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Research Article

Optimizing Growth Performance in New Zealand White Rabbits: The Effects of Varying Energy and Protein Levels

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Authors' Contributions
MBA did the conceptualization, data curation, formal analysis. MRA did the conceptualization, validation and supervision. KAS did the writing original draft, visualization and review. AAJ Conducted data analysis and interpretation of result. All authors read and approved the final manuscript.

Keywords
New Zealand white rabbit, Energy supplementation, Protein levels, Dietary manipulation, Rabbit nutrition, Animal feed efficiency

Abstract | Efficient nutritional strategies are essential for optimizing growth and productivity in small livestock such as rabbits, which are increasingly valued in meat production systems. The purpose of the study was to observe the supplementation of different levels of energy and protein on feed intake and growth performance of New Zealand rabbit. For this, Twenty (20) New Zealand White Rabbits of 2 months of age were used in a 95 days experimental period. The Rabbits were divided into five treatment groups with different concentrate mixtures, *i.e.* diet T_0 = standard concentrate mixture (energy 2600 Kcal/Kg, protein 17%) are used as control, diet T_1= low energy and low protein (energy 2400 Kcal/kg, protein 15%), diet T_2= high energy and low protein (energy 2800 Kcal/Kg, protein 15%), diet T_3= low energy and high protein (energy 2400 Kcal/Kg, protein 19%), diet T_4= high energy and high protein (energy 2800 Kcal/Kg, protein 19%). Green grasses (Napier Pakchong) were supplied ad-libitum. The live weight (gm) at 95 days of experiment was found 818.75, 833, 903, 1001 and 918.25 g in $T_{0,}$ T_1, T_2, T_3, and T_4 group respectively which deffer significantly ($p<0.05$). In group T_3, live weight was highest and it was lowest in T_0 group. The calculated growth velocities were 0.75 in T_0, 0.8 in T_1, 0.86 in T_2, 0.77 in T_3, 0.48 in T_4. In conclusion, low energy and high protein diet (T_3) positively influenced the growth of New Zealand white rabbit. In conclusion, a diet with low energy and high protein (T3) was found to be most effective in promoting growth in New Zealand White rabbits under the conditions of this study. These findings can inform feed formulation strategies aimed at improving rabbit production efficiency.

Novelty Statement | This study provides one of the first comprehensive evaluations of the combined effects of dietary energy and protein levels on the growth performance of New Zealand White rabbits under Bangladesh environmental and management conditions. This research uniquely explores their interactive effects, offering valuable insights into optimal feed formulations for enhanced growth and feed efficiency. The findings demonstrate that a low-energy, high-protein diet significantly improves growth performance, challenging conventional feeding norms and contributing to more cost-effective and sustainable rabbit production practices in developing countries.

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Introduction

Rabbits are considered a valuable micro-livestock (Vietmeyer, 1985; Walia and Kaur, 2023). Globally,

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rabbit farming is increasingly recognized as a viable solution to address protein deficiency, particularly in low-income and resource-limited regions due to their high reproductive rate, efficient feed conversion, and small space requirement (Chikwanha *et al*., 2024; Goswami *et al*., 2025). Commercial rabbit production has gained significant attention and is seen as a promising source of income and employment (Omolade *et al*., 2016). In developing countries, rabbits are particularly valued for their efficiency and cost-effectiveness in providing protein to meet the growing nutritional demands (Jones *et al*., 2024). Rabbits offer numerous advantages for improving nutrition, as they convert roughage into meat efficiently, with the ability to convert up to 20% of the protein they consume into edible meat under optimal management. Their growth rate is comparable to that of broiler chickens, with Soviet Chinchilla rabbits reaching a live weight of 2 kg in 12 weeks (Handa *et al*., 1995).

Rabbits mature sexually at 4-5 months, with a litter size ranging from 2-7 and a gestation period of about 1 month. A female rabbit can reproduce 5-7 times per year (Cheeke, 1986; Hasanat *et al*., 2006). Although rabbit farming is increasingly accepted in Bangladesh, particularly in regions where commercial factors and social aspects support it, challenges such as marketing difficulties in remote areas persist. Proper nutrition is crucial for optimizing rabbit growth, with dietary protein levels having a significant impact on performance, which varies with age (Yassein *et al*., 2011). Dietary manipulation, especially the balance of energy and protein, plays a critical role in maximizing growth performance, yet optimal ratios remain under-researched for specific breeds and climates. Current dietary recommendations suggest a crude protein (CP) level of 17-18% for growth and 15-16% for fattening (De Blas and Wiseman, 2010). Additionally, citric acid levels in diets can influence growth performance, with 1.5% citric acid showing positive effects (Uddin *et al*., 2014).

