10-1-2006

Effect of Varying Metabolizable Energy and Crude Protein Concentrations in Diets of Pearl Gray Guinea Fowl Pullets 1. Growth Performance

Samuel N. Nahashon
Tennessee State University

Nathaniel Adefope
Tennessee State University

Abravi Amenyenu
Tennessee State University

D. Wright
Tennessee State University

Effect of Varying Metabolizable Energy and Crude Protein Concentrations in Diets of Pearl Gray Guinea Fowl Pullets 1. Growth Performance

S. N. Nahashon,[1] N. Adefope, A. Amenyenu, and D. Wright

Institute of Agricultural and Environmental Research, Tennessee State University, Nashville 37209

ABSTRACT This study was undertaken to assess dietary ME and CP concentrations for optimum growth performance of Pearl Gray guinea fowl pullets. In a 3 × 3 factorial arrangement, 540 one-day-old Pearl Gray guinea keets were randomly assigned to experimental diets with 2,900, 3,000, and 3,100 kcal of ME/kg of diet, each containing 20, 22, and 24% CP, respectively, from 0 to 8 wk of age (WOA). From 9 to 16 WOA, these diets were adjusted to contain 3,000, 3,100, and 3,200 kcal of ME/kg, and each had 17, 19, and 21% CP, respectively. Each dietary treatment was replicated 4 times, and feed and water were provided ad libitum. Body weight and feed consumption were measured weekly. Mortality was recorded as it occurred. Overall, feed consumption was higher in birds on 2,900 and 3,000 kcal of ME/kg of feed and the 24 and 21% CP diets than other dietary treatments at 0 to 8 and 9 to 16 WOA, respectively. When compared with other dietary treatments, cumulative BW gains were higher ($P < 0.05$) in birds fed 3,000, 3,000 and 3,100, and 3,100 and 3,200 kcal of ME/kg of diet at 2 to 5, 6 to 8, and 9 to 16 WOA, respectively. Pullets receiving 24 and 21% CP diets also exhibited higher BW gains than other dietary treatments at 0 to 8 and 9 to 16 WOA, respectively. Feed conversion ratios were lower ($P < 0.05$) in birds fed 3,000, 3,100, and both 3,100 and 3,200 kcal of ME/kg of diet at 1 to 5, 6 to 8, and 9 to 16 WOA, respectively, than other dietary treatments. Pullets fed 24% CP diets and either 17 or 19% CP diets exhibited lower ($P < 0.05$) feed conversion ratios than other dietary treatments at 1 to 8 and 9 to 16 WOA, respectively. Thus, diets comprising 3,000 and 3,100 kcal of ME/kg were utilized more efficiently by the Pearl Gray guinea fowl pullets at 0 to 5 and 5 to 16 WOA, respectively. Also, these birds more efficiently utilized diets containing 24 and 17% CP at 0 to 8 and 9 to 16 WOA, respectively.

Key words: Pearl Gray guinea fowl pullet, metabolizable energy, crude protein

2006 Poultry Science 85:1847–1854

INTRODUCTION

The Pearl Gray guinea fowl is raised primarily for egg production. Guinea layers raised in cages lay, on average, 170 eggs per hen during a 36- to 40-wk lay period, whereas conventionally floor-reared breeders lay from 50 to 100 eggs per season (Hayes, 1987). This translates to high costs of production (Ayorinde, 1991; Ayorinde and Oluyemi, 1989) as a result of poor efficiency in converting feed to eggs. Poor egg production in guinea fowl is the primary cause of premium prices of day-old keets that must be raised to meet the increasing demand for guinea fowl. There is, therefore, a need to improve production performance of the Pearl Gray guinea fowl.

Growing and developing a good pullet is one of the most important steps in ensuring success in an egg production enterprise. The quality of the bird at the time it's production cycle begins will greatly determine how profitable it will be during the period of lay. The NRC (1994) suggested that, in addition to reproductive performance, growth rate should be included among factors used to assess and define nutrient use and nutritional status of poultry. Therefore, special emphasis must be placed on feeding the growing bird so that it may develop into a healthy, productive bird and one that can fulfill it's genetic potential (Bell and Weaver, 2002). There is general consensus that the determination of nutrient requirements of different types of poultry is necessary to efficiently utilize the genetic potential of these birds for specific production goals (Pym, 1990). Therefore, understanding the ME and CP requirements of the Pearl Gray guinea pullets will, in part, aid in designing least-cost rations to enhance their growth performance and, ultimately, improve their egg production capacity.

Several studies have evaluated the ME and CP requirements of the Pearl Gray guinea fowl, however, they are inconclusive, and most do not cover the period from 0 to 16 wk of age (**WOA**). Further, some of these studies were conducted using mixed sexes, whereas in other studies, either the ME or CP concentrations were held

Received February 22, 2006.
Accepted June 1, 2006.
[1]Corresponding author: Snahashon@tnstate.edu

constant when evaluating the requirement for either of the 2 nutrients. Using guinea fowl of both sexes, Blum et al. (1975) evaluated energy and protein requirements of the growing guinea fowl. They reported that, for the growing guinea fowl, the diet should contain about 3,010 kcal of ME/kg of diet and 24 to 26% CP at 0 to 4 WOA; 3,010 kcal of ME/kg of diet and 19 to 20% CP at 5 to 8 WOA, and 3,010 kcal of ME/kg of diet and CP concentrations of 16% or less at 8 to 12 WOA. According to Sales and Du Preez (1997), guinea fowl have their highest protein and energy requirement from 5 to 10 WOA (about 10 g/d) and from 6 to 15 WOA (about 196 kcal/d), respectively. Other related studies (Vo et al., 2000) have demonstrated that dietary energy concentrations of 3,100, 3,150, and 3,200 kcal of ME/kg of diet were optimal for growing guinea fowl during the first, second, and third 4-wk periods, respectively. These diets were claimed to be isonitrogenous, however, their CP concentrations were not provided. There is, therefore, a need to evaluate simultaneously the optimum ME and CP for growth performance of the Pearl Gray guinea fowl pullet in preparation for egg production.

