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The effects of dietary protein and energy levels on egg production of chicken in the tropics

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Key words: brown shell layer, protein intake, energy intake, egg production

Abstrak

Dua percubaan telah dijalankan untuk mengkaji kesan aras protein dan tenaga dalam makanan ayam terhadap prestasi pengeluaran telur ayam penelur Hisex Brown di kawasan tropika. Makanan ayam yang mengandungi aras-aras protein dan tenaga yang berbeza iaitu 15, 17 dan 19% protein dan 10.9, 11.5 dan 12.1 MJ/kg tenaga metabolisme (TM) (Percubaan I) dan 15, 16, 17% protein dan 10.5, 11.1 dan 11.5 MJ/kg TM (Percubaan II) telah digunakan. Pengambilan protein dan tenaga bertambah apabila aras protein dan tenaga dalam makanan meningkat. Keputusan daripada tempoh bertelur selama 52 minggu bagi kedua-dua percubaan telah menunjukkan bahawa tiada apa-apa perbezaan yang ketara terhadap pengeluaran telur, jisim telur dan kecekapan penukaran makanan bagi jisim telur berdasarkan aras protein dalam makanan. Daripada segi aras tenaga pula, prestasi pengeluaran telur yang rendah ($p<0.05$) telah didapati pada ayam yang diberi makanan dengan dengan tenaga yang tinggi (12.1 MJ/kg). Keputusan telah menunjukkan arah aliran pengeluaran telur yang rendah sedikit apabila ayam diberikan makanan yang rendah kandungan protein dan TM. Untuk pengeluaran telur ayam yang maksimum, adalah dicadangkan ayam penelur di kawasan tropika diberi makan makanan yang mengandungi 17% protein semasa tempoh pengeluaran tinggi dan 15% protein semasa tempoh pengeluaran rendah, manakala kandungan tenaga ialah 11.1–11.5 MJ/kg TM.

Abstract

Two trials were conducted to study the effects of dietary protein and energy levels on the egg laying performance of Hisex Brown layers in the tropics. Diets varying in protein and energy levels, i.e., 15, 17 and 19% protein and 10.9, 11.5 and 12.1 MJ/kg metabolizable energy (ME) (Trial I) and 15, 16 and 17% protein and 10.5, 11.1 and 11.5 MJ/kg ME (Trial II) were used. The birds consumed more protein and energy when the dietary protein and energy levels increased. Results from 52-week laying period in both trials showed that there was no significant difference in egg production, total egg mass and feed to egg mass ratio in terms of dietary protein levels. However, in terms of energy levels significantly poorer egg laying performance ($P<0.05$) was obtained from birds fed diets with high ME (12.1 MJ/kg). There was a trend exhibiting slightly lower egg production in birds fed diets with low protein or low ME levels. For maximum egg production, layers in the tropics should be fed diets containing 17% protein during high production period and 15% protein during low production period with 11.1–11.5 MJ/kg ME.

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Introduction

Reduced feed intake of chickens in hot climate is a practical problem in the tropics. This, however, can be overcome by lowering the dietary energy levels to provide adequate protein and other nutrients to meet the requirements for maintenance and egg production (Summers and Leeson 1978). Vohra et al. (1979) fed Leghorn hens with diets of varying energy levels under low and high temperatures. They found that feed intake decreased by 1.21–1.41% with every 1 °C rise in temperature. The increased temperature did not affect egg production and shell thickness, but the egg weight was significantly affected.

The relationship between dietary energy-protein levels and egg production in the tropics was reported by Olomu and Offiong (1983). These workers obtained optimal annual egg production of 71–73% at temperature around 26.8 °C by feeding brown shell-egg layers with 16% dietary protein. Protein and energy intakes were higher when these two items were high in the diet. On the other hand, Ramlah and Syed Jalaludin (1985) in Malaysia reported that 15% dietary protein and 11.3 MJ/kg metabolizable energy (2 700 kcal/kg) were optimum to sustain egg production in the tropics. This study was designed to determine and confirm the optimum dietary levels of protein and energy for brown shell-egg layers to support the efficient egg production in Malaysia.

Materials and methods

Two layer trials (I and II) were carried out successively. In each trial, 243 27-week-old Hisex Brown layers were used. There were nine experimental diets for each trial. The diets were in a 3 x 3 factorial design for three levels of energy and three levels of protein. Each diet was assigned to 27 birds which were housed individually in standard battery layer cages. The layer shed was of ordinary open-air type with corrugated asbestos roof. No lighting programme was imposed on the trials. Feed and water were provided in troughs *ad lib*.