In Bangladesh, limited studies have explored the combined influence of energy and protein levels on rabbit growth, highlighting the need for targeted nutritional trials to support the growing interest in commercial rabbit production. Despite the availability of literature, research on the combined effects of energy and protein levels on the growth performance of New Zealand White rabbits in Bangladesh remains limited. This study aims to address this gap by examining how different dietary energy and protein levels impact rabbit growth and feed intake.

Materials and Methods

Study area and period

The experiment was conducted at the Department of Animal Science, Bangladesh Agricultural University, Mymensingh from November 2019 to May 2020. The trial lasted for 95 days.

Experimental animals and housing

A total of 20 healthy New Zealand White rabbits, aged approximately 2 months and with similar initial body weights (468g-621g) and either sex, were selected for the study. Rabbits were housed in well-ventilated cages under standard environmental conditions. The housing area maintained a temperature range of 20–28°C, relative humidity between 65–75%, and a 12-hour light/12-hour dark cycle throughout the experimental period.

All rabbits were clinically examined before the start of the study. They were dewormed two weeks prior using albendazole at a standard dosage. No antibiotics, growth promoters, or additional supplements were used during the study period.

Table 1: Layout of the experiment.

Treat-ments	Initial live weight (g) of the rabbits				
	R_1	R_2	R_3	R_4	Average (g)
T_0	479	448	576	370	468.25 ± 42.61
T_1	492	502	442	412	462 ± 21.21
T_2	502	418	505	518	485.75 ± 22.84
T_3	554	659	507	547	566.75 ± 32.44
T_4	680	549	683	574	621.5 ± 35.02

Experimental design and diets

The study followed a Completely Randomized Design (CRD) with five dietary treatments, each comprising four replicates (n= 4) (Table 1). The rabbits were randomly allocated to the following treatment groups:

The experimental diets were as follows:

- T_0= Ad libitum Napier pakchong grass + concentrate mixture containing 2600 kcal ME/kg DM and 17%CP
- T_1= Ad libitum Napier pakchong grass + concentrate mixture containing 2400 kcal ME/kg DM and 15%CP
- T_2= Ad libitum dhal grass + concentrate mixture containing 2800 kcal ME/kg DM and 15%CP
- T_3= Ad libitum Napier pakchong grass + concentrate mixture containing 2400 kcal. ME/kg DM and 19%CP
- T_4= Ad libitum Napier pakchong grass + concentrate mixture containing 2800 kcal ME/kg DM and 19%CP

Preparation of concentrate mixture

Five concentrate mixtures were formulated having five different combinations of energy and protein per kg DM (T0, T1, T2, T3 and T4.) The ingredient composition, nutrient composition and price per kg concentrate mixtures are shown in Table 2. The formulated concentrate mixtures

Table 2: Ingredient composition, nutrient composition of the concentrate mixtures.

Ingredients (kg)	Experimental diets				
	T_0	T_1	T_2	T_3	T_4
Napier grass (Pennisetum purpureum)	Adlibitum	Adlibitum	Adlibitum	Adlibitum	Ad libitum
Maize	0.424	0.295	0.52	0.29	0.516
Rice	0.201	0.2525	0.2025	0.17	0.09
Mustard oil cake	0.1	0.075	0.15	0.17	0.085
Wheat bran	0.094	0.27	0.05	0.2025	0.069
Soyabean meal	0.163	0.09	0.06	0.15	0.2225
DCP	0.01	0.01	0.01	0.01	0.01
Vit-min-pre	0.0025	0.0025	0.0025	0.0025	0.0025
Salt	0.005	0.005	0.005	0.005	0.005
Total	1 kg	1kg	1kg	1kg	1kg
CP (crude protein)	16.92	24.02	2788.725	2404.05	2727.36
** ME(kcal/kgDM)	2655	15	14.145	19.02	18.51
*Ca	0.366	0.413	0.3787	0.4273	0.430
*P	0.33	0.13	0.3536	0.415	0.343
Cost = Tk./kg concenrate mixutre (Fresh basis)	33.21	35.70	31.19	34.44	32.32

**Calculated from the manual of selected Topics in Animal Nutrition by W. Close and K. H. Menke (1976).

were fortified with vitamin mineral premix (*Rhodivit* L) at the inclusion level of 2.5 kg/1000 kg to all mixtures, DCP 10 kg/1000kg, salt 5kg/1000kg was also added with all mixture at inclusion level.

