

Growth performance and production efficiency of indigenous chickens in different dietary of protein levels and rearing duration

Performa pertumbuhan dan efisiensi produksi ayam kampung pada perbedaan level protein dan lama pemeliharaan

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ABSTRACT

Feed cost represents the largest component of poultry production, making feed efficiency a key determinant of economic sustainability. Indigenous chickens are economically and culturally important but exhibit relatively slow growth and suboptimal feed utilization. This study evaluated the effects of different dietary protein regimens on the growth performance of indigenous chickens, focusing on feed conversion ratio (FCR), feed efficiency (FE), and performance index (PI). A total of 168 day-old chicks were reared for 10 weeks in a completely randomized design (four treatments, six replicates). The treatments consisted of: T0 (22% crude protein for 3 weeks followed by 15% for 7 weeks), T1 (18% for 4 weeks followed by 16% for 6 weeks), T2 (18% for 2 weeks, 16% for 4 weeks, and 14% for 4 weeks), and T3 (18% for 3 weeks, 16% for 3 weeks, and 14% for 4 weeks). Dietary protein level significantly affected FCR and FE ($P < 0.05$). T0 produced the lowest FCR (3.35) and highest FE (37.20%), whereas T2 and T3 showed higher FCR values (4.47) and lower FE (25–28%). Results indicate that adequate protein supply during the starter phase is critical to long-term feed efficiency. Diets with balanced protein levels and appropriate energy–protein ratios improve nutrient utilization and overall production performance in indigenous chickens.

ABSTRAK

Pakan merupakan komponen terbesar dalam biaya produksi unggas sehingga efisiensi pakan menjadi faktor penentu keberlanjutan usaha. Ayam kampung memiliki nilai ekonomi dan sosial yang tinggi, namun pertumbuhannya relatif lambat dan pemanfaatan pakannya belum optimal. Penelitian ini bertujuan mengevaluasi pengaruh berbagai pola pemberian protein ransum terhadap performa ayam kampung yang diukur melalui feed conversion ratio (FCR), feed efficiency (FE), dan indeks performa (IP). Sebanyak 168 ekor DOC dipelihara selama 10 minggu menggunakan rancangan acak lengkap (4 perlakuan \times 6 ulangan). Perlakuan meliputi: T0 (22% protein kasar selama 3 minggu dilanjutkan 15% selama 7 minggu), T1 (18% selama 4 minggu dilanjutkan 16% selama 6 minggu), T2 (18% selama 2 minggu, 16% selama 4 minggu, dan 14% selama 4 minggu), serta T3 (18% selama 3 minggu, 16% selama 3 minggu, dan 14% selama 4 minggu). Hasil analisis ragam menunjukkan bahwa taraf protein berpengaruh nyata terhadap FCR dan FE ($P < 0,05$). Perlakuan T0 menghasilkan FCR terendah (3,35) dan FE tertinggi (37,20%), sedangkan T2 dan T3 menunjukkan FCR lebih tinggi (4,47) dan FE lebih rendah (25–28%). Hasil penelitian menunjukkan bahwa kecukupan protein pada fase starter berperan penting dalam meningkatkan efisiensi pakan jangka panjang. Pemberian protein yang seimbang dengan rasio energi–protein yang tepat mampu meningkatkan pemanfaatan nutrisi dan performa produksi ayam kampung.

Kata kunci:

Ayam kampung

Efisiensi pakan

Rasio konversi pakan

Taraf protein



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INTRODUCTION

Feed cost is widely recognized as the largest component of poultry production expenses, often representing 60–80% of total production costs in indigenous chicken systems in Indonesia (Akhadiarto et al., 2025). This makes feed efficiency a central determinant of economic sustainability in poultry enterprises. The high proportion of feed costs frequently limits profit margins for smallholder farmers, thus necessitating more strategic approaches to diet formulation and nutrient utilization. Among these strategies, optimizing protein supply and integrating locally available feed resources have become increasingly relevant to sustain growth performance while reducing production costs (Manyeula et al., 2019; Waithaka et al., 2022).

Indigenous chickens (*Gallus gallus domesticus*), commonly referred to as village chickens in Indonesia, contribute significantly to rural food systems by providing an important source of animal protein and supplemental household income for smallholder farmers. Village chicken production has been widely recognized as an effective tool for enhancing food and nutrition security, supporting livelihood resilience, and contributing to income diversification among rural and resource-poor communities in developing countries (Idamokoro et al., 2022). Despite their economic and social value, their productivity remains relatively low due to slow growth rates, poor feed conversion efficiency, and suboptimal ration formulation that often fails to meet specific nutrient requirements (Hidayat et al., 2015). Nevertheless, indigenous chickens retain several advantages, including adaptability to tropical environments, strong consumer preference, and relatively low input requirements. Improving their feed utilization efficiency is therefore vital not only for household profitability but also for strengthening local food security in rural areas (Tenza et al., 2024).