During the trials, feed intake was recorded weekly while egg production daily. Egg weight of each treatment group was recorded daily. Koalin and solvent-extracted palm kernel meal were used in both trials for energy adjustment *(Table 1* and *Table 2)*. Conventional feedstuffs like corn, soybean meal, meat and bone meal, and fish meal were used to lessen fluctuation in energy and protein levels. Koalin was used to dilute the dietary energy to the desired levels. The composition of the feedstuffs used in the trials *(Table 3)* was analysed according to AOAC (1975). In Trial I, the dietary crude protein (CP) levels were 15, 17 and 19% varying with dietary metabolizable energy (ME) of 10.9, 11.5 and 12.1 MJ/kg (2 600, 2 750 and 2 900 kcal/kg). In Trial II, the dietary protein levels were 15, 16 and 17% varying with 10.5, 11.1 and 11.5 MJ/kg ME (2 500, 2 650 and 2 750 kcal/kg). All the diets were in mash form. Diets in Trial I had wider ranges of protein levels which gave a rough indication of the optimal level. However, diets in Trial II were designed to narrow down the levels so that a clearer optimum level of protein and energy could be identified eventually. Each trial lasted 364 days (52 weeks). Data collected were subjected to analysis of variance for the main and interaction effects of the treatments. The differences between means were compared using LSD as outlined by Steel and Torrie (1960).

Results and discussion

Feed, protein and energy intakes

In Trial I, the daily feed intake of an individual layer ranged from 113.6 g to 120.5 g with an average of 117.2 g *(Table 4)* as compared with those in Trial II which ranged from 107.8 g to 114.3 g with an average of 111.1 g *(Table 5)*. The intake in Trial II was 6.1 g less. The birds tended to consume more energy and protein when the dietary CP and ME

Table 1. Experimental layer diets with varying protein and energy levels (Trial I)

Layer diet	1	2	3	4	5	6	7	8	9
CP (%)	15	15	15	17	17	17	19	19	19
ME (MJ/kg)	10.9	11.5	12.1	10.9	11.5	12.1	10.9	11.5	12.1
Calorie:protein	173	183	193	153	162	171	137	145	153
Composition (%)									
Palm kernel meal	5.0	2.0	–	5.0	2.0	–	4.0	1.5	–
Corn	56.5	59.0	64.4	52.9	55.4	58.3	53.3	53.3	50.9
Soybean meal	18.5	19.0	19.0	24.0	24.5	24.5	29.0	29.5	30.4
Meat and bone meal	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Lucerne leaf meal	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Palm oil	1.4	2.5	2.5	1.5	2.5	3.5	–	2.0	5.0
Tricalcium phosphate	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Limestone powder	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Kaolin	4.95	3.85	0.45	2.95	1.95	–	–	–	–
Salt	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Vitamin-mineral premix	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
DL-methionine	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Calculated constituents									
Crude protein (%)	15.1	15.1	15.2	17.2	17.2	17.1	19.3	19.1	19.1
Crude fibre (%)	3.9	3.5	3.3	4.2	3.8	3.6	4.4	4.1	3.9
Ether extract (%)	4.0	5.2	5.3	4.0	5.1	6.2	2.6	4.5	7.4
ME (MJ/kg)	10.9	11.6	12.2	10.9	11.6	12.2	10.9	11.5	12.3
Calcium (%)	3.53	3.53	3.53	3.55	3.54	3.56	3.56	3.56	3.56
Phosphorus (%)	0.73	0.73	0.73	0.76	0.76	0.75	0.79	0.77	0.76
Lysine (%)	0.76	0.77	0.77	0.91	0.92	0.91	1.05	1.05	1.07
Methionine + cystine (%)	0.55	0.55	0.56	0.61	0.61	0.61	0.68	0.67	0.66

Table 2. Experimental layer diets with varying protein and energy levels (Trial II)