Diets and feeding practice

The experimental rabbits were reared in five different dietary treatments (Table 2). Different type of protein and energy were supplied on the ration. Napier grass supplied on ad-libitum basis to the growing rabbits. Concentrate mixture was supplied at the rate of 50g/day during first 60 days and 60g/d for the rest of the periods. The Locally available Napier grass were collected every morning then washed, chopped, weighed and supplied to the rabbits. The required amount of concentrate mixture and green grass were offered twice daily, half of mixture and green grass in the morning at 8.00 am. And another half in the afternoon at 4.00 pm. Fresh clean drinking water was supplied to rabbits at all time.

Measurement procedures

Feed intake: Rabbits were provided with a measured amount of concentrate mixture in the morning, while Napier Pakchong grass was given ad libitum (10% excess). The grass was divided and supplied in the morning and evening. Refusals were collected, weighed, and recorded the next morning. Daily feed intake was calculated by subtracting the refusals from the supplied diet.

Live weight: Rabbits were weighed individually before the experiment to record initial live weight. Subsequently, they were weighed every five days before morning feeding. Total live weight gain was calculated by subtracting the initial weight from the final weight, and daily weight gain was determined by dividing this by the 95-day experimental period.

Average daily gain

Average daily live weight gain (ADG) was calculated as follows:

$$\frac{\text{(Final live weight - initial live weight)}}{\text{Number of days of the experiment}}$$

Growth velocity

The growth velocity (GV) of rabbits in a period of time 90 days was calculated by following formula:

$$\frac{\text{(Final body weight - initial body weight)}}{\text{Initial boddy weight}}$$

Statistical analysis

Completely randomized design (CRD) was followed in this study. Analysis of variance were done by SPSS computer program. Significant differences among the treatments were identified using least Significant Difference test.

Results and Discussion

Total feed intake

Total feed intake has been shown in Table 3. Different treatments groups had significantly different ($p<0.01$) feed intake level where T_4 group had the highest (4742.50 g)

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Table 3: Total feed intake and different growth parameters for different treatment groups.

Parameters	T_0	T_1	T_2	T_3	T_4	Level of significance
Initial live weight (g)	468.25±42.61bc	462.00±21.21c	485.75±22.85bc	566.75±32.45ab	621.50±35.02a	**
Final live weight (g)	818.75±24.71c	833.00±15.80c	903.00±10.24b	1001.00±12.01a	918.25±25.78b	**
Total live weight gain (g)	350.50±59.69a	371.00±16.77a	417.25±18.25a	434.25±27.19a	296.75±43.68b	NS
Daily live weight gain (g)	3.69±0.081c	3.91±0.091b	4.39±0.061a	4.57±0.069a	3.12±0.058d	**
Growth velocity	0.75±0.023c	0.80±0.025b	0.86±0.00a	0.77±0.018bc	0.48±0.018d	**
Total feed intake	3208.02±66.44d	3482.37±38.92c	3643.32±74.14c	4055.85±41.59b	4742.50±49.57a	**

T_0 = ME: 2600Kcal/Kg, CP: 17%; T_1 = ME: 2400Kcal/Kg, CP: 15%; T_2 = ME: 2800 Kcal/Kg, CP: 15%; T_3 = ME: 2400Kcal/Kg, CP: 19%; T_4 = ME: 2800, CP: 19%. NS, non significant. **, Significant at 1% level of significance; *, Significant at 5% level of significance. [abc], mean values for different treatment groups with different superscripts in a raw differ significantly.

feed intake and T_0 (control) group had lowest feed (3208.02) intake. Again the feed intake level reduced gradually in the T_3, T_2 and T_1 groups. It had been reported that an increase in dietary energy was accompanied by corresponding reduction in feed consumption (Wiseman, 1987). Omoleke *et al.* (2016) conducted an experiment on rabbit fed *Moringa oliefera* and *Daucus* based diets (diet were formulated forages level 25%+18% crude protein) had found significantly ($p<0.05$) higher feed intake in treatment group. Prasad *et al.* (1996) concluded that total feed intake and daily DM intake (g) were higher in low energy (2585 kcal/kg) and medium energy (2778 kcal/kg) regimes and they were lowest in high energy (3043 kcal/kg) regimes.

