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# Broiler response to different energy levels within the same protein levels on feed intake, body weight gain, and feed conversion

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**Abstract:** This study aimed to examine how different energy levels in the same protein affect feed intake, body weight gain, and feed conversion. The study used treatments in the form of differences in metabolizable energy levels at the same protein level, namely 19%. The feed treatments were as follows: T1 = 2800 kcal/kg, T2 = 2900 kcal/kg, T3 = 3000 kcal/kg, and T4 = 3100 kcal/kg. A total of 100 one-day-old unsexed broiler chickens were divided into four treatments, each of which was repeated five times. The feed treatment was administered from 1 to 35 days of age. The experimental design used a completely randomized design, followed by Duncan's test. The research parameters were feed intake, weight gain, and feed conversion. The results showed that increasing metabolic energy reduced feed intake and feed conversion ($p<0.05$) and increased weight gain ($p<0.05$). Feed intake was lowest at an energy level of 2900 kcal/kg, while weight gain was highest at an energy level of 3100 kcal/kg. Broiler performance was optimal at a protein level of 19% and a metabolizable energy level above 2900 kcal/kg.

**Keywords:** broilers, metabolizable energy, performance, protein

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## 1. Introduction

Energy is an expensive nutritional component in chicken feed formulations, especially for broilers [1]. The main sources of energy in feed usually come from ingredients such as corn, vegetable oils (soybean oil, palm oil), and wheat, which are relatively expensive compared to plant-based protein feed ingredients such as soybean meal. Therefore, the metabolizable energy level in the ration greatly determines the total feed cost.

In general, feed energy is defined at several levels: gross energy, digestible energy, metabolizable energy, and net energy. For commercial poultry, apparent metabolisable energy is commonly used, and apparent metabolisable energy corrected for zero nitrogen retention is used more frequently in modern formulations because nitrogen correction provides a more consistent comparison between diets and raw materials [2].

Chickens, as monogastric animals, have a relatively simple and efficient digestive system for digesting carbohydrates, proteins, and fats [3]. Energy for chickens mainly comes from carbohydrates and fats in feed, expressed as metabolizable energy [4]. Protein is composed of essential and non-essential amino acids, which are utilized for the synthesis of body tissues, enzymes, hormones, and other metabolic products [5]. Protein

and energy have a synergistic relationship: energy is needed to utilize protein, while protein is used to build tissue only if energy requirements are met [6].

Energy functions include maintaining vital processes, such as heartbeat, respiration, blood circulation, as well as muscle activity, movement, body temperature regulation, and growth and production of meat and eggs [7]. Metabolizable energy is allocated to the following: maintenance of basal metabolism, body temperature regulation, physical activity, and synthesis of lean tissue (protein) or fat reserves [8]. Dietary energy, which is derived from carbohydrates, lipids, and proteins, makes up the largest proportion of poultry diets and has a significant impact on diet costs [9].

Chickens exhibit a protein-leverage effect: when their diet contains too little protein, they consume more feed than necessary to meet their protein requirements. This results in elevated energy intake and fat accumulation. Heat production is especially elevated when protein intake is high due to the high heat increment of protein metabolism [10].

A balanced diet without excessive undigested protein helps to maintain the balance of the microbiota in the ileum and caecum and the integrity of the intestinal epithelium [11]. Undigested protein in the lower intestine can promote the growth of proteolytic microbes and toxic metabolites, which can disrupt the barrier and impair performance. Therefore, an adequate supply of digestible amino acids alongside the correct energy levels is essential for intestinal health and performance [12]. An excess of energy without an increase in protein or amino acids will lead to increased fat deposition, reduced carcass efficiency, and higher feed costs per kg of gain [9].

Previous studies have shown that broiler chickens can be fed a low-energy, low-protein diet as long as the energy-to-protein ratio is maintained [13]. However, the specific proportions of energy and protein have not been specified. The novelty of this study is to evaluate the optimal energy level for the protein recommended by the National Research Council, thereby validating the ideal proportions of energy and protein for achieving optimal production performance. Understanding the impact of different protein and metabolizable energy concentrations in broiler chicken diets is fundamental to achieving optimal performance, reducing production costs, and maintaining sustainability in poultry production systems. This study aims to explore how broiler chickens respond to feed with the same protein content but different levels of metabolisable energy.

## 2. Materials and Methods

The study used 100 one-day-old unsexed broilers, which were divided into four groups. Each group was repeated five times. Each repetition consists of five chickens. Each experimental repetition was placed in one cage, resulting in 20 treatment cages. The cages were open-housed, with curtains used for cover at night and during rain. These treatments involved different levels of metabolic energy, all with a protein content of 19%. The levels of energy were T1 (2800 kcal/kg), T2 (2900 kcal/kg), T3 (3000 kcal/kg), and T4 (3100 kcal/kg). The composition of feed ingredients used in each treatment is listed in Table 1, while the nutrient composition of each treatment is listed in Table 2.