In the present study, the effect of various concentrations of dietary ME and CP for optimum growth performance of the Pearl Gray guinea fowl pullets in preparation for egg production was evaluated. Pesti (1982) and Pesti and Fletcher (1983) also reported differences in weight gain and feed consumption with changes in either dietary energy or protein content. The rationale behind the evaluation of growth performance of the Pearl Gray guinea fowl pullet from hatch to 16 WOA is 3-fold: 1) the age at first egg of the Pearl Gray guinea fowl was estimated at 28 to 32 wk (Oke et al., 2003), implying a significant delay in sexual maturity when compared with other avian species such as chickens; 2) the Pearl Gray guinea fowl exhibits a growth pattern characterized by an accelerated growth phase from 0 to 11 WOA (Sales and Du Preez, 1997; Nahashon et al., 2004); and 3) the Pearl Gray guinea fowl also exhibits a slower, but significant, growth phase from 11 to 16 WOA (Sales and Du Preez, 1997; Nahashon et al., 2004). Thus, 0 to 16 WOA is a critical period in the development of the Pearl Gray guinea fowl pullet, and providing adequate ME and CP will, in part, have an important bearing on the birds' productivity during the laying period.

MATERIALS AND METHODS

Birds and Dietary Treatments

Five hundred forty day-old guinea keets of the Pearl Gray variety were obtained from Ideal Poultry Breeding Farms Inc. (Cameron, TX). Sexed females were randomly assigned to 9 dietary treatments in a 3 × 3 factorial arrangement. The dietary treatments fed from 0 to 8 WOA had 2,900, 3,000, and 3,100 kcal of ME/kg of diet, and each contained 20, 22, and 24% CP (Table 1). From 9 to 16 WOA, these diets had 3,000, 3,100, and 3,200 kcal of ME/kg of diet, and each contained 17, 19, and 21% CP (Table 2). The birds receiving the lowest energy and lowest protein treatment at 0 to 8 WOA also received the lowest energy and lowest protein treatment at 9 to 16 WOA, respectively. Bell and Weaver (2002) suggested that, in order for a pullet to reach sexual maturity at an opportune and economical age, protein must be reduced materially to justify the requirement and to produce the pullet at the lowest cost possible. In the present study, each dietary treatment was replicated 4 times. The diets were fed in mash form and were provided ad libitum. Water was also provided ad libitum throughout the experimentation period.

Management of Experimental Birds

At 1-d-old, experimental birds were weighed individually and randomly assigned to electrically heated, temperature-controlled Petersime battery brooders (Petersime brood units, model 2SD12, Petersime Incubator Co., Gettysburg, OH) equipped with raised wire floors for the first 4 WOA. The battery cages measured 99 × 66 × 26 cm, and each housed 15 birds. From 1 d old, the brooder temperature was maintained at 32.2°C for the first week and reduced gradually by 2.8°C every week until 23.9°C, and, at this point on, no artificial heating was provided to the birds. At 5 WOA, the guinea keets were transferred into growing batteries, which were not supplied with supplemental heating. However, constant room temperature was maintained at 21°C. The growing cages measured 163 × 69 × 33 cm, and each housed 7 to 8 birds from 5 to 9 WOA. Birds were then transferred to floor pens measuring 226 × 237 × 106 cm (15 birds/pen), where they were raised from 9 to 16 WOA. The birds received 23 and 8 h of constant lighting from 0 to 11 and 12 to 16 WOA, respectively. Ventilation within the growing cages was maintained by thermostatically controlled exhaust fans. Body weight and feed consumption were measured weekly from hatch to 16 WOA. Feed conversion ratio (FCR) was calculated by dividing weekly feed consumption by weekly BW gain for each replicate. Mortality was recorded as it occurred.

Statistical Analyses

Data were analyzed by the ANOVA option of the GLM of SAS/STAT software (SAS Institute, 1999) as a 3 × 3 factorial arrangement of dietary treatments with dietary ME and CP as main effects. The statistical model used was

$$Y_{ijkl} = \mu + M_i + P_j + (MP)_{ij} + R_{ijk} + \gamma_{ijkl},$$

where Y_{ijkl} = response variables from each individual replication or pen, μ = the overall mean; M_i = the effect of dietary ME; P_j = the effect of dietary CP; $(MP)_{ij}$ = the effect due to interactions between dietary ME and CP; R_{ijk} = the interexperimental unit (replications) error term; and γ_{ijkl} = the intraexperimental unit error term. Two-way interactions between CP and ME were not signifi-

