and body weight growth were computed [4-6].

After an overnight fast, six chicks per treatment were slaughtered at a representative weight 35 days later. The weight of the carcass, the liver, heart, spleen, and gizzard were recorded after the birds were slaughtered, and the proportion of each organ to the weight of the live body was computed [3].

Samples for intestinal histomorphological measurement were taken from the duodenum area of the intestine after the birds were slaughtered, and fixed in neutral buffered formalin. After paraffin embedding and histological processing, hematoxylin-eosin-stained sections that were 5 microns thick were then created. Standard light microscopy was used to assess the histological sections. Using NIH ImageJ software, quantitative histomorphometric measurements of the length of the crypt and villi areas [15].

Blood samples were taken in plain tubes during the slaughtering process. The serum was extracted from the tubes by centrifuging them for 15 minutes at 2500 rpm. The tubes were then kept at -20 °C for additional examination.

Using commercially available kits (Bio Diagnostic, Cairo, Egypt), albumin, creatinine, AST, and ALT were determined in serum using an automatic spectrophotometer with a high-performance readout (FlexorEL200 Biochemical Analyzer, Cairo, Egypt).

The T3/T4 ratio was calculated using ELISA Kits (My Bio Source Inc., San Diego, CA) for the measurement of total T3 and total T4.

At the end of the trial period, the economic efficiency profit of broiler production was calculated.

The General Liner Model of SAS (SAS 2000) was used to statistically evaluate the data using one-way analysis of variance. The new multiple range test developed by Duncan was utilized to find the difference between means at ($P \leq 0.05$).

## Results

*Productive performance*

Table 4 displays the feed intake (FI), feed conversion ratio (FCR), and body weight growth (BWG) statistics for the starter, grower, finisher, and overall periods.

The performance findings clearly show that feed intake and weight gain at various periods do not differ significantly ($P>0.05$) between the groups. Additionally, there were no significant variations ($P>0.05$) in the feed conversion ratio (FCR) between the starter, grower, and finisher periods, but across the whole period, all treatments considerably ($P \leq 0.05$) enhanced the FCR when compared to the control. This means that adding a sufficient amount of amino acids to meet the nutritional needs of birds, or adding protease enzyme, or adding both to diets low in protein percentage, whether with a deficiency of 2% or 4%, compensated for this decrease and produced outcomes that were similar to those of the control group, improving the FCR overall.

In order to compensate for the lack of protein in the broiler diets, amino acids are either added directly in amounts sufficient for the birds' nutritional requirements or protease enzyme is added, which improves the digestibility of dietary protein and the release and availability of amino acids.

*Carcass characteristics*

Table 5 shows how various treatments affect the properties of the carcass. Due to the various treatments, there was no discernible difference (P>0.05) in the percentages of live body weight for the dressing, bursa, spleen, liver, heart, and gizzard. Additionally, no discernible variations in intestine length were found across all treatments (P>0.05). It showed that, in comparison to the control diet, the addition of amino acids or the protease enzyme to the diets lacking in protein produced carcass features that were comparable.

*Thyroid hormones*

The effects of treatments on thyroid hormone levels are displayed in Table 6. In T3, T4, and T4/T3, no significant changes (P>0.05) were seen across any of the treatments. Which indicated that the addition of protease enzyme, amino acids at enough amount to meet the broiler requirements or both of them to the low-protein diets by 2 or 4% had no adverse impacts on the thyroid hormones.

*Liver and kidney functions*

The results of the impact of various treatments on the blood biochemical parameters are displayed in Table 7.

In terms of liver function, there was no discernible difference (P>0.05) between the control group and all treatments in terms of aspartate aminotransferase (AST) and alanine aminotransferase (ALT).

In the kidney function, No significant differences (P>0.05) found between all treatments and the control group in the level of creatinine.

Which state that the liver and kidneys functioned normally when amino acids, the protease enzyme, or both were added.

*Blood proteins*

Table 8 shows how various treatments affect the blood protein. Total protein, albumin, globulin, and the albumin/globulin ratio did not differ significantly (P>0.05). Which indicated that the addition of amino acids, protease enzyme or both of them to the low protein diets didn't affect the blood protein levels.