The Growth performance for instance live weight gain, daily live weight gain and growth velocity (GV) of rabbits fed on different diets containing different combination of energy and protein were note down in this study and result are shown Table 3.

Growth performance

The growth performance of the rabbits, including average live weight, daily live weight gain, total live weight gain, and growth velocity, was influenced by the dietary energy and protein levels.

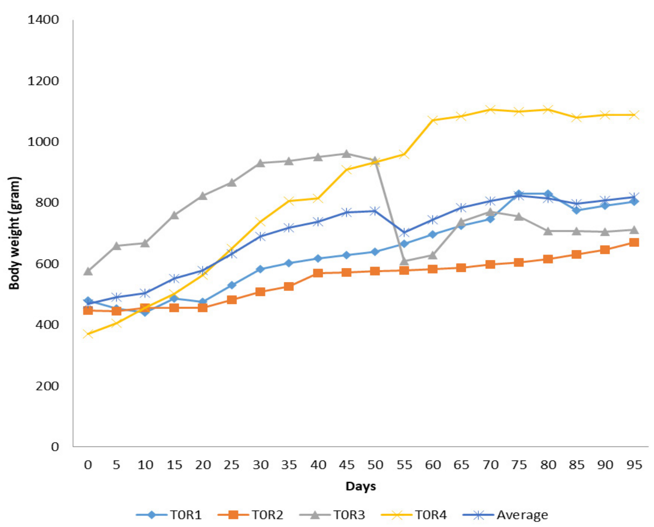

Figure 1: Average live weight of T_0 treatment groups of rabbits.

Figure 1 shows a gradual increase in the average live weight of rabbits receiving the control diet (2600 Kcal/kg ME and 17% CP). While there was steady growth over the experimental period, this group had the lowest final live weight (818.75 g), indicating limited growth efficiency under standard nutritional conditions.

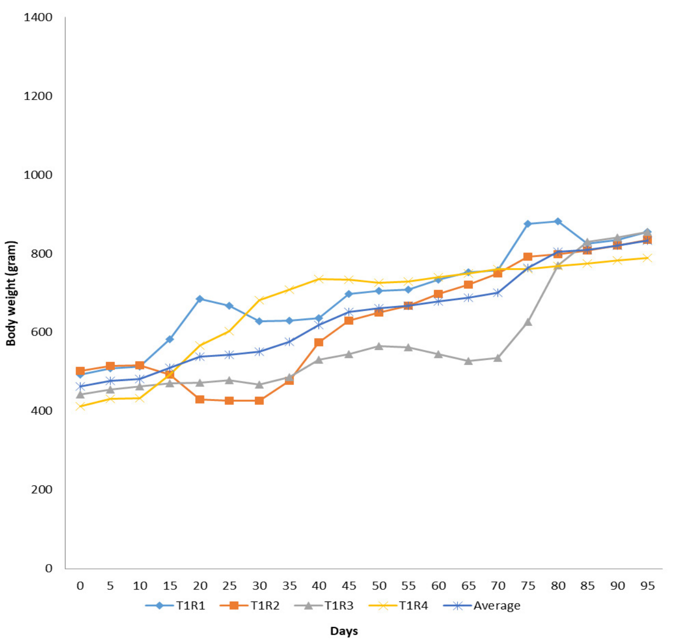

Figure 2: Average live weight of T_1 treatment groups of rabbits.

Rabbits fed with a low-energy, low-protein diet (2400 Kcal/kg ME and 15% CP) showed modest growth improvement over the control. The final average live weight reached 833 g, suggesting that although energy and protein were lower than standard, the diet still supported marginally better growth than the control.

This group, which received a high-energy, low-protein diet (2800 Kcal/kg ME and 15% CP), showed improved growth performance, with a final average live weight of 903 g. The Figure 3 reflects a steady and more pronounced growth trend compared to T0 and T1, indicating that increased energy positively influenced growth, despite limited protein content.

