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Research Article

The Effects of Different Levels of Crude Protein and Energy on Growth Performance Parameters and Economic Viability of Tanbro Chickens in Tanzania

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Abstract

This study evaluated the effects of varying crude protein (CP) and metabolizable energy (ME) levels on growth performance and economic viability of Tanbro chickens. A total of 200-day-old chicks were brooded for 26 days and randomly allotted to four dietary treatments (T0-T3) in a completely randomized design, with four replicates of 12 birds each. Diets were formulated separately for growing (G) and finisher (F) phases. T0-G was a commercial control diet (T0-G: 2959 kcal/kg ME, 19.6% CP; T0-F 3068 kcal/kg ME, 19.3% CP). T1-G contained 2978 kcal/kg ME, 20.12% CP), T1-F had (3018.8 kcal/kg ME, 18.29% CP). T2-G (2567.68 kcal/kg ME and 20.06% CP) while T2-F had (2741.17 kcal/kg ME and 16.1% CP) and T3-G: had (ME, 2583.84 kcal/kg &, 18.64%CP); T3F (ME, 2661.04 kcal/kg &, 14.77%CP). Dietary crude protein and metabolizable energy levels significantly affected the growth performance of Tanbro chickens during grower and finisher phases. During the grower phase, birds fed T0-G exhibited significantly ($P < 0.001$) higher body weight (1327.0 g), body weight gain and (67.1 g/day), compared to other treatments. Feed conversion ratio (FCR) in grower phase was also significantly affected ($P = 0.0001$), with T1-G showing better efficiency (2.4), than T2-G and T3-G. Likewise, final body weight and body weight gain were significantly influenced by dietary treatments. Birds on T1-F achieved the higher final BW (1984.5 g) and weight gain (59.3 g/day), than other tested diets. Feed intake and FCR differed significantly ($P < 0.0001$), with the highest intake observed in T2-F (156.2g) while T1-F showing better FCR compared to other testable diets (2.5). Economically, T1-F yielded the highest cost advantage, with a differential gain of 1005.27 TSH and a relative cost per kilogram of weight gain representing 23% of the control diet. These findings highlight the need for balanced diet formulation tailored to breed, the growth stage and production goals, especially in resource-limited production settings.

Keywords

Tanbro Chickens, Crude Protein, Metabolizable Energy, Growth Performance, Economic Viability

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1. Introduction

Poultry production is an important sector in Tanzania's economic growth and one of the fastest-growing agricultural industries, playing a critical role in improving household nutrition, generating income, and contributing to national food security [1]. Poultry species, particularly chickens, require significantly less land, water, and feed resources per unit of meat or egg produced compared with ruminants such as cattle, sheep, and goats [2]. Their short production cycle allows for faster turnover and more efficient conversion of feed into edible protein, enabling producers to meet market demand within a relatively short time [3]. Additionally, poultry farming is characterized by lower start-up and maintenance costs, making it more accessible to small-scale and resource-limited farmers, especially women, who constitute the majority of rural chicken producers in Tanzania [4]. Poultry meat and eggs also possess favorable nutritional profiles, providing highly digestible protein, essential amino acids, vitamins, and minerals that are important for combating malnutrition and improving public health [5].

Moreover, poultry production systems are adaptable and can be integrated into diverse agro-ecological zones, unlike larger livestock species that require extensive grazing land or specialized environmental conditions. The ability to raise chickens under intensive, semi-intensive, or free-range systems enables farmers to tailor production to locally available resources while maintaining efficiency [6]. Because poultry reproduce rapidly and attain market weight within a few weeks, the industry can respond quickly to fluctuations in food demand, making it strategically important for enhancing national food security [1, 7]. These advantages underscore the pivotal role of the poultry industry in meeting protein requirements and promoting sustainable agricultural development, particularly in Sub-Saharan Africa where population growth continues to increase. However, poultry production in Tanzania remains dominated by indigenous chickens, which are characterized by relatively low genetic potential for growth and productivity [1].

