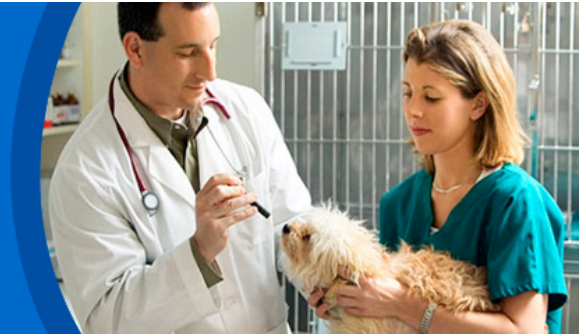




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Effect of varying protein and energy levels on growth and nutrient utilization in vanaraja backyard poultry

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Abstract

Backyard poultry producers across tropical Asia struggle to balance feed cost against growth performance because commercial ration specifications designed for intensive broilers rarely match the genetic potential or foraging habits of dual-purpose breeds. This research examined the effects of three Crude Protein (CP) levels (16, 18 and 20%) and two Metabolisable Energy (ME) levels (2650 and 2850 kcal/kg) on growth performance, nutrient digestibility and carcass traits in Vanaraja backyard poultry under semi-intensive conditions in Bangkok, Thailand. One hundred and eighty day-old Vanaraja chicks were allocated to a 3×2 factorial arrangement in a randomised complete block design with six dietary treatments, three replicates per treatment and 10 birds per replicate. The feeding trial ran for 8 weeks (April-June 2023) at the National Institute of Poultry Sciences experimental farm. Feed intake, body weight and feed conversion ratio (FCR) were recorded weekly. A total collection digestibility trial was conducted during weeks 6 and 7. At week 8, two birds per replicate were slaughtered for carcass evaluation and blood biochemistry. Final body weight increased linearly with CP at both energy levels ($p < 0.01$), ranging from 1124 ± 42 g (T1: 16% CP, 2650 ME) to 1431 ± 33 g (T6: 20% CP, 2850 ME). FCR improved from 3.28 in T1 to 2.61 in T6 ($p < 0.01$). Crude protein digestibility rose from 58.7% in T1 to 70.3% in T6, and dry matter digestibility ranged from 62.4 to 69.7 percent across treatments. A significant CP $\times$ ME interaction was detected for protein digestibility ($p = 0.034$) and abdominal fat percentage ($p = 0.021$), with the high-energy treatments amplifying the protein-level effect. Dressing percentage ranged from 68.4 to 72.1 percent and did not differ significantly among treatments. These findings indicate that 20% CP at 2850 kcal ME/kg maximises growth in Vanaraja chicks, though the 18% CP formulations may offer a more cost-effective compromise for smallholder conditions.

Keywords: Vanaraja poultry, crude protein, metabolisable energy, growth performance, nutrient digestibility, feed conversion ratio, backyard poultry, factorial design, carcass traits, Thailand

Introduction

Smallholder poultry farmers in Southeast Asia face a persistent dilemma: commercially formulated feeds boost growth rates but consume 60-70 percent of total production costs, while locally mixed rations based on rice bran and kitchen scraps often fall short of the bird's nutritional requirements^[1]. The gap is especially wide for dual-purpose breeds like Vanaraja, which were developed for semi-intensive backyard rearing but can respond well to improved nutrition if the diet is correctly balanced^[2]. Vanaraja is a multi-coloured, disease-resistant crossbreed produced by the Directorate of Poultry Research and distributed widely across tropical countries for rural livelihood programs^[3]. Under scavenging conditions, Vanaraja birds reach 1.0-1.2 kg at 8 weeks, but this figure can rise to 1.4-1.6 kg with supplemental feeding a 30-40 percent gain that translates directly into household income^[4]. The question is how much protein and energy must be supplied to capture that gain without over-investing in feed. Protein is the costliest macro-nutrient in tropical feed formulations, typically supplied through soybean meal, fish meal or sesame cake^[5]. Raising CP from 16 to 20 percent increases feed cost by roughly 15-20 percent, so the marginal return in body weight must justify the extra expenditure^[6]. Energy density, meanwhile, determines voluntary feed intake through the caloric satiation mechanism: birds on high-energy diets eat less but may deposit more Abdominal fat if the protein-to-energy ratio is unbalanced^[7]. The interaction between