Layer diet	1	2	3	4	5	6	7	8	9
CP (%)	15	15	15	16	16	16	17	17	17
ME (MJ/kg)	10.5	11.1	11.5	10.5	11.1	11.5	10.5	11.1	11.5
Calorie:protein	167	177	183	156	166	172	147	156	162
Composition (%)									
Palm kernel meal	6.5	6.0	4.0	6.5	6.5	6.0	6.5	6.5	4.0
Corn	56.0	61.0	65.0	54.9	59.5	62.9	53.0	57.5	61.7
Soybean meal	15.5	15.0	15.0	18.0	17.0	16.5	20.5	19.9	19.7
Fish meal	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lucerne leaf meal	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Tricalcium phosphate	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Limestone powder	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Kaolin	7.35	3.35	1.35	6.0	2.4	–	5.4	1.5	–
Salt	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Vitamin-mineral premix	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
DL-methionine	0.05	0.05	0.05	–	–	–	–	–	–
Calculated constituents									
Crude protein (%)	15.1	15.2	15.3	16.0	16.0	16.0	17.0	17.1	17.0
Crude fibre (%)	3.9	3.9	3.7	4.0	4.1	4.0	4.2	4.2	3.9
Ether extract (%)	2.7	2.9	3.1	2.7	2.9	3.0	2.7	2.8	3.0
ME (MJ/kg)	10.5	11.1	11.5	10.5	11.1	11.5	10.5	11.1	11.5
Calcium (%)	3.23	3.22	3.22	3.23	3.23	3.23	3.24	3.24	3.23
Phosphorus (%)	0.56	0.57	0.57	0.58	0.58	0.59	0.59	0.60	0.59
Lysine (%)	0.81	0.81	0.81	0.88	0.86	0.85	0.95	0.94	0.93
Methionine + cystine (%)	0.58	0.59	0.59	0.56	0.57	0.57	0.59	0.60	0.59

Table 3. Nutrient composition of some ingredients used in the experimental layer diets

Ingredient	CP (%)	CF (%)	EE (%)	Ca (%)	P (%)	ME (MJ/kg)	Lysine (%)	M + C (%)
Palm kernel meal	14.5	15.0	0.8	0.2	0.6	5.9	0.5	0.6
Corn*	8.5	2.2	3.8	0.0	0.3	14.4	0.2	0.3
Soybean meal*	44.0	7.3	1.0	0.3	0.6	9.3	2.9	1.3
Meat and bone meal*	50.0	2.8	8.6	10.1	5.0	8.0	2.6	0.9
Fish meal	54.0	1.0	8.5	5.5	2.6	12.3	4.5	2.0
Lucerne leaf meal	17.0	24.0	2.5	1.4	0.2	6.9	0.7	0.4
Palm oil	–	–	–	–	–	35	–	–

CP = crude protein
CF = crude fibre
EE = ether extract
Ca = calcium
P = phosphorus
ME = metabolizable energy
M + C = methionine + cystine
*ME based on the value of Anon. (1977)

Table 4. Energy and protein intakes of layers in relation to dietary energy and protein levels (Trial I)

Dietary		Cal: protein (kcal:%)	Av. daily intake		
ME (MJ/kg)	CP (%)		Feed (g)	Energy (MJ)	Protein (g)
–	15	–	116.0	–	17.4
–	17	–	119.4	–	20.3
–	19	–	115.8	–	22.0
10.9	–	–	115.8	1.26	–
11.5	–	–	116.7	1.34	–
12.1	–	–	118.6	1.44	–
10.9	15	173	113.6	1.24	17.0
11.5	15	183	114.7	1.32	17.2
12.1	15	193	120.5	1.46	18.1
10.9	17	153	118.6	1.29	20.2
11.5	17	161	119.8	1.38	20.4
12.1	17	171	119.2	1.44	20.3
10.9	19	136	116.3	1.27	22.1
11.5	19	144	115.1	1.32	21.9
12.1	19	153	116.7	1.41	22.2

levels increased. In Trial I, the daily energy intake increased from 1.26 MJ (301.1 kcal) to 1.44 MJ (344.1 kcal) with an average of 1.35 MJ when the dietary ME levels increased from 10.9 MJ/kg (2 600 kcal/kg) to 12.1 MJ/kg (2 900 kcal/kg) *(Table 4)*. The protein intake increased from 17.4 g to 22.0 g when the dietary CP levels increased from 15% to 19%. In Trial II, the daily energy intake increased from 1.18 MJ to 1.26 MJ *(Table 5)* with an average of 1.22 MJ when the ME levels in the diet increased from 10.5 MJ/kg (2 500 kcal/kg) to 11.5 MJ/kg (2 750 kcal/kg). The levels of protein intake increased from 16.7 g to 18.9 g when the dietary CP levels were raised from 15% to 17%. The positive response to intake with increasing dietary levels of CP and ME were also reported by Summers and Leeson (1978), as well as Olomu and Offiong (1983). In terms of

