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