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THE EFFECT OF ENERGY AND PROTEIN LEVELS ON THE PERFORMANCE OF BROILER CHICKENS

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RINGKASAN

Tiga percubaan telah dilaksanakan untuk mengkaji kesan perhubungan kalori-protin serta nisbah kalori-protin di atas tumbesar anak ayam daging dari lima minggu sehingga sepuluh minggu. Didapati makanan-makanan dengan 20% ke 22% protin kasar dan 3,200 Kcal/kg tenaga ungkaibina memberi kesan yang baik dan bermakna ($P<0.05$) ke atas kadar kecepatan tumbesar dan kecekapan penukaran makanan (feed conversion efficiency), manakala nisbah kalori-protin hanya memberi kesan yang sedikit kepada kedua-dua faktor tersebut.

INTRODUCTION

The concept of optimum ratio of energy to protein at which deficiency of either one limits the utilisation of the other for a specific production purpose has long been recognised in diets for poultry (HILL and DANSKY, 1950). The relationship between energy and protein in broiler diets is also well documented in the works of DONALDSON, COMBS and ROMOSER (1956), COMBS (1961) and N.R.C. (1971). The general belief is that as the dietary energy levels vary, the protein levels should also follow the same pattern so that the calorie-protein ratio is maintained at approximately a constant value.

More recently, the rations for broilers tended to change to higher nutrient density due to the rapid growth of the chickens resulted from intensive selection for better body weight gain and feed efficiency. In this case, the feeds should contain higher levels of nutrients, particularly protein and energy as compared to those used in the past. The feeds should also contain minimum fibre and more digestible ingredients.

To investigate the effect of protein and energy relationship on the performance of broiler in tropical environment, three trials with varying dietary energy and protein level as well as calorie-protein ratio in diets were carried out.

MATERIALS AND METHODS

In the first trial, 200 five-week old commercial Hubbard broiler chicks were used. Three rations were computed to contain 3,200, 2,900 and 2,600 Kcal/kg metabolizable energy (ME) and calorie-protein ratios of 160, 145 and 130 respectively. The crude protein levels were maintained isonitrogenous at 20%. Two other rations were computed to contain 2,900 and 2,600 Kcal/kg ME while the crude protein levels varied from 18.13% to 16.25% in order to maintain the calorie-protein ratio at 160 *(Table 1)*.

The birds were raised to five-week of age with a proprietary starter mash, thereafter, they were fed the treatment diets up to ten weeks old. These birds were randomly allocated to the treatment groups. Each groups consisted of ten chicks housed in wire cage (193 cm x 91.5 cm) and replicated 4 times. Feed and water were provided *ad libitum* in troughs placed along the walls of the cages. Body weight and feed intake were recorded weekly.

In the second trial, 180 five-week old birds were randomised to 4 treatment diets *(Table 2)* with 3 replicates of 15 birds each. Same cages and same management procedures were given

TABLE 1. COMPOSITION OF EXPERIMENTAL DIETS[1] (TRIAL I)

	Dietary Variables				
ME/Kcal/Kg	3200	2900	2600	2900	2600
Protein, %	20	20	20	18.13	16.25
Calorie-protein ratio	160	145	130	160	160
Ingredients, %					
Corn	51.00	49.50	30.50	39.25	18.00
Soybean meal	22.00	22.00	22.00	23.00	19.00
Fish meal	11.00	10.00	9.25	7.00	5.00
Cassava meal	5.00	6.00	11.00	20.00	28.00
Palm kernel meal	1.25	3.00	10.00	1.50	1.50
Rice bran	1.00	5.00	12.00	5.50	10.00
Grass meal	1.00	1.25	3.00	1.25	3.00
Palm oil	5.50	1.50	0.50	0.75	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Vit-min premix[2]	0.50	0.50	0.50	0.50	0.50
Trical. phosphate	1.00	1.00	1.00	1.00	1.00
Calculated Analysis (As fed)					
Energy, Kcal ME/kg	3,222	2,926	2,617	2,919	2,606
Crude protein, %	20.05	20.04	20.02	18.17	16.28
Calorie-protein ratio[3]	160	146	130	160	160
Crude fibre, %	3.83	4.60	6.42	4.65	6.65
Calcium, %	0.86	0.83	0.84	0.76	0.72
Phosphorus (total), %	0.75	0.78	0.80	0.52	0.61
L-lysine, %	1.27	1.24	1.21	1.11	0.89
DL–Methionine, %	0.64	0.62	0.57	0.52	0.40