The treatments were administered from day one to day 35; the feed and drinking water were provided ad libitum. The parameter measured was feed intake, calculated as the amount of feed given minus the amount left over, and weighed daily. Weight gain was measured weekly from the first to the fifth week, with data compiled over this period. Feed conversion was calculated using the ratio of feed intake to weight gain, calculated cumulatively over the five weeks [10].

**Table 1.** The composition of feed ingredients

| Feed Ingredients | Protein (%) | Metabolizable Energy (Kcal/Kg) | Fat (%) | Fiber (%) |
|---|---|---|---|---|
| Corn | 8.5 | 3440 | 3.0 | 2.78 |
| Rice Bran | 11.2 | 1860 | 2.5 | 7.0 |
| Coconut Meal | 22.0 | 2120 | 7.0 | 15.0 |
| Fish Meal | 40.0 | 2980 | 10.0 | 2.5 |
| Soybean Meal | 38.0 | 2440 | 3.5 | 4.0 |
| Tofu Pulp | 28.0 | 1800 | 16 | 4.5 |

Data Source: Feed Ingredient Composition Table [14]

**Table 2.** The Nutrient Composition of Treatments (%)

| Feed Ingredients | T1 | T2 | T3 | T4 |
|---|---|---|---|---|
| Corn | 45 | 50 | 60 | 62 |
| Rice Bran | 10 | 10 | 0 | 0 |
| Coconut Meal | 17 | 10 | 2 | 5 |
| Fish Meal | 10 | 10 | 12 | 10 |
| Soybean Meal | 14 | 20 | 23 | 23 |
| Tofu Pulp | 4 | 0 | 3 | 0 |

Data Source: Feed Formulation Calculation

The data were analyzed using a completely randomized design. Duncan's test was then used to check for significant differences ($p<0.05$) in the means of treatment[15].

## 3. Results and Discussion

The difference in metabolic energy levels in feed affects the growth performance of broiler chickens, as shown in Table 3. The feed plays a crucial role in determining the growth performance, health status, and production efficiency of broiler chickens. Energy homeostasis is of fundamental importance to the well-being of animals, as well as to the feeding of species such as chickens [16]. Efficient, highly productive flocks require optimising the balance between energy intake and expenditure, and understanding its relationship to production.

**Table 3.** Effect of different levels of metabolizable energy on the performance of broiler

| Feed Ingredients | T1 | T2 | T3 | T4 |
|---|---|---|---|---|
| Feed Intake | 3228.12±49.45$^{b}$ | 3108.68±83.26$^{a}$ | 3172.68±89.30$^{ab}$ | 3163.94±77.32$^{ab}$ |
| Body Weight Gain | 1878.56±30.56$^{a}$ | 1829.20±40.95$^{a}$ | 1874.06±47.08$^{b}$ | 1942.62±27.84$^{b}$ |
| Feed Conversion | 1.72±0.04$^{b}$ | 1.70±0.05$^{a}$ | 1.69±0.06$^{a}$ | 1.63±0.08$^{a}$ |

### *3.1. Feed intake*

Dietary energy, which is derived from carbohydrates, lipids, and proteins, makes up the largest proportion of poultry diets and has a significant impact on diet costs. It also interacts with other nutrients, such as amino acids, to promote efficient and productive chicken farming. There is an effect of the ratio of protein content and energy content of feed on broiler performance [17]. Chickens eat to meet their energy requirements [10].

Table 3 shows that an increase in energy levels in feed reduces feed intake. The energy content of the feed significantly influences feed intake, as animals strive to balance their energy intake with their body's energy needs [18]. With low-energy feed, chickens tend to

increase feed consumption to meet their daily energy requirements. However, there is a limit to this increase, especially when crop capacity is limited. Meanwhile, with high-energy feed, chickens will reduce feed consumption because their energy requirements are met with a smaller amount of feed.

Several researchers report that the regulation of feed intake by energy occurs through metabolic signals, such as blood glucose levels, free fatty acids, and adenosine triphosphate energy in tissues, which can signal satiety or hunger; hormonal regulation of leptin, insulin, and ghrelin plays a role in appetite regulation, and body temperature. In hot conditions, high-energy feed produces more metabolic heat, and poultry will reduce consumption to reduce heat load [18][19][20].

Feeds with the same protein content show differences in feed consumption due to differences in energy levels. Other factors that modify the effect of energy levels on feed consumption, such as the balance between energy and other nutrients (protein, vitamins, minerals), which is very important to ensure optimal growth, production, and health of chickens [9].

