A study of different dietary energy and protein levels in European quail (Coturnix coturnix) during the grower phase and their effect on productive performance

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Abstract.

This study was conducted in one of the research halls of the Department of Animal Production, College of Agriculture, University of Tikrit, from 19 January to 2 March 2025, to evaluate the effects of different dietary energy and crude protein levels on the productive performance of European quail (Coturnix coturnix) during the rearing period from 21 days of age, equivalent to 3 weeks, up to 8 weeks of age. A total of 208 unsexed chicks were randomly distributed into four dietary treatments, with four replicates per treatment and 13 chicks per replicate. The experimental diets were as follows: T1, 2900 kcal metabolizable energy/kg diet with 24% crude protein; T2, 2800 kcal/kg with 22% crude protein; T3, 2900 kcal/kg with 22% crude protein; and T4, 2800 kcal/kg with 24% crude protein.

The results showed significant differences among treatments in total energy and protein intake during the overall experimental period. The highest total protein intake was recorded in T4 (349.89 g), followed by T1 (331.50 g), whereas T2 and T3 recorded the lowest values and did not differ significantly from each other. However, overall energy conversion efficiency did not differ significantly among treatments, indicating that increased energy intake was not associated with improved energy utilization. In contrast, overall protein conversion efficiency differed significantly among treatments, with T2 and T3 showing better efficiency than T1 and T4. This suggests that diets containing 22% crude protein allowed more efficient protein utilization than diets containing 24% crude protein.
It can be concluded that feeding European quail diets containing 22% crude protein with 2800–2900 kcal/kg metabolizable energy may improve protein conversion efficiency during the rearing period without reducing overall performance.
Key words: **European quail, Metabolizable energy, Energy conversion ratio, Protein conversion ratio**

Introduction

Introduction

Balanced dietary protein and metabolizable energy supply is an essential requirement for efficient poultry production, because these nutrients directly affect growth, feed intake, nutrient utilization, and productive

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performance [1]. Metabolizable energy is the main source of energy used by birds after feed consumption and accounts for approximately 50–80% of poultry diet composition; therefore, determining its optimal level is important for improving performance and reducing unnecessary feeding costs [2]. Dietary energy level is also one of the main nutritional factors regulating voluntary feed intake, as birds tend to adjust their feed consumption according to dietary energy density [3]. In addition, feed represents the major proportion of total poultry production costs, while crude protein and energy are among the most expensive and influential dietary components [4]. Therefore, recent nutritional strategies have focused on optimizing protein and energy levels while maintaining the proper balance between them to sustain productive performance, reduce diet cost, and minimize nutrient losses [5,6].

European quail (Coturnix coturnix) is a promising meat-type quail characterized by rapid growth, good adaptability to different rearing systems, and suitability for short production cycles. However, compared with Japanese quail, information on its nutritional requirements during the grower phase remains limited, particularly under Iraqi production conditions.

Several studies have shown that dietary metabolizable energy and crude protein levels, as well as the balance between them, influence feed intake, protein intake, feed conversion efficiency, nutrient digestibility, and protein conversion efficiency in quail [7–13]. Overall, these studies indicate that productive responses are not determined by increasing energy or protein levels separately, but rather by achieving an appropriate dietary balance that supports growth, improves nutrient utilization, and avoids unnecessary increases in feeding cost.

Despite the importance of this relationship, limited local data are available regarding the optimal combination of metabolizable energy and crude protein for European quail during the grower period. Therefore, this study aimed to evaluate the effects of different dietary energy and crude protein levels on productive performance, nutrient intake, feed conversion efficiency, energy conversion efficiency, and protein conversion efficiency of European quail from 21 days of age to 8 weeks of age.