[1] Supplemented with Amprol-plus at 50.60g/100kg diet and Zinc-bacitracin at 125.4g/100kg diet.
[2] Vitamin-mineral premix: Commercial premix supplied by Mark Sharp and Dohme, U.S.A., Vitamin-mineral mix No. 21
[3] Expressed as $\frac{\text{Kcal ME/Kg diet}}{\%\ \text{crude protein in diet}}$

TABLE 2. THE EXPERIMENTAL RATIONS (TRIAL II)

	Dietary Variables			
ME, Kcal/Kg	3,100	3,100	2,900	2,750
Protein, %	20	19	18	17
Calorie-protein ratio	155	160	160	160
Ingredients, %				
Corn	60.65	54.65	51.65	44.65
Rice bran	–	8.00	15.00	17.00
Grass meal	–	3.00	3.00	4.00
Soybean meal	29.00	26.00	23.00	18.00
Fish meal	4.00	4.00	4.00	4.00
Palm kernel meal	–	–	–	8.00
Palm oil	3.00	3.00	1.00	1.00
Trical. phosphate	2.00	2.00	1.00	1.00
Vit-min premix[1]	1.00	1.00	1.00	1.00
Salt	0.25	0.25	0.25	0.25
Limestone powder	–	–	1.00	1.00
DL–Methionine	0.10	0.10	0.10	0.10
Calculated Analysis (As fed)				
Crude protein, %	20.08	19.40	18.20	17.30
Ether extract, %	6.00	6.87	5.50	5.61
Crude fibre, %	3.00	4.74	5.40	6.91
Calcium, %	1.05	1.08	1.08	1.06
Phosphorus, %	0.85	0.95	0.85	0.09
Metabolizable energy (Kcal/Kg.)	3,128	3,104	2,916	2,768
Lysine, %	1.16	1.15	1.11	1.01
Methionine, %	0.47	0.47	0.46	0.46
Cystine, %	0.34	0.35	0.35	0.35
Calorie-protein ratio, %	156	160	160	150

[1]Vitamin-mineral premix : Same as in Table 1

TABLE 3. EXPERIMENTAL RATIONS (TRIAL III)

	Dietary variables			
ME, Kcal/Kg	2,950	3,000	2,950	2,900
Protein, %	22	20	18	16
Calorie-protein ratio	130	150	160	180
Ingredients, %				
Corn	54.00	53.00	50.00	54.00
Cassava meal	–	–	4.00	6.00
Rice bran	–	4.00	9.00	17.00
Brewer's grain	–	4.00	4.00	7.00
Grass meal	2.00	2.00	2.00	2.00
Soybean meal	35.00	27.00	22.00	15.00
Fish meal	4.00	4.00	4.00	4.00
Palm oil	2.00	3.00	2.00	1.00
Trical. phosphate	1.00	1.65	1.00	1.00
Vit-min premix[1]	1.00	1.00	1.00	1.00
Salt	0.25	0.25	0.25	0.25
DL-Methionine	0.10	0.10	0.10	0.10
Limestone powder	0.65	–	0.65	0.65
Calculated Analysis (As fed)				
Crude protein, %	22.41	20.10	18.30	16.30
Ether extract, %	4.84	6.50	5.99	6.30
Crude fibre, %	3.78	4.48	4.47	5.99
Calcium, %	0.98	0.96	0.98	0.98
Phosphorus, %	0.71	0.84	0.77	0.85
Metabolizable energy, (Kcal/kg.)	2,957	3,010	2,974	2,891
Lysine, %	1.34	1.17	1.06	0.94
Methionine, %	0.50	0.48	0.45	0.43
Cystine, %	0.37	0.35	0.33	0.31
Calorie-protein ratio	132	150	163	178

[1]Vitamin-mineral mix same as Table 1

to the birds as in trial I. The experimental diets contained crude protein 20%, 19%, 18% and 17% with ME maintained at the range of 2,750 to 3,100 Kcal/kg so that the calorie-protein ratios could maintain at approximately 160 for all the rations. All the parameters were measured as in trial I.