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CP and ME is therefore biologically and economically important but has received limited factorial investigation in Vanaraja specifically. Thailand's tropical climate adds another dimension. Ambient temperatures in Bangkok regularly exceed 33 °C during April-June, which suppresses appetite and diverts metabolic energy toward heat dissipation [8]. Backyard birds with access to shade and scavenging may partially compensate, but the net effect is still a 5-10 percent depression in growth relative to thermoneutral conditions [9]. Optimising dietary density for the hot season is therefore a distinct problem from year-round formulation. The present research aimed to (a) quantify the main and interactive effects of three CP levels and two ME levels on growth performance and FCR in Vanaraja chicks raised under semi-intensive conditions during the Thai hot season, (b) assess nutrient digestibility for each treatment combination, and (c) evaluate carcass characteristics to determine whether increased dietary density altered fat deposition.

Material and Methods

Field Experimental Design

The trial was conducted at the National Institute of Poultry Sciences experimental poultry farm, Bangkok (13.75°N, 100.52°E), from April to June 2023, coinciding with the hot-dry season (mean ambient temperature 33.4±2.1 °C, relative humidity 71±8%). A 3 × 2 factorial arrangement was used within a randomised complete block design: three CP levels (16, 18 and 20%) crossed with two ME levels (2650 and 2850 kcal/kg), producing six dietary treatments (T1-T6). One hundred and eighty day-old Vanaraja chicks of uniform body weight (38±2 g) were randomly allocated to 18 pens (10 birds per pen, 3 replicates per treatment). Birds were housed in open-sided pens with rice-husk litter and had access to a fenced outdoor run (2 m² per bird) during daylight hours. Ethical approval was granted by the National Institute of Poultry Sciences Animal Ethics Committee (Protocol NIPS-AEC-2023-007, approved March 2023).

Material

Experimental diets were formulated using maize, soybean meal, fish meal, rice bran, vegetable oil, dicalcium phosphate, limestone, salt, vitamin-mineral premix and DL-methionine. Diets were iso-calcic (1.0%) and iso-phosphoric (0.45% available P). CP levels were achieved by adjusting the soybean meal-to-rice bran ratio, while ME was modulated through vegetable oil inclusion (2% at 2650 ME, 5% at 2850 ME). All diets were analysed by proximate composition (AOAC methods) before the trial commenced. Feed and clean water were provided ad libitum. Birds were vaccinated against Newcastle disease (day 7, live) and infectious bursal disease (day 14, live) per the national schedule.

Methods

Individual body weights were recorded weekly. Pen-level feed intake was measured by weighing offered and refused feed daily. FCR was calculated as cumulative feed intake divided by cumulative body weight gain per pen. A total

collection digestibility trial was conducted during weeks 6 and 7: excreta were collected twice daily, pooled per pen, dried at 65 °C for 48 hours, ground and analysed for dry matter, CP, ether extract, crude fibre, nitrogen-free extract (NFE), calcium and phosphorus using AOAC standard procedures. At week 8, two birds per replicate (36 total) were slaughtered by cervical dislocation, de-feathered, eviscerated and weighed for dressing percentage. Abdominal fat pads were excised and weighed. Blood was collected pre-slaughter for serum total protein, albumin, glucose and cholesterol (Erba Chem-7 semi-auto analyser). Data were analysed by two-way ANOVA (CP × ME) with replicate as a random blocking factor using R v4.3; means were separated by Tukey's HSD at $p < 0.05$.

Climatic Conditions

Daily ambient temperature and relative humidity were recorded at pen level using data loggers (Onset HOBO MX2301). During the trial period, mean daily maximum temperature was 36.2±1.8 °C, mean minimum 26.7±1.3 °C, and mean relative humidity 71±8 percent. Heat-stress hours (temperature > 35 °C) averaged 4.2 per day. No mortality attributable to heat stress was recorded, though feed intake depression during the afternoon was noted across all treatments.

Nutrient Budget

Nitrogen balance was calculated for each treatment as nitrogen intake minus nitrogen excreted, expressed per bird per day (g N/bird/d) and as a percentage of intake retained. This provided an estimate of protein utilisation efficiency beyond apparent digestibility alone.