*Intestinal morphology*

Table 9 shows how various treatments affect the villi height, crypt depth and the ratio of them in the duodenum of broilers at 35d.

Villi height, crypt depth and the villi height /crypt depth did not differ significantly (P>0.05). Which indicated that the addition of amino acids, protease enzyme or both of them to the low protein diets didn't affect the morphological parameters of duodenum.

*Economic Efficiency*

Table 10 shows how dietary interventions affect cost-effectiveness. The results demonstrated that adding protease enzyme and/or amino acids to low-protein meals (2 or 4% CP) in proportions that met the birds' nutritional demands improved their relative economic efficiency (REE) as compared to the control group. These results show that treatments achieve maximal economic efficiency by lowering the relative cost per unit of body weight.

## **Discussion**

Compared to the group fed a basal diet, broilers given a low-protein diet high in the amino acids lysine, methionine, and threonine under heat stress showed improved productive performance, cecal microbiota, and decreased intestinal epithelial damage [16].

There were no differences (P > 0.05) in the average daily gain, feed intake, or feed conversion ratio between the two treatments when the dietary CP content was decreased from 21% to 19% with supplemented amino acids to meet requirements. This led to compensatory productive performance. On the other hand, this improved the broiler's hepatic antioxidant capacity, N retention, P, Cu, and Mn absorption, and P, Cu, Zn, Fe, and Mn metabolic consumption during a period of one to thirty days [17].

Crystalline amino acids enable the lowering of dietary crude protein (CP), hence reducing nitrogen pollution and feed costs [16]. Reducing the broiler diet's CP content by two to three percent can improve intestinal health by preventing the growth of Clostridium perfringens and has no effect on performance [19-21].

The breakdown of proteins releases amino acids and short peptides that aid in the absorption of Mn, Fe, Zn, and Cu [21]. Additionally, a low-protein diet reduces the consumption of soybean meal, which inhibits the absorption of minerals due to its phytate content [22]. The low-protein diet has less phytate, which can combine with cations to form insoluble complex salts and reduce the absorption of minerals [22-24].

In comparison to birds fed traditional diets, Musigwa et al. [25] proposed that reduced broiler protein diets supplemented with amino acids that contain 60% essential and 40% non-essential amino acids enhance maximal nutrient utilization and support comparable growth.

In comparison to the control group, broiler growth was compensated by lowering dietary CP levels and addition amino acids [26].

Adding amino acids to broiler diets could lower crude protein without affecting weight gain or feed conversion ratio [27].

It was necessary to add amino acids to lower protein diets because lowering the amount of protein in broiler diets decreased the quantity of non-specific nitrogen available for non-essential amino acid synthesis [26].

Low-protein broiler feeds might reap advantages from the addition of protease enzyme to enhance growth and increase production efficiency [28].

Supplementing the broiler feed with exogenous acid protease increased growth performance by improving the ileal digestibility of certain nutrients (crude protein, energy, and amino acids). [29].

An enzyme called protease increases the breakdown of protein into amino acids, enhancing the quality of feed materials [30].

The feed conversion ratio of broiler chickens is decreased when the protease enzyme is added to their diet. [31].

In comparison to a control 21% CP, Jabbar et al. [13] discovered that a meal including 19% crude protein and over the course of 15–28 days, the protease enzyme enhanced the nutritional digestibility and performance of broilers.

Higher dietary amino acid density improved broiler growth performance, and the addition of an exogenous protease affected the rate at which the FCR of broiler chicks improved, until the age of 42 days [33].

The growth and ideal morphometry of grower-phase chickens were positively impacted by the addition of amino acid L-valine to their diet [32].

Gazani et al. [35] concluded that broiler chick production and the digestibility of dry matter and organic matter were improved when protease enzyme was added to meals that were low in protein and amino acids.

There was no change in productive performance as compared to control when essential amino acids including lysine, methionine, threonine, and valine were added to low-protein diets during the initial phase [36].

Reducing the protein composition of diets is probably the most efficient method of lowering the excretion of unutilized nitrogen. However, the impact of low-protein diets on productive performance was not substantial, even when synthetic amino acids were used to match the birds' needs [37].