The interaction between metabolizable energy and dietary protein levels strongly influences the growth and feed intake of poultry (Perween et al., 2016; Widyaratne et al., 2011). Previous studies in indigenous chicken populations have shown that higher dietary protein and energy concentrations can

improve body weight and daily weight gain. However, the actual feed intake response largely depends on the balance between energy and protein. Adjusting protein content without considering energy density is often ineffective; thus, identifying the optimal energy-to-protein ratio is essential for enhancing feed efficiency and production outcomes (Aldiyanti et al., 2025; Zardadzaei et al., 2023).

Protein source and quality also play critical roles in the performance of indigenous chickens, particularly during the grower phase. A recent meta-analysis by Kurniawan et al., (2023) demonstrated that different protein sources significantly affected weight gain and protein digestibility in crossbred indigenous chickens, though not all protein variations improved performance when digestibility was poor. Similarly, Kemba et al. (2023) reported that supplementing low-protein diets with arginine and lysine enhanced body weight gain, feed intake, and feed conversion ratio (FCR) in local chickens aged 6–12 weeks, underscoring the importance of amino acid balance. In addition, Musigwa et al. (2024) found that crude protein, net energy, and essential amino acid-to-true protein ratios had synergistic effects on growth and feed efficiency in broilers. This concept could be applied to indigenous chickens with appropriate local adaptations.

Biological indicators commonly used to evaluate feed efficiency in poultry include FCR and feed efficiency (FE), which together reflect how effectively dietary nutrients are converted into body weight gain (Musigwa et al., 2024). Both parameters are strongly influenced by the balance of dietary protein and energy, meaning that changes in one component can alter feed intake levels and growth outcomes (Rizkuna et al., 2024; Zardadzaei et al., 2023). In local chickens, higher dietary protein levels during the starter phase have been reported to increase final body weight and improve FCR, suggesting that early nutrition is a critical determinant of long-term growth performance (Khatun et al., 2025).

Nutrient utilization in indigenous chickens is not solely dependent on protein levels but also on energy–protein balance. (Gao et al., 2025) emphasized that balancing energy metabolism with adequate protein supply is essential

for improving FCR and supporting optimal growth, especially during the starter phase. This aligns with Khobondo et al. (2015), who noted that nutritional development in African indigenous chickens requires attention not only to protein enrichment but also to energy-protein interactions to prevent suboptimal growth and reduced production efficiency. Thus, ration formulation that incorporates balanced energy-protein ratios represents a key strategy for sustainable indigenous chicken production.

The starter period is particularly critical for indigenous chickens, as it is marked by rapid development of vital organs, the digestive system, and muscle tissue. Protein deficiency during this stage can have long-term adverse effects on growth, even when adequate nutrition is supplied later in life (Puger et al., 2022). Conversely, adequate protein provision during early growth has been shown to enhance energy utilization and accelerate growth rates in indigenous chicken populations (Khatun et al., 2025).

Beyond nutrition, environmental conditions also influence feed utilization and growth performance. Under tropical conditions, heat stress often reduces feed intake, disrupts metabolic efficiency, and compromises nutrient utilization (Teyssier et al., 2022). Several nutritional strategies, including increasing dietary energy density and optimizing essential amino acid supply, have been reported to help alleviate the adverse effects of heat stress on growth performance and feed efficiency in poultry (Abdel-Moneim et al., 2021). In tropical poultry production, adjusting nutrient strategies to environmental stressors is therefore essential to ensure optimal performance even under high ambient temperatures (Ahmad et al., 2022).

Despite growing interest in indigenous poultry production, evidence-based dietary protein recommendations for slow-growing native chickens remain limited, especially under tropical rearing conditions. Most existing studies emphasize body weight gain without integrating feed efficiency indicators and production indices across rearing phases. The present study addresses this gap by evaluating phase-specific protein levels and their implications for feed conversion ratio, feed efficiency, and performance index over a

10-week production cycle. Thus, this research provides a more comprehensive assessment of protein management strategies for improving the economic sustainability of indigenous chicken production systems. The objective of this study was to determine the effects of graded dietary protein levels on feed utilization and production efficiency in indigenous chickens.