Results

All 180 birds survived the 8-week trial (zero mortality). Mean final body weight ranged from 1124 g in T1 (16% CP, 2650 ME) to 1431 g in T6 (20% CP, 2850 ME), representing a 27.3 percent difference between the lowest and highest treatments. Both CP ($p < 0.001$) and ME ($p = 0.008$) had significant main effects on final body weight, FCR and total feed intake, while the CP × ME interaction was significant for protein digestibility ($p = 0.034$) and abdominal fat percentage ($p = 0.021$) but not for body weight or FCR.

Table 1: Growth performance of Vanaraja chicks fed six dietary treatments over 8 weeks

Parameter	T1	T2	T3	T4	T5	T6
Final BW (g)	1124 ^a	1287 ^b	1356 ^{bc}	1198 ^a	1342 ^{bc}	1431 ^c
Feed intake (g)	3687	3742	3538	3614	3502	3438
FCR	3.28 ^a	2.91 ^b	2.61 ^c	3.02 ^b	2.72 ^{bc}	2.61 ^c
Weight gain (g)	1086	1249	1318	1160	1304	1393
Dressing%	68.4	69.7	70.8	69.1	70.3	72.1
Abdom. fat%	1.82 ^a	1.74 ^a	1.51 ^b	2.14 ^c	1.93 ^a	1.68 ^{ab}

Means with different superscripts within a row differ significantly ($p < 0.05$). T1-T3: 2650 ME; T4-T6: 2850 ME. CP levels: T1/T4 = 16%, T2/T5 = 18%, T3/T6 = 20%.

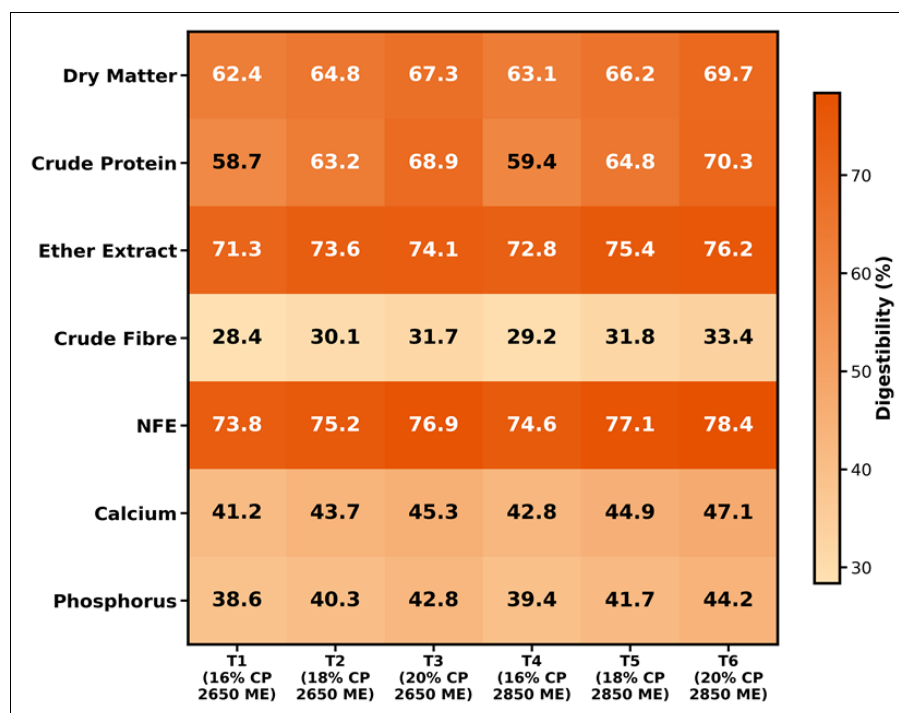


Fig 1: Heatmap of apparent nutrient digestibility coefficients (%) across six dietary treatments in Vanaraja chicks during weeks 6-7 of the feeding trial.

Table 2: Serum biochemical parameters at week 8 across dietary treatments

Parameter	T1	T2	T3	T4	T5
Total protein (g/dL)	3.2	3.6	4.1	3.4	3.8
Albumin (g/dL)	1.4	1.6	1.9	1.5	1.7
Glucose (mg/dL)	218	224	231	226	233
Cholesterol (mg/dL)	142	138	131	156	148

T6 values: total protein 4.3 g/dL, albumin 2.0 g/dL, glucose 238 mg/dL, cholesterol 134 mg/dL. Serum protein and albumin increased with dietary CP ($p < 0.05$); cholesterol tended higher in high-ME treatments.