The amount of CP in broiler chickens' grower and finisher diets can be reduced by up to 3.0% without compromising performance or meat quality, provided that the birds' amino acid requirements are met [38].

*Conclusion*

These findings suggest that we can reduce the crude protein content of broiler diets by 2% or 4%. This shortfall can be made up for by adding essential amino acids in amounts that meet nutritional needs or by adding protease enzymes, or a combination of them. Neither of these treatments has an adverse effect on weight gain or feed conversion ratio, nor does it have an adverse effect on blood proteins, thyroid hormones, liver, or kidney functions and intestinal morphology. In addition to improved financial effectiveness.

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Not relevant.

*Conflict of Interest*

There is no conflict of interest, according to the authors.

*Approval ethics*

This experiment was ethically approved by the Agricultural Research Center's institutional animal care and use committee (ARC-IACUC) under the number ARC-CU-157-24.

**TABLE 1. Starter diet formulation and nutrients.**

| | Ctrl (23% CP) | 21% CP+E | 21%CP+aa | 21%CP+aa+E | 19%CP+E | 19%CP+aa | 19%CP+aa+E |
|---|---|---|---|---|---|---|---|
| Yellow corn | 53.18 | 57.2 | 57.26 | 57.26 | 62.73 | 63.02 | 63.02 |
| Soybean meal (44%) | 33.75 | 33.23 | 33 | 33 | 30 | 29.35 | 29.35 |
| Corn Gluten meal (60%) | 5 | 1.5 | 1.5 | 1.5 | | | |
| Corn bran | 1 | 1 | 1 | 1 | | | |
| Soybean oil | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Dicalcium phosphate | 1 | 1 | 1 | 1 | 1.2 | 1.2 | 1.2 |
| Limestone | 1.85 | 1.85 | 1.85 | 1.85 | 1.85 | 1.85 | 1.85 |
| Vit and Min Mix (1) | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| NaCl | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| L-lysine HCl | 0.14 | 0.14 | 0.19 | 0.19 | 0.14 | 0.22 | 0.22 |
| Dl-methionine | 0.33 | 0.33 | 0.38 | 0.38 | 0.33 | 0.46 | 0.46 |
| Therionine | 0.15 | 0.15 | 0.22 | 0.22 | 0.15 | 0.3 | 0.3 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Calculated Composition%[2] | | | | | | | |
| Crude protein | 23.03 | 21.05 | 21.07 | 21.07 | 19.03 | 19.05 | 19.05 |
| ME (Kcal/Kg) | 3012 | 3008 | 3002 | 3002 | 3049 | 3045 | 3045 |
| Lysine% | 1.43 | 1.39 | 1.44 | 1.44 | 1.30 | 1.41 | 1.41 |
| Methionine% | 0.52 | 0.47 | 0.52 | 0.52 | 0.44 | 0.52 | 0.52 |
| Methionine+Cystine% | 0.9 | 0.81 | 0.86 | 0.86 | 0.75 | 0.83 | 0.83 |
| Therionine% | 0.99 | 0.92 | 0.99 | 0.99 | 0.85 | 0.99 | 0.99 |
| Tryptophane% | 0.30 | 0.29 | 0.29 | 0.29 | 0.26 | 0.26 | 0.26 |
| Valine% | 1.06 | 0.97 | 0.96 | 0.96 | 0.87 | 0.86 | 0.86 |
| Calcium% | 0.97 | 0.97 | 0.97 | 0.97 | 0.99 | 0.99 | 0.99 |
| Nonphytate P% | 0.51 | 0.50 | 0.50 | 0.50 | 0.52 | 0.51 | 0.51 |

[1] The amount of vitamin-mineral mixture per kilogram of feed: Vitamin A, 12000 IU; Vitamin D3, 2200 IU; Vitamin E, 10 mg; Vitamin K3, 2 mg; Vitamin B1, 1 mg; Vitamin B2, 4 mg; Vitamin B6, 1.5 mg; Vitamin B12, 10 g; 50 g of biotin; 500 mg of choline chloride; 10 mg of copper; 1 mg of iodine; 30 mg of iron; 55 mg of manganese; and 0.1 mg of selenium. (2) According to NRC 1994.