Table 1. Composition of experimental diets fed from hatch to 8 wk of age

	ME (kcal/kg of diet)								
	2,900	3,000	3,100	2,900	3,000	3,100	2,900	3,000	3,100
	CP (%)								
Ingredients	20	20	20	22	22	22	24	24	24
	(%)								
Corn, yellow no. 2 (8% CP)	61.58	58.97	56.25	54.90	51.95	49.35	47.58	44.93	42.03
Soybean meal (48% CP)	30.69	31.00	31.60	36.25	36.80	37.30	42.20	42.70	43.30
Alfalfa meal (17% CP)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Meat and bone meal (50% CP)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Poultry-blended fat	1.00	3.30	5.42	2.20	4.50	6.70	3.60	5.80	8.00
Dicalcium phosphate (18% P, 22% Ca)	1.10	1.10	1.10	1.00	1.10	1.00	0.95	0.90	1.20
Limestone flour (38.8% Ca)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.70
Salt	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
Vitamin–mineral premix[1]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
DL-Met[2] (98%)	0.11	0.11	0.11	0.13	0.13	0.13	0.15	0.15	0.15
Calculated levels									
ME (kcal/kg of diet)	2,900	3,000	3,100	2,900	3,000	3,100	2,900	3,000	3,100
Crude fat, %	3.88	5.85	7.66	4.75	6.72	8.60	5.80	7.70	9.56
CP, %	20	20	20	22	22	22	24	24	24
Ca, %	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
P, total, %	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Available P, %	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
Met, %	0.43	0.43	0.43	0.48	0.48	0.48	0.53	0.53	0.53
Met + Cys, %	0.78	0.78	0.78	0.85	0.85	0.85	0.92	0.92	0.92
Lys, %	1.14	1.14	1.14	1.31	1.31	1.31	1.46	1.46	1.46
Analyzed levels									
Crude fat, %	3.79	5.80	7.57	4.72	6.68	8.52	5.74	7.64	9.49
CP, %	19.92	19.96	19.89	21.93	21.91	21.88	23.97	23.96	23.94

[1]Provided per kilogram of diet: retinyl acetate, 3,500 IU; cholecalciferol, 1,000 ICU; DL-α-tocopheryl acetate, 4.5 IU; menadione Na bisulfite complex, 2.8 mg; vitamin B_{12}, 5.0 mg; riboflavin, 2.5 mg; pantothenic acid, 4.0 mg; niacin, 15.0 mg; choline, 172 mg; folic acid, 230 mg; ethoxyquin, 56.7 mg; manganese, 65 mg; I, 1 mg; Fe, 54.8 mg; Cu, 6 mg; Zn, 55 mg; and Se, 0.3 mg.

[2]Degussa Corp., Kennesaw, GA.

cant ($P > 0.05$), thus, data were analyzed for main effects. Least significant difference comparisons were made between treatment means for main effects when there was a significant F-value. Differences in mortality among dietary treatments were analyzed using the χ^2 method. Significance implies $P < 0.05$, unless stated otherwise.

RESULTS AND DISCUSSION

The average weekly feed consumption of Pearl Gray guinea keets fed diets with varying ME and CP levels from 0 to 16 WOA are presented in Table 3. The birds fed diets containing 2,900 kcal of ME/kg of diet consumed about 7% more feed than those fed diets comprising 3,000 and 3,100 kcal of ME/kg of feed at 2 to 5 and 8 WOA. However, at 6 and 7 WOA, mean feed consumption of birds on 2,900 kcal of ME/kg of diet was not different ($P > 0.05$) from those of birds on diets containing 3,000 kcal of ME/kg of diet. This observation was in agreement with the report of Golian and Maurice (1992) and Leeson et al. (1993) that birds consume feed to primarily meet their energy requirement. Birds on high-energy diets, often due to relatively high fat content, have, on average, lower feed consumption due to the reduced rate of passage of digesta through the gastrointestinal tract (Sturkie, 1976). Except at 6 and 7 WOA, in which birds on 3,000 kcal of ME/kg of diet consumed about 4 to 6% more feed than those on 3,100 kcal of ME/kg of diet, feed consumption was not different in birds receiving diets with 3,000 kcal of ME/kg of diet and those receiving diets with 3,100 kcal of ME/kg of diet from 1 to 8 WOA.

When the dietary ME was increased by 100 kcal/kg of diet at 9 to 16 WOA, a similar pattern to that observed at 1 to 8 WOA was noted. Except at 9 and 14 WOA, in which birds on 3,200 kcal of ME/kg of diet consumed significantly ($P < 0.05$) less feed than those fed diets containing 3,100 kcal of ME/kg of diet, differences in feed consumption of birds on 3,100 and those on 3,200 kcal of ME/kg of diet were not significant ($P > 0.05$). For the most part, birds on 3,200 and 3,100 kcal of ME/kg of diet consumed 6% less feed than those fed diets containing 3,000 kcal of ME/kg of diet. This observation is consistent with a recent report (Veldkamp et al., 2005) that feed intake decreased linearly as dietary energy increased. Analysis of published reports by Morris (1968) also suggested that the effect of dietary energy on performance of growing birds is dependent on the birds' capacity to alter feed intake to meet changing demands for calories. Previous studies (Plavnik et al., 1997; Nahashon et al., 2005) have also suggested that as dietary energy increases, birds satisfy their energy needs by decreasing feed intake.

Feed intake was also influenced by dietary CP levels. Average feed consumption of Pearl Gray guinea fowl pullets, as influenced by feeding diets varying in dietary CP concentrations at 0 to 16 WOA, is presented in Table 3. At 1 and 2 WOA, mean feed consumption of birds

Table 2. Composition of experimental diets fed from 9 to 16 wk of age

	ME (kcal/kg of diet)								
	3,000	3,100	3,200	3,000	3,100	3,200	3,000	3,100	3,200
	CP (%)								
Ingredients	17	17	17	19	19	19	21	21	21
	(%)								
Corn, yellow no. 2 (8% CP)	70.13	67.75	64.85	63.01	59.90	56.80	55.78	52.96	50.50
Soybean meal (48% CP)	22.30	22.60	23.20	28.00	29.47	29.93	34.00	34.50	34.96
Alfalfa meal (17% CP)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Meat and bone meal (50% CP)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Poultry-blended fat	1.02	3.10	5.40	2.47	4.06	6.70	3.69	6.00	8.00
Dicalcium Phosphate (18% P, 22% Ca)	1.10	1.10	1.10	1.00	1.10	1.10	1.00	1.10	1.10
Limestone flour (38.8% Ca)	0.75	0.75	0.75	0.80	0.75	0.75	0.80	0.70	0.70
Salt	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
Vitamin–mineral premix[1]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
DL-Met[2] (98%)	0.08	0.08	0.08	0.10	0.10	0.10	0.11	0.12	0.12
Calculated levels									
ME (kcal/kg of diet)	3,000	3,100	3,200	3,000	3,100	3,200	3,000	3,100	3,200
Crude fat, %	4.13	5.92	7.88	5.22	6.55	8.81	6.11	8.08	9.79
CP, %	17	17	17	19	19	19	21	21	21
Ca, %	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
P, total, %	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Available P, %	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
Met, %	0.37	0.37	0.370.41	0.41	0.41	0.45	0.45	0.45	
Met + Cys, %	0.68	0.68	0.68	0.75	0.75	0.75	0.81	0.81	0.81
Lys, %	0.92	0.92	0.92	1.07	1.07	1.07	1.23	1.23	1.23
Analyzed levels									
Crude fat, %	4.06	5.80	7.79	5.14	6.51	8.67	5.90	7.91	9.68
CP, %	16.94	16.89	16.95	18.91	18.96	18.93	20.88	20.94	20.91