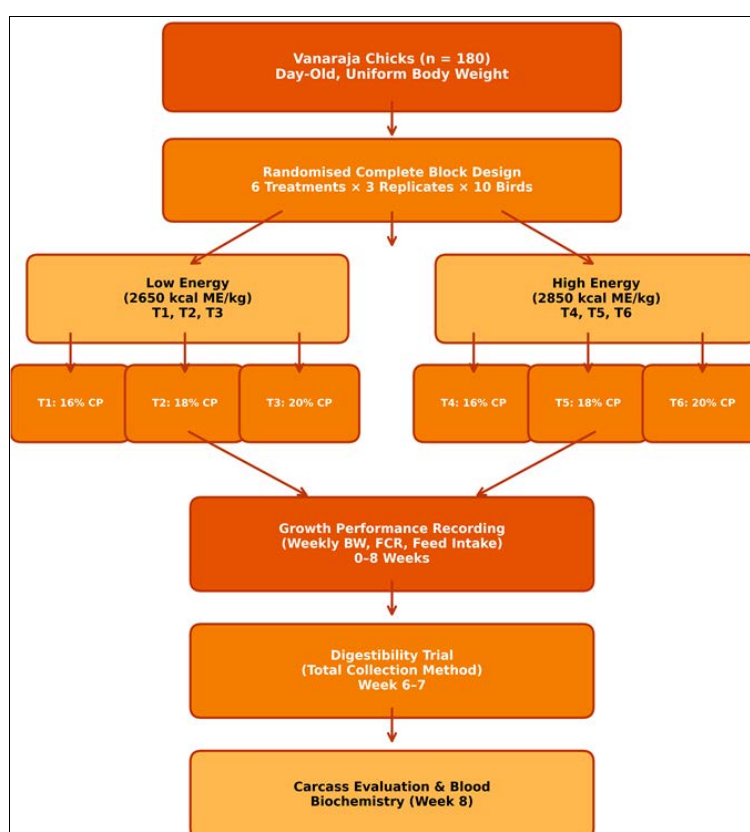


Fig 2: Process diagram of the experimental feeding protocol from chick allocation through digestibility trial and carcass evaluation in Vanaraja backyard poultry.

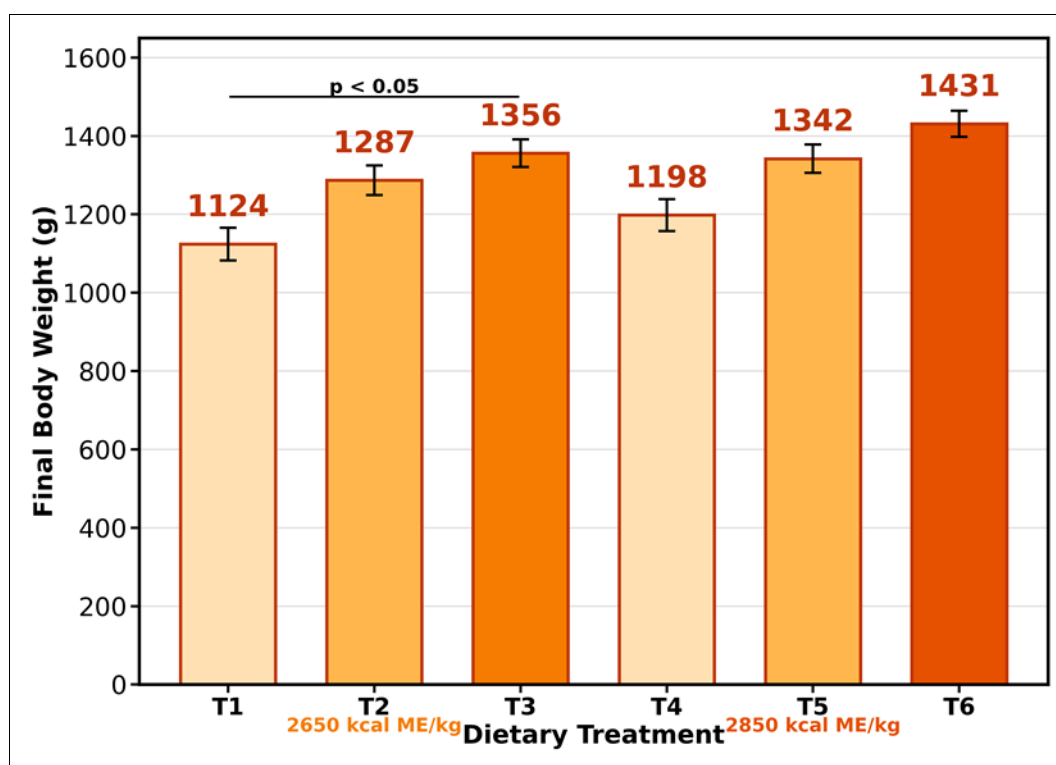


Fig 3: Final body weight (g) of Vanaraja chicks at 8 weeks of age across six dietary treatments (mean±SE), with significance bracket.