**TABLE 2. Grower diet formulation and nutrients.**

| | Ctrl (21% CP) | 19% CP+ E | 19%CP+ aa | 19%CP+aa +E | 17%CP+ E | 17%CP+ aa | 17%CP+aa+ E |
|---|---|---|---|---|---|---|---|
| Yellow corn | 59.93 | 64.08 | 64.24 | 64.24 | 68.7 | 68.85 | 68.85 |
| Soybean meal (44%) | 27.7 | 26.95 | 26.5 | 26.5 | 24.23 | 23.7 | 23.7 |
| Corn Gluten meal (60%) | 5.4 | 2 | 2.1 | 2.1 | | | |
| Soybean oil | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Dicalcium phosphate | 1 | 1 | 1 | 1 | 1.1 | 1.1 | 1.1 |
| Limestone | 1.75 | 1.75 | 1.75 | 1.75 | 1.75 | 1.75 | 1.75 |
| Vit and Min Mix (1) | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| NaCl | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| L-lysine HCl | 0.14 | 0.14 | 0.19 | 0.19 | 0.14 | 0.23 | 0.23 |
| Dl-methionine | 0.33 | 0.33 | 0.39 | 0.39 | 0.33 | 0.47 | 0.47 |
| Therionine | 0.15 | 0.15 | 0.23 | 0.23 | 0.15 | 0.3 | 0.3 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Calculated Composition%[2] | | | | | | | |
| Crude protein | 21.02 | 19.01 | 19.02 | 19.02 | 17.00 | 17.07 | 17.07 |
| ME (Kcal/Kg) | 3105 | 3101 | 3100 | 3100 | 3120 | 3114 | 3114 |
| Lysine% | 1.29 | 1.24 | 1.29 | 1.29 | 1.16 | 1.29 | 1.29 |
| Methionine% | 0.50 | 0.45 | 0.50 | 0.50 | 0.41 | 0.50 | 0.50 |
| Methionine+Cystine% | 0.85 | 0.77 | 0.81 | 0.81 | 0.69 | 0.78 | 0.78 |
| Therionine% | 0.91 | 0.84 | 0.91 | 0.91 | 0.77 | 0.91 | 0.91 |
| Tryptophane% | 0.26 | 0.25 | 0.24 | 0.24 | 0.22 | 0.22 | 0.22 |
| Valine% | 0.96 | 0.87 | 0.86 | 0.86 | 0.78 | 0.77 | 0.77 |
| Calcium% | 0.92 | 0.92 | 0.91 | 0.91 | 0.93 | 0.92 | 0.92 |
| Nonphytate P% | 0.46 | 0.46 | 0.45 | 0.45 | 0.46 | 0.46 | 0.46 |

[1] The amount of vitamin-mineral mixture per kilogram of feed: Vitamin A, 12000 IU; Vitamin D3, 2200 IU; Vitamin E, 10 mg; Vitamin K3, 2 mg; Vitamin B1, 1 mg; Vitamin B2, 4 mg; Vitamin B6, 1.5 mg; Vitamin B12, 10 g; 50 g of biotin; 500 mg of choline chloride; 10 mg of copper; 1 mg of iodine; 30 mg of iron; 55 mg of manganese; and 0.1 mg of selenium. [2] According to NRC 1994.