### *3.2. Body weight gain*

Increasing the energy level in the feed increases body weight (Table 3). Maintaining a healthy protein-energy balance is very important. If there is sufficient energy, protein will be used optimally for tissue growth [21]. However, if energy intake is low, protein will be used as an energy source, thereby reducing tissue synthesis. If energy intake is too high, feed intake decreases, resulting in a relative decrease in protein intake and a low protein/energy ratio. The protein and energy ratio (P/E ratio) greatly influences growth efficiency in broiler chickens. A balanced ratio leads to rapid growth and good feed efficiency. An unbalanced ratio leads to nutrient wastage and suboptimal growth [22].

Protein is the main building block for muscle development and tissue synthesis, while metabolisable energy provides essential fuel for maintenance, growth, and metabolic activities. Changes in dietary protein and energy levels can result in variations in feed intake, nutrient utilisation, and weight gain [10].

The metabolizable energy and protein requirements of broilers of different ages and strains are met by a balanced formulation. In a balanced diet, nitrogen (N) retention increases (more nitrogen enters the tissue), resulting in a decrease in nitrogen output in the form of uric acid and volatile $NH_3$ [23]. This is important for two reasons: feed efficiency, less nitrogen is burned for energy and eliminated, and reducing ammonia and its environmental impact. Formulations containing synthetic amino acids, which reduce crude protein while maintaining the amino acid profile, also help to reduce nitrogen excretion when the energy balance is maintained. This occurs at energy levels of 2900 Kcal/Kg and above. The result is maximised protein deposition (lean tissue), reduced excess fat deposition and nitrogen excretion, stable feed intake, and improved gut health and carcass quality [24]. These improvements occur because the body allocates energy more efficiently towards protein synthesis (anabolism) than towards burning or storing energy as fat, and because the mechanisms of nutrient sensing and hormones are in harmony [15].

### *3.3. Feed conversion ratio*

Metabolizable energy levels starting at 2900 kcal/kg and above reduce feed conversion, while simultaneously increasing broiler feed efficiency. As shown in Table 3, feed conversion decreased with an increase in the energy content of the feed.

The composition of feed is the most important factor in determining the efficiency of producing broiler chickens. Among the key nutritional components, dietary protein and metabolisable energy levels play a central role in influencing growth performance and

feed utilisation [2]. In broiler chickens, protein-energy balance determines growth rate, feed conversion ratio, and carcass quality [22].

Protein provides the essential amino acids necessary for muscle development and overall growth, while metabolisable energy supplies the fuel needed for maintenance and metabolic activities [12]. Variations in the protein and metabolizable energy levels of broiler diets directly affect feed intake, nutrient absorption, and energy partitioning. These factors then influence the feed conversion ratio [2]. A well-balanced diet with optimal levels of both improves the utilisation of nutrients, resulting in better growth rates and reduced feed costs. Sufficient energy will ensure that protein is optimally used for tissue synthesis, while energy deficiency causes protein to be wasted as an energy source

## 4. Conclusions

Imbalances in these nutrients can result in poor feed conversion ratio, slower growth, and higher production costs. Therefore, it is crucial to understand the relationship between dietary protein, metabolisable energy, and feed conversion when formulating feeding strategies for broilers. Broiler performance was optimal at a protein level of 19% and a metabolizable energy level above 2900 Kcal/Kg.

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**Conflicts of Interest:** The authors declare no conflict of interest.

## References

[1] R. A. Alhotan, "Commercial poultry feed formulation: Current status, challenges, and future expectations," *Worlds. Poult. Sci. J.*, vol. 77, no. 2, pp. 279–299, 2021.

[2] S. Barzegar, S.-B. Wu, M. Choct, and R. A. Swick, "Factors affecting energy metabolism and evaluating net energy of poultry feed," *Poult. Sci.*, vol. 99, no. 1, pp. 487–498, 2020.

[3] G. Cherian, *A guide to the principles of animal nutrition*. Oregon State University Corvallis, OR, USA, 2020.

[4] M. M. Khalil, M. R. Abdollahi, F. Zaefarian, and V. Ravindran, "Influence of feed form on the apparent metabolisable energy of feed ingredients for broiler chickens," *Anim. Feed Sci. Technol.*, vol. 271, p. 114754, 2021.

[5] M. J. Lopez and S. S. Mohiuddin, "Biochemistry, essential amino acids," in *StatPearls [Internet]*, StatPearls Publishing, 2024.

[6] S. P. Macelline, P. V Chrystal, S. Y. Liu, and P. H. Selle, "The dynamic conversion of dietary protein and amino acids into chicken-meat protein," *Animals*, vol. 11, no. 8, p. 2288, 2021.