In trial III, same number of chicks and same experimental procedures were used as in trial II. The spacing of crude protein levels in the experimental diets were wider than those in trial II, which were 22%, 20%, 18% and 16% with ME within the range of 2,900 to 3,000 Kcal/kg *(Table 3)*. The calorie-protein ratio increased from 132 to 178 as the dietary protein levels decreased.

Data from all the trials were analysed for analysis of variance based on the method described by STEEL and TORRIE (1960). When the F-value indicated significance at 5 or 1% levels, the differences responsible for the significance were compared using least significant differences (LSD) test.

RESULTS

The results of the three trials on the effect of calorie-protein relationship on the performance of broiler chickens from fifth to tenth week of age are summarised in *Tables 4,* and *5* respectively.

In trial I *(Table 4),* birds fed diets with calorie-protein ratio of 160 and 20% crude protein were not significantly better than those with calorie-protein ratio of 145 in daily body weight gain and feed conversion efficiency but significantly better ($P<0.05$) than those fed on diets with calorie-protein ratio of 130 with same crude protein level. When compared the birds fed all the diets with calorie-protein ratio of 160, it was found that those on diets with 18 and 20% crude protein performed significantly better than those on diets containing 16% crude protein in both daily weight gain ($P<0.01$) and feed conversion efficiency ($P<0.05$).

Bird fed on diets with 18 and 20% crude protein with ME ranging from 2,900 to 3,200 Kcal/kg did not differ significantly in body weight gain and feed conversion efficiency. However, the birds appeared to perform better when the dietary crude protein and energy were higher.

TABLE 4. EFFECTS OF CALORIE–PROTEIN RELATIONSHIP ON PERFORMANCE OF BROILER CHICKENS (5th–10th week) (Trial I)

	Dietary variables				
ME, Kcal/Kg	3200	2900	2600	2900	2600
Protein, %	20	20	20	18.13	16.25
Calorie-protein ratio	160	145	130	160	160
Avg daily gain[1], g	34.9[a]	32.4[a]	29.0[b]	32.4[a]	26.0[b]
Avg daily intake[2], g	93.21	90.58	94.75	92.75	91.91
Feed conversion efficiency[1] (F/G)	2.67[a]	2.80[a]	3.27[b]	2.86[a]	3.53[b]
Avg daily ME intake[1], Kcal	300.3[a]	265.1[bc]	248.0[cd]	271.1[b]	236.5[d]
Avg daily protein intake[1], g	18.7[a]	18.2[a]	19.0[a]	16.9[b]	16.0[c]

[1]Significant at ($P<0.01$)
[2]Non significant
a.b.c.d. = Values along the same row bearing different superscripts are significantly different at ($P<0.05$).

In trial II *(Table 5)*, it was observed that birds fed diets with higner dietary protein and energy had significantly better feed conversion efficiency ($P<0.05$) than those fed diets with lower crude protein and energy. No significant difference was observed between the 18% and 19%. crude protein groups, but significant difference was found in 17% crude protein group although all of them had calorie-protein ratio of 160. The birds in 20% crude protein group were more superior than those in the other three groups ($P<0.05$). The feed intake in the 20% crude protein groups was significantly lower ($P<0.05$) than those in other groups. However, no significant difference in daily body weight gain was observed among the treatments. In terms of daily protein and energy intake, no significant difference was found in the former parameter and no consistent difference was found in the latter.

In trial III *(Table 5)*, it was observed that the birds on diets with 22% and 20% crude protein obtained significantly better feed conversion efficiency ($P<0.05$) than those on diets with 18% and 16% crude protein. The daily body weight gain was significantly heavier ($P<0.05$) in birds on 22% crude protein diets. However, there was no significant difference in feed intake among the 22%, 20% and 18% crude protein groups. In terms of daily protein intake, the higher protein groups consumed significantly more protein than those lower protein groups. However, no significant difference in energy consumption was observed among the treatments.