[1]Provided per kilogram of diet: retinyl acetate, 3,500 IU; cholecalciferol, 1,000 ICU; DL-α-tocopheryl acetate, 4.5 IU; menadione Na bisulfite complex, 2.8 mg; vitamin B_{12}, 5.0 mg; riboflavin, 2.5 mg; pantothenic acid, 4.0 mg; niacin, 15.0 mg; choline, 172 mg; folic acid, 230 mg; ethoxyquin, 56.7 mg; manganese, 65 mg; I, 1 mg; Fe, 54.8 mg; Cu, 6 mg; Zn, 55 mg; and Se, 0.3 mg.

[2]Degussa Corp., Kennesaw, GA.

consuming 22 and 24% CP diets were not different; however, feed consumption of these birds was about 14% higher than that of birds on 20% CP diets. Although feed consumption of birds fed 24% CP diets was, on average, 6 to 7% higher than that of birds fed 22 and 20% CP diets, differences in feed consumption of birds on the 22 and 20% CP diets were not significant, except at 1, 2, and 4 WOA. On average, birds on 22% CP diets consumed more feed ($P < 0.05$) than those fed diets containing 20% CP at 1, 2, and 4 WOA. The higher feed intake for birds on higher CP diets is consistent with recent reports (Nahashon et al., 2005). Using the French variety of the guinea fowl, Nahashon et al. (2005) reported a 3 to 4% increase in feed consumption in birds fed 25% CP diets when compared with those fed 21 and 23% CP diets. Other reports using chickens (Sengar, 1987; Leeson et al., 1993) also support this premise that low-CP diets significantly suppress appetite. The larger differences in feed consumption at 1 to 2 WOA, as opposed to later ages between birds on 22 and 24% CP diets and those on 20% CP diets, may be attributed to higher demand for CP at an early age or period of accelerated growth rate than at later ages (5 to 8 WOA).

Increasing dietary CP concentrations from 17 to 19 to 21% at 9 to 16 WOA increased feed consumption of the Pearl Gray guinea fowl pullets. Although differences in feed consumption of birds consuming 17 and 19% CP diets were not significant at 9, 12, and 16 WOA, birds on 19% CP diets consumed about 3% more feed ($P < 0.05$) than those on 17% CP diets at 10 to 11 and 13 to 15 WOA. Although differences in feed consumption of birds on 19 and 21% CP diets were not significant at 11 to 13 and 16 WOA, birds consuming diets containing 21% CP consumed approximately 2 to 4% more feed than those on 19% CP diets at 9, 10, 14, and 15 WOA. Recent studies (Nahashon et al., 2005) have shown that dietary CP concentrations can modulate feed intake, and the effect of dietary energy and protein levels on feed intake of the guinea fowl pullets is age-dependent. There were no significant differences in total feed consumption between birds on 3,000 and 3,100 kcal of ME/kg of diet and also between birds on 20 and 22% CP diets at 1 to 8 WOA. However, the differences in mean total feed consumption of these treatment groups were significant ($P < 0.05$) at 9 to 16 WOA.

The influence of varying concentrations of dietary ME on BW gain of Pearl Gray guinea fowl pullets at 0 to 16 WOA is presented in Table 4. Although differences in cumulative BW gain of birds fed diets containing 2,900 and 3,100 kcal of ME/kg of diet were not significant ($P > 0.05$), these BW gains were 7 to 11% lower ($P < 0.05$) than those of birds fed diets containing 3,000 kcal of ME/kg of diet at 2 to 5 WOA. However, at 6 to 8 WOA, cumulative BW gains of guinea pullets on either 3,000 or 3,100 kcal of ME/kg of diet were not different, but they were 5 to 7% higher than those of birds on 2,900 kcal of ME/kg of diet. Mean differences in cumulative BW gain of birds fed diets containing either 3,100 or

Table 3. Feed consumption of Pearl Gray guinea fowl pullets fed diets with varying concentrations of ME and CP from hatch to 16 wk of age (WOA)