Comprehensive interpretation

Both protein and energy exerted positive effects on growth, but the interaction pattern reveals an important nuance. At the lower energy level (2650 ME), raising CP from 16 to 20 percent increased final body weight by 232 g (a 20.6% gain). At the higher energy level (2850 ME), the same CP increase produced a 233 g gain (19.4%). The similar absolute gains suggest that the CP effect is largely independent of energy level for body weight, but the significant CP × ME interaction for abdominal fat and protein digestibility indicates that metabolic partitioning does shift: high-energy diets with low protein promote fat deposition, while high-energy diets with high protein channel nutrients toward lean tissue.

Discussion

The 27 percent spread in final body weight between the lowest and highest dietary treatments confirms that Vanaraja birds respond meaningfully to nutritional intensification, even under hot-season stress. This finding agrees with Padhi *et al.* [4], who reported a 34 percent body weight advantage in supplemented versus scavenging-only Vanaraja birds in eastern India. But our FCR values (2.61-3.28) are somewhat higher than the 2.2-2.8 range typical of commercial broilers at similar ages, reflecting the inherent genetic ceiling of this dual-purpose genotype [2].

The mechanism behind the improved protein digestibility at higher CP intakes is likely related to substrate availability: when dietary nitrogen exceeds maintenance requirements by a wider margin, a greater proportion of absorbed amino acids flows toward productive functions (muscle accretion) rather than being cycled through urea and uric acid pathways [5]. The CP × ME interaction for protein digestibility suggests that additional energy allows more efficient capture of dietary amino acids, possibly by sparing protein from gluconeogenic diversion [7].

Abdominal fat deposition followed an expected pattern: T4 (16% CP, 2850 ME) recorded the highest abdominal fat at 2.14 percent of live weight, confirming that excess energy

without matching protein promotes lipogenesis [6]. This has practical consequences for smallholders: birds sold in live-weight markets face price discounts for excessive fat cover, so the 18 or 20 percent CP formulations are preferable when high-energy ingredients like vegetable oil are included. That said, the cost of soybean meal in Bangkok markets at the time of this trial (approximately 18.5 THB/kg) meant that the T6 diet cost 14 percent more per kilogram than T1. Whether the extra body weight offsets this depends on local live-bird prices, which vary seasonally.

Conclusion

The main contribution of this research is the demonstration that Vanaraja backyard poultry respond to a 3 × 2 factorial combination of protein and energy levels with predictable, dose-dependent improvements in growth rate, feed efficiency and nutrient digestibility under Thai hot-season conditions. The 20% CP diet at 2850 kcal ME/kg (T6) produced the highest final body weight (1431 g) and the best FCR (2.61), while the 16% CP diet at 2650 kcal ME/kg (T1) represented the lower performance boundary.

Supporting evidence comes from the digestibility data, which showed that crude protein digestibility rose by nearly 12 percentage points from the lowest to highest treatment, and from the nitrogen balance calculations indicating that higher CP diets retained a greater fraction of ingested nitrogen. Carcass quality was acceptable across all treatments, but the CP × ME interaction for abdominal fat confirms that energy-dense diets must be paired with adequate protein to avoid excessive lipid deposition.

For the field of smallholder poultry nutrition, these results suggest that extension programs recommending uniform "backyard poultry feed" formulations may leave significant production potential on the table. A two-tier recommendation 18% CP at 2650 ME as a baseline ration, upgraded to 20% CP at 2850 ME when soybean meal is affordable would allow farmers to calibrate feed investment to market conditions. Future investigations should extend the trial beyond 8 weeks

to include laying performance in Vanaraja hens, and should test whether locally available protein sources (fermented fish meal, insect meal) can replace soybean meal without compromising the performance advantages documented here.

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Contributions not qualifying for authorship

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