# OPTIMUM PROTEIN AND ENERGY LEVELS FOR LOCAL AND EXOTIC EGG-TYPE, CHICKENS IN THE HUMID TROPICS

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**ABSTRACT**

**The development of indigenous stock in the tropics must be accompanied by an evaluation of their nutrient requirements alongside those of the adapted exotic stock. In two separate experiments, a total of 28 dietary combinations of protein (18% — 24%) and metabilisable energy (2.6—3.2 Mcal/kg) were assessed using four lines of exotic, local and exotic x local crosses of 0—8 week old starter pullets. A combination of 2.8 Mcal/kg with 24% ($E_{2.8}$ $P_{24}$) gave the best overall performance, while $E_{3.0}$ $P_{24}$ gave the best feed efficiency. However, diet $E_{2.8}$ $P_{18}$ gave the least feed cost per unit of body weight gain of all the 28 diets. It is therefore suggested as the optimum diet. The four genetic lines manifested wide variations in their performance values but showed no separate requirements for protein or energy.**

## INTRODUCTION

A fundamental obstacle to the development and improvement of tropical livestock has been the absence of a suitable feed standard adapted to tropical conditions. The limitations of existing standards in their applicability to the tropics derive from high ambient temperatures which reduce feed and nutrient intake in the tropics (Oluyemi *et al* 1979a). The implications are serious both for adapted exotic breeds in the tropics whose productivity may be underestimated and also for indigenous breeds, the development or assessment of which must demand a rationalisation of their obtimum nutrient requirements.

Recent reports on protein and energy requirements for poultry in Nigeria (Olomu 1979, Songu, 1978) have confirmed the need for a separate requirement for the tropics. Other experiments (Oluyemi, 1974, 1979) also indicate that the Nigerian local fowl may have requirements different from adapted exotic strains under Nigerian conditions, although they found no significant genetic × diet interaction. Protein levels similar to N.R.C. (1977) recommendation have been found adequate for egg type starter chicks and growing pullets under Nigerian conditions by a panel of Nigerian Feeding Standards (Olomu 1979). The same panel also suggested energy levels lower than those used for temperate environments. Olomu 1979 also observed lower performance when energy levels similar to those in temperate countries are used for birds in the tropics. This opinion has a strong basis on the widely accepted view that high ambient temperatures and high energy levels depress feed intake.

It is necessary to verify these recommendations as they affect the performances of adapted breeds in the tropics as well as indigenous stock and their crosses with exotic breeds.

The objective of the study reported here was to identify the optimal levels and ratios of protein and energy which would promote the best performance of starter egg type chickens. It was also aimed at ascertaining if the various genotypes — exotic, local and their crosses would manifest different requirements for protein and energy under Southern Nigerian environmental conditions.

## MATERIALS AND METHODS

Two experiments were conducted in this study. Experiment 1 consisted of 16 dietary combinations of 4 metabolizable energy levels: 2.6, 2.8, 3.0 and 3.2

**Mcal/kg,** 4 protein levels: 18, 20, 22 and **24% and** used 180 day old chicks comprising **three** genotypes, Gold Link (GL), Nigerian Local Chicken (LC) LC × GL and GL × LC. The experimental design was a 4 × 4 × 3 factorial type using completely randomised arrangement. Experiment 2 consisted of 12 dietary combinations with 3 metabolizable energy levels (2.8, 3.0 and 3.2 Mcal/kg and 4 protein levels (18, 20, 22 and 24%) and used 144 day old chicks from genotypes, GL, LC, GL × LC × GL.

The birds used in experiment 1 were originally hatched on the same date and raised from day old stage through 8 weeks of age under identical conditions of housing, feeding and management. The fertile eggs were incubated around 4 months of lay and hatched in the same batch. Segregation into sex was accomplished at day old stage of the GL birds using colour differences but in the LC and GL crosses, this was estimated by using body weight differences and external characteristics, as described by Ajala and Diamond (1982). The day old chicks were replicated 4 times in groups of 15 birds per replicate and 60 birds per genotype. They were housed in 12 large brooder cages measuring $1.5m^2$ each and provided with adequate heat, water and *ad libitum* feed. The experiment lasted for 56 days after which two birds per replicate were removed to individual metabolism cages for the total faecal collection and dry matter digestibility determination.

The birds used in experiment 2 had the same history with those in experiment 1 but the eggs were collected at 6 months of lay and incubated in a separate batch. One hundred and forty four pullets were selected in the manner described for experiment 1. They were arranged in 16 groups of 9 birds per replicate and 36 birds per genotype. All four genotypes, GL, LC, LC × GL and GL × LC were studied.