In recent years, the introduction of improved chicken strains has provided farmers with new opportunities to enhance productivity and profitability. Among these is the Tanbro chicken, a newly introduced dual-purpose breed developed to improve meat yield, adapt well to local production environments, and satisfy the growing demand for high-quality poultry products [8]. Nevertheless, the productivity of these improved breeds continues to be constrained by management practices and policy-related challenges [6, 8, 9]. Feed constitutes the largest component of poultry production costs, often accounting for more than 60-70% of total production expenses [10]. Therefore, optimizing dietary nutrient levels, particularly crude protein (CP) and metabolizable energy (ME), is essential not only for maximizing growth performance and carcass characteristics but also for improving the economic viability of poultry enterprises [11]. Protein is fundamental for muscle development and overall growth, whereas energy supports essential physiological processes and regulates feed intake. However, supplying nutrients either above or below the birds' requirements may result in inefficient feed utilization, poor performance, and unnecessary increases in production costs [12]. Since nutrient requirements vary among breeds and production systems, breed-specific feeding recommendations are needed for Tanbro chickens.

Despite the increasing popularity of Tanbro chickens, scientific information regarding their nutritional requirements and profitability under smallholder production systems when fed diets containing different crude protein and metabolizable energy levels remains limited. Such information is essential for farmers and feed formulators seeking to improve productivity while maintaining cost-effectiveness. Therefore, this study was designed to evaluate the effects of different dietary crude protein and metabolizable energy levels on the growth performance and economic viability of Tanbro chickens. The findings are expected to provide evidence-based nutritional recommendations that enhance both biological performance and economic returns for smallholder poultry producers.

2. Materials and Methods

2.1. Study Area

The research was conducted at the lower farm poultry unit in the Department of Animal, Aquaculture, and Range Sciences at Sokoine University of Agriculture (SUA) in Morogoro, Tanzania. SUA is situated on the slopes of the Uluguru Mountains, at an altitude of 500 to 600 meters above sea level. The area receives yearly rainfall ranging from 600 to 1000 mm. Temperatures range from 30 to 35°C during the hottest period (October to January) and from 20 to 27°C during the cooler months (April to August).

2.2. Source of Experimental Units and Their Management

A total of 200-day-old Tanbro chicks were sourced from Interchick Company Limited. Upon arrival, they were wing-tagged, weighed, and housed together in a disinfected brooding room. Brooding lasted for 26 days, with temperatures maintained at approximately 35°C during the first week, 32°C during the second week, and 29°C during the third week in accordance with standard brooding practices. Throughout this period, the chicks were offered a commercial starter diet supplied by Irvine Company. At day 26, a total of 192 Tanbro grower birds were randomly allotted to four dietary treatments during the growing and finishing phases in a completely randomized design, with four replicates per treatment and 12 birds per replicate. The control diet (T0) consisted of commercial broiler grower and finisher feeds purchased from Irvine Company. At this stage, birds were transferred from the brooding house to elevated grower cages. The grower phase lasted three weeks, followed by a two-week finisher phase. Clean drinking water was provided ad libitum, and birds were vaccinated against Newcastle disease, Gumboro disease, and fowl pox following recommended vaccination schedules [13].

2.3. Feed Ingredients and Feed Formulations

Feed ingredients used to formulate the experimental grower and finisher diets were obtained from commercial feed suppliers in Morogoro. Representative samples of each ingredient (Table 1) were submitted to the Tanzania Veterinary Laboratory Agency (TVLA), Temeke Centre, for proximate analysis. Analyses were conducted using a Near-Infrared Reflectance Spectrophotometer (NIRS Systems 5000, Firmware Version 156, USA). The instrument was calibrated specifically for concentrate mixed-ration formulations (tmrgpfe.eqa) according to the procedures described by Berglund et al. [14] and Aufrère and Michalet-Doreau [15]. Metabolizable energy (ME) of the formulated diets was also determined using the same NIRS system. The formulated mash diets were analyzed for dry matter (DM), crude protein (CP), crude fibre (CF), ash content, and metabolizable energy (ME).

The proximate composition of the feed ingredients and formulated experimental diets is presented in Tables 2 and 3. The analytical results confirmed that the ingredients and diets supplied adequate nutrient concentrations required to support the growth of dual-purpose Tanbro chickens.