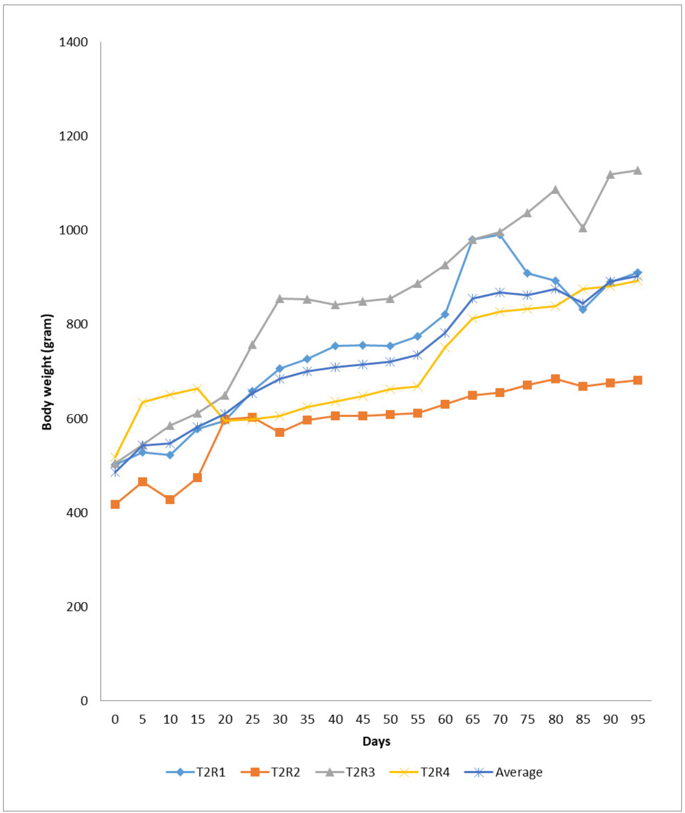

Figure 3: Average live weight of T_2 treatment groups of rabbits.

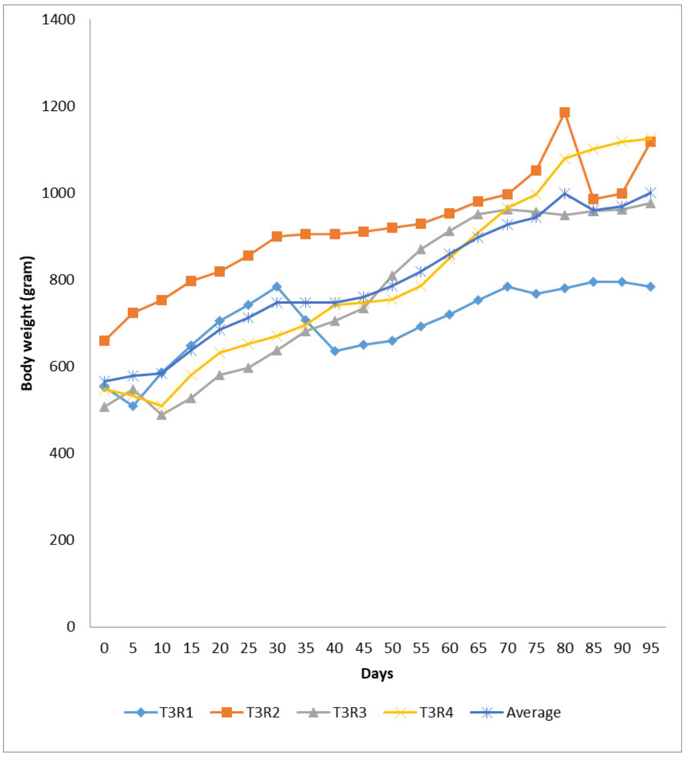

Figure 4: Average live weight of T_3 treatment groups of rabbits.

The T3 group (low-energy, high-protein: 2400 Kcal/kg ME and 19% CP) demonstrated the highest growth rate among all groups. The final live weight reached 1001 g, as clearly depicted in the Figure 4. This suggests that higher protein content in the diet played a crucial role in enhancing growth, even at a lower energy level.

Rabbits fed a high-energy, high-protein diet (2800 Kcal/kg ME and 19% CP) achieved a final average live weight of 918.25 g. Though higher than most other groups, the growth rate was lower than T3, possibly due to metabolic imbalances or inefficiencies when both energy and protein levels are elevated (Figure 5).