Materials and Methods

Experimental site and duration

This study was conducted in one of the animal field halls of the Department of Animal Production, College of Agriculture, University of Tikrit, Iraq, during the period from 19 January 2025 to 2 March 2025. The experiment aimed to determine the appropriate dietary levels of energy and protein and their effects on the productive performance of

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European quail during the grower period up to 8 weeks of age. Birds and management

A total of 210 European quail chicks, 13 days of age, were obtained from a private farm in Baghdad city. The chicks were initially placed in a room measuring 2 × 3 m, where the floor was covered with wood shavings for group brooding. Appropriate environmental conditions, including temperature, lighting and ventilation, were provided, and a starter diet was offered.

At 21 days of age, all birds were individually weighed and then randomly allocated to the experimental treatments in a research hall. The birds were housed in square wire cages measuring 1 m in length, 1 m in width and 50 cm in height.

Experimental design and diets

The experiment included four dietary treatments. Each treatment consisted of 4 replicates, with 13 unsexed quail per replicate. Four experimental grower diets were formulated as follows:

T1: 2900 kcal/kg metabolizable energy (ME) and 24% crude protein (CP)

T2: 2800 kcal/kg ME and 22% CP

T3: 2900 kcal/kg ME and 22% CP

T4: 2800 kcal/kg ME and 24% CP

The birds were reared from 3 to 8 weeks of age (21–56 days) on these diets. The grower diets were formulated according to the experimental treatments, as shown in Table (1). Measured traits During

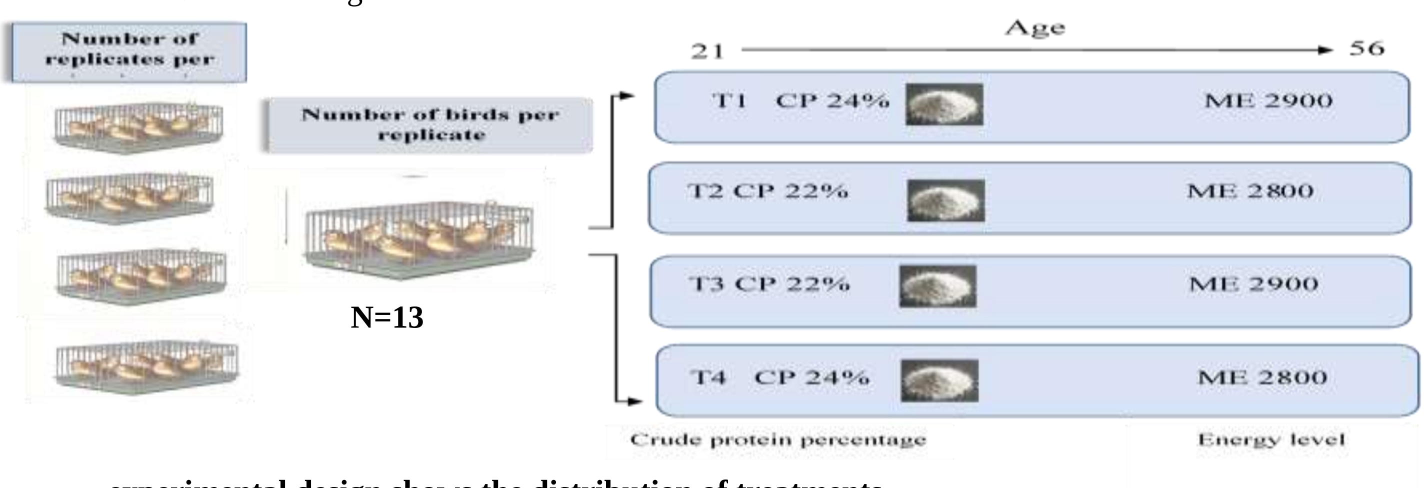
the experimental period, the following productive traits were recorded:

Energy intake, Energy conversion efficiency (energy conversion ratio) , Protein intake, Protein conversion efficiency (protein conversion ratio)

These traits were calculated on a weekly basis and for the overall experimental period according to the dietary treatments.