Table 1. *Dietary composition of experimental diets (grower and finisher) with varying levels of calculated crude protein and metabolizable energy.*

Feedstuff	Growers			Finishers		
	T1-G	T2-G	T3-G	T1-F	T2-F	T3-F
Maize bran	0	30	30	0	30	35
Maize meal	60	33	35	60	34	40
Sorghum	13	0	0	18	15	0
Blood meal	2	2	2	2	2	2
Sunflower Seed Cake	0	10	10	0	1	6
Fish meal	10	10	10	8	4	3
Soya meal	12	4	0	9	7	1
Rice polishing	0	8	10	0	4	10
Bone meal	1.12	1.12	1.12	1.12	1.12	1.12
Limestone	1	1	1	1	1	1
Methionine	0.13	0.13	0.13	0.13	0.13	0.13
Broiler premix	0.25	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100	100
Calculated CP%	21.26	21.20	19.78	19.06	17.0	15.18
Calculated ME Kcal/kg	3114.59	2601.59	2601.19	3145.79	2814.29	2623.19

The proximate composition of the raw materials, commercial feeds (starter, grower, and finisher), and experimental diets is presented in Tables 2 & 3. The results indicate that both the ingredients and formulated diets contained adequate levels of essential nutrients required to support optimal growth of dual-purpose chickens/broilers.

Table 2. Proximate composition of identified feed ingredients used.

List of Ingredients	DM	CP	Crude Fibre	Crude Fat	Ash	ME
Maize bran	94.9	10.9	9.7	11	6.1	2891
Maize meal	88.1	8.6	3.4	4	1.5	3408
Sorghum	89.1	9	2.2	2.8	1.6	3250
Blood meal	95.1	91.7	0.2	4.1	3.4	3020
Sunflower Seed Cake	94.1	29	23.3	17.2	4.8	2868
Fish meal	84.4	57.3	0	9.5	17.9	2310
Soya meal	93.7	45.5	7.1	21.3	5	3592
Rice polishing	89.7	11.3	16.5	10.5	12	2463

Table 3. Proximate composition of formulated treatments and commercial diets.

	DM	CP	Crude fibre	Crude fat	Sugar	Starch	Ash	ME
T0-S (Starter)	90.8	24.2	2.5	2.8	3.5	42.8	9	3029
T0-G (grower)	90	19.6	7.5	5.9	3.8	39.2	8.6	2956
T0-F (Finisher)	90.4	19.3	7	6.5	4.1	40.8	7.8	3068
Growers								
T1-G	87.9	20.1	2.3	3.7	3.7	37.6	12.6	2978
T2-G	89.0	20.1	7.2	4.8	3.3	33.6	13.4	2568
T3-G	89.0	18.6	7.4	5.0	3.3	33.7	13.9	2584
Finishers								
T1-F	87.8	18.1	2.2	3.6	3.7	37.6	12.7	3021
T2-F	88.4	16.4	4.5	4.3	3.4	35.1	13.6	2741
T3-F	88.6	14.8	6.9	4.7	3.3	33.5	14.0	2661

2.4. Data Collection

2.4.1. Effect of Different Levels of Crude Protein and Metabolizable Energy on the Growth Performance of Tanbro Chickens

To determine how different levels of CP and ME of dietary treatments affect the growth performance of Tanbro chickens, several important growth parameters were monitored during the study. Feed intake (FI) was computed to evaluate the amount of feed consumed by the birds over specific timeframes, providing insights into feed palatability, appetite, and feeding efficiency. The amount of feed offered and refusals was weighed each morning. FI was computed by subtracting the total weight of feed offered from the refusals. Birds were initially weighed, followed by weighing at the end of each week up to the age of 9 weeks. This parameter helped to indicate how efficiently the birds converted feed into body mass, taking their health and development into account. Then body weight gain (g/day) was calculated by subtracting the weight of the current week to the previous one divided by time. Meanwhile, feed conversion ratio (FCR) was computed as the quantity of feed needed for a bird to gain one unit of weight, where lower values denote greater efficiency. It was obtained by dividing the average feed intake by the average weight gain.

2.4.2. Economic Benefits of Tanbro Chickens Fed Diets with Varying Level of CP and ME

At the finishing phase, growth parameters for the finisher diet were used to compute the economic analysis. The feed cost per kilogram of weight gain was determined by adding the variable costs of all ingredients used to formulate 1 kg of feed for each treatment, as per Waithaka et al. [16]. Relative cost and cost differential analyses were applied to assess the economic benefits of diets with varying levels of crude protein (CP) and metabolizable energy (ME).

