Determination of Optimum Protein and Energy Levels for Broiler Chicks in the Tropics

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SUMMARY

THREE experiments were conducted to investigate the effects of different protein levels (17, 20, 23 and 26%) and energy levels (2800, 3000 and 3200 KCals/Kg diet) on the performance of broiler chicks in the tropics. Maximum weight gains and efficiency of feed conversion were obtained on the rations containing 23 or 26% protein. As the dietary energy level increased, there was a slight depression in weight gain. The best performance of chicks was obtained on the rations containing 2800 KCals/Kg diet. Feed intake was observed to be inversely related to energy content, although in most cases not significantly so at each protein and energy series. Generally birds were observed to meet their energy requirements.

From these studies, a protein level of 23 or 26% and energy level of 2800 or 3000 KCal/Kg diet may be tentatively recommended for a tropical country like Nigeria.

INTRODUCTION

MODERN fast-growing broiler strains are now raised in Nigeria often with feed formulae containing protein and energy levels developed in the temperate zones. This is probably because there is very little, if any, published information on the optimum protein and energy levels for broiler chicks in the tropics in general and Nigeria in particular. In the temperate countries however, numerous studies have been conducted along this line. The National Research Council (NRC, 1971) recommended a protein level of 23% and metabolisable energy (ME) of 3200 KCals/Kg diet while the Agricultural Research Council (ARC, 1963) recommended protein level of 20% and ME of 2850 KCals/Kg diet for broiler chicks.

Various other workers have observed broiler chicks to perform optimally at similar or different protein and energy levels recommended by these bodies. Spring and Wilkinson (1957) reported that a 22% protein ration was adequate for optimum chick performance at ME levels of 2640, 2970 and 3300 KCal/Kg diet. O'Neil *et al* (1962) reported that the growth and feed efficiency of chicks improved as the protein level was increased stepwise from 16% to 28%. These workers also reported that an excess of energy in relation to amount of protein in the diet depressed the growth rate and feed efficiency of the experimental birds. Summers *et al* (1964) noted that differences in weight gain on rations containing protein levels between 20 and 26% were very small and reported the optimum protein level to be 22%. Rajaguru *et al* (1966) and Yoshida and Morimoto (1970) obtained maximum growth at approximately 25% protein level while Olomu *et al* (1973, unpublished data), using North American ingredients, obtained maximum performance at 24% protein level. Bartov *et al* (1974) reported that rearing broilers on diets containing protein levels slightly above or below the accepted optimum did not affect growth rate. The effects of dietary energy concentration on broiler performance have also been the subject of studies by most workers. Hill and Dansky (1954) reported that over a wide range of dietary energy concentration, chicks tended to eat to meet their energy requirements. Recently, Farrel *et al* (1973) and Farrel (1974) found that a

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metabolisable energy of 3100 KCal/Kg diet was optimal for growth to a specified live weight.

The above review clearly indicates the need for constant determination of the optimum protein and energy levels for broiler chicks. This is more so for a tropical country like Nigeria where different feedstuffs are available for ration formulation and where the environmental temperature and other conditions may be different from those available in the temperate zones.

The present studies were designed to examine the effects of varying protein and energy levels on performance of broiler chicks in Nigeria. It is hoped that from these studies tentative levels of protein and energy for broiler chicks in Nigeria would be recommended.

MATERIALS AND METHODS

Indian River broiler-type chicks purchased from a commercial farm were used in these studies. The chicks were divided into groups of 20 chicks per group such that the average initial weights and weight range were similar for the groups. Two such groups were placed at random on each treatment. In Experiments 1 and 2, day-old chicks of mixed sexes with average initial weight of 37 g per bird were used;

in Experiment 3, 7 day old bird (average initial weight of 69.75 g per bird) which have been prefed a commercial type ration were used. The experiments were terminated when the birds were 42 days old.

The birds were reared on cement floor covered with wood shavings as the bedding materials and heat was provided for the first 4 weeks of age by Kerosene-heated lamps placed under hovers. Food and water were supplied *ad libitum*. The composition of the experimental rations used in the respective experiments are shown in Tables 1, 2 and 3.

The chicks were weighed at weekly intervals and feed consumption was also recorded at weekly intervals. A record of mortality was kept. At the conclusion of the experiments, the data were subjected to analysis of variance and significance of differences were assessed by applying Duncan's Multiple Range Test at the 5% level of significance (Steel and Torrie, 1960).

Experiments 1 and 2

Four different protein levels (17, 20, 23 and 26%) and 2 energy levels (3000 and 3200 KCal ME/kg diet) were evaluated. In Experiment 1, groundnut meal was the only source of supplementary protein while in Experiment 2, 5% fish meal was also included in addition to groundnut meal.