[7] G. Krishnan, C. Devaraj, M. V Silpa, and V. Sejian, "Thermoregulation in birds," in *Textbook of veterinary physiology*, Springer, 2023, pp. 751–764.

[8] P. Singh, R. K. Kesharwani, and R. K. Keservani, "Protein, carbohydrates, and fats: Energy metabolism," in *Sustained Energy for Enhanced Human Functions and Activity*, Elsevier, 2017, pp. 103–115.

[9] E. U. Ahiwe, A. A. Omede, M. B. Abdallh, and P. A. Iji, "Managing dietary energy intake by broiler chickens to reduce production costs and improve product quality," *Anim. Husb. Nutr.*, vol. 115, pp. 115–145, 2018.

[10] H. L. Classen, "Diet energy and feed intake in chickens," *Anim. Feed Sci. Technol.*, vol. 233, pp. 13–21, 2017.

[11] N. Ma, Y. Tian, Y. Wu, and X. Ma, "Contributions of the interaction between dietary protein and gut microbiota to intestinal health," *Curr. Protein Pept. Sci.*, vol. 18, no. 8, pp. 795–808, 2017.

[12] W. He, P. Li, and G. Wu, "Amino acid nutrition and metabolism in chickens," in *Amino acids in nutrition and health: Amino acids in the nutrition of companion, zoo and farm animals*, Springer, 2021, pp. 109–131.

[13] F. A. S. Dairo, A. O. K. Adesehinwa, T. A. Oluwasola, and J. A. Oluyemi, "High and low dietary energy and protein levels for broiler chickens," *African J. Agric. Res.*, vol. 5, no. 15, pp. 2030–2038, 2010.

[14] S. K. Mutayoba, E. Dierenfeld, V. A. Mercedes, Y. Frances, and C. D. Knight, "Determination of chemical composition and antinutritive components for Tanzanian locally available poultry feed ingredients," *Int. J. Poult. Sci*, vol. 10, no. 5, pp. 350–357, 2011.

[15] R. N. Henson, "Analysis of variance (ANOVA)," *Brain Mapp.*, vol. 1, pp. 477–481, 2015.
[16] M. Zampiga, F. Calini, and F. Sirri, "Importance of feed efficiency for sustainable intensification of chicken meat production: implications and role for amino acids, feed enzymes and organic trace minerals," *Worlds. Poult. Sci. J.*, vol. 77, no. 3, pp. 639–659, 2021.
[17] R. M. Gous, A. S. Faulkner, and H. K. Swatson, "The effect of dietary energy: protein ratio, protein quality and food allocation on the efficiency of utilisation of protein by broiler chickens," *Br. Poult. Sci.*, vol. 59, no. 1, pp. 100–109, 2018.
[18] M. R. Abdollahi, F. Zaefarian, and V. Ravindran, "Feed intake response of broilers: Impact of feed processing," *Anim. Feed Sci. Technol.*, vol. 237, pp. 154–165, 2018.
[19] W. Y. Chuang, Y. C. Hsieh, L. W. Chen, and T.-T. Lee, "Evaluation of the relationship between adipose metabolism patterns and secretion of appetite-related endocrines on chicken," *Animals*, vol. 10, no. 8, p. 1282, 2020.
[20] A. R. Sesay, "Impact of heat stress on chicken performance, welfare, and probable mitigation strategies," *Int. J. Environ. Clim. Chang.*, vol. 12, no. 11, pp. 3120–3133, 2022.
[21] J.-R. Teyssier, G. Brugaletta, F. Sirri, S. Dridi, and S. J. Rochell, "A review of heat stress in chickens. Part II: Insights into protein and energy utilization and feeding," *Front. Physiol.*, p. 1521, 2022.
[22] S. Musigwa, P. Cozannet, C. A. Asiamah, and S.-B. Wu, "Effects of dietary protein levels, net energy levels, and essential amino acid-to-true protein ratios on broiler performance," *Animals*, vol. 14, no. 21, p. 3065, 2024.
[23] A. Prakash, V. K. Saxena, and M. K. Singh, "Genetic analysis of residual feed intake, feed conversion ratio and related growth parameters in broiler chicken: A review," *Worlds. Poult. Sci. J.*, vol. 76, no. 2, pp. 304–317, 2020.
[24] M. Ghasemi-Sadabadi, Y. Ebrahimnezhad, B. Eshratkhah, and N. Maheri-Sis, "The effects of different diet total volatile nitrogen levels on blood biochemical parameters in broilers," *J. Biol. Environ. Sci.*, vol. 9, no. 27, pp. 151–158, 2015.