MATERIALS AND METHODS

This study used 168 day-old indigenous chicks (DOC) with an average initial body weight of 28.68 ± 1.13 g and a coefficient of variation (CV) of 4.00% as experimental animals. The DOC were obtained from a local indigenous chicken hatchery operated by smallholder farmers in Bantul, Special Region of Yogyakarta (Indonesia). The parent stocks were maintained under traditional management systems typical of local indigenous chicken production. Upon arrival, the chicks were clinically healthy and uniform in body weight. The chicks were not sexed and were reared for 10 weeks. The chicks were housed in individual floor pens measuring $90 \times 80 \times 80$ cm, with a stocking density of seven birds per unit, resulting in 24 experimental units in total. This stocking rate was equivalent to 9.7 birds/m², or approximately 9.7 kg live weight/m² at market age, which remained within the recommended welfare standards for poultry reared under tropical conditions.

Each pen was equipped with a hanging feeder, a bell-type drinker, and a 60-watt incandescent bulb that served as a heat source during the first three weeks of rearing. Feed was provided according to the respective dietary treatments, while drinking water was available ad libitum throughout the experimental period.

Ethical Statement

All animal handling and experimental procedures were conducted in accordance with generally accepted animal welfare principles for poultry research. Housing, feeding, and environmental management were performed under standard husbandry practices to ensure bird welfare and to minimize stress throughout the 10-week rearing period.

Experimental Diets

Four types of experimental diets were formulated with varying protein levels to match the growth phases of indigenous chickens. The diets were based on locally available feed ingredients, including ground yellow corn, rice bran, soybean meal, coconut meal, fish meal, and poultry meat meal. A vitamin-mineral premix was also included to ensure that the nutrient requirements of the birds were adequately met.

The dietary treatments were as follows:

Control diet: 22% crude protein during the three-week starter phase, followed by 15% during the seven-week finisher phase.

Diet 1: 18% crude protein for a four-week starter phase, followed by 16% for a six-week finisher phase.

Diet 2: 18% for two weeks, 16% for four weeks, and 14% for four weeks.

Diet 3: 18% for three weeks, 16% for three weeks, and 14% for four weeks.

Feed was provided in crumble form during the starter phase and in pellet form during the finisher phase. Nutrient content of the diets was determined by proximate analysis of feed ingredients and calculated using standard nutritional requirement tables.

Experimental Procedure

Preparation phase

A two-week preparation phase was carried out before the experiment. Activities included assembling experimental cage units, cleaning the rearing area, disinfecting all equipment, and installing heat lamps. During the same period, the experimental diets were prepared in the form of crumbles for the starter phase

and pellets for the grower–finisher phase. Once the facilities were ready, day-old indigenous chicks (DOC) were distributed according to the assigned treatments.

Diet formulation phase

The experimental diets were formulated using locally available feed ingredients, with protein levels adjusted according to each treatment. Diet formulation was based on the nutrient requirements for poultry recommended by the National Research Council (NRC, 1994) and was adjusted to accommodate the slower growth rate and lower nutrient requirements of indigenous chickens. The control diet contained 22% crude protein during the first three weeks (starter phase) and was reduced to 15% during the finisher phase. The three experimental treatments applied stepwise protein levels of 18%, 16%, and 14%, combined with varying durations of the starter and finisher phases. Feed was provided twice daily in restricted amounts according to the treatment, while drinking water was available ad libitum throughout the experimental period.

Treatment phase

The birds were reared for 10 weeks in total. A total of 168 DOC were distributed into 24 cage units, each containing 7 chicks, with 4 dietary treatments and 6 replicates per treatment. Each group received the fed according to the assigned protein levels. The rearing process included monitoring of bird health, recording environmental temperature, and administering vaccines following the standard vaccination schedule for indigenous chickens.

Table 1. Nutrient composition of the experimental diets

Nutrient composition	T0 (Control)				
	Starter	Finisher	CP 18%	CP 16%	CP 14%
ME** (kcal/kg)	3100.00	3207.00	2934.00	2941.00	2946.00
CP* (%)	22.06	15.02	18.20	16.47	14.52
EE* (%)	7.94	5.53	6.60	6.88	7.37
CF* (%)	11.84	7.84	10.71	11.81	13.48
Ca** (%)	0.90	0.50	0.33	0.23	0.16
P ** (%)	0.60	0.47	0.71	0.68	0.68
CP: ME ratio	0.14	0.19	0.15	0.16	0.18

Note: *Calculated based on proximate analysis results

**Estimated according to Scott et al. (1976) in Wahju (2004) and product labels

Data Collection

The parameters observed in this study included feed conversion ratio (FCR), feed efficiency (FE), and performance index (PI). Feed conversion ratio (FCR) was calculated as the ratio of total feed intake (g) to total body weight gain (g) during the experimental period ($FCR = \text{feed intake}/\text{body weight gain}$) and is widely used as an indicator of feed utilization efficiency in poultry production (NRC, 2024). Feed efficiency was determined as the reciprocal expression of FCR, calculated as body weight gain divided by feed intake and expressed as a percentage ($FE = \text{body weight gain}/\text{feed intake} \times 100$). Although FE is mathematically derived from FCR, it was included to provide a more intuitive interpretation of nutrient conversion efficiency, as higher FE values directly indicate better feed utilization (Lestari et al., 2022).