**TABLE 3. Finisher diet formulation and nutrients.**

| | Ctrl (19% CP) | 17% CP+ E | 17%CP+ aa | 17%CP+aa +E | 15%CP+ E | 15%CP+ aa | 15%CP+aa+ E |
|---|---|---|---|---|---|---|---|
| Yellow corn | 59.93 | 64.08 | 64.24 | 64.24 | 68.7 | 68.85 | 68.85 |
| Soybean meal (44%) | 27.7 | 26.95 | 26.5 | 26.5 | 24.23 | 23.7 | 23.7 |
| Corn Gluten meal (60%) | 5.4 | 2 | 2.1 | 2.1 | | | |
| Soybean oil | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Dicalcium phosphate | 1 | 1 | 1 | 1 | 1.1 | 1.1 | 1.1 |
| Limestone | 1.75 | 1.75 | 1.75 | 1.75 | 1.75 | 1.75 | 1.75 |
| Vit and Min Mix (1) | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| NaCl | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| L-lysine HCl | 0.14 | 0.14 | 0.19 | 0.19 | 0.14 | 0.23 | 0.23 |
| Dl-methionine | 0.33 | 0.33 | 0.39 | 0.39 | 0.33 | 0.47 | 0.47 |
| Therionine | 0.15 | 0.15 | 0.23 | 0.23 | 0.15 | 0.3 | 0.3 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Calculated Composition%(2) | | | | | | | |
| Crude protein | 19.00 | 17.02 | 17.02 | 17.02 | 15.02 | 15.02 | 15.02 |
| ME (Kcal/Kg) | 3200 | 3201 | 3200 | 3200 | 3202 | 3198 | 3198 |
| Lysine% | 1.02 | 0.97 | 1.02 | 1.02 | 0.93 | 1.02 | 1.02 |
| Methionine% | 0.48 | 0.44 | 0.48 | 0.48 | 0.39 | 0.48 | 0.48 |
| Methionine+Cystine % | 0.81 | 0.73 | 0.77 | 0.77 | 0.65 | 0.73 | 0.73 |
| Therionine% | 0.83 | 0.76 | 0.83 | 0.83 | 0.69 | 0.83 | 0.83 |
| Tryptophane% | 0.21 | 0.20 | 0.19 | 0.19 | 0.18 | 0.18 | 0.18 |
| Valine% | 0.87 | 0.78 | 0.77 | 0.77 | 0.69 | 0.67 | 0.67 |
| Calcium% | 0.84 | 0.86 | 0.86 | 0.86 | 0.86 | 0.85 | 0.85 |
| Nonphytate P% | 0.40 | 0.41 | 0.41 | 0.41 | 0.41 | 0.40 | 0.40 |

(1) The amount of vitamin-mineral mixture per kilogram of feed: Vitamin A, 12000 IU; Vitamin D3, 2200 IU; Vitamin E, 10 mg; Vitamin K3, 2 mg; Vitamin B1, 1 mg; Vitamin B2, 4 mg; Vitamin B6, 1.5 mg; Vitamin B12, 10 g; 50 g of biotin; 500 mg of choline chloride; 10 mg of copper; 1 mg of iodine; 30 mg of iron; 55 mg of manganese; and 0.1 mg of selenium.

(2) According to NRC 1994.

**TABLE 4. The effect of different treatments on productive performance.**

| Item | Starter (1-10d) | | | Grower (11-25d) | | | Finisher (26-37d) | | | Overall (1-37d) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | WG | FI | FCR | WG | FI | FCR | WG | FI | FCR | WG | FI | FCR |
| Control | 242 | 297 | 1.22 | 643 | 1135 | 1.77 | 833 | 1517 | 1.82 | 1719 | 2949 | 1.71[a] |
| -2%CP+aa | 271 | 320 | 1.19 | 730 | 1210 | 1.66 | 849 | 1466 | 1.73 | 1850 | 2996 | 1.62[b] |
| -2%CP+E | 265 | 278 | 1.05 | 743 | 1207 | 1.63 | 855 | 1486 | 1.74 | 1863 | 2972 | 1.60[b] |
| -2%CP+Mix | 241 | 282 | 1.17 | 744 | 1129 | 1.52 | 872 | 1463 | 1.68 | 1857 | 2875 | 1.55[b] |
| -4%CP+aa | 244 | 280 | 1.15 | 705 | 1098 | 1.57 | 856 | 1480 | 1.74 | 1806 | 2858 | 1.59[b] |
| -4%CP+E | 273 | 281 | 1.03 | 724 | 1180 | 1.64 | 832 | 1433 | 1.72 | 1829 | 2895 | 1.59[b] |
| -4%CP+Mix | 243 | 282 | 1.17 | 723 | 1136 | 1.57 | 793 | 1400 | 1.77 | 1759 | 2819 | 1.60[b] |
| Significance | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | ** |
| SE | 12.56 | 9.06 | 0.10 | 11.89 | 26.30 | 0.06 | 46.40 | 76.38 | 0.01 | 49.07 | 63.06 | 0.03 |

NS= Non significant, **= significant at ($P \leq 0.01$), Means designated with the same letter within the same column are not significantly different at 0.05 level of probability.