	Diet[1] (ME, kcal/kg)				Diet[1] (CP, %)				Probability		
WOA	2,900/3,000	3,000/3,100	3,100/3,200	PSEM[2]	20/17	22/19	24/21	PSEM	ME	CP	CP × ME
	(g/bird)										
1	57	55	54	1.3	50^{b}	59^{a}	57^{a}	1.2	NS	0.05	NS
2	92^{a}	84^{b}	86^{b}	1.9	84^{b}	92^{a}	93^{a}	2.2	0.05	0.05	NS
3	137^{a}	129^{b}	127^{b}	2.1	131^{b}	134^{ab}	138^{a}	2.1	0.01	0.05	NS
4	185^{a}	171^{b}	172^{b}	2.7	169^{c}	182^{b}	193^{a}	2.4	0.05	0.05	NS
5	329^{a}	277^{b}	281^{b}	3.2	230^{b}	223^{b}	246^{a}	3.0	0.04	0.03	NS
6	275^{a}	270^{a}	254^{b}	3.1	265	259	266	3.1	0.01	NS	NS
7	367^{a}	362^{a}	348^{b}	3.7	335^{b}	335^{b}	361^{a}	2.8	0.05	0.01	NS
8	384^{a}	364^{b}	366^{b}	3.4	378^{b}	375^{b}	390^{a}	3.3	0.04	0.05	NS
9	421^{a}	391^{b}	382^{c}	2.7	407^{b}	401^{b}	417^{a}	3.4	0.05	0.05	NS
10	445^{a}	427^{b}	420^{b}	4.2	410^{c}	436^{b}	445^{a}	3.2	0.05	0.05	NS
11	436^{a}	411^{b}	413^{b}	3.6	416^{b}	428^{a}	425^{a}	3.0	0.05	0.05	NS
12	433^{a}	415^{b}	410^{b}	3.8	419^{b}	427^{ab}	432^{a}	3.1	0.05	0.03	NS
13	453^{a}	440^{b}	441^{b}	3.2	331^{b}	352^{a}	351^{a}	3.4	0.05	0.05	NS
14	490^{a}	442^{b}	411^{c}	4.3	415^{c}	431^{b}	449^{a}	4.0	0.04	0.02	NS
15	508^{a}	486^{b}	481^{b}	3.9	485^{c}	490^{b}	510^{a}	3.8	0.05	0.05	NS
16	479^{a}	454^{b}	450^{b}	4.1	460	464	466	4.3	0.05	NS	NS
TFC[3]	5,491^{a}	5,178^{b}	5,096^{c}	19.3	4,985^{c}	5,088^{b}	5,239^{a}	21.4	0.02	0.04	NS

[a–c]Gram weight means within rows of ME or CP levels with no common superscript differ ($P < 0.05$).

[1]First value indicates ME/CP from 0 to 8 WOA; second value indicates ME/CP from 9 to 16 WOA.

[2]PSEM = pooled SEM.

[3]TFC = total feed consumed.

3,200 kcal of ME/kg of diet were not significant, but they were 4 to 7% higher ($P < 0.05$) than those of birds on 3,000 kcal of ME/kg of diet from 9 to 16 WOA. This observation is supported by the report of Waldroup et al. (1990) that found that growth rate is promoted by increasing dietary energy level. It is also well documented that dietary ME composition has a major effect on body composition of chickens (Collin et al., 2003) and guinea fowl (Nahashon et al., 2005). Although the 3,000 and 3,100 kcal of ME/kg of diet fed from 1 to 8 WOA and the 3,100 and 3,200 kcal of ME/kg of diet fed at 9 to 16 WOA seem adequate for the Pearl Gray guinea pullet, 2,900 kcal of ME/kg of diet fed at 1 to 8 WOA and 3,000 kcal of ME/kg of diet fed at 9 to 16 WOA seem suboptimal.

The influence of varying concentrations of dietary CP on cumulative BW gain of Pearl Gray guinea fowl pullets at 1 to 16 WOA is also presented in Table 4. The cumulative BW gain of birds fed diets containing 20% CP was not different ($P > 0.05$) from that of birds fed diets continuing 22% CP. However, cumulative BW gain of Pearl Gray guinea fowl pullets fed the 24% CP diets was approximately 14 to 20% higher ($P < 0.05$) than that of birds fed the 20% CP diet. Except at 1 and 2 WOA, in which differences in BW gain of birds on 22 and 24% CP diets were not significant, the birds fed diets comprising 24%

Table 4. Cumulative BW gain of Pearl Gray guinea fowl pullets fed diets with varying concentrations of ME and CP from hatch to 16 wk of age (WOA)

	Diet[1] (ME, kcal/kg)				Diet[1] (CP, %)				Probability		
WOA	2,900/3,000	3,000/3,100	3,100/3,200	PSEM[2]	20/17	22/19	24/21	PSEM	ME	CP	CP × ME
	(g/bird)										
1	58.3	56.8	57.0	1.8	52.8^{b}	56.9^{ab}	60.2^{a}	2.1	NS	0.05	NS
2	106.4^{b}	113.8^{a}	106.2^{b}	2.2	100.4^{b}	111.1^{ab}	118.0^{a}	2.9	0.05	0.05	NS
3	180.0^{b}	199.2^{a}	181.9^{b}	3.6	170.2^{b}	182.5^{b}	211.5^{a}	5.8	0.04	0.05	NS
4	270.0^{b}	294.5^{a}	278.1^{b}	7.3	264.5^{b}	279.7^{b}	314.5^{a}	7.4	0.05	0.05	NS
5	371.8^{b}	403.1^{a}	380.6^{b}	8.1	372.5^{b}	384.7^{b}	431.4^{a}	9.3	0.03	0.05	NS
6	457.8^{b}	491.4^{a}	480.6^{a}	9.3	466.9^{b}	475.6^{b}	540.4^{a}	10.6	0.02	0.05	NS
7	558.1^{b}	587.8^{a}	585.6^{a}	8.0	559.4^{b}	563.2^{b}	642.0^{a}	10.9	0.05	0.05	NS
8	679.2^{b}	707.8^{a}	717.9^{a}	8.3	685.1^{b}	686.1^{b}	796.6^{a}	11.7	0.05	0.05	NS
9	802.9^{b}	832.1^{a}	837.9^{a}	8.4	805.6^{b}	811.3^{b}	916.9^{a}	9.6	0.05	0.01	NS
10	894.4^{b}	930.7^{a}	931.6^{a}	9.3	898.8^{b}	907.2^{b}	1,011.7^{a}	12.4	0.05	0.01	NS
11	985.1^{b}	1,026.3^{a}	1,034.7^{a}	11.6	997.5^{b}	1,010.5^{b}	1,099.5^{a}	14.1	0.04	0.02	NS
12	1,070.2^{b}	1,118.0^{a}	1,128.3^{a}	12.8	1,089.4^{b}	1,102.2^{b}	1,186.4^{a}	13.8	0.05	0.01	NS
13	1,132.3^{b}	1,195.0^{a}	1,203.5^{a}	13.5	1,159.1^{b}	1,163.7^{b}	1,249.5^{a}	15.3	0.04	0.03	NS
14	1,197.5^{b}	1,262.2^{a}	1,276.9^{a}	13.7	1,228.4^{b}	1,235.9^{b}	1,313.7^{a}	16.7	0.03	0.01	NS
15	1,287.8^{b}	1,346.7^{a}	1,361.6^{a}	14.2	1,312.5^{b}	1,319.9^{b}	1,395.1^{a}	17.1	0.05	0.04	NS
16	1,370.4^{b}	1,435.1^{a}	1,450.9^{a}	15.3	1,405.6^{b}	1,405.0^{b}	1,468.1^{a}	17.3	0.05	0.05	NS