The performance index (PI) was calculated by multiplying the final body weight (kg) by the livability percentage (100 – mortality rate), dividing the result by the product of FCR and rearing period (days), and multiplying the result by 100. This calculation is adapted from the European Production Efficiency Factor concept commonly used in poultry performance evaluation (Adaszyńska-Skwirzyńska et al., 2025). The PI integrates growth performance, feed efficiency, survivability, and production duration into a single comprehensive indicator of overall production efficiency.

Data Analysis

Data collected from the experiment were subjected to Analysis of variance (ANOVA) using a completely randomized design by Statistical Product and Service Solutions version 22. The data were analyzed using following linear model:

$$Y_{ij} = \mu + \tau_i + \varepsilon_{ij},$$

where Y_{ij} represents the observed value, μ is the overall mean, τ_i denotes the effect of dietary protein level, and ε_{ij} is the random experimental error.

When the F-test indicated significant differences ($P < 0.05$), Duncan's multiple range test (DMRT) was performed to determine differences among treatments. In addition, the Performance index (PI) was analyzed descriptively by presenting the average values

to provide a general overview of the growth performance of indigenous chickens in each treatment group.

RESULTS AND DISCUSSION

Feed Conversion Ratio (FCR)

The feed conversion ratio (FCR) of indigenous chickens over the 10-week rearing period is presented in Table 2. Analysis of variance revealed that dietary protein levels had a significant effect on FCR ($P < 0.05$). The average FCR ranged from 3.35 to 4.47. The control treatment (T0; 22% protein during the starter phase and 15% during the finisher phase) produced the most efficient FCR (3.35), which was significantly lower than those of T2 and T3 (4.47). Meanwhile, the FCR of T1 (3.89) was intermediate between T0 and T2-T3.

The weekly pattern showed that differences among treatments appeared as early as the first week, where T0 consistently demonstrated a lower FCR compared to the other treatments. The gap became more pronounced during weeks 5 to 7, while FCR values tended to fluctuate during weeks 8 to 10. These findings indicate that reducing dietary protein levels to 14–16% was insufficient to support optimal feed efficiency in indigenous chickens.

Feed conversion ratio is a key indicator for evaluating feed efficiency in indigenous chickens. As presented in Table 2, FCR values varied across treatments throughout the 10-week rearing period. In general, the control group (T0) exhibited lower FCR during the early weeks, whereas T1, T2, and T3 consistently showed higher values. This suggests that increasing dietary protein levels did not always translate into improved feed efficiency.

During weeks 1 to 3, T0 demonstrated superior efficiency, with FCR values ranging from 1.62 to 1.97, compared with 2.42–3.29 in the other treatments. Lower FCR values indicate more efficient conversion of feed into body weight. In the present study, the starter diets were classified as high protein (22% CP; T0), moderate protein (18% CP; T1), and moderate-to-low protein (18% followed by reduction; T2 and T3). Previous studies have reported that indigenous chickens generally perform optimally at moderate protein levels of approximately

18–20% during the starter phase (Khatun et al., 2021; Kingori, Tuitoek et al., 2003). However, protein levels above 20% may still enhance early growth when energy supply and amino acid balance are adequate (Waithaka et al., 2022). In contrast, insufficient protein ($\leq 16\%$) can limit muscle protein deposition and impair feed efficiency. Excessive protein beyond the birds metabolic capacity may lead to amino acid imbalance, increased deamination, and elevated nitrogen excretion, thereby increasing metabolic costs and reducing efficiency.

From weeks 4 to 7, FCR values increased across all treatments. This trend was expected, as the growth rate of chickens began to slow, leading to greater energy allocation for body maintenance rather than weight gain (Nindria et al., 2025).