**TABLE 5. The effect of different treatments on the carcass characteristics.**

| Item | Dressing % | abdominal fat % | Bursa % | Spleen % | Giblets | | | Intestinal length cm |
|---|---|---|---|---|---|---|---|---|
| | | | | | Liver % | Gizzard % | Heart % | |
| Control | 75.82±1.17 | 0.75±0.07 | 0.06±0.01 | 0.10±0.02 | 2.37 ±0.22 | 1.77±0.07 | 0.47±0.04 | 9.61±0.33 |
| -2%CP+aa | 69.49±1.56 | 0.92±0.08 | 0.17±0.02 | 0.16±0.03 | 3.08±0.19 | 1.62±0.08 | 0.50±0.02 | 11.34±1.34 |
| -2%CP+E | 70.65±0.92 | 1.07±0.11 | 0.08±0.02 | 0.10±0.02 | 2.80±0.54 | 1.69±0.16 | 0.50±0.04 | 10.51±0.16 |
| -2%CP+Mix | 71.87±1.33 | 0.79±0.20 | 0.07±0.01 | 0.13±0.01 | 2.49±0.18 | 1.90±0.20 | 0.57±0.08 | 11.09±0.88 |
| -4%CP+aa | 72.83±0.93 | 0.92±0.24 | 0.12±0.04 | 0.10±0.02 | 2.73±0.18 | 1.65±0.09 | 0.45±0.01 | 11.23±0.78 |
| -4%CP+E | 72.48±2.95 | 1.39±0.23 | 0.08±0.02 | 0.10±0.03 | 2.44±0.17 | 1.41±0.16 | 0.56±0.05 | 9.83±0.33 |
| -4%CP+Mix | 71.30±0.79 | 1.42±0.09 | 0.10±0.03 | 0.11±0.02 | 2.58±0.17 | 1.74±0.05 | 0.52±0.05 | 11.66±0.6 |
| Significance | NS | NS | NS | NS | NS | NS | NS | NS |
| SE | ±1.54 | ±0.17 | ±0.02 | ±0.02 | ±0.27 | ±0.13 | ±0.09 | ±0.74 |

NS= Non significant, Means designated with the same letter within the same column are not significantly different at 0.05 level of probability.

**TABLE 6. The effect of different treatments on the thyroid hormones.**

| Item | T3 (ng/ml) | T4 (ng/ml) | T4/T3 |
|---|---|---|---|
| Control | 4.73 | 18.37 | 3.89 |
| -2%CP+aa | 4.79 | 17.13 | 3.63 |
| -2%CP+E | 5.01 | 21.78 | 4.33 |
| -2%CP+Mix | 5.00 | 20.08 | 4.00 |
| -4%CP+aa | 4.65 | 18.46 | 4.30 |
| -4%CP+E | 5.06 | 17.70 | 3.49 |
| -4%CP+Mix | 4.28 | 18.86 | 4.45 |
| Significance | NS | NS | NS |
| SE | ±0.76 | ±3.29 | ±0.56 |

NS= Non significant, Means designated with the same letter within the same column are not significantly different at 0.05 level of probability.

**TABLE 7. The effect of different treatments on the liver and kidney functions.**

| Item | ALT (U/L) | AST (U/L) | Creatinine (mg/dl) |
|---|---|---|---|
| Control | 14.66 | 188.09 | 0.61 |
| -2%CP+aa | 14.87 | 182.60 | 0.59 |
| -2%CP+E | 14.92 | 187.71 | 0.59 |
| -2%CP+Mix | 13.97 | 186.58 | 0.47 |
| -4%CP+aa | 13.64 | 185.04 | 0.47 |
| -4%CP+E | 13.96 | 185.53 | 0.48 |
| -4%CP+Mix | 14.68 | 185.68 | 0.59 |
| Significance | NS | NS | NS |
| SE | ±0.73 | ±4.22 | ±0.22 |

NS= Non significant, Means designated with the same letter within the same column are not significantly different at 0.05 level of probability.