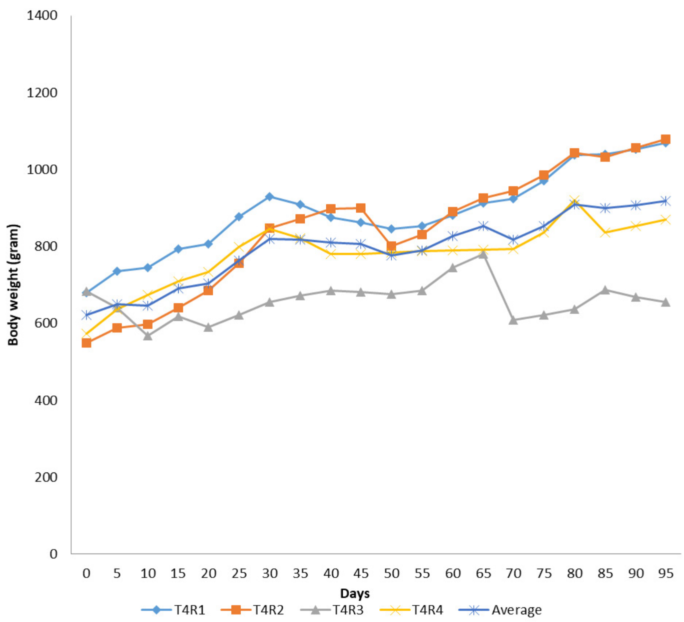

Figure 5: Average live weight of T_4 treatment groups of rabbits.

The relationship between final live weight and energy level had been shown in Figure 6 where the difference was significant. That indicated that with the increase of dietary energy level, final live weight of rabbit increased significantly. Daily live weight gains for T_0 (control), T_1, T_2, T_3 and T_4 diet treatments groups are 3.69 g/d, 3.91 g/d, 4.39 g/d, 4.57 g/d and 3.12 g/d, respectively.

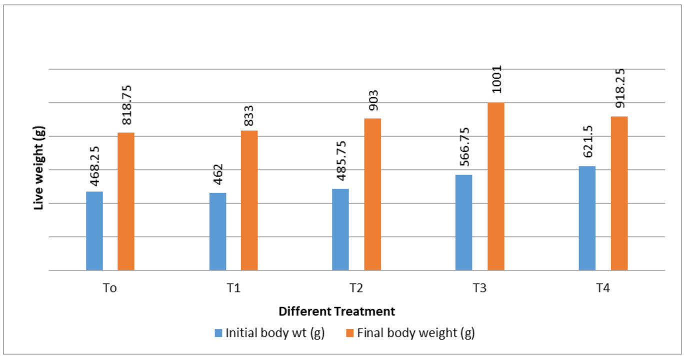

Figure 6: Initial live weight and final live weight of rabbits for different treatment groups.

Total live weight gain for groups T_0, T_1, T_2, T_3 and T_4 are 350.5 g, 371 g, 417.25 g, 434.25 g and 296.25 g respectively. Though total live weight gain did not differ significantly but the daily live weight gain differ significantly (Tabel 3, Figures 7 and 8). Prasad *et al.*

(2000) also found that viable growth rate 15-18 g/d can be obtained on complete diets utilizing locally available concentrate supplements for economic broiler production. Alade *et al.* (2002) conducted a 56 days feeding trial to investigate the effect of varing levels of wheat bran on growth performance. The result indicates that the daily weight gain was 9.20, 8.90, 8.00 and 5.20 g/d, respectively. Hasnanat *et al.* (2002) found growth rate of 13.02 g/d when rabbits were fed fresh green grass and vegetable leaves with concentrate supplements in rural condition under farmers own managements. Xuepeng *et al.* (2012) found average daily gain of 22-26 g/d using different level of protein and energy.

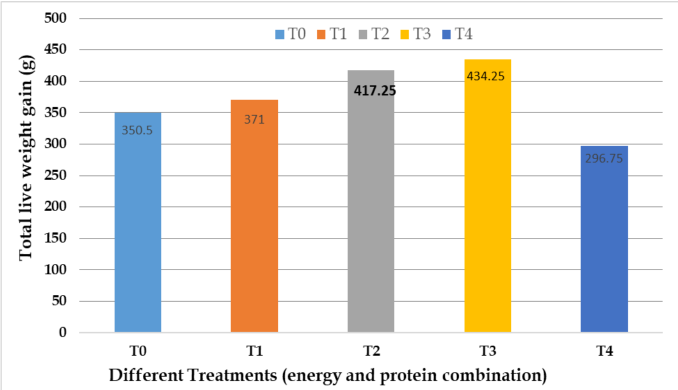

Figure 7: Total live weight gains at different treatment (energy and protein combination) groups.