Statistical analysis

The data were statistically analyzed using a Completely Randomized Design (CRD) to study the effect of dietary treatments on the measured traits. Significant differences among treatment means were separated using Duncan's Multiple Range Test [14]. The [15] statistical software package was used for all statistical analyses.



experimental design shows the distribution of treatments

Table 1. Diets Used

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The chemical composition values of the feed ingredients used in the formulation of the diets

Feed Ingredients	Diet 1	Diet 2	Diet 3	Diet 4
Yellow Corn	54.2	53.5442	57.85	50.5
Wheat Bran	3.7	11.0133	5.6	8.5
Soybean Meal (48%)	37.65	31.1925	32.3	36.75
*Premix	2.5	2.5	2.5	2.5
Sunflower Oil	0.5	0.3	0.3	0.3
Limestone	1	1	1	1
Dicalcium Phosphate	0.2	0.2	0.2	0.2
Salt	0.25	0.25	0.25	0.25
Total	100	100	100	100
****Calculated Chemical Composition**				
Metabolizable Energy (kcal/kg)	2902	2800	2900	2800
Crude Protein (%)	24.00	22	22.04	24.01
Crude Fiber (%)	4.24	4.57	4.15	4.62
Lysine (%)	1.43	1.30	1.30	1.42
Methionine (%)	0.71	0.69	0.69	0.71
Methionine + Cystine (%)	0.697	0.65	0.65	0.69
Calcium (%)	0.69	0.68	0.68	0.69
Phosphorus (%)	0.42	0.49	0.43	0.47

were calculated according to [16]

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Results and Discussion:

Rate of energy consumption: Table (2) shows that energy intake was significantly affected by dietary treatments during several experimental weeks and over the total experimental period (P≤0.05). In the fourth week, T3 recorded the highest energy intake compared with the other treatments, whereas in the fifth week, T4 showed the highest value, followed by T1 and T3, which were significantly higher than T2. During the sixth, seventh, and eighth weeks, T1 and T4 generally recorded higher energy intake than T2 and T3. A similar trend was observed for total energy intake, where T4 and T1 achieved the highest values compared with the other treatments (P≤0.05). This response may be related to the interaction between dietary energy density and feed intake regulation. Birds fed the T4 diet, which contained lower metabolizable energy and higher crude protein, may have increased feed consumption to compensate for the lower energy concentration of the diet, resulting in greater total energy intake. This agrees with the general nutritional principle that birds tend to adjust feed intake according to dietary energy density [3]. In addition, the higher protein level in T4 may have contributed to greater nutrient intake, especially when accompanied by increased feed consumption. Similarly, T1, which contained both higher metabolizable energy and higher crude protein, maintained high energy intake because each unit of feed supplied greater energy and protein density. Therefore, the higher total energy intake observed in T1 and T4 appears to be associated with both dietary composition and the birds' physiological adjustment of feed intake

.**Table (2): Effect of different dietary energy and protein levels on Rate of energy consumption of quail (kcal/bird/week) (mean ± standard error).**

Treatments	Week 4 -3	Week 4 -5	Week 5 -6	Week 6 -7	Week 7 -8	Total energy intake
T1	546 ± 6.95 b	728.71±14.87 ab	910.89±18.58 a	910.89±18.58 ab	910.90±18.58 a	4007.67±72.17 a
T2	542.5±11.76 b	689.23 ±0.01 b	850.66±10.87 b	861.53 ± 0.01 b	861.54±0.001 b	3805.47±22.40 b
T3	582.0 ± 8.93 a	728.71±14.87 ab	886.0±6.30 ab	910.90 ± 1.41 ab	886.73 ± 5.57 ab	3994.58±13.20 ab
T4	528.7 ± 9.10 b	786.61±44.55 a	900.96±36.86 ab	955.96 ± 3.15 a	910.05±17.34 a	4082.08±97.44 a
Level of significace	*	*	*	*	*	*

Different letters within the same column denote statistically significant differences among

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treatments at the ($p<0.05$) level T1: 2900 kcal/kg + 24% CP **.**T2: 2800 kcal/kg + 22% CP **.** T3:2900 kcal/kg + 22% CP**.** T4: 2800 kcal/kg + 24% CP.