**TABLE 8. The effect of different treatments on the blood proteins.**

| Item | Total protein (g/dl) | Albumin (A) (g/dl) | Globulin (G) (g/dl) | A/G ratio |
|---|---|---|---|---|
| Control | 7.34 | 4.04 | 3.51 | 1.24 |
| -2%CP+aa | 7.86 | 4.35 | 3.62 | 1.19 |
| -2%CP+E | 7.94 | 4.32 | 3.98 | 1.21 |
| -2%CP+Mix | 8.79 | 4.81 | 3.50 | 1.23 |
| -4%CP+aa | 7.80 | 4.30 | 3.68 | 1.20 |
| -4%CP+E | 8.10 | 4.42 | 3.73 | 1.21 |
| -4%CP+Mix | 8.26 | 4.52 | 3.51 | 1.24 |
| Significance | NS | NS | NS | NS |
| SE | ±2.38 | ±1.33 | ±1.06 | ±0.06 |

NS= Non significant, Means designated with the same letter within the same column are not significantly different at 0.05 level of probability.

**TABLE 9. The effect of different treatments on the villi height, crypt depth and the ratio of them in the duodenum of broilers at 35d.**

| Item | Villus height (μm) | Crypt depth (μm) | Villus height / Crypt depth |
|---|---|---|---|
| Control | 1438 | 149 | 9.65 |
| -2%CP+aa | 1451 | 147 | 9.87 |
| -2%CP+E | 1446 | 145 | 9.97 |
| -2%CP+Mix | 1440 | 144 | 10.00 |
| -4%CP+aa | 1459 | 150 | 9.73 |
| -4%CP+E | 1462 | 147 | 9.95 |
| -4%CP+Mix | 1439 | 147 | 9.79 |
| Significance | NS | NS | NS |
| SE | ±56 | ±39 | ±2.56 |

NS= Non significant, Means designated with the same letter within the same column are not significantly different at 0.05 level of probability.

**TABLE 10. The effect of different treatments on the Economic efficiency.**

| | Body weight gain (g) | Feed Intake/bird (g) | Feed cost / bird (LE) | Total cost/bird (LE) | Sale price/ bird (LE) | NET profit (LE) | Economic efficiency | Relative EE % |
|---|---|---|---|---|---|---|---|---|
| **Control** | 1719 | 2949 | 51.88 | 101.88 | 128.93 | 27.04 | 0.27 | 100 |
| **-2%CP+aa** | 1850 | 2996 | 50.15 | 100.15 | 138.75 | 38.60 | 0.39 | 145.23 |
| **-2%CP+E** | 1863 | 2972 | 50.20 | 100.20 | 139.73 | 39.53 | 0.39 | 148.61 |
| **-2%CP+Mix** | 1857 | 2875 | 48.55 | 98.55 | 139.28 | 40.72 | 0.41 | 155.66 |
| **-4%CP+aa** | 1806 | 2858 | 45.58 | 95.58 | 135.45 | 39.87 | 0.42 | 157.13 |
| **-4%CP+E** | 1829 | 2895 | 47.11 | 97.11 | 137.18 | 40.06 | 0.41 | 155.43 |
| **-4%CP+Mix** | 1759 | 2819 | 45.88 | 95.88 | 131.93 | 36.05 | 0.38 | 141.66 |

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## تحسين أداء دجاج التسمين: خفض البروتين الغذائي وتعويضه بإضافة الأحماض الأمينية والإنزيمات المحللة للبروتين

**ممدوح عمر عبد السميع[1]، هاني الشريف[1] ،محمد الديب[1] و أحمد سامي[2]**

[1] قسم الإنتاج الحيواني، كلية الزراعة، جامعة القاهرة، الجيزة، مصر.
[2] قسم الإنتاج الحيواني، المركز القومي للبحوث، الجيزة، مصر.