[a,b]Gram weight means within rows of ME or CP levels with no common superscript differ ($P < 0.05$).

[1]First value indicates ME/CP from 0 to 8 WOA; second value indicates ME/CP from 9 to 16 WOA.

[2]PSEM = pooled SEM.

Table 5. Feed conversion ratios and mortality of Pearl Gray guinea fowl pullets fed diets with varying concentrations of ME and CP from hatch to 16 wk of age (WOA)

	Diet[1] (ME, kcal/kg)				Diet[1] (CP, %)				Probability		
WOA	2,900/3,000	3,000/3,100	3,100/3,200	PSEM[2]	20/17	22/19	24/21	PSEM	ME	CP	CP × ME
	(g of feed/g of weight gain)										
1	1.79[ab]	1.72[b]	1.82[a]	0.04	1.84[a]	1.87[a]	1.65[b]	0.05	0.04	0.05	NS
2	1.76[a]	1.50[b]	1.76[a]	0.08	1.78[a]	1.72[a]	1.61[b]	0.04	0.05	0.05	NS
3	1.90[a]	1.53[c]	1.69[b]	0.06	1.89[a]	1.92[a]	1.49[b]	0.06	0.05	0.05	NS
4	2.05[a]	1.80[b]	1.77[b]	0.11	1.84	1.88	1.85	0.05	0.05	NS	NS
5	3.25[a]	2.57[c]	2.74[b]	0.12	2.13	2.11	2.10	0.11	0.05	NS	NS
6	3.17[a]	3.06[a]	2.54[b]	0.13	2.76[a]	2.83[a]	2.48[b]	0.12	0.05	0.05	NS
7	3.69[a]	3.71[a]	3.34[b]	0.14	3.67[ab]	3.85[a]	3.54[b]	0.09	0.05	0.05	NS
8	3.20[a]	3.05[a]	2.80[b]	0.11	3.04[a]	3.11[a]	2.61[b]	0.13	0.04	0.02	NS
9	3.49[a]	3.15[b]	3.18[b]	0.09	3.41[a]	3.20[b]	3.48[a]	0.11	0.04	0.05	NS
10	4.92[a]	4.39[b]	4.47[b]	0.13	4.43[b]	4.54[b]	4.81[a]	0.15	0.05	0.05	NS
11	4.82[a]	4.33[b]	4.01[c]	0.11	4.27[b]	4.20[b]	4.84[a]	0.12	0.05	0.05	NS
12	5.12[a]	4.56[b]	4.45[b]	0.17	4.53[b]	4.64[b]	4.98[a]	0.11	0.05	0.05	NS
13	7.32[a]	5.71[b]	5.87[b]	0.18	4.75[b]	5.76[a]	5.54[a]	0.22	0.02	0.05	NS
14	7.55[a]	6.57[b]	5.64[c]	0.15	6.10[b]	5.69[b]	7.11[a]	0.16	0.05	0.05	NS
15	5.66	5.78	5.67	0.19	5.75[b]	5.82[b]	6.34[a]	0.17	NS	0.05	NS
16	5.83[a]	5.18[b]	5.07[b]	0.18	4.95[c]	5.47[b]	6.38[a]	0.15	0.04	0.03	NS
AFCR[3]	4.10[a]	3.67[b]	3.56[b]	0.15	3.57	3.68	3.81	0.13	0.05	NS	NS
Mortality	3.41	3.10	3.35	0.12	3.67[a]	3.19[b]	3.43[b]	0.07	NS	0.05	NS

[a–c]Gram weight means within rows of ME or CP levels with no common superscript differ ($P < 0.05$).

[1]First value indicates ME/CP from 0 to 8 WOA; second value indicates ME/CP from 9 to 16 WOA.

[2]PSEM = pooled SEM.

[3]AFCR = average FCR.

CP also exhibited 12 to 16% higher cumulative BW gain than those fed the diet containing 22% CP. This observation is consistent with the report of Sengar (1987) that lowering dietary CP also reduces BW gain and feed efficiency of chicks. The lower BW gain of birds on 20 and 22% CP diets when compared with those on 24% CP diets could be due to inadequate levels of 1 or more essential amino acids in the 20 and 22% CP diets. Other studies (Schutte, 1987) revealed minimal decrease in performance of birds fed 16% CP diets supplemented with all essential amino acids, at levels equivalent to that present in 20% CP diets. The diets fed at 1 to 8 WOA containing 20, 22, and 24% CP were adjusted to contain 17, 19, and 21% CP at 9 to 16 WOA (Table 4). Mean cumulative BW gain of birds fed diets containing 17 and 19% CP were not different ($P > 0.05$) at 9 to 16 WOA. However, birds on 21% CP diets exhibited cumulative BW gains that were as high as 14% at 9 WOA and as low as 5% at 16 WOA when compared with birds on 17 and 19% CP diets. It is likely that energy expenditure, which would have otherwise been utilized on BW gain in birds on 21% CP diets, was utilized for the excess amino acid catabolism (MacLeod, 1997).