Treatments T2 and T3 recorded the highest FCR values, reaching up to 6.88, indicating poor feed efficiency. Such inefficiency could be attributed to surplus dietary protein that was not effectively utilized, resulting in increased deamination and nitrogen excretion, which in turn imposed additional metabolic burdens on the birds (Torres et al., 2023). In addition to crude protein level, the protein–energy balance of the diet also played an important role in determining feed utilization. As presented in Table 1, the CP:ME ratio differed among treatments, ranging from 1:140 in the T0 starter diet to 1:202 in the lower-protein diets. The relatively tighter ratio in T0 during the starter phase likely optimized amino acid availability

relative to energy supply, thereby enhancing growth efficiency. In contrast, wider CP:ME ratios in T2 and T3 may have limited protein deposition efficiency, as dietary energy was not proportionally synchronized with essential amino acids. These findings suggest that feed conversion was influenced not only by crude protein concentration but also by the balance between dietary energy and protein supply.

Between weeks 8 and 10, FCR values again increased across treatments, despite potential improvements from dietary supplementation. Susan et al. (2023) reported that supplementing indigenous chicken diets with termites (*Macrotermes bellicosus*) improved feed efficiency. Nevertheless, indigenous chickens are inherently slow-growing, which limits efficiency gains during the later rearing stages. Indigenous chickens are genetically characterized by slower growth trajectories and lower muscle accretion compared with commercial broilers (Agustini et al., 2021). These intrinsic genetic differences result in higher relative energy requirements for maintenance and less efficient feed utilization during the finishing phase.

On average, FCR values over the 10-week trial differed significantly among treatments ($P < 0.05$). The control group (T0) achieved the lowest FCR (3.35), followed by T1 (3.89), while T2 and T3 both recorded higher values (4.47). These results indicate that higher dietary protein levels did not necessarily improve feed efficiency; in fact, excess protein may have reduced efficiency. This is consistent with

Table 2. Average feed conversion ratio (FCR) of indigenous chickens during 10 weeks of rearing

Age (weeks)	Treatments			
	T0	T1	T2	T3
1	1.90±0.11 ^b	2.79±0.17 ^a	2.70±0.16 ^a	2.80±0.18 ^a
2	1.62±0.10 ^b	2.42±0.14 ^a	2.51±0.15 ^a	2.50±0.15 ^a
3	1.97±0.12 ^c	2.54±0.16 ^b	3.29±0.20 ^a	2.82±0.18 ^b
4	2.48±0.15 ^{ns}	2.64±0.16 ^{ns}	3.23±0.20 ^{ns}	3.19±0.20 ^{ns}
5	2.94±0.18 ^b	4.53±0.28 ^a	4.76±0.30 ^a	4.76±0.31 ^a
6	2.82±0.17 ^b	4.26±0.26 ^{ab}	4.92±0.32 ^a	5.30±0.34 ^a
7	2.74±0.17 ^b	5.00±0.32 ^a	6.88±0.44 ^a	6.88±0.45 ^a
8	4.60±0.28 ^{ns}	6.41±0.40 ^{ns}	5.24±0.33 ^{ns}	5.24±0.34 ^{ns}
9	5.19±0.32 ^{ns}	3.40±0.21 ^{ns}	3.50±0.22 ^{ns}	4.25±0.26 ^{ns}
10	6.83±0.43 ^{ns}	4.47±0.29 ^{ns}	6.37±0.41 ^{ns}	6.37±0.42 ^{ns}
Total	3.35±0.21 ^b	3.89±0.25 ^{ab}	4.47±0.28 ^a	4.47±0.29 ^a

Note: Different superscripts in the same row indicate significant differences ($P < 0.05$). ns= not significant

Kingori et al. (2003), who noted that indigenous chickens require moderate protein levels, and excessive protein can reduce energy utilization efficiency while increasing feed costs.

Compared with commercial broilers raised under optimized intensive systems, the indigenous chickens in this study exhibited higher FCR values (3.35–4.47), indicating lower feed utilization efficiency typical of slow-growing genetic lines. Perween et al. (2016) reported that Vanaraja chickens achieved FCR values of 2.0–2.3 with optimized energy–protein diets, while Kompudu et al. (2020) reported average FCR values of 1.64 in commercial broilers at market age (35 days). These comparisons highlight the inherent differences between slow-growing indigenous chickens and fast-growing broilers. Although indigenous chickens are less efficient in feed utilization, they are still valued for their meat quality, disease resistance, and economic importance in traditional markets. Therefore, diets with moderate protein levels (T0–T1) may be considered optimal, balancing feed efficiency with production costs.

The differences in feed conversion ratio among treatments can be further explained by total feed intake and body weight gain reported previously by Rizkuna et al. (2025) in that study, total feed intake ranged from 2,463.49 to 2,958.04 g/bird and was not significantly affected by dietary protein level, whereas total body weight gain differed significantly among treatments. Chickens fed the T0 diet achieved the highest body weight gain (819.53

g/bird), compared with 627.56–565.23 g/bird in the other treatments. Therefore, the lower FCR observed at T0 in the present study was primarily driven by superior growth performance rather than increased feed consumption, confirming that feed efficiency in indigenous chickens is mainly influenced by weight gain.