TABLE 5. EFFECT OF CALORIE–PROTEIN RELATIONSHIP ON PERFORMANCE OF BROILER CHICKENS (5th TO 10th WEEK, TRIAL II AND III)

	Dietary Variables							
	Trial II				Trial III			
ME, Kcal/Kg	3,100	3,100	2,900	2,750	2,950	3,000	2,950	2,900
Protein, %	20	19	18	17	22	20	18	16
Calorie-protein ratio	155	160	160	160	130	150	165	180
Avg. daily gain, g	35.7	34.7	34.1	33.6	31.8^{a}	28.8^{b}	28.5^{b}	27.3^{b}
Avg. daily intake, g	92.1^{a}	101.0^{b}	100.0^{b}	103.8^{b}	84.5^{a}	82.0^{a}	84.7^{a}	92.1^{b}
Feed conversion efficiency (F/G)	2.58^{a}	2.91^{b}	2.93^{b}	3.08^{c}	2.66^{a}	2.85^{ab}	2.97^{b}	3.38^{c}
Avg. daily ME, intake, Kcal	288.1^{a}	313.3^{b}	291.7^{ab}	287.4^{a}	249.9	246.8	251.9	266.3
Avg. daily protein intake, g	18.5	19.6	18.2	18.0	18.9^{a}	16.5^{b}	15.5^{a}	15.0^{c}

a,b,c, = Figures with different superscripts in the same row differ significantly ($P<0.05$)

DISCUSSIONS

From the results of the three trials, it seemed that calorie-protein ratio was not a suitable index to determine the performance of the chickens. The increase of protein and energy levels in the diets had achieved better body weight gain and feed conversion efficiency. The crude protein levels of 20% and 22% together with metabolizable energy of 3,000 to 3,200 Kcal/kg in diets showed more favourable results in terms of feed intake, body weight gain and feed conversion efficiency when compared to other treatments. This might mean that broiler chickens required high protein and energy levels for optimum growth. This condition is quite similar to the report of LIMCANGCO-LOPEZ (1974), who found that broiler chickens performed best with crude protein levels in diets between 20% and 22% and metabolizable energy between 2,800 to 3,000 Kcal/kg. The protein levels in the present study were quite similar to the NRC recommendation of 20% for broiler finisher (NRC, 1971). Due to the high ambient temperature in this country, the optimum metabolizable energy could be as low as 3,000 Kcal/kg instead of 3,200 Kcal/kg in the diets which gave the same effect to the performance of the chickens.

The body weight gain in all the trials tended to increase with increase in protein and energy levels. This result was in agreement with that of KHOO (1974), DONALDSON, COMB and ROMOSER (1955), who indicated that the growth rate of chickens was improved by an increase in level of dietary protein in high energy diets.

It was also observed that the improvement of growth was more prominent with an increase in dietary energy level as compared to an increase in dietary protein level. This could probably be due to the supplementation of palm oil in order to bring up the energy level. When fats were included in the ration for growing animals, the efficiency of utilization of energy consumed was improved compared with those animals in the low-fat diets. This improvement could be attributed to the lower heat increment in the diets containing fat (SCOTT *et al.*, 1969).

The poorer feed conversion efficiency that was observed in the lower energy groups resulted from the higher feed intake and lower body weight gain. The higher feed intake could be due to the fact that the birds tended to consume more feed to compensate the need for energy. The lower body weight gain inspite of higher feed intake could be caused by the higher crude fibre in the diets. In non-ruminants, particularly pigs, dietary crude fibre has been reported to reduce the digestibility of dry matter (DINUSSON *et al.*, 1969; FARREL, 1973), protein and energy (DINUSSON *et al.*, 1969). In chickens, the digestibility of crude fat, nitrogen-free-extract and organic matter was reported to decrease by the addition of crude fibre in the form of cellulose to the diets (SAITO *et al.*, 1959). This effect of crude fibre on the digestibility of nutrient coupled with the high level of crude fibre in the low-energy and low-protein diets in all the trials could probably explain the poor performance of chickens receiving low protein-low energy diets as compared to those receiving diets high in energy and protein.

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SUMMARY

Three trials were conducted to study the effect of protein-energy relationship as well as calorie-protein ratio on the performance of broiler chickens from 5th to 10th weeks. It was

observed that diets with 20 to 22% crude protein and 3,000 to 3,200 Kcal/kg. metabolizable energy produced significant improvement in both body weight gain and feed conversion efficiency ($P<0.05$), whereas calorie-protein ratio played only an insignificant role on the two parameters.

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