The total feeding cost for each bird over the study period was obtained by multiplying its feed intake by the cost per kilogram of feed. The cost per kilogram of weight gain was then derived by dividing the total feeding cost by the corresponding weight gain. The cost differential and relative cost benefit were calculated as follows:

Cost differential (TZS) = Cost/kg weight gain of control feed (T0-F) − Cost/kg weight gain of each test diet (T1-F, T2-F, and T3-F).

Relative cost (%) = (Cost differential ÷ Cost per kg weight gain of the control diet) × 100.

The relative cost benefit represents the percentage gain realized by feeding diets with different CP and ME levels relative to the commercial control diet [17].

2.5. Statistical Analysis

Data analysis was conducted using the General Linear Model (GLM) procedure in SPSS (version 25). Prior to analysis, data distribution was assessed using the Shapiro-Wilk test. The dietary treatments were treated as fixed effects (independent variables). Initial body weight was included as a covariate. Pairwise comparisons were evaluated using Duncan Multiple Range test at a significance level of $p < 0.05$. Least square means (LSMs) were computed for all variables.

3. Results

3.1. Effect of Dietary Crude Protein and Energy Levels on Growth Performance During the Grower and Finisher Phases

The effects of varying dietary crude protein (CP) and metabolizable energy (ME) levels on the growth performance of Tanbro chickens are presented in Table 4. During the grower phase, dietary treatments significantly ($P < 0.001$) affected body weight (BW), average daily body weight gain (ADBW gain), feed conversion ratio (FCR), and feed intake (FI). Birds fed the control diet, T0G, recorded the highest BW and ADBWG (1652.0 g and 67.1 g/bird/day, respectively). In comparison, birds fed the testable diets T1G and T2G had higher values of BW and ADBWG (1327 g and 1246 g vs 49.8 and 46.3 g/bird/day, respectively) compared to their counterpart T3G. In addition, FI differed significantly among treatments ($P < 0.001$). Compared to the control diet (136.5 g/day), FI was lower in all test diets. Within testable diets, T2G had higher FI (122.8 g) compared to T1G and T3G. Moreover, FCR was significantly affected by dietary treatment, with the control diet showing the best feed efficiency (2.1). Relative to T0, FCR was best in T1G (2.4) and T2G (2.8) than that in T3.

During the finisher phase, final BW and ADBW gain were also significantly influenced by dietary treatments ($P < 0.001$). Birds fed the control diet T0F achieved the highest final BW (2349.6 g). Compared to the control, final BW was significantly higher in T1 (1984.5 g) than T2F and T3F. A similar trend was observed for ADBW gain, where birds fed T1F recorded the highest gain (59.3 g/bird/day) than its counterparts (T2 and T3).

Feed intake during the finisher stage varied significantly among treatments ($P < 0.001$). Compared to the control diet (144.4 g/bird/day), birds fed T2 consumed more feed (156.2 g/bird/day) than its counterparts. In addition, FCR showed efficient value in T1 (2.5) than other testable diets.

Table 4. *Effect of different levels of crude protein and energy levels on growth parameters during the grower and finisher phases of Tanbro chickens.*

Diet	Grower (G)				Finisher (F)			
	Parameter				Parameter			
	BW (g)	ADBW gain (g/day)	FCR	FI (g)	Final BW (g)	ADBW gain (g/day)	FCR	FI (g/bird/day)
T0	1652.0^{a}	67.1^{a}	2.1^{c}	136.5^{a}	2349.6^{a}	60.5^{a}	2.5^{c}	144.4^{b}
T1	1327.0^{b}	49.8^{b}	2.4^{b}	114.1^{c}	1984.5^{b}	59.3^{a}	2.5^{c}	140.6^{b}
T2	1246^{b}	46.3^{b}	2.8^{b}	122.8^{b}	1794.75^{c}	47.1^{b}	3.5^{b}	156.2^{a}
T3	1120.4^{c}	28.8^{c}	4.2^{a}	95.6^{d}	1668.5^{c}	32.5^{c}	4.0^{a}	125.1^{c}
SEM	32.71	1.61	0.16	1.37	46.18	2.1	0.1	1.59
P-value	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

Notice; a-d superscripts with different letters within the same column indicate significant difference ($p<0.05$); T0= commercial diet with ME, 2959 kcal/kg & CP, 19.6% (grower); ME, 3068 kcal/kg & CP, 19.3% (finisher); T1= ME, 2978 kcal/kg & CP, 20.12% (grower); ME, 3018.8 kcal/kg & CP, 18.29% (finisher); T2= ME, 2567.68 kcal/kg & CP, 20.06% (grower); ME, 2741.17 kcal/kg & CP, 16.1% (finisher); T3= ME, 2583.84 kcal/kg & CP, 18.64% (grower); ME, 2661.04 kcal/kg & CP, 14.77% (finisher).