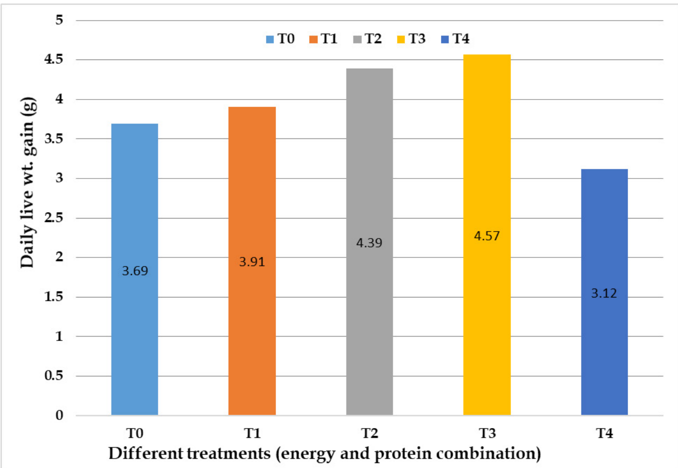

Figure 8: Daily live weight gains at different treatment (energy and protein combination) groups.

Growth velocity

Growth velocity differed significantly as shown in Table 3. The relationship of daily live weight gain and growth velocity for different treatment had shown in Figure 9. However, significant difference was found between daily live weight gain and growth velocity.

The graph shows a positive correlation between daily weight gain and growth velocity. T2 exhibited the highest growth velocity (0.86), closely followed by T1 (0.80) and T3 (0.77). Interestingly, T4, despite its high nutrient content, showed the lowest growth velocity (0.48), suggesting potential overfeeding or nutrient imbalance (Figure 9).

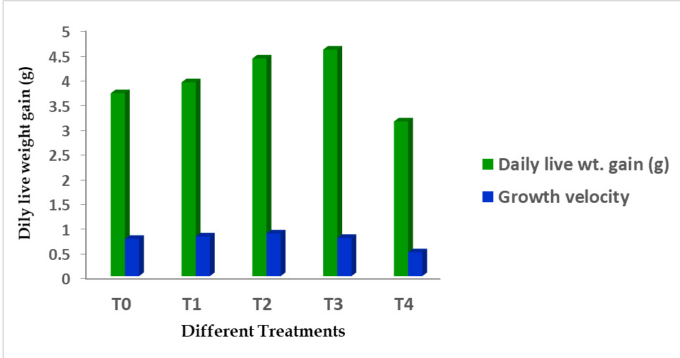

Figure 9: Relationship between daily live weight gain and growth velocity for different treatment groups.

Conclusion

This study explored how different energy and protein levels in rabbit diets affect growth over 95 days. The results showed that diet composition strongly influences feed intake and weight gain. Rabbits fed a low-energy (2400 Kcal/kg) but high-protein (19%) diet (T3) achieved the best final weight and daily growth rate, outperforming even the standard diet group (T0). This suggests that current feeding practices may not be fully optimized for maximum growth.

Rabbits that received both high energy and high protein (T4) consumed the most feed but did not show the fastest growth, indicating that excess nutrients can be inefficient and may burden metabolism. The study highlights that the balance between protein and energy is more important than increasing either alone. Overall, a low-energy, high-protein diet offers better growth performance and feed efficiency, potentially lowering production costs. Further research with larger samples and economic evaluation is recommended to create practical feeding guidelines for rabbit farming.

Declarations

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Ethical approval

All animal care and experimental procedures were approved by the Animal Ethics Committee of Bangladesh Agricultural University in accordance with institutional and international guidelines.

Data availability

The data supporting the findings of this study is included in the article. Additional datasets generated or analyzed during the study are available from the corresponding author upon reasonable request.

Generative AI and AI-assisted technology statement

The authors declare that no generative AI and AI assisted technology was used in the creation of this manuscript.

Statement of conflict of interest

The authors have declared no conflict of interest.

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