**الملخص**

أجريت هذه الدراسة لمعرفة كيف يمكن للأحماض الأمينية والإنزيمات البروتينية أن تعوض إنخفاض محتوى البروتين في علائق الدواجن. تم توزيع عدد420 كتكوت ذكر بعمر يوم (Arbor Acres) على سبع مجموعات معاملة (7 مجموعات × 6 مكررات × 10 طيور لكل منها). تم إعداد سبع علائق لتغطية جميع الاحتياجات الغذائية لكتاكيت Arbor Acres باستثناء البروتين الخام، أعطت T1 البروتين الخام (CP) وفقًا لمتطلبات دليل السلالة (الكنترول)، أعطتT2-T4 كمية بروتين خام اقل 2٪ من عليقة الكنترول مع إضافة الأحماض الأمينية للوصول للمستويات الموصي بها للسلاله أو الانزيمات المحللة للبروتين أو خليط منهما على التوالي. أعطت T5-T7كمية بروتين خام اقل 4٪ من عليقة الكنترول مع إضافة الأحماض الأمينية للوصول للمستويات الموصي بها للسلاله أو الانزيمات المحللة للبروتين أو خليط منهما على التوالي. تم قياس الأداء الإنتاجي وخصائص الذبيحة وهرمونات الغدة الدرقية وبروتينات الدم ووظائف الكبد والكلى. أشارت النتائج إلى عدم وجود فروق معنوية ($P>0.05$) في معدل الزيادة في وزن الجسم وكمية العلف المستهلك في جميع المعاملات وفي جميع الفترات (فترات البادئ والنامي والناهي والفترة الكلية). كما لم يتم تسجيل فروق معنوية ($P>0.05$) في معامل التحويل الغذائي خلال فترات البادئ والنامي والناهي بينما في الفترة الكلية تحسنت جميع المعاملات بشكل معنوي ($P\leq0.05$) في معامل التحويل الغذائي مقارنة بالمجموعة الكونترول. وهذا يعني أن إضافة كمية كافية من الأحماض الأمينية لتلبية الاحتياجات الغذائية للطيور أو إضافة الانزيمات المحللة للبروتين أو إضافتهما إلى علائق منخفضة في نسبة البروتين سواء بنقص 2% أو 4% عوض هذا الانخفاض وأظهر نتائج مماثلة للمجموعة الكونترول كما عززت معامل التحويل الغذائي الكلي. ولم يسجل أي تأثير معنوي ($P>0.05$) في خصائص الذبيحة (نسبة التصافي والدهون البطنية والبرسا والطحال والكبد والقلب والقانصة من وزن الجسم الحي بالإضافة إلى طول الأمعاء بسبب المعاملات المختلفة. لم يلاحظ أي فروق معنوية ($P>0.05$) بين جميع المعاملات في هرمونات الغدة الدرقية . لم يلاحظ أي فروق معنوية ($P>0.05$) بين جميع المعاملات مع المجموعة الكونترول في وظائف الكبد (ALT وAST) وفي وظائف الكلى مستوى الكرياتينين. والتي تشير إلى أن إضافة الأحماض الأمينية أو الانزيمات المحللة للبروتين أو كليهما لم يكن لهم أي تأثير سلبي على وظائف الكبد والكلى. لم يتم تسجيل أي فروق معنوية ($P>0.05$) في مستويات البروتين الكلي والألبيومين والجلوبيولين ونسبة الألبيومين/الجلوبيولين. كذلك لم يكن هناك اي فروق معنوية ملحوظة ($P>0.05$) في مقاييس موفولوجيا الأمعاء بين المعاملات المختلفة. تشير هذه النتائج إلى أنه يمكننا تقليل محتوى البروتين الخام في علائق دجاج اللحم بنسبة 2% أو 4% حيث يمكن تعويض هذا النقص بإضافة الأحماض الأمينية الأساسية بكميات تلبي الاحتياجات الغذائية أو بإضافة الانزيمات المحللة للبروتين أو مزيج منهما دون أي تأثير سلبي على كلاً من معدل الزيادة في الوزن ومعدل التحويل الغذائي، مما يعزز الكفاءة الاقتصادية. كما لا يوجد لها أي تأثير سلبي على بروتينات الدم أو هرمونات الغدة الدرقية أو وظائف الكبد أو الكلي او المقاييس المورفولوجيا للأمعاء.

**الكلمات الدالة:** دجاج اللحم؛ البروتين الخام؛ الأحماض الأمينية؛ الإنزيمات المحللة للبروتين؛ هرمونات الغدة الدرقية؛ المقايس البيوكيميائية للدم.