TABLE 1

Composition of rations used in Experiment 1

	Rations							
	1	2	3	4	5	6	7	8
Ground Yellow								
Corn	64.80	54.15	43.50	32.85	69.00	58.35	47.70	37.05
Groundnut meal	23.15	32.15	41.15	50.15	24.75	33.75	42.75	51.75
Palm oil	0.95	2.60	4.25	5.90	2.00	3.65	5.30	6.95
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Periwinkle shell	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Premix ¹	.5	.50	0.50	0.50	0.50	0.50	0.50	0.50
Wheat bran	6.85	6.85	6.85	6.85	—	—	—	—
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Calculated analysis:								
Crude protein (%)	17.01	20.02	23.03	26.05	17.04	20.07	23.06	26.08
ME (kCal/kg)	3000	3000	3000	3000	3000	3000	3000	3000
C : P ratio	176.5	150.0	130.4	115.4	188.2	160.0	139.1	123.1

¹ Premix is a vitamin-mineral premix containing all the vitamins, trace minerals amprolium and antibiotics required for optimum performance of broiler chicks.

TABLE 2

Composition of rations used in Experiment 2

Ingredients (%)	Rations							
	1	2	3	4	5	6	7	8
Ground Yellow								
Corn	68.10	57.45	46.80	36.95	72.30	61.65	51.00	40.35
Groundnut meal	15.75	24.75	33.75	42.75	17.35	26.35	35.35	44.35
Palm oil	0.05	1.70	3.35	5.00	1.10	2.75	4.40	6.05
Fish meal	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Periwinkle shell	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Premix ¹	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Wheat bran	6.85	6.85	6.85	6.85	-	-	-	-
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Calculated analysis								
Crude protein (%)	17.0	20.0	23.0	26.0	17.0	20.0	23.0	26.0
ME (kCals/kg diet)	3000	3000	3000	3000	3200	3200	3200	3200
C : P ratio	176.5	150.0	130.4	115.4	188.2	160.0	139.1	123.1

¹ Premix is a vitamin-mineral mixture containing all the vitamins, trace minerals amprolium and antibiotic required for optimum performance of broilers.

TABLE 3

Ingredients (%)	Rations							
	1	2	3	4	5	6	7	8
Ground Yellow								
Corn	48.80	46.80	51.00	38.15	36.15	46.35		
Groundnut meal	32.75	33.75	35.35	41.75	42.75	44.75		
Fish meal	5.00	5.00	5.00	5.00	5.00	5.00		
Palm oil	0.35	3.35	4.40	2.00	5.00	6.05		
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00		
Periwinkle shell	0.50	0.50	0.50	0.50	0.50	0.50		
Premix ¹	0.50	0.50	0.50	0.50	0.50	0.50		
Wheat Bran	8.85	6.85	-	8.85	6.85	-		
Salt	0.25	0.25	0.25	0.25	0.25	0.25		
Calculated analysis								
Crude protein (%)	23.0	23.0	23.0	26.0	26.0	26.0		
ME (kCals/kg diet)	2800	3000	3200	2800	3000	3200		
C : P ratio	121.8	130.4	139.1	107.7	115.4	123.1		
Cost per 1000 kg	₦185.62	203.29	213.95	194.00	210.80	221.57	273.00	

¹ Premix is a vitamin-mineral mixture containing all the vitamins, trace minerals, amprolium and antibiotic required for optimum performance of broiler chicks.

Experiment 3

Since Experiments 1 and 2 had shown that performance of chicks fed rations containing ME of 3000 kCal/kg diet was slightly better than those fed ME of 3200 kCal/kg diet, the energy content of the ration was further reduced to 2800

kCal/kg diet in this experiment. Thus the rations used consisted of 3 energy levels (2800, 3000 and 3200 kCal/kg diet) and 2 protein levels (23 and 26%). In addition, a commercial ration containing 23% protein and purchased from Livestock Feeds (Nigeria) Limited was included as one of the experimental rations.

TABLE 4

Weight gain, feed consumption and efficiency of feed conversion as affected by variation in the protein and energy levels in the diet (Experiment 1)

Dietary treatments	Average weight gain ¹ g	Feed Consumption g	Efficiency of feed conversion (g feed/g gain)
A. 3000 kCals/kg diet			
1. 17% protein	229.4d	1034.6	4.51d
2. 20% protein	361.0bc	1238.2	3.43c
3. 23% protein	451.3a	1245.6	2.76a
4. 26% protein	419.5ab	1207.2	2.88ab
B. 3200 kCals/kg diet			
1. 17% protein	222.0d	914.6	4.12d
2. 20% protein	319.2c	1024.6	3.21bc
3. 23% protein	399.2abc	1093.8	2.74a
4. 26% protein	454.6a	1200.1	2.64

¹ Column values with same superscripts or not superscripts are not significantly different ($P > 0.05$).