Energy conversion efficiency:

Table (3) shows that there were no significant differences in weekly or total energy conversion efficiency. The values of energy conversion ratio indicate that the birds required lower amounts of energy to produce 1 g of body weight gain in the fourth week (6.46–7.49 kcal/g), which reflects the marked increase in growth rate and protein deposition during the early growth phase. As age advanced, the energy conversion ratio gradually increased to much higher values in the seventh and eighth weeks, exceeding 37 kcal/g in all treatments, indicating a slowdown in growth and a greater proportion of energy being directed to covering maintenance requirements and fat deposition rather than muscle protein accretion.

The results show that treatment T3 (22% crude protein and 2900 kcal ME/kg diet) achieved the lowest numerical value of energy conversion ratio (16.54 kcal/g), suggesting a better balance between energy and protein levels and a more efficient utilization of energy compared with treatment T4 (24% crude protein and 2800 kcal ME/kg diet).

Table (3): Effect of different dietary energy and protein levels on energy conversion efficiency of quail (mean ± standard error).

Treatments	Week4 -3	Week 4 -5	Week 5 -6	Week 6 -7	Week 7 -8	Total energy conversion efficiency
T1	6.46±0.08	15.03±0.88	19.73±1.49	37.79± 3.88	37.86 ± 3.88	17.07± 0.48
T2	7.12±0.19	12.87±0.56	17.90±1.82	55.70±27.06	65.80±21.27	16.76 ±0.20
T3	6.99±0.30	12.82±0.28	19.55±1.81	42.29 ±7.67	46.49 ± 6.77	16.54 ±0.15
T4	7.49±0.62	16.22±2.19	22.59±0.84	61.87±23.75	47.31 ± 7.45	17.26 ±0.19
Level of significace	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**

Different letters within the same column denote statistically significant differences among treatments at the ($p<0.05$) level T1: 2900 kcal/kg + 24% CP **.**T2: 2800 kcal/kg + 22% CP **.**T3: 2900 kcal/kg + 22% CP**.** T4: 2800 kcal/kg + 24% CP

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Protein intake

Table (4) shows that there were significant differences in weekly protein intake. In the fourth week, the first (T1) and fourth (T4) treatments were superior to the second (T2) and third (T3) treatments. In the fifth week, T4 recorded higher protein intake than all other treatments. In the sixth week, T1 and T4 surpassed T2 and T3. Likewise, in the seventh week, T4 was superior to all treatments, while T1 was higher than T2 and T3. In the eighth week, T1 and T4 again exceeded T2 and T3, recording values of 75.38, 67.69, 67.25 and 78.00 g protein/bird/week, respectively.

Total protein intake showed a significant variation among treatments, where T4 (24% crude protein and 2800 kcal ME/kg diet) recorded the highest cumulative protein intake (349.89 g), followed by T1 (24% crude protein and 2900 kcal ME/kg diet) with an intermediate value of 331.50 g. In contrast, T2 and T3 (22% crude protein at 2800 and 2900 kcal ME/kg diet, respectively) had the lowest protein intake and did not differ significantly from each other. This pattern is related to the direct relationship between dietary crude protein percentage and energy level, since protein intake is the product of feed intake and crude protein percentage. Because T1 and T4 contained a higher crude protein level (24%), they resulted in greater protein intake compared with T2 and T3 (22% crude protein).

Table (4): Effect of different dietary energy and protein levels on protein intake of quail (g protein/bird/week) (mean ± standard error)

Treatments	**Week 4 -3**	**Week 4 -5**	**Week 5 -6**	**Week 6 -7**	**Week 7 -8**	**Total protein intake**
T1	45.20±1.23 a	60.30±1.23 b	75.38±1.53 a	75.38±1.53 b	75.38 ± 1.53 a	331.5±5.97 b
T2	42.62±0.01 b	54.15±0.01 b	66.83±0.85 b	67.69±0.01 c	67.69±0.0013 b	299±1.76 c
T3	44.16±1.12 ab	55.28±1.12 b	67.21±0.47 b	69.10±1.41 c	67.26 ± 0.42 b	303±1 c
T4	45.32±3.80 a	67.42±3.80 a	77.20±2.45 a	81.94 ±3.15 a	78± 1.48 a	349.89±8.35 a
Level of significace	*	*	*	*	*	*