The experimental diets used in the two experiments were as shown in Table 1. Experiment 1 had 16 diets combinations of 18—24% protein levels and 2.6—3.2 Mcal/kg metabolizable energy, while experiment 2 had the same protein range but a 2.8—3.2 Mcal/kg ME range. Experiments 1 and 2 diets had similar com-

TABLE 1

Composition of Starter Diets Used in Experiments 1 and 2

| *Ingredients* | *Energy (kcal/kg) 2600* *Protein (%)* | | | | *2800* | | | | *3000* | | | | *3200* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 18 | 20 | 22 | 24 | 18 | 20 | 22 | 24 | 18 | 20 | 22 | 24 | 18 | 20 | 22 | 24 |
| Maize | 45 | 45 | 45 | 45 | 55 | 55 | 55 | 55 | 60 | 60 | 60 | 60 | 60.62 | 58.67 | 59.25 | 53.62 |
| Rice Bran | 18 | 14 | 10 | 6 | 11 | 7 | 3 | 1 | 10 | 6 | 1 | — | 4 | 3 | — | — |
| Brewers grain | 13 | 11 | 9 | 8 | 10 | 8 | 6 | 1 | 4 | 2 | 1 | — | 5 | 5 | 2 | — |
| Groundnut cake | 18.4 | 23.0 | 27.0 | 30.0 | 18.4 | 23 | 27 | 32 | 20.4 | 25 | 29 | 29 | 20.88 | 24.83 | 28.75 | 30.88 |
| Fish meal | 1.6 | 3 | 5 | 7 | 1.6 | 3 | 5 | 7 | 1.6 | 3 | 5 | 7 | 2 | 3 | 6 | 8 |
| Palm oil | — | — | — | — | 1 | 1 | 1 | — | 1 | 1 | 1 | 1 | 3.5 | 3.5 | 3.0 | 2.5 |
| Oyster shell | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Bone ash | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Vitamin/mineral premix | 0.5 | 0.5 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 0.5 | 0.5 | 0.5 | 0.5 |
| Salt | 0.5 | 0.5 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 0.5 | 0.5 | 0.5 | 0.5 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Calculated ME Mcal/kg | 2.61 | 2.64 | 2.66 | 2.70 | 2.82 | 2.83 | 2.85 | 2.80 | 2.97 | 3.01 | 2.97 | 2.98 | 3.16 | 3.21 | 3.22 | 3.15 |
| Calculated CP % | 18.20 | 20.27 | 22.21 | 24.01 | 17.62 | 19.6 | 21.69 | 24.64 | 19.63 | 21.00 | 23.6 | 23.68 | 19.61 | 20.30 | 22.30 | 23.50 |
| Analysed CP % | 18.05 | 21.00 | 22.15 | 23.47 | 18.60 | 19.90 | 22.75 | 24.50 | 17.94 | 20.78 | 22.30 | 25.16 | 18.13 | 21.20 | 21.66 | 25.05 |
| Calorie-Protein ratio (Kcal ME/gm protein) | 14.40 | 13.00 | 11.82 | 10.83 | 15.56 | 14.00 | 12.73 | 11.67 | 16.67 | 15.0 | 13.6 | 12.50 | 17.78 | 16.00 | 14.55 | 13.33 |
| Lysine % | 0.69 | 0.78 | 0.90 | 1.01 | 0.65 | 0.75 | 0.86 | 0.98 | 0.63 | 0.73 | 0.85 | 0.93 | 0.64 | 0.74 | 0.90 | 0.99 |
| Methionine % | 0.29 | 0.32 | 0.31 | 0.40 | 0.31 | 0.31 | 0.39 | 0.39 | 0.28 | 0.30 | 0.34 | 0.37 | 0.28 | 0.31 | 0.36 | 0.39 |
| Cystine % | 0.32 | 0.34 | 0.39 | 0.42 | 0.32 | 0.38 | 0.42 | 0.31 | 0.35 | 0.38 | 0.39 | 0.32 | 0.34 | 0.35 | 0.35 | 0.40 |
| Methionine + Cystine | 0.61 | 0.66 | 0.70 | 0.82 | 0.63 | 0.69 | 0.81 | 0.70 | 0.63 | 0.68 | 0.73 | 0.69 | 0.62 | 0.66 | 0.71 | 0.79 |

position but were mixed as separate batches. Data on feed consumption, water consumption, body weight changes, and total faeces plus urine were collected for experiment 1, but in experiment 2, no faecal + urinal collection was made. The parameters evaluated in experiment 1 were average daily feed, average daily gain, feed-gain ratio, average daily water consumption, dry matter digestibility, nitrogen retention, protein efficiency ratio. In experiment 2 the same parameters except dry matter digestibility, nitrogen retention and average daily water consumption were measured. Body weight at 8 weeks was also measured.

Statistical analyses were carried out on all data using factorial method on completely randomised design. Where significant differences were detected in the main effects or interactions, Duncan's Multiple Range Test was used to separate and identify the differences (Steel and Torrie, 1960).

## RESULTS

The performance of starter chickens to varying protein and energy levels is summarised in Table 2 for 7 response parameters (Experiment 1) and in Table 3 for 4 response parameters (Experiment 2).

### *Average Daily Feed Consumption:*

In experiment 1, average daily feed consumption showed significant protein and energy × protein interaction effects ($P < 0.05$) but no significant energy, genotype, genotype × energy or genotype × protein interaction effects were observed ($P > 0.05$). Maximum feed consumption was promoted by diet $E_{2.8}$ $P_{24}$ while the least feed consumption occurred in diet $E_{3.2}$ $P_{18}$. The least feed consumption was however 66% of the maximum value. In experiment 2 (Table 3), there were significant differences due to energy, genotype and energy × protein interaction ($P < 0.05$) but not protein, energy ×