3.2. Economic Viability of Varying Crude Protein and Energy Levels of Tanbro Chickens

The results showed that the cost of feed per kg weight gain was lowest in T1-F (3365.72TSH) as compared to the other tested dietary treatments (Table 5). In addition, T1-F yielded the highest cost advantage, with a differential gain of 1005.27 TSH and a relative cost per kilogram of weight gain of 23% of the control diet, compared to other testable diets (T1-F & T2-F).

Table 5. Financial analysis of Tanbro chickens rearing fed varying crude protein and energy levels during the finisher phase.

	T0F	T1F	T2F	T3F
Initial BW (g)	372.4	258.5	239.4	250.8
Final BW (g)	2349.6	1984.5	1794.8	1668.5
weight gain (g)	1977.2	1726	1555.4	1417.7
daily weight gain	56.5	49.3	44.4	40.5
Total FI	5054	4921	5467	4378.5
Daily FI	144.4	140.6	156.2	125.1
FCR	2.5	2.5	3.5	4.0
Cost per Kg of feed	1710	1180.5	1009.86	1129.86
cost of FI per bird	8642.34	5809.24	5520.90	4947.09
cost of feed per Kg weight gain (TSH)	4371.00	3365.72	3549.51	3489.52
Differential cost per Kg gain (TSH)	..	1005.27	821.49	881.48
Relative cost per Kg gain (%)	...	23.00	18.79	20.17

Notice; T0-F= ME, 3068 kcal/kg & CP, 19.3%; T1-F= ME, 3018.8 kcal/kg & CP, 18.29%; T2-F= ME, 2741.17 kcal/kg & CP, 16.1%; T3-F= ME, 2661.04 kcal/kg & CP, 14.77%.

4. Discussion

4.1. Effect of Dietary Crude Protein and Metabolizable Energy on Growth Performance of Tanbro Chickens

The present study demonstrates that varying dietary crude protein (CP) and metabolizable energy (ME) levels among the test diets (T1-T3) consistently influenced the growth performance of Tanbro chickens during both the grower and finisher phases. A clear nutritional trend was observed in which progressive reductions in CP and ME levels from T1 to T3 resulted in corresponding declines in body weight, average daily body weight gain (ADBWG), and feed conversion efficiency. This pattern indicates that Tanbro chickens are highly responsive to dietary nutrient density throughout the production cycle.

Among the test diets, birds fed T1 consistently exhibited superior growth performance during both phases compared with T2 and T3. During the grower phase, T1 birds achieved higher body weight and daily gain than birds fed T2 and T3, while also maintaining a relatively better feed conversion ratio (FCR). A similar trend was maintained during the finisher phase, where T1 birds recorded body weight gain comparable to the highest-performing group and substantially higher than T2 and T3. The better performance observed in T1 may be attributed to improved amino acid availability and a more balanced dietary energy supply, which are critical for protein deposition and muscle development. Similar findings were reported by Kamran et al. [18], who observed that maintaining adequate crude protein and energy levels enhances growth performance through improved nutrient utilization. Likewise, Jahan et al. [11] and Musigwa et al. [12] demonstrated that diets with relatively higher nutrient density improved growth rate and feed efficiency in slow- and medium-growing chickens.

In contrast, birds fed T2 and especially T3 showed marked reductions in growth performance across both phases. The decline was more pronounced in T3, which consistently recorded the lowest body weight, daily gain, and poorest FCR values during both grower and finisher stages. These findings indicate that further reductions in CP and ME below moderate levels negatively affect growth potential and feed efficiency. Poor performance in low-protein and low-energy diets may result from insufficient amino acid supply for tissue development and inadequate dietary energy to support optimal metabolism and growth. Similar observations were reported by Sarwar et al. [19] and Gheisari et al. [20], who found that inadequate dietary protein significantly reduces muscle accretion and overall growth performance in poultry. Khatun et al. [21] also reported that indigenous chickens fed low-protein diets exhibited reduced growth performance, highlighting the sensitivity of slower-growing genotypes to nutrient deficiencies.