Different letters within the same column denote statistically significant differences among treatments at the ($p<0.05$) level T1: 2900 kcal/kg + 24% CP .T2: 2800 kcal/kg + 22% CP .T3: 2900 kcal/kg + 22% CP**.** T4: 2800 kcal/kg + 24% CP.

Protein conversion efficiency:

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Table (5) shows that protein conversion efficiency was significantly affected by dietary treatments during the fourth and fifth weeks of age and during the overall experimental period ($P \leq 0.05$). In the fourth week, T2 and T4 recorded better protein conversion efficiency than T1 and T3, whereas in the fifth week, T2 and T3 were superior to T1 and T4. However, no significant differences were observed among treatments during the seventh and eighth weeks, indicating a convergence in protein utilization efficiency at the later stage of growth.

The superiority of T2 and T3 in overall protein conversion efficiency may be related to the more suitable balance between crude protein and metabolizable energy in these diets. Both treatments contained 22% crude protein, with either 2800 or 2900 kcal ME/kg diet, which may have provided adequate amino acids for growth without supplying excessive protein. In contrast, the diets containing 24% crude protein, particularly T1 and T4, may have increased protein intake beyond the birds' actual requirement, reducing the apparent efficiency of protein conversion. This interpretation agrees with recent poultry nutrition concepts indicating that productive performance is not determined by crude protein level alone, but by the balance between energy supply and digestible amino acid availability. A 2025 quail nutrition study confirmed that metabolizable energy and crude protein are key dietary factors for quail growth, and that quail growth responses are highly sensitive to dietary crude protein level and its interaction with energy supply [17].

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Table (5): Effect of different dietary energy and protein levels on protein conversion efficiency of quail during the experimental weeks (mean ± standard error).

Treatments	Week 4 -3	Week 4 -5	Week 5 -6	Week 6 -7	Week 7 -8	Total protein conversion ratio
T1	0.53±0.007 b	0.80 ±0.046 b	0.62 ± 0.046 ab	0.32±0.029	0.35±0.064	0.70 ±0.021 b
T2	0.55±0.015 ab	0.99 ±0.043 a	0.73 ± 0.080 a	0.41±0.150	0.29±0.113	0.75 ±0.009 a
T3	0.53±0.023 b	1.02 ±0.023 a	0.68 ± 0.057 ab	0.33±0.003	0.30±0.040	0.79±0.007 a
T4	0.64±0.053 a	0.75 ±0.093 b	0.51 ± 0.019 b	0.29±0.050	0.26±0.049	0.67 ±0.007 b
Level of significace	*	*	*	N.S	N.S	*

Different letters within the same column denote statistically significant differences among treatments at the ($p<0.05$) level T1: 2900 kcal/kg + 24% CP .T2: 2800 kcal/kg + 22% CP .T3: 2900 kcal/kg + 22% CP. T4: 2800 kcal/kg + 24% CP.

Conclusions

No significant differences were recorded in energy conversion efficiency (weekly or overall) among the dietary energy and protein levels used, indicating that the range of 2800–2900 kcal/kg and 22–24% crude protein does not clearly alter the efficiency of energy utilization. Increasing the crude protein level in the diet to 24% was associated with a significant increase in total protein intake, whereas the 22% protein treatments showed lower protein intake with close values among them.

The 22% protein treatments (T2 and T3) exhibited better overall protein conversion efficiency compared with the 24% protein diets, indicating that the crude protein level can be reduced to 22% while maintaining a high efficiency of protein utilization. The results suggest that the choice of protein level depends on the production objective: the higher level (24%) increases the amount of protein consumed, whereas the lower level (22%) is more efficient and may be economically preferable when productive performance is simila

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