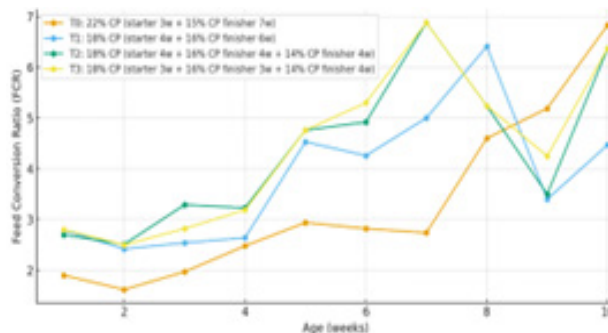


Figure 1. Weekly Feed Conversion Ratio of Indigenous Chickens During a 10-Week Trial

Feed Efficiency (FE)

Feed efficiency is a parameter used to evaluate the extent to which consumed feed is converted into body weight gain. A higher FE value reflects better utilization of feed for growth, whereas a lower FE value indicates inefficiency in nutrient utilization. FE is closely related to the feed conversion ratio (FCR), as it represents the inverse of FCR. Accordingly, a lower FCR corresponds to higher feed efficiency (Lestari et al., 2022). The superior feed efficiency observed in T0 may also be explained by its more favorable protein–energy ratio. Although

Table 3. Average feed efficiency (FE) of indigenous chickens during 10 weeks of rearing

Age (weeks)	Treatments (%)			
	T0	T1	T2	T3
1	52.63±3.1 ^b	35.84±2.2 ^a	37.04±2.3 ^a	35.71±2.1 ^a
2	61.73±3.7 ^b	41.32±2.5 ^a	39.84±2.4 ^a	40.00±2.6 ^a
3	50.76±3.2 ^c	39.37±2.5 ^b	30.40±1.9 ^a	35.46±2.3 ^b
4	40.32±2.4 ^{ns}	37.88±2.3 ^{ns}	30.96±1.9 ^{ns}	31.35±2.0 ^{ns}
5	34.01±2.0 ^b	22.08±1.4 ^a	21.01±1.3 ^a	21.01±1.2 ^a
6	35.46±2.1 ^b	23.47±1.5 ^{ab}	20.33±1.2 ^a	18.87±1.1 ^a
7	36.50±2.3 ^b	20.00±1.3 ^a	14.53±0.9 ^a	14.53±1.0 ^a
8	21.74±1.3 ^{ns}	15.60±0.9 ^{ns}	19.08±1.1 ^{ns}	19.08±1.2 ^{ns}
9	19.27±1.2 ^{ns}	29.41±1.7 ^{ns}	28.57±1.7 ^{ns}	23.53±1.4 ^{ns}
10	14.64±0.9 ^{ns}	22.37±1.3 ^{ns}	15.70±1.0 ^{ns}	15.70±1.0 ^{ns}
Total	29.85±1.8 ^b	25.71±1.6 ^{ab}	22.37±1.4 ^a	22.37±1.3 ^a

Note: Different superscripts in the same row indicate significant differences (P<0.05). ns=not significant

dietary energy level was not experimentally varied, the calculated CP:ME ratios indicate that T0 provided a more synchronized nutrient balance during the starter phase than the other treatments. An optimal energy-protein balance improves nutrient partitioning toward lean tissue deposition, whereas imbalanced ratios may increase nitrogen excretion or inefficient energy utilization, ultimately reducing feed efficiency.

As shown in Table 3, FE values of indigenous chickens over the 10-week experimental period differed significantly among treatments ($P < 0.05$). Treatment T0 achieved the highest average FE (37.20%), followed by T1 (28.73%), while T2 and T3 recorded the lowest values (25.35% and 25.12%, respectively). These results are consistent with the FCR findings, confirming that T0 facilitated superior conversion of feed into body weight. Similarly, Olawumi et al. (2017) reported that increasing dietary protein in broilers does not always improve performance or nutrient efficiency; protein supplied above the optimal requirement may even reduce feed utilization efficiency.

In support of this, studies in Bangladesh demonstrated that energy-protein balance played a more decisive role in feed efficiency than simply increasing dietary protein levels (Khatun et al., 2021). Comparable results were also reported in African indigenous poultry, where simple but balanced diets yielded better FE than high-protein diets lacking energy balance (Waithaka et al., 2022).