Phase-related differences in feeding response were also evident among the test diets. During the finisher phase, birds fed T2 consumed more feed than those on T1 and T3, suggesting compensatory feeding behaviour in response to lower dietary energy concentration. This response is consistent with findings by Maliwan et al. [22], who reported that chickens offered low-energy diets tend to increase feed intake in an attempt to satisfy their energy requirements. However, despite the increased feed consumption observed in T2, growth performance and feed efficiency remained poorer than that in T1, indicating that increased feed intake alone was insufficient to overcome nutrient imbalance. Birds fed T3, despite having the lowest feed intake, also recorded the poorest growth performance, suggesting that severe nutrient restriction may have reduced appetite and growth simultaneously.

Feed conversion ratio further illustrated the nutritional differences among the test diets. Birds fed T1 maintained relatively efficient FCR values during both grower and finisher phases compared with T2 and T3, indicating better utilization of dietary nutrients. In contrast, the progressively poorer FCR observed in T2 and T3 reflects inefficient conversion of feed into body mass under reduced CP and ME levels. Although dietary effects on FCR appeared less pronounced in older birds, the same overall trend persisted across phases. Similar observations were reported by Rahimi and Hassanzadeh [23], who suggested that older birds may adapt physiologically to moderate nutrient variation, although severe nutrient deficiencies continue to impair feed efficiency and growth performance.

The findings of this study have important practical implications for poultry feeding strategies, particularly under smallholder production systems where feed costs remain a major challenge. Among the tested diets, T1 appeared to provide the most balanced nutritional approach by sustaining relatively high growth performance and feed efficiency without the severe reductions observed in T2 and T3. This suggests that moderate reductions in CP and ME may reduce feed costs while still maintaining acceptable productivity. In contrast, excessive reductions in nutrient density, as observed in T2 and especially T3, may compromise growth and ultimately reduce production efficiency. These findings support the recommendations of Zampiga et al. [3], who emphasized the importance of optimizing nutrient utilization for sustainable poultry production. Similarly, Ngongolo et al. [4] and Giti et al. [8] highlighted that balanced feeding strategies are essential for improving productivity and profitability in poultry production systems under developing-country settings. Therefore, optimizing CP and ME levels in practical diets remains essential for achieving sustainable and economically viable Tanbro chicken production.

4.2. Economic Viability of Varying Crude Protein and Energy Levels of Tanbro Chickens

The economic performance of Tanbro chickens was strongly influenced by dietary crude protein (CP) and metabolizable energy (ME) levels during the finisher phase. Among the test diets, T1F (ME: 3018.8 kcal/kg; CP: 18.29%) demonstrated superior economic viability compared to T2-F and T3-F, indicating that moderate reductions in dietary nutrient density can maintain productive performance while potentially reducing feed costs. This finding is particularly important because feed accounts for approximately 60-70% of total poultry production costs, especially in developing countries where access to quality feed ingredients is limited [13, 24]. Therefore, identifying nutritionally balanced diets that optimize feed utilization without excessive formulation costs is essential for sustainable poultry production systems.

The better economic performance observed in T1-F may be attributed to its relatively high and balanced ME and CP levels, which supported efficient growth and feed utilization. Birds fed T1-F maintained growth performance and feed conversion efficiency closer to the higher nutrient-density diet, suggesting that moderate nutrient reductions did not severely compromise productive efficiency. Adequate dietary energy and protein are essential for efficient nutrient metabolism, muscle deposition, and body weight gain [25]. Similar findings were reported by Jahan et al. [11], who observed improved growth performance and carcass yield in chickens fed diets with balanced energy and protein concentrations. Likewise, Musigwa et al. [12] and Perween et al. [26] demonstrated that maintaining adequate dietary protein-energy balance improves feed efficiency and economic returns in poultry production systems.