RESULTS

Experiment 1

Results obtained in Experiment 1 are shown in Table 4. At both dietary energy levels (3000 and 3200 kCal/kg diet), there was a significant depression in weight gain and feed efficiency when the rations contained 17% or 20% protein. The differences in weight gain and feed efficiency between the rations containing 23 and 26% protein were not significant. Apart from the rations containing 26% protein, weight gains obtained on the

ration containing 3000 kCal/kg diet were slightly higher than those containing 3200 kCal/kg diet although at each protein level, the differences in weight gain were not significant. Conversely, slightly better feed efficiency was obtained with the higher energy ration although differences in feed efficiency at each protein level but same energy level, were not significant. Although feed consumption was not significantly affected by dietary treatments, it was observed that feed consumption on the low energy ration (3000 kCal/kg diet) was higher than that on the high energy ration (3200 kCal/kg diet).

TABLE 5

Weight gain, feed consumption and efficiency of feed conversion as affected by variation in the protein and energy levels of the diet (Experiment 2).

Dietary treatments	Average weight gain ¹ g	Feed consumption ¹ g feed/bird	Efficiency of feed conversion (g feed/g gain)
A. 3000 kCals/kg diet			
1. 17% protein	403.3bc	1352.6cd	3.35c
2. 20% protein	528.7ab	1438.8abc	2.72ab
3. 23% protein	573.5a	1518.4ab	2.65a
4. 26% protein	605.0a	1588.7a	2.63a
B. 3200 kCals/kg diet			
1. 17% protein	333.5c	1204.8d	3.61c
2. 20% protein	524.9ab	1432.8abc	2.73ab
3. 23% protein	528.2ab	1417.7bc	2.68a
4. 26% protein	570.1a	1451.3bc	2.55a

¹ Column values with same superscript are not significantly different ($p > 0.05$).

Experiment 2

Presented in Table 5 are results obtained in Experiment 2. At both dietary energy levels, there was a progressive improvement in weight gain and feed efficiency as the protein level was increased stepwise from 17% to 26%. It was noted however that the differences in weight gain and feed efficiency between the rations containing 20, 23 and 26% were not significant although the highest weight gain and feed efficiency were obtained on the rations containing 26% protein. The weight gain and feed efficiency on the rations containing 17% protein were particularly low. In general, as was observed in Experiment 1, the weight gains obtained on the rations containing 3000 kCal/kg diet were slightly higher than those obtained on the rations containing 3200 kCal/kg diet although such differences in weight gain were not significant.

The lowest feed consumption was obtained with the groups fed the 17% protein diet as was observed in Experiment 1. At each energy level, feed consumption was not significantly affected when the rations contained 20, 23 or 26% protein. As was also observed in Experiment 1, the amount of feed consumed were slightly higher for the 3000 kCal/kg diet groups

than for the 3200 kCal/kg diet groups, although at comparable protein levels, such differences in feed consumption were not significant.

Experiment 3

As shown on Table 6, birds fed rations containing 2800 kCal/kg diet grew slightly better than those fed rations containing 3000 kCals/kg diet and these in turn grew better than those fed rations containing 3200 kCal/kg diet. At each energy level, the weight gains of birds were not significantly affected by the dietary protein level. Thus the difference in weight gains between the 23% protein level and the 26% protein level were not significant, results similar to those obtained in Experiments 1 and 2. The differences in feed consumptions were not significant although there was a slight decrease in feed consumption as the dietary energy level was increased, results similar to those obtained in Experiment 1 and 2.

The best feed efficiency was obtained on the ration containing 3000 kCal/kg diet although this was not significantly different from that obtained on the ration containing 2800 kCal/kg diet. The highest feed to gain ratio was obtained on the rations containing 3200 kCal/kg diet

TABLE 6

Weight, feed consumption, efficiency of feed conversion, Caloric intake and mortality as affected by variation in Calorie: protein ratio (Experiment 3).

Dietary treatment								
Ration No.	ME level (kCal)	Protein level %	Av wt gain g	Feed Consumption g feed / bird	EFC; g feed/g gain	Caloric intake kCal/bird 3	Mortality	Cost of feed/kg live wt gain ₦
1	2800	23	533.0ab	4438.6	2.70ab	4028.1	2.5	0.51c
2	3000	23	530.2ab	1352.0	2.55a	4056.0	0.0	0.52c
3	3200	23	470.2ab	1331.6	2.84bc	4261.1	0.0	0.61b
4	2800	26	543.8a	1422.2	2.62ab	3982.2	5.0	0.51c
5	3000	26	499.9ab	1294.7	2.59ab	3888.4	2.5	0.55c
6. Commercial ² ration		23	526.50ab	1413.1	2.68ab	?	2.5	0.71a

1 Column values with same superscripts or no superscript are not significantly different ($P < 0.05$.)

2 The Commercial ration is a 'Special' broiler ration purchased from Desba Feeds, an agent of Pfizer Feed Ltd. The ME level is not known.