During the starter phase (weeks 1–3), FE in T0 exceeded 50%, meaning more than half of the feed consumed was successfully converted into weight gain. In contrast, treatments with higher protein levels (T1–T3) exhibited lower FE, dropping to around 30% by week 3. This suggests that excess protein did not enhance efficiency but instead reduced it, likely due to increased deamination and nitrogen excretion (Fatmarischa et al., 2025; Kingori et al., 2003). Similar outcomes were observed in hybrid chickens in India, where diets containing over 20% protein did not improve FE, as surplus protein was inefficiently metabolized for energy (Perween et al., 2016). Zardadzaei et al. (2023) further emphasized that the energy-protein ratio is a more critical determinant of nutrient

conversion efficiency than protein alone.

In the grower phase (weeks 4–7), FE declined across all treatments. T0 maintained relatively higher values (34.01–36.50%), while T2 and T3 dropped sharply to 14–21%. This decline was associated with the reduced growth rate of indigenous chickens after six weeks, whereby a greater proportion of dietary energy was diverted to body maintenance rather than growth. These findings are in line with Susan et al. (2023), who noted that feed efficiency in indigenous chickens is strongly influenced by intrinsic growth potential and dietary supplementation strategies. Miyumo et al. (2023) also highlighted the genetic limitations of indigenous chickens, including declining nutrient efficiency with advancing age. Likewise, Tenza et al. (2024) stressed that the inherently slow growth of local chickens is a major constraint on feed efficiency compared with fast-growing broilers.

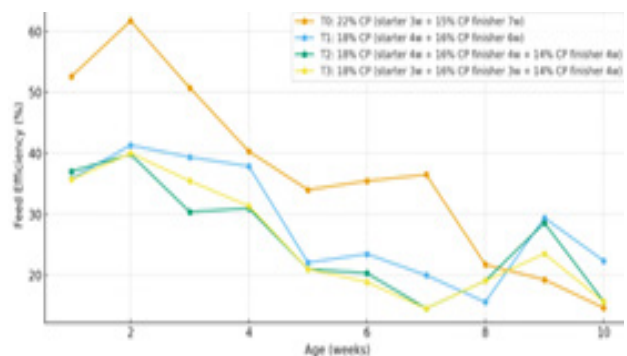


Figure 2. Weekly Feed Efficiency of Indigenous Chickens During a 10-Week Trial

During the finisher phase (weeks 8–10), FE further declined in all treatments, ranging only from 14–22%. This observation is consistent with Agustini et al. (2021) who reported that indigenous chickens are characteristically slow-growing, with reduced feed efficiency in later stages. Similar patterns were noted in Ethiopian local chickens, where nutrient efficiency decreased with age (Aleme, 2022). Nevertheless, indigenous chickens remain advantageous in terms of adaptability, meat quality, and consumer preference compared with commercial broilers, as traditional poultry often exhibits distinct sensory attributes, firmer texture, and preference by some consumer segments that differentiate it from broiler meat (Idamokoro

et al., 2022). Waithaka et al. (2022) also emphasized that although indigenous poultry generally exhibit lower FE, their relatively low rearing costs and stable consumer demand render them economically viable.

The feed efficiency pattern observed in this study is consistent with the previously reported growth performance of the same experimental animals (Rizkuna et al., 2025). Although total feed intake among treatments was relatively similar (2.46–2.96 kg/bird), body weight gain differed markedly, resulting in higher feed efficiency in T0 (37.20%) compared with T1–T3 (25.12–28.73%). This indicates that improved feed efficiency was associated with enhanced nutrient utilization for growth rather than higher feed intake, highlighting the importance of adequate protein supply during the starter phase.

Performance Index (PI)

The performance index (PI) is a comprehensive parameter integrating final body weight, feed conversion ratio (FCR), livability, and rearing duration to evaluate overall production efficiency. A higher PI indicates better growth performance, feed utilization efficiency, survivability, and production sustainability. This integrative concept is analogous to the European Production Efficiency Factor (EPEF), which has been widely applied in poultry production systems to assess overall flock performance by combining body weight, feed efficiency, mortality, and age at marketing into a single indicator (Adaszyńska-Skwirzyńska et al., 2025). The use of composite performance indices is recommended because individual parameters, such as FCR or body weight, alone may not adequately represent biological efficiency at the flock level (González Ariza et al., 2021).

In the present study, PI was calculated using a modified EPEF formula and analyzed descriptively, as it is an integrative indicator derived from multiple biological and managerial components that influence production efficiency. During the 10-week rearing period, total mortality was 8 birds out of 168 (4.76%), resulting in an overall livability rate of 95.24%. Mortality was not associated with any specific dietary treatment and was considered within the acceptable range for indigenous chickens

reared under tropical conditions. Since livability was similar across treatments, differences in PI values were primarily attributed to variations in final body weight and FCR.