In contrast, the poorer economic performance observed in T2-F and particularly T3-F suggests that excessive reductions in dietary energy and protein negatively affect growth efficiency and increase production cost per unit of gain. Although birds fed T2-F consumed more feed during the finisher phase, this compensatory increase in feed intake did not translate into proportional body weight gain or improved feed conversion efficiency. This indicates that the lower nutrient density limited effective nutrient utilization and growth performance. Similar observations were reported by Maliwan et al. [22], who found that excessively low-energy diets increased feed intake but reduced growth performance and economic returns in indigenous and crossbred chickens. Comparable findings were also reported by Abouelezz et al. [27] and Sarwar et al. [19], who demonstrated that inadequate dietary energy and protein levels impair feed efficiency and overall production profitability.

The progressive decline in economic performance from T1-F to T3-F further highlights the importance of maintaining an appropriate CP-ME balance in poultry diets. Protein and energy deficiencies reduce nutrient availability for muscle development and metabolic functions, thereby lowering growth rate and increasing feed required per unit of weight gain [18, 20]. Similar reductions in performance under low-protein diets have also been reported in native and slow-growing chicken breeds by Khatun et al. [21] and Srilatha et al. [28]. These findings indicate that although reducing nutrient density may lower feed formulation costs, excessive nutrient restriction can compromise biological efficiency and ultimately reduce economic returns. From a practical perspective, the results suggest that T1-F provided the most favorable balance between nutrient density and production efficiency among the tested diets. This has important implications for smallholder poultry systems in Tanzania and other developing countries, where feed cost remains a major constraint to profitable poultry production [4]. Optimizing dietary CP and ME levels is therefore essential for improving feed efficiency, profitability, and sustainability of Tanbro chicken production.

5. Conclusion and Recommendations

The study revealed that there is a clear relationship between dietary nutrient density and growth performance. The Higher CP and ME (T0) improved growth, better FCR, higher intake while moderate levels (T1) had an acceptable performance with slight reductions in growth performance. The lower levels of diets (T2 and T3) led to reduced growth and efficiency. In addition, the economic analysis revealed that finisher diet with elevated ME, and CP, resulted in the best economic return than other tested dietary treatments. This supports the strategy of phase-specific nutrient adjustment to maximize performance and economic returns in Tanbro chickens. It is recommended that for farmers raising dual-purpose birds such as Tanbro, the use of slightly elaveated CP and ME diets (such T2 & T3) may be justified to improve both growth performance as well as profitability.

Abbreviations

%	Percentage
°C	Degree Celsius or Degree Centigrade
ADWG	Average Daily Weight Gain
ANOVA	Analysis of Variance
CP	Crude Protein
BW	Body Weight
ADBW	Average Daily Body Weight
DM	Dry Matter
FI	Feed Intake
F	Finishers Phase
FCR	Feed Conversion Ratio
G	Grower Phase
Kcal/kg	Kilocarolies Per Kg
Kg	Kilogram
ME	Metabolizable Energy
NIRS	Near-infrared Reflectance Spectrophotometer
P-value	Probability Value
SEM	Standard Error of the Mean
SUA	Sokoine University of Agriculture
T_0	Control Diet
T_1	Diet Two
T_2	Diet Three
T_3	Diet Four
TZS	Tanzanian Shilling
TVLA	Tanzania Veterinary Laboratory Agency
URT	United Republic of Tanzania

Author Contributions

Michael Salu Giti: Conceptualization, Formal Analysis, Funding acquisition, Investigation, Methodology, Resources, Software, Writing – original draft

Isack Ibrahim Kerario: Conceptualization, Supervision, Validation, Visualization, Writing – review & editing

Said Hemed Mbaga: Conceptualization, Supervision, Validation, Visualization, Writing – review & editing

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Data Availability Statement

The data is available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest.

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Research Field

Michael Salu Giti: Poultry Nutrition, Poultry Production Systems, Animal Feed Formulation, Livestock Production, Chicken Growth Performance, Animal Health Management, Agricultural Economics, Sustainable Livestock Farming, Smallholder Poultry Systems, Animal Science.

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Isack Ibrahim kerario: Animal nutrition, Poultry production systems, Livestock feed formulation, Feed resource evaluation, Poultry growth performance, Animal production economics, Sustainable livestock production, Smallholder poultry farming, Feed efficiency studies, Livestock management practices.