The average FCR of Pearl Gray guinea fowl pullets was significantly lower ($P < 0.05$) in birds fed diets containing 3,000 kcal of ME/kg than those fed 2,900 kcal of ME/kg of diet at 1 to 5 WOA (Table 5). Because diets containing 3,000 kcal of ME/kg have a higher fat content than those containing 2,900 kcal of ME/kg of diet, the dietary fat content may have a positive effect on energy use as well as ME intake, as suggested by Mateos and Sell (1980). The longer transition time of high-fat diets through the digestive tract may also be a contributing factor to better FCR of birds on 3,000 kcal of ME/kg of diet when compared with those fed diets containing 2,900 kcal of ME/kg of diet. Likewise, FCR of birds on 3,000 kcal of ME/kg of diet were also lower than those of birds on 3,100 kcal of ME/kg of diet at 1 to 3 and 5 WOA. This may be attributed to decreases in feed consumption, resulting in inadequate utilization of essential nutrients, such as amino acids of birds, on the 3,100 kcal of ME/kg of diet. Although differences in FCR of birds fed diets containing 2,900 and 3,000 kcal of ME/kg of diet were not significant ($P > 0.05$) at 6 to 8 WOA, these FCR were 9 to 20% higher ($P < 0.05$) than those of birds fed diets containing 3,100 kcal of ME/kg.

Birds receiving 3,100 kcal of ME/kg of diet exhibited FCR that were about 11 to 28% lower than those of birds on 3,000 kcal of ME/kg of diet at 9 to 14 and 16 WOA. Although optimum environmental conditions were maintained uniformly to all experimental birds throughout the study period, the birds fed low-ME diets exhibited higher FCR at 13 and 14 WOA when compared with other age periods. The high FCR were attributed to lower BW gains and possibly higher feed consumption of the experimental birds at 13 and 14 WOA. There is also the likelihood that feed wastage may have contributed to the high feed consumption values as well. At 15 WOA, differences in FCR of birds on 3,000 and 3,100 kcal of ME/kg of diet were not significant. With the exception of 11 WOA, in which FCR of birds on 3,100 kcal of ME/kg of diet were 8% lower than that of birds on 3,200 kcal of ME/kg of diet, mean FCR of the guinea pullets fed these 2 dietary energy concentrations were not different ($P > 0.05$) at 9 to 16 WOA. While investigating the protein and energy requirement of the Pearl Gray guinea fowl, Sales and Du Preez (1997) reported a steady increase in energy requirement proportionate to age of birds. They reported the highest requirement for energy in these birds to be at 9 and 10 WOA in males and females, respectively.

Average FCR of birds consuming diets containing 20 and 22% CP were not different ($P > 0.05$) at 1 to 8 WOA (Table 5). However, FCR was significantly reduced ($P < 0.05$) when dietary CP was increased from 22 to 24%. The average differences in FCR between birds on 22% CP diets and those on 24% CP diets were as low as 7% at 2 WOA and as high as 29% at 3 WOA. Previous studies using the Pearl Gray guinea fowl (Sales and Du Preez, 1997), which were in agreement with this report, suggested that the highest protein requirement in guinea fowl is during the period from 5 to 10 WOA. The improved feed conversion of birds fed the 24% CP diets could be attributed to the larger BW and increased N and energy consumption when compared with the 20 and 22% CP diets.

For the most part, mean differences in FCR of birds on 17% CP diets were not different from those of birds on 19% CP diets, except at 9, 13, and 16 WOA. At these age groups, birds on 19% CP diets exhibited FCR that were lower than those of birds on 17% CP diets by as little as 7% at 9 WOA to 21% at 13 WOA. Increasing dietary CP levels from 19 to 21% significantly increased FCR of the Pearl Gray guinea fowl pullets at 9 to 16 WOA, except at 13 WOA. The average increase in FCR was as low as 6% at 10 WOA and as high as 19% at 14 WOA. In evaluating the CP and ME requirements of the French variety of guinea fowl, Nahashon et al. (2005) observed that increasing the dietary CP levels from 23 to 25% resulted in a 5 to 8% increase in FCR. The increase in FCR that is associated with increase in dietary CP levels may have been attributed to increased feed consumption of birds on higher CP diets, which also tend to have lower energy-to-protein ratios.

Throughout the study period, differences in percentage of mortality among dietary ME concentrations were not significant (Table 5). However, birds consuming 20% CP diets at 1 to 8 WOA exhibited mortality that was about 15 and 7% higher than that of birds on 22 and 24% CP diets, respectively. This may suggest that 20% dietary CP may not be adequate in promoting optimum growth and physiological functions of the Pearl Gray guinea fowl pullets at 1 to 8 WOA. Differences in percentage of mortality of birds on 17, 19, and 21% CP diets were not significant ($P > 0.05$) at 9 to 16 WOA.

Therefore, based on this study, Pearl Gray guinea fowl pullets seem to more efficiently utilize diets containing 3,000 and 3,100 kcal of ME/kg from 0 to 5 and 6 to 16 WOA, respectively. These pullets will also more efficiently utilize diets containing 24 and 17% CP at 0 to 8 and 9 to 16 WOA, respectively. Birds on these dietary treatments exhibited superior BW gain and FCR. The BW and FCR of birds on diets containing 3,100 and 3,200 kcal of ME/kg of diet, as well as those containing 17 and 19% CP, were not different at 9 to 16 WOA. As such, the Pearl Gray guinea fowl pullets fed diets containing 3,100 kcal of ME/kg of diet and 17% CP exhibited lower FCR. Therefore, choice of these diets for the Pearl Gray guinea fowl would reduce feed cost.