Table 4. Average performance index (PI) of indigenous chickens

Treatments	Performance index (PI)
T0	34.44±2.16
T1	22.95±1.48
T2	18.30±1.17
T3	18.08±1.18

As presented in Table 4, T0 achieved the highest PI (34.44), followed by T1 (22.95), while T2 and T3 showed the lowest values (18.30 and 18.08, respectively). T0 achieved the highest PI compared with other treatments. This indicates that the diet formulation in T0 supported overall production performance, encompassing not only weight gain and feed efficiency but also growth quality and adaptability. The higher performance index observed in T0 is supported by its superior total body weight gain (819.53 g/bird) achieved without increasing total feed intake, as reported by (Rizkuna et al., 2025). This combination contributed to improved feed conversion, feed efficiency, and overall production performance. The higher performance index in T0 further supports the importance of dietary energy–protein balance. Although metabolizable energy was not directly manipulated as a treatment factor, differences in the CP: ME ratio among diets indicate that nutrient synchronization influenced overall production efficiency. Balanced protein and energy supply during early growth appears critical in maximizing integrative performance indicators such as PI. These findings are consistent with González Ariza et al. (2021), who emphasized that overall performance, including production indices, is shaped by nutritional balance, breed characteristics, and genetic variability. Similarly, Kpomasse et al. (2023) highlighted that production performance in tropical indigenous chickens depends strongly on the compatibility between diet, genotype, and management conditions. Furthermore, Adaszyńska-Skwirzyńska et al. (2025) underscored the utility of indices such as the European Production

Efficiency Factor (EPEF) in evaluating the balance between final body weight, feed intake, and overall efficiency in poultry systems.

T1, with a PI of 22.95, still reflected relatively good performance, albeit lower than T0. This difference suggests that reducing crude protein during the starter phase (18% CP) hindered early growth, thereby affecting final PI. Waithaka et al. (2022) emphasized that the starter phase is critical for indigenous chickens, as nutritional quality at this stage determines tissue development and subsequent metabolic efficiency. Khatun et al. (2025) also confirmed that protein–energy combinations during the starter phase directly influence the PI of hilly chickens in Bangladesh. Zardadzaei et al. (2023) further supported the importance of nutrient balance in shaping the final performance index of local poultry.

The lowest PI values were observed in T2 (18.30) and T3 (18.08). These outcomes suggest that diets with high initial protein levels followed by sharp reductions during the finisher phase did not enhance PI, but instead reduced production efficiency. Similar findings were reported by Ochieng et al. (2011), who noted that excess dietary protein does not necessarily increase PI due to the limited capacity of indigenous chickens to utilize surplus protein. Aleme (2022) also observed that Ethiopian indigenous chickens with slow growth trajectories exhibited declining PI with age, particularly when diets were imbalanced.

Although the PI values obtained in this study (18.08–34.44) are lower than those reported for genetically improved chickens, they remain biologically consistent with the expected performance of slow-growing indigenous chickens reared under tropical conditions. Despite lower integrative efficiency, indigenous chickens maintain advantages in adaptability, meat quality, and consumer preference, which sustain their economic value in traditional and niche markets (Sow et al., 2010). For comparison, Syadik (2017) reported an average performance index of 77.9 in Kampung Super chickens reared for 10 weeks under experimental feeding conditions. The markedly higher PI observed in Kampung Super chickens compared with the present study is primarily attributable to genetic improvement,

as Kampung Super represents a crossbred line selected for faster growth and better feed efficiency. In contrast, the indigenous chickens used in the present study represent unimproved local genetic resources characterized by slower growth rates and inherently higher FCR values. Therefore, direct numerical comparison should be interpreted cautiously, as genotype differences substantially influence composite performance indices.

CONCLUSIONS

This study demonstrated that dietary protein levels significantly influenced the growth performance of indigenous chickens. The T0 treatment (22% protein in the starter phase and 15% in the finisher phase) produced the best feed conversion ratio (FCR, 3.35), the highest feed efficiency (FE, 37.20%), and the greatest performance index (PI, 34.44). These findings indicate that diets with moderate protein levels are more effective in supporting growth and nutrient utilization. In contrast, treatments with high protein in the starter phase followed by sharp reductions in the finisher phase (T2 and T3) did not improve FCR or PI and instead decreased overall production efficiency, likely due to surplus protein utilization costs and metabolic burden.

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