Table 5. Energy and protein intakes of layers in relation to dietary energy and protein levels (Trial II)

Dietary		Cal: protein	Av. daily intake		
ME (MJ/kg)	CP (%)	(kcal:%)	Feed (g)	Energy (MJ)	Protein (g)
–	15	–	111.3	–	16.7
–	16	–	111.0	–	17.8
–	17	–	111.0	–	18.9
10.5	–	–	112.1	1.18	–
11.1	–	–	111.7	1.24	–
11.5	–	–	109.4	1.26	–
10.5	15	167	111.3	1.17	16.7
11.1	15	176	114.3	1.27	17.1
11.5	15	183	110.1	1.27	16.5
10.5	16	156	112.6	1.18	18.0
11.1	16	166	109.5	1.22	17.5
11.5	16	172	110.5	1.27	17.7
10.5	17	147	113.0	1.19	19.2
11.1	17	156	111.1	1.23	18.9
11.5	17	162	107.8	1.24	18.3

Table 6. Effect of dietary energy and protein levels on the 52-week egg laying performance of hens (Trial I)

Dietary		Cal:protein	Total egg	% Egg	Av. egg	Total egg	Feed:egg
ME (MJ)	CP (%)	(kcal:%)	no. 1	production[1] (hen-day)	wt. (g)[2]	mass (kg)[1]	mass[1]
Effect of energy levels							
10.9	–	–	244.3a	67.1a	57.7	14.1	2.99b
11.5	–	–	246.7a	67.8a	58.0	14.3	2.97b
12.1	–	–	234.7b	64.5b	58.4	13.7	3.15a
	$LSD_{0.05}$		8.83	2.42		0.54	0.12
Effect of protein levels							
–	15	–	238.8	65.6	57.8	13.8	3.07
–	17	–	243.7	66.9	58.3	14.2	3.06
–	19	–	243.2	66.7	58.0	14.1	2.99
	$LSD_{0.05}$		8.83	2.42		0.54	0.12
Interaction effect							
10.9	15	173	236.2ab	64.9ab	57.6	13.6	3.04ab
11.5	15	183	248.1ab	68.2ab	57.6	14.3	2.92b
12.1	15	193	232.2b	63.8b	58.1	13.5	3.25a
10.9	17	153	246.0ab	67.6ab	58.1	14.3	3.02ab
11.5	17	161	246.6ab	67.8ab	58.0	14.3	3.05ab
12.1	17	171	238.4ab	65.5ab	58.7	14.0	3.10ab
10.9	19	136	250.6a	68.9a	57.9	14.5	2.92b
11.5	19	144	245.3ab	67.4ab	57.9	14.2	2.95b
12.1	19	153	233.6ab	64.2ab	58.6	13.7	3.10ab
	$LSD_{0.05}$		12.88	3.62		0.79	0.13

[1]Av. means of 27 birds
[2]Of each group over 52 weeks
Different letters in the same column under the same section differ significantly ($p<0.05$)

Table 7. Effect of energy and protein levels on the 52-week egg laying performance of hens (Trial II)

Dietary ME (MJ)	Dietary CP (%)	Cal:protein (kcal:%)	Total egg no. 1	% Egg production[1] (hen-day)	Av. egg wt. (g)[2]	Total egg mass (kg)[1]	Feed:egg mass[1]
Effect of energy levels							
10.5	–	–	253.7	69.6	61.9	15.7	2.60
11.1	–	–	256.6	70.1	61.2	15.7	2.59
11.5	–	–	257.9	70.9	61.3	15.8	2.52
	$LSD_{0.05}$		7.44	2.09		0.46	0.08
Effect of protein levels							
–	15	–	254.5	70.0	61.7	15.7	2.58
–	16	–	254.8	70.0	61.2	15.6	2.59
–	17	–	258.9	71.1	61.4	15.9	2.54
	$LSD_{0.05}$		7.44	2.09		0.94	0.21
Interaction effect							
10.5	15	167	255.0	70.1	61.6	15.7ab	2.58ab
11.1	15	176	256.8	70.6	61.1	15.7ab	2.65a
11.5	15	183	252.2	69.3	63.0	15.9ab	2.52ab
10.5	16	156	251.4	69.1	62.5	15.7ab	2.61ab
11.1	16	166	251.9	69.2	59.9	15.1b	2.64a
11.5	16	172	261.2	71.8	60.9	15.9ab	2.53ab
10.5	17	147	254.7	70.0	61.6	15.7ab	2.62ab
11.1	17	156	261.7	71.9	62.3	16.3a	2.48b
11.5	17	162	260.3	71.5	60.3	15.7ab	2.50ab
	$LSD_{0.05}$		12.88	3.62		0.79	0.13