ACKNOWLEDGMENTS

This study was supported by USDA/CSREES Evans Allen Funds.

REFERENCES

Ayorinde, K. L. 1991. Body weight increase of indigenous Pearl Guinea fowl in Nigeria through crossbreeding. Br. Poult. Sci. 32:295–302.

Ayorinde, K. L., and J. A. Oluyemi. 1989. Heritability estimates for body weight in the indigenous Pearl Guinea fowl in Nigeria. Nig. J. Genet. VII:19–26.

Bell, D. E., and W. D. Weaver Jr. 2002. Feeding commercial egg-type layers. Pages 287–328 in Commercial Chicken Meat and Egg Production. D. E. Bell and W. D. Weaver, ed. Cluwer Acad. Publ., Dordrecht, The Netherlands.

Blum, J. C., J. Guillaume, and B. Leclercq. 1975. Studies on the energy and protein requirements of the growing guinea fowl. Br. Poult. Sci. 16:157–168.

Collin, A., R. D. Malheiros, V. M. B. Moraes, P. Van As, V. M. Darras, M. Taouis, E. Decuypere, and J. Buyse. 2003. Effects of dietary macronutrient content on energy metabolism and uncoupling protein mRNA expression in broiler chickens. Br. J. Nutr. 90:261–269.

Golian, A., and D. V. Maurice. 1992. Dietary poultry fat and gastrointestinal transit time of feed and fat utilization in broiler chickens. Poult. Sci. 71:1357–1363.

Hayes, C. 1987. Mature guinea fowl management. Pages 169–184 in Raising Turkeys, Ducks, Geese, Pigeons and Guineas. C. Haynes, ed. Tab Books. Blue Ridge Summit, PA.

Leeson, S., J. D. Summers, and L. Caston. 1993. Growth response of immature brown-egg strain pullet to varying nutrient density and lysine. Poult. Sci. 72:1349–1358.

MacLeod, M. G. 1997. Effect of amino acid balance an energy: Protein ratio on energy and nitrogen metabolism in male broiler chickens. Br. Poult. Sci. 38:405–411.

Mateos, G. G., and J. M. Sell. 1980. Influence of carbohydrates and supplemental fat sources on the metabolizable energy of the diet. Arch. Geflügelkd. 59:2129–2135.

Morris, T. R. 1968. The effect of dietary energy level on the voluntary calorie intake of laying hens. Br. Poult. Sci. 9:285–295.

Nahashon, S. N., N. Adefope, A. Amenyenu, and D. Wright. 2005. Effect of dietary metabolizable energy and crude protein concentrations on growth performance and carcass characteristics of French guinea broilers. Poult. Sci. 84:337–344.

Nahashon, S. N., S. Aggrey, N. Adefope, A. Amenyenu, and D. Wright. 2004. Growth characteristics of the pearl gray guinea fowl as predicted by Richard's. Gompertz and Logistic Models. Poult. Sci. 83:1798.

National Research Council. 1994. Nutrient Requirements of Poultry. 9th ed. Natl. Acad. Press, Washington, DC.

Oke, U. K., U. Herbert, and A. H. Akinmutimi. 2003. Early lay characteristics and hematology of Pearl Guinea fowls as influenced by dietary protein and energy levels. Int. J. Poult. Sci. 2:128–132.

Pesti, G. M. 1982. Characterization of the response of male broiler chickens to diets of various proteins and energy contents. Br. Poult. Sci. 23:527–537.

Pesti, G. M., and D. L. Fletcher. 1983. The response of male broiler chickens to diets with various protein and energy contents during the growing phase. Br. Poult. Sci. 24:90–99.

Plavnik, I., E. Wax, D. Sklan, I. Bartov, and S. Hurwitz. 1997. The response of broiler chickens and turkey poults to dietary energy supplies either by fat or carbohydrates. Poult. Sci. 76:1000–1005.

Pym, R. A. E. 1990. Nutritional genetics. Pages 847–876 in Poultry Breeding and Genetics. R. D. Crawford, ed. Elsevier Publishing Co., New York, NY.

Sales, J., and J. J. Du Preez. 1997. Protein and energy requirements of the Pearl Gray guinea fowl. World's Poult. Sci. J. 53:382–385.

SAS Institute. 1999. SAS/STAT User's Guide, Version 6. 5th ed. SAS Inst. Inc., Cary, NC.

Schutte, J. B. 1987. Utilization of synthetic amino acids in poultry. Pages 11–12 in World's Poult. Sci. Assoc., 6th Eur. Symp. Poult. Nutr., Konigslutter, Germany.

Sengar, S. S. 1987. Feed intake and growth rate pattern in White Leghorn chicks maintained on different planes of nutrition. Poult. Advisor 20:23–27.

Sturkie, P. D. 1976. Alimentary canal: Anatomy, prehension, deglutition, feeding, drinking, passage of ingesta and motility. Pages 186–195 in Avian Physiology. 3rd ed. P. D. Sturkie, ed. Springer-Verlag, New York, NY.

Veldkamp, T., R. P. Kwakkel, P. R. Ferket, and M. W. A. Verstegen. 2005. Growth response to dietary energy and lysine at high and low ambient temperature in male turkeys. Poult. Sci. 84:273–282.

Vo, K. V., N. A. Adefope, D. Wright, C. L. Fenderson, and S. H. Kolison Jr. 2000. Growth performance and processing yield of guinea fowl as influenced by genotypes and dietary energy. Poult. Sci. 79(Suppl. 1):29. (Abstr.)

Waldroup, P. W., N. M. Tidwell, and A. L. Izat. 1990. The effect of energy and amino acid levels on performance and carcass quality of male and female broilers grown separately. Poult. Sci. 69:1513–1521.