3 Calculated by multiplying feed consumed by metabolizable energy of the ration.

The caloric intakes on all rations were similar. Percentage mortality was moderate for broiler chicks and showed no statistical significance.

In general, the growth rates and feed efficiency of the birds fed the experimental rations were similar to those of birds fed the commercial ration particularly the birds fed rations containing 23 or 26% protein and 2800 or 3000 kCal/kg diet.

The cost of feed per 1000 kg (excluding labour costs) showed that the ration with ME of 2800 kCal/kg diet and protein level of 23% was the cheapest (N185.62) and ration with ME of 3200 kCal/kg and protein of 26% was the costliest (N221.57). As shown in Table 6, when the cost of feed was expressed in terms of cost per/kg live weight gain, the rations with ME of 3200 kCals were the most costly (N0.61 and N0.66) while those with ME of 2800 were the cheapest (N0.51).

DISCUSSION

The present results clearly indicate that as the dietary protein level increased up to a certain optimum, there was an improvement in performance of broilers, an observation similar to those of other workers (Summers *et al*, 1964; Rajaguru *et al*, 1966 and Bartov *et al*, 1974). Optimum performance of the birds in these studies was obtained at protein levels of 23 and 26%.

The overall results relating to weight gains, feed consumption and feed efficiency agree with previous findings (Farrell *et al*, 1973) in that there is an optimum energy concentration in the ration beyond which performance of birds does not appear to improve and in some cases actually deteriorates. In the present studies, above 2800 kCal/ME/kg diet, there was hardly any further improvement in weight gain, feed consumption and feed efficiency. The observation that feed consumption reduced as the dietary energy increased agree with the findings of Farrell *et al* (1973) who showed that food intake of chickens was inversely related to dietary energy concentration. The energy consumption on

all rations were similar inspite of the differences in dietary energy concentration. This observation is in accordance with the widely accepted concept that over a wide range of dietary energy concentrations, chickens tend to eat in order to satisfy their energy requirement (Hill and Dansky, 1954; Farrell *et al*, 1973).

The results also indicate the need for supplementation of groundnut-based rations with a high quality protein source like fishmeal. This is because performance of birds in Experiment 1 was much lower than that of birds in Experiment 2. Both experiments were performed simultaneously with the same batch of birds and under similar environmental conditions. Therefore a direct comparison between both experiments is possible. The observation on the need to supplement groundnut-based rations with fishmeal agrees with the previous observation of Rajaguru *et al* (1966).

In recommending the optimum protein and energy levels for these chicks, 3 factors have been taken into consideration namely: the growth rate, feed conversion efficiency and cost of feed per kg. live-weight gain. Using these criteria, the rations containing ME of 3200 kCal/kg diet are not recommended. The growth rates of the chicks were slightly higher on the rations containing 2800 kCals/kg diet than those of chicks on the rations containing 3000 kCals/kg diet. Based on the relative costs of the diet, the ration containing 2800 kCals/kg diet was the cheapest and therefore seems adequate. In most cases, the performance of birds fed rations containing 23% protein was similar to that of birds fed rations containing 26% protein diet. At these protein levels again, the relative cost of the ration would seem to be the most important factor determining which protein level would be adequate. Based on these studies, the 23% protein diet seems adequate.

In general, a lower limit of 23% protein and upper limit of 26% protein may be recommended for broiler chicks in the tropics. An upper limit of 3000 kCal/kg

diet and an optimum ME level of 2800 kCal/kg diet are recommended. The 23% optimum protein level recommended is similar to that recommended for some temperate countries (NRC, 1971) but the energy level recommended is less than the 3200 kCal recommended for temperate countries (NRC, 1971). The present results thus indicate that a narrower calorie: protein ratio (122) may be needed in Nigeria as compared to a wider calorie: protein ratio (139) recommended by NRC (1971). A possible reason for this difference may be that with the higher environmental temperatures obtainable in the tropics, less energy is needed by these chicks as compared to the chicks reared in the temperate countries. The present results and our previous findings with pigs (Babatunde *et al*, 1972) where protein levels recommended for pigs were higher than the recommendations for temperate countries probably indicate a need for further evaluation of nutrient requirements of farm animals reared in the tropics. The recent findings of Sugandi *et al* (1975) where protein level (17%) recommended for layers in the tropics was higher than that (15%) for the temperate zones and energy level of 2650 and 2850 kCal/kg diet was lower than that for the temperate zones (2900, NRC, 1971) confirm the need for further evaluation of nutrient requirements of farm animals reared in the tropics.

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