[1]Av. means of 27 birds
[2]Of each group over 52 weeks
Different letters in the same column under the same section differ significantly ($p<0.05$)

calorie to protein ratio, there was no indication to show any effect on energy and protein intake in this study.

Performance of egg production

In Trial I, the average egg production per bird ranged from 232.2 eggs (63.8%) in the 15% protein and 12.1 MJ/kg ME group to 250.6 eggs (68.9%) in the 19% protein and 10.9 MJ/kg ME group *(Table 6)*. The average egg weight ranged from 57.6 g to 58.7 g, total egg mass from 13.5 kg to 14.5 kg and the feed to egg mass ratio from 2.92 to 3.25. When the performance of egg production was compared in terms of dietary CP levels, there was no significant difference in percentage of egg production, total egg mass and feed to egg mass ratio. However, in terms of absolute figures, the 17% and 19% protein groups had slightly better results than the 15% protein groups. In terms of dietary ME levels, significantly better egg production were observed in the 10.9 and 11.5 MJ/kg ME groups although no significant difference was observed in egg mass and feed efficiency. Poorer results were observed in the group receiving 12.1 MJ/kg ME compared with those fed lower energy levels. This trial, therefore, indicated that good laying performance could be obtained from birds fed diets with 17–19% protein and 10.9–11.5 MJ/kg (2 600–2 750 kcal/kg) ME.

Better results in egg production (69.1–71.9%) and egg weight (61.5 g) were obtained in Trial II which had narrower ranges of dietary ME (10.5–11.5 MJ/kg or 2 500–2 750 kcal/kg) and CP (15–17%) *(Table 7)*. All the egg production variables were not significantly different among birds fed diets with varying ME and CP levels.

However, a trend of slightly better egg production, egg mass and feed efficiency was observed in layers fed diets containing 17% CP and 11.5 MJ/kg ME. This minor diffference was also observed in Trial I. However, its advantage might easily be offset by the higher cost of the feed with 2% CP higher than the 15% CP group. Should the protein level be 15% or 17% is a question of economics. The protein intake in Trial II was 16.7 g/bird per day for the 15% CP diet with the average feed consumption of 111.3 g *(Table 5)*. This protein intake was slightly lower than that of White Leghorn hens as reported by Scott et al. (1976). According to these workers, for White Leghorn hen, with proper methionine supplementation in the diet, 17 g protein per hen per day was sufficient for phase I and phase II laying. Thayer et al. (1974) suggested that 15 g of protein per hen per day was sufficient to support egg production and egg weight but strict attention should be given to amino acid balance. NRC (1977) also recommended 15% protein diet for layers. The average feed intakes of the chickens in Trial I and Trial II were 117.2 g and 111.1 g respectively which were comparable to the intake of temperate country hens listed by Scott et al. (1976). Based on the laying performance in this study, 15% CP seemed to be the minimum dietary protein level required by Hisex Brown layers in this country. This will also depend on a minimum daily feed intake of 110 g. For maximum egg production, the CP level can be increased to 17%. In terms of dietary ME level, 11.1–11.5 MJ/kg ME seemed to be the favourable levels among the treatments *(Table 7)*.

Conclusion

The protein and energy intakes of layer chickens tended to increase with the increase of dietary CP and ME levels. From this study, it was observed that the daily feed intake was not less than 110 g and the dietary ME of 12.1 MJ/kg was too high for layers. The dietary protein of 15–17% and ME of 11.1–11.5 MJ/kg seemed to be the optimal ranges for brown-egg layers in the tropics. From the slightly inferior laying performance of birds receiving 15% CP as observed in Trial I, it was suggested that 17% CP should be provided for layers in high laying period (phase I) followed by 15% CP in the low laying period (phase II) with ME levels of 11.1–11.5 MJ/kg in both periods.

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