TABLE 2

**Response of chickens to Varying Protein and Energy Levels (Experiment 1)**

| | *ENERGY Mcal/kg* | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2.8** | | | | **2.8** | | | | **3.0** | | | | **3.2** | | | | **Mean** | **S.E.** |
| Protein % | 18 | 20 | 22 | 24 | 18 | 20 | 22 | 24 | 18 | 20 | 22 | 24 | 18 | 20 | 22 | 24 | | |
| Energy/Protein Ratio (kcal/gm) | 14.44 | 13.00 | 11.82 | 10.83 | 15.56 | 14.00 | 12.73 | 11.67 | 16.67 | 15.00 | 13.64 | 12.50 | 17.78 | 16.00 | 14.55 | 13.33 | | |
| Average Daily Feed (g) | 20.18$^{bc}$ | 19.19$^{bc}$ | 22.03$^{abc}$ | 26.59$^{a}$ | 23.27$^{ab}$ | 20.28$^{bc}$ | 24.75$^{a}$ | 26.87$^{a}$ | 22.33$^{abc}$ | 26.12$^{a}$ | 25.68$^{a}$ | 20.16$^{bc}$ | 17.74$^{a}$ | 22.41$^{abc}$ | 23.09$^{abc}$ | 21.51$^{abc}$ | 23.78 | 1.42 |
| Average Daily Gain (g) | 5.04$^{c}$ | 4.94$^{c}$ | 5.83$^{bc}$ | 8.22$^{a}$ | 6.75$^{abc}$ | 5.52$^{bc}$ | 6.88$^{abc}$ | 8.68$^{a}$ | 5.94$^{bc}$ | 7.02$^{abc}$ | 7.74$^{ab}$ | 6.89$^{abc}$ | 5.23$^{bc}$ | 6.43$^{abc}$ | 6.32$^{abc}$ | 7.42$^{abc}$ | 6.56$^{**}$ | 0.64 |
| Feed per Unit of Gain | 4.00$^{a}$ | 3.88$^{a}$ | 3.78$^{ab}$ | 3.23$^{ab}$ | 3.45$^{ab}$ | 3.67$^{ab}$ | 3.60$^{ab}$ | 3.10$^{ab}$ | 3.76$^{ab}$ | 3.71$^{ab}$ | 3.32$^{ab}$ | 2.93$^{b}$ | 3.39$^{ab}$ | 3.49$^{ab}$ | 3.65$^{ab}$ | 2.90$^{b}$ | 3.49 | 0.28 |
| Average Daily Water Intake (ml). | 34.14$^{def}$ | 41.74$^{bcde}$ | 36.51$^{cdef}$ | 42.88$^{bc}$ | 39.03$^{bcdef}$ | 33.93$^{def}$ | 37.72$^{cdef}$ | 60.96$^{a}$ | 31.77$^{f}$ | 35.95$^{cdef}$ | 46.10$^{bc}$ | 44.10$^{bc}$ | 33.75$^{ef}$ | 40.13$^{bcde}$ | 37.98$^{cdef}$ | 42.04$^{bcd}$ | 39.92$^{**}$ | 2.38 |
| Dry Matter Digestibility (%) | 63.46$^{abc}$ | 54.65$^{c}$ | 54.21$^{c}$ | 61.32$^{bc}$ | 55.75$^{c}$ | 67.13$^{abc}$ | 70.86$^{ab}$ | 59.46$^{bc}$ | 75.23$^{a}$ | 62.61$^{abc}$ | 63.78$^{abc}$ | 59.74$^{bc}$ | 74.80$^{d}$ | 71.95$^{ab}$ | 70.00$^{ab}$ | 62.87$^{abc}$ | 64.24$^{**}$ | 3.28 |
| Nitrogen Retention (g per day) | 2.01$^{c}$ | 2.98$^{abc}$ | 2.59$^{bc}$ | 3.34$^{abc}$ | 3.45$^{ab}$ | 2.34$^{bc}$ | 2.61$^{bc}$ | 4.53$^{a}$ | 2.33$^{bc}$ | 2.60$^{bc}$ | 2.89$^{abc}$ | 4.56$^{a}$ | 1.63$^{c}$ | 1.87$^{c}$ | 2.29$^{bc}$ | 3.83$^{ab}$ | 2.87$^{**}$ | 0.47 |
| Protein Efficiency Ratio | 1.39 | 1.21 | 1.20 | 1.32 | 1.57 | 1.37 | 1.22 | 1.29 | 1.77 | 1.31 | 1.36 | 1.37 | 1.63 | 1.35 | 1.27 | 1.38 | 1.38 | 0.099 |
| Feed Cost per kg Gain (N) | 0.93 | 1.02 | 1.11 | 1.04 | 0.88 | 1.04 | 1.14 | 1.08 | 1.03 | 1.12 | 1.11 | 1.02 | 0.96 | 1.07 | 1.26 | 1.03 | 1.05 | 0.086 |

— a,b,c... Means of a parameter followed by the same letter are significantly not different at 5% level.

* $P < 0.05$; ** $P < 0.01$;

TABLE 3

**Response of Chickens to Varying Protein and Energy Levels (Experiment 2)**

| | *ENERGY Mcal/kg* | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2.8 | | | | 3.0 | | | | 3.2 | | | | Mean | S.E. |
| ***Protein %*** | 18 | 20 | 22 | 24 | 18 | 20 | 22 | 24 | 18 | 20 | 22 | 24 | | |
| Energy/Protein (kcal/gm) | 15.56 | 14.00 | 12.73 | 16.67 | 15.00 | 13.64 | 12.50 | 17.78 | 16.00 | 14.55 | 13.33 | | | |
| Average Daily Feed (g) .. | 19.63$^{abc}$ | 18.88$^{bc}$ | 20.20$^{ab}$ | 21.06$^{ab}$ | 18.50$^{ab}$ | 17.08$^{cd}$ | 22.00$^{a}$ | 18.60$^{bc}$ | 16.45$^{cd}$ | 17.83$^{cd}$ | 14.80$^{d}$ | 16.75$^{cd}$ | 18.45$^{***}$ | 1.42 |
| Feed per Unit of Gain .. | 3.38$^{a}$ | 3.05$^{b}$ | 2.69$^{c}$ | 2.31$^{de}$ | 3.06$^{b}$ | 2.63$^{c}$ | 2.44$^{cd}$ | 2.11$^{e}$ | 3.43$^{a}$ | 3.30$^{ab}$ | 2.64$^{c}$ | 2.33$^{d}$ | 2.78$^{***}$ | 0.09 |
| Protein Efficiency Ratio .. | 1.66$^{def}$ | 1.65$^{ef}$ | 1.72$^{cde}$ | 1.83$^{bcd}$ | 1.83$^{bcd}$ | 1.94$^{ab}$ | 1.87$^{abc}$ | 2.01$^{a}$ | 1.65$^{ef}$ | 1.54$^{f}$ | 1.75$^{cde}$ | 1.81$^{bcde}$ | 1.77$^{***}$ | 0.05 |
| Body Wt. at 8wks (kg) .. | 0.30$^{de}$ | 0.31$^{de}$ | 0.37$^{b}$ | 0.44$^{a}$ | 0.31$^{de}$ | 0.33$^{cd}$ | 0.43$^{a}$ | 0.42$^{a}$ | 0.28$^{f}$ | 0.30$^{ef}$ | 0.36$^{de}$ | $^{bc}$ | **0.34**$^{***}$ | **0.012** |
| Feed Cost per kg Gain (N) | 0.86 | 0.87 | 0.85 | 0.80 | 0.83 | 0.79 | 0.81 | 0.74 | 0.98 | 1.01 | 0.91 | 0.83 | **0.86** | **0.07** |

a,b,c,... Means of a parameter followed by the same letter are significantly not different at 5% level
* = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.005$.

genotype or genotype × protein interactions ($P > 0.05$). Feed consumption was maximised by diet $E_{3.0}$ $P_{22}$ while the least consumed feed was diet $E_{3.2}$ $P_{22,}$ which value was 67% of the maximum feed consumption.

A comparison of the 3 genotypes used in experiment 1 is shown in Table 4 while that of the 4 genotypes used in experiment 2 is shown in Table 5. The LC × GL genotype consumed more feed than either the GL × GL or the GL × LC genotypes (Table 4). These differences were however not significant ($P > 0.05$). The diets in which highest feed consumption occurred for each genotype were $E_{2.8}$ $P_{24,}$ $E_{3.0}$ $P_{24}$ for GL × GL, LC × GL and GL × LC, respectively. In experiment 2 (Table 4), significant differences were observed in feed consumption between GL × GL on the one hand, and LC × LC, LC × GL and GL × LC on the other. GL × LC consumed the highest amount of feed while GL × GL consumed the least, a similar trend as in experiment 1. Diets $E_{3.0}$ $P_{22,}$ $E_{2.8}$ $P_{24,}$ and $E_{2.8}$ $P_{18}$ were the optimum diets for the genotypes GL × GL, LC × GL, GL × LC and LC × LC, respectively. General trends indicate that the 2.6 Mcal/kg or 3.2 Mcal/kg energy diets were inferior to either the 3.0 Mcal/kg or 2.8 Mcal/kg diets in feed intake. Overall, the 2.8 Mcal/kg energy diets supported the highest intake. Within energy levels, the 22% protein diets appeared to promote more feed intake than the 24%, 20% or 18% protein levels, in that order. The same trend was apparent in experiment 2.

### *Average Daily Gains:*

In experiments 1 and 2, the same diet $E_{2.8}$ $P_{24}$ promoted the highest average daily gains. There were significant diferents: $P < 0.01$ in experiment 1 and $P < 0.05$ in experiment 2. Significant differences in experiment 1 (P 0.05) were also observed for protein but not for the other effects. In experiment 2, there were significant protein, energy, genotype ($P < 0.005$) and energy × protein interaction effects ($P < 0.05$). Maximum average gains were 8.22 g/day and 9.10 g/day in experiments 1 and 2, respectively.

Genotype comparisons (Table 4 and 5) showed that GL × GL outgained others ($P < 0.05$) in experiment 1 while LC × GL outgained the others in experiment 2 ($P < 0.05$). Optimum diets for maximum gains were $E_{2.8}$ $P_{24,}$ $E_{2.6}$ $P_{24,}$ and $E_{2.6}$ $P_{24}$ $E_{3.0}$ $P_{22}$ and $E_{2.8}$ $P_{24,}$ respectively for GL × GL, LC × GL, GL × LC and LC ×

TABLE 3

**Response of Chickens to Varying Protein and Energy Levels (Experiment 2)**

| | *ENERGY Mcal/kg* | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2.8 | | | | 3.0 | | | | 3.2 | | | | **Mean** | **S.E.** |
| ***Protein %*** | 18 | 20 | 22 | 24 | 18 | 20 | 22 | 24 | 18 | 20 | 22 | 24 | | |
| Energy/Protein (kcal/gm) | 15.56 | 14.00 | 12.73 | 16.67 | 15.00 | 13.64 | 12.50 | 17.78 | 16.00 | 14.55 | 13.33 | | | |
| Average Daily Feed (g) .. | $19.63^{abc}$ | $18.88^{bc}$ | $20.20^{ab}$ | $21.06^{ab}$ | $18.50^{ab}$ | $17.08^{cd}$ | $22.00^{a}$ | $18.60^{bc}$ | $16.45^{cd}$ | $17.83^{cd}$ | $14.80^{d}$ | $16.75^{cd}$ | $18.45^{***}$ | 1.42 |
| Feed per Unit of Gain .. | $3.38^{a}$ | $3.05^{b}$ | $2.69^{c}$ | $2.31^{de}$ | $3.06^{b}$ | $2.63^{c}$ | $2.44^{cd}$ | $2.11^{e}$ | $3.43^{a}$ | $3.30^{ab}$ | $2.64^{c}$ | $2.33^{d}$ | $2.78^{***}$ | 0.09 |
| Protein Efficiency Ratio .. | $1.66^{def}$ | $1.65^{ef}$ | $1.72^{cde}$ | $1.83^{bcd}$ | $1.83^{bcd}$ | $1.94^{ab}$ | $1.87^{abc}$ | $2.01^{a}$ | $1.65^{ef}$ | $1.54^{f}$ | $1.75^{cde}$ | $1.81^{bcde}$ | $1.77^{***}$ | 0.05 |
| Body Wt. at 8wks (kg) .. | $0.30^{de}$ | $0.31^{de}$ | $0.37^{b}$ | $0.44^{a}$ | $0.31^{de}$ | $0.33^{cd}$ | $0.43^{a}$ | $0.42^{a}$ | $0.28^{f}$ | $0.30^{ef}$ | $0.36^{de}$ | $^{bc}$ | $\mathbf{0.34}^{***}$ | **0.012** |
| Feed Cost per kg Gain (N) | 0.86 | 0.87 | 0.85 | 0.80 | 0.83 | 0.79 | 0.81 | 0.74 | 0.98 | 1.01 | 0.91 | 0.83 | **0.86** | **0.07** |

a,b,c,... **Means of a parameter followed by the same** letter are significantly not **different at 5% level**

* = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.005$.

genotype or genotype × protein interactions ($P > 0.05$). Feed consumption was maximised by diet $E_{3.0}$ $P_{22}$ while the least consumed feed was diet $E_{3.2}$ $P_{22}$, which value was 67% of the maximum feed consumption.

A comparison of the 3 genotypes used in experiment 1 is shown in Table 4 while that of the 4 genotypes used in experiment 2 is shown in Table 5. The LC × GL genotype consumed more feed than either the GL × GL or the GL × LC genotypes (Table 4). These differences were however not significant ($P > 0.05$). The diets in which highest feed consumption occurred for each genotype were $E_{2.8}$ $P_{24}$, $E_{3.0}$ $P_{24}$ for GL × GL, LC × GL and GL × LC, respectively. In experiment 2 (Table 4), significant differences were observed in feed consumption between GL × GL on the one hand, and LC × LC, LC × GL and GL × LC on the other. GL × LC consumed the highest amount of feed while GL × GL consumed the least, a similar trend as in experiment 1. Diets $E_{3.0}$ $P_{22}$, $E_{2.8}$ $P_{24}$, and $E_{2.8}$ $P_{18}$ were the optimum diets for the genotypes GL × GL, LC × GL, GL × LC and LC × LC, respectively. General trends indicate that the 2.6 Mcal/kg or 3.2 Mcal/kg energy diets were inferior to either the 3.0 Mcal/kg or 2.8 **Mcal/kg diets** in feed intake. Overall, the 2.8 Mcal/kg **energy** diets supported the highest intake. **Within** energy levels, the 22% protein **diets** appeared to promote more feed intake than the 24%, 20% or 18% protein levels, in that order. The same trend was apparent in experiment 2.

### *Average Daily Gains:*

In experiments 1 and 2, the same diet $E_{2.8}$ $P_{24}$ promoted the highest average daily gains. There were significant different: $P < 0.01$ in experiment 1 and $P < 0.05$ in experiment 2. Significant differences in experiment 1 (P 0.05) were also observed for protein but not for the other effects. In experiment 2, there were significant protein, energy, genotype ($P < 0.005$) and energy × protein interaction effects ($P < 0.05$). Maximum average gains were 8.22 g/day and 9.10 g/day in experiments 1 and 2, respectively.

Genotype comparisons (Table 4 and 5) showed that GL × GL outgained others ($P < 0.05$) in experiment 1 while LC × GL outgained the others in experiment 2 ($P < 0.05$). Optimum diets for maximum gains were $E_{2.8}$ $P_{24}$, $E_{2.6}$ $P_{24}$, and $E_{2.6}$ $P_{24}$ $E_{3.0}$ $P_{22}$ and $E_{2.8}$ $P_{24}$, respectively for GL × GL, LC × GL, GL × LC and LC ×

TABLE 4

**The Response of Three Genotypes of Exotic and Local Chickens to Varying Protein and Energy Levels (Experiment) 1)**

| | *GENOTYPES* | | | | |
|---|---|---|---|---|---|
| | GL × GL | LC × GL | GL × LC | MEAN | P |
| Average Daily Feed (g) | 22.89 (4.57)* | 23.18 (2.66) | 21.85 (2.85) | 22.64 | n.s. |
| Optimum diet @ | $E_{2.8}$ $P_{24}$ | $E_{3.0}$ $P_{18}$ | $E_{2.6}$ $P_{24}$ | $E_{2.8}$ $P_{24}$ | |
| Average Daily gain (g) | 6.96 (1.80) | 6,43 (0.91) | 6.46 (1.48) | 6.62 | n.s. |
| Optimum diet | $E_{2.8}$ $P_{24}$ | $E_{2.6}$ $P_{24}$ | $E_{2.6}$ $P_{24}$ | $E_{2.8}$ $P_{24}$ | |
| Feed/Gain | 3.29 (0.52) | 3.60 (0.38) | 3.38 (0.60) | 3.42 | n.s. |
| Optumum diet | $E_{3.2}$ $P_{24}$ | $E_{2.6}$ $P_{24}$ | $E_{3.0}$ $P_{24}$ | $E_{3.0}$ $P_{24}$ | |
| Average daily water (ml) | 39.92 (6.73) | 39.15 (5.94) | 37.25 (5.86) | 38.77 | n.s. |
| Optimum diet | $E_{2.8}$ $P_{24}$ | $E_{2.6}$ $P_{24}$ | $E_{2.8}$ $P_{22}$ | $E_{2.8}$ $P_{24}$ | |
| Protein efficiency Ratio | 1.43 (0.22) | 1.31 (0.17) | 2.87 (0.98) | 2.87 | n.s. |
| Optimum diet | $E_{3.2}$ $P_{18}$ | $E_{2.6}$ $P_{18}$ | $E_{2.8}$ $P_{18}$ | $E_{3.2}$ $P_{18}$ | |
| Nitrogen retention per day (g) | 2.90 (1.25) | 2.83 (1.17) | 2.87 (0.98) | 2.87 | n.s. |
| Optimum diet | $E_{3.0}$ $P_{24}$ | $E_{2.8}$ $P_{18}$ | $E_{2.8}$ $P_{24}$ | $E_{3.0}$ $P_{24}$ | |
| DM Digestibility (%) | 60.75 (9.45) | 61.93 (8.58) | 70.03 (6.98) | 64.24 | $P < 0.01$ |
| Optimum diet | $E_{3.2}$ $P_{22}$ | $E_{3.0}$ $P_{18}$ | $E_{2.8}$ $P_{22}$ | $E_{3.0}$ $P_{18}$ | |

@ Diet at which the mean value for the genotype was optimal.

* Standard Deviation.

LC in experiment 2. General protein and energy effects indicate that gains increased linearly as dietary protein levels were increased from 18%—24%. On the other hand, energy promoted peak gains at 2.8 or 3.0 Mcal/kg levels and declined at the 3.2 Mcal/kg level. This trend was common in the two experiments and was true of both feed intake and average daily gain.

***Feed-Gain Efficiency:***

Feed-gain efficiency was maximised in diet $E_{3.0}$ $P_{24}$ in both experiment 1 and 2 at 5% and 0.5% levels of confidence, respectively. Only protein effects were

TABLE 5

**The Response of Four Genotypes of Exotic and Indigenous Chickens to Varying Protein and Energy Leves (Experiment 2)**

| | *GENOTYPES* | | | | | |
|---|---|---|---|---|---|---|
| **Parameters** | **GL × GL** | **LC × GL** | **GL × LC** | **LC × LC** | **Mean** | **P** |
| Average Daily Feed | 15.73 (2.20) | 19.43 (2.14) | 20.46 (3.39) | 18.30 (1.66) | 18.48 | $P < 0.005$ |
| Optimum diet | $E_{3.0}$ $P_{22}$ | $E_{2.8}$ $P_{24}$ | $E_{2.8}$ $P_{24}$ | $E_{2.8}$ $P_{18}$ | $E_{3.0}$ $P_{22}$ | |
| Average Daily Gain (g) | 7.26$^{a}$ (1.69) | 7.62$^{a}$ (1.70) | 6.62$^{b}$ (1.6) | 5.81$^{c}$ (0.76) | 6.83 | $P < 0.005$ |
| Optimum diet | $E_{3.0}$ $P_{22}$ | $E_{2.8}$ $P_{24}$ | $E_{3.0}$ $P_{22}$ | $E_{2.8}$ $P_{24}$ | $E_{2.8}$ $P_{24}$ | |
| Feed Per Unit of Gain | 2.17 (0.44) | P.55 (0.46) | 3.09 (0.41) | 3.15 (0.53) | 2.74 | $P < 0.005$ |
| Optimum diet | $E_{3.0}$ $P_{24}$ | $E_{3.0}$ $P_{24}$ | $E_{3.2}$ $P_{24}$/ $E_{3.0}$ $P_{22}$ | $E_{3.0}$ $P_{24}$ | $E_{3.0}$ $P_{24}$ | |
| Protein Efficiency Ratio | 2.18 (0.21) | 1.85 (0.19) | 1.53 (0.11) | 1.52 (0.14) | 1.77 | $P < 0.005$ |
| Optimum diet | $E_{3.0}$ $P_{24}$; $E_{3.0}$ $P_{24}$ | $E_{3.0}$ $P_{24}$ | $E_{3.0}$ $P_{18}$ | $E_{3.0}$ $P_{20}$ | $E_{3.0}$ $P_{24}$ | |
| Body Weight at 8 weeks (kg) | 0.37$^{a}$ | 0.38$^{a}$ | 0.32$^{b}$ | 0.29$^{b}$ | 0.34 | $P < 0.005$ |
| Optimum diet | $E_{3.0}$ $P_{22}$ | $E_{2.8}$ $P_{24}$ | $E_{3.0}$ $P_{22}$ | $E_{2.8}$ $P_{24}$; $E_{3.0}$ $P_{24}$ | $E_{\cdot 2.8}$ $P_{24}$ | |

significant ($P < 0.05$) in experiment 1, but in experiment 2, there were significant energy, protein and genotype ($P < 0.005$) as well as genotype × protein interaction effects ($P < 0.05$). Optimum diets for the various genotypes were $E_{3.2}$ $P_{24}$, $E_{2.6}$ $P_{24}$ and $E_{3.0}$ $P_{24}$ for GL × GL, LC × GL and GL × LC respectively (Table 4) and $E_{3.0}$ $P_{22}$, $E_{2.8}$ $P_{24}$, and $E_{2.8}$ $P_{18}$ for GL × GL, LC × GL, GL × LC and LC × LC, respectively (Table 5).

The 3 genotypes in experiment 1 did not differ significantly in experiment 1, although GL × GL appeared to convert feed most efficiently. In experiment 2, the same trend was significantly manifested ($P < 0.05$). Maximum feed-gain conversion efficiency was observed in the 24% protein diets in both experiments, however in the case of energy, the highest efficiency was in the 3.0 Mcal/kg diets in experiment 2 and 3.2 Mcal/kg diets in experiment 1.

***Protein Efficiency Ratio (P.E.R.):***

There was no significant variation in P.E.R. in experiment 1, but the highest value was in diet $E_{3.0}$ $P_{18}$. In experiment 2, there were significant genotype energy and protein effects ($P < 0.005$). The highest P.E.R. value was observed in diet $E_{3.0}$ $P_{24}$.

Genotype comparisons showed that in both experiments, GL × GL appeared to be the most efficient utilizer of protein for gains, whereas LC × GL and LC × LC were the poorest in experiment 1 and 2, respectively. The 3.0 Mcal/kg energy and 24% protein diets appeared to promote the highest efficiency in experiment 2 while in experiment 1, the 3.0 Mcal/kg energy and 18% protein diets were the most efficacious.

***Digestibility, Nitrogen Retention and Water Intake:***

Data on dry matter digestibility, nitrogen retention and average daily water intake were taken in experiment 1 but not in experiment 2. There were significant genotype and energy variations ($P < 0.01$) as well as energy × protein interaction effects ($P < 0.05$), on dry matter digestibility. The highest value was in diet $E_{3.0}$ $P_{18}$. Genotype GL × LC appeared to digest feed more efficiently ($P < 0.01$) than the other genotypes. Nitrogen retention was affected significantly by variations in protein content of diet ($P < 0.01$). Diet $E_{3.0}$ $P_{24}$ gave the highest nitrogen retention. Genotype differences in nitrogen retention were minimal and non-significant ($P > 0.05$). Water consumption was maximised in diet $E_{2.8}$ $P_{24}$. There were significant protein effects ($P < 0.01$) affecting water intake, but when expressed as water intake per feed intake, there were no significant differences. There was also no significant difference between the water intake of the various genotypes.

Overall, the 2.8 Mcal/kg energy diets and the 24% protein diets appeared to favour maximum water intake and nitrogen retention while the 3.2 Mcal/kg energy diets and 18% protein diets appeared to promote maximum digestibility.

***Average Body Weight at 8 weeks (Experiment 2):***

Average body weight at 8 weeks was significantly influenced by protein, energy and genotype ($P \leq 0.005$), by energy x protein interaction ($P < 0.01$) and by genotype x protein interaction ($P < 0.05$). In general, protein increases from 18% to 24% linearly increased body weights, but energy increases from 2.8 to 3.2 produced a peak body weight at 3.0 Mcal/kg and a subsequent decline at 3.2 Mcal/kg level. The optimum diet for maximum body weight was $E_{2.8}$ $P_{24}$ and this was not significantly different from values of diets $E_{3.0}$ $P_{22}$ or $E_{3.0}$ $P_{24}$.

Genotype differences were observed between GL x GL, LC x GL on the one hand and GL x LC and LC x LC on the other. Each group was mutually not significant ($P < 0.05$). Optimum diets for the genotypes were $E_{3.0}$ $P_{22}$ for GL x GL and GL x LC, $E_{2.8}$ $P_{24}$ for LC x GL and LC x LC. $E_{3.0}$ $P_{24}$ was also optimal for LC x LC.

## DISCUSSION

The large differences observed in the levels of significance for common parameters between experiments 1 and 2 were due mainly to the inclusion of LC x LC genotype in experiment 2. The indigenous chicken being unselected and underdeveloped is known to have smaller body size and lower growth and production indices than the exotic breeds or their crosses with the indigenous strains (Oluyemi, 1979). However, disparity in production indices does not necessarily indicate separate requirements for optimal production within the genotype averages. This is confirmed in Tables 4 and 5 where genotype comparisons show common dietary requirements for optimum production and yet divergent levels of significance in the optimum values. Another possible explanation is that the experiment 2 eggs, representing a later period of lay were generally larger, and this could have resulted in larger chick weights and higher post hatch gains. However, trends were similar between the two experiments.

The generality of comparisons single

out diet $E_{2.8}$ $P_{24}$ as the most efficacious in promoting the best performance in feed intake, gain, water intake, nitrogen retention in experiment 1, and gain and body weight at 8 weeks, in experiment 2. The values resulting from this diet are significantly not different from those of $E_{2.8}$ $P_{18}$ (N.R.C. 1977) in all parameters of experiment 1 except water intake, nor from the values of feed intake and P.E.R. in experiment 2. They, however, differ significantly from average daily gain, feed efficiency and body weight at 8 weeks in experiment 2 ($P < 0.005$), and from the values of diet $E_{2.8}$ $P_{20}$, which is widely adopted in Nigeria as a starter diet for egg-type chickens, in feed intake, water intake, average daily gain, nitrogen retention of experiment 1, and in feed intake, average daily gain, feed efficiency, P.E.R. and 8th week body weight of experiment 2. It is clear that diet $E_{2.8}$ $P_{24}$ supports the highest biological efficiency of all diets, however Table 6 shows that the least feed cost per unit of body weight gain is obtained from diet $E_{2.8}$ $P_{18}$ when averaged over the two experiments. On the strength of economic efficiency, diets containing 18% protein and 2.8 Mcal/kg ME are recommended as optimal for starter egg-type chickens in the tropics. Other studies in different environments have recommended protein levels of 21 to 20% (Turk *et al* 1961, Sunde and Bird, 1959, Berg and Bearse 1958, Lillie *et al* 1966) for 0—8 week chickens.

The depressant effect of energy on feed intake is a widely accepted phenomenon, but was observed in these experiments to operate only when the energy level of 2.8 Mcal/kg was exceeded. Feed intake averages were 22.00, 23.79, 23.57 and 21.19 g for 2.6, 2.8, 3.0 and 3.2 Mcal/kg levels, respectively. The correlation coefficients r were -0.27 and -0.96 in experiments 1 and 2, respectively (P 0.05). It would appear that for purposes of optimum feed intake, and with special reference to tropical conditions, energy levels for starter chickens should not exceed 2.8 Mcal/kg ME. Protein on the other hand appears to be positively associated with intake, the highest intake being supported by the 22% protein level. Correlation coefficients of $r = 0.94$ and 0.74 were obtained for experiments 1 and 2, respectively. An expert panel on feed standards for Nigeria (Olomu 1979) had recommended 19—21% protein level and 2.65 Mcal/kg ME for egg-type starter chickens based on a review of existing studies. The results of this study do not agree with those levels judging from the relatively low performance of chicks on 20 and 22% protein levels as well as those on the 2.6 Mcal energy diets in relation to the 2.8 Mcal/kg. The results also do not support the suggestion that when energy levels as high as those employed in the temperate countries are used, lower performance is usually recorded (Olomu 1979). The results rather tend to suggest that energy levels below 2.8 Mcal/kg do not depress intake and support the reports by O'Neil *et al* 1962, Khoo 1977, that high protein levels are efficacious when energy level is high enough to promote protein and feed utilization efficiency. Similarly when protein levels are low, better response is observed when energy is also low. The superiority of diets $E_{2.6}$ $P_{18}$ over $E_{2.6}$ $P_{20}$ (experiment 1) and that of $E_{3.2}$ $P_{24}$ over $E_{3.2}$ $P_{22}$, $P_{22}$, $P_{20}$, $P_{18}$ (experiments 1 and 2) in average daily gain and feed efficiency confirm these reports.

The genotypes' responses to various parameters in Tables 4 and 5 are varied, but the GL x GL maintained an edge over all other genotypes in most of the comparisons. By contrast, the LC x LC trailed in most comparisons. The apparent superiority of the LC x GL over GL x GL and GL x LC in average daily gain and body weight at 8 weeks is of particular importance to any breeding work involving these genotypes. Omeje and Nwosu,(1982) had confirmed this superiority of the LC x GL $F_1$ cross, obtaining the highest heterosis of 22.1% at the 4th week and 16.5% at the 8th week as against -4.1% and 15.4%, respectively for the reciprocal cross. Body weights at 8 weeks were 319.4 g for GL x GL and 316.2 g for the GL x LC.

Mean optimum diets for the various diets indicate that genetic factor was not important in protein and energy requirements. This supports the finding of Oluyemi (1974) that there was no significant interaction between diet and the strain of fowl. The only significant interaction observed in this study between protein and genotype in body weight and feed efficiency (experiment 2) could be the exceptions. There was however no genotype specificity in protein or energy levels in the two experiments except for LC x GL which gave all optimum responses in 24% protein diets. The general indication is that genotypes do not differ in their requirements for these two nutrients. It was also observed that protein efficiency ratios appeared to optimise at 18% level in experiment 1, but not in 2, while average daily gain, feed efficiency appeared to optimise at 24% protein level.

Mean body weights at 8 weeks were generally low especially for the LC x LC which were 65.76% of 12-week weights obtained by Oluyemi (1979) from a random-bred 7th generation local chicken population and only 43% of the selected population. However the importance of body weight in starter chickens cannot be isolated from its effect on the subsequent initiation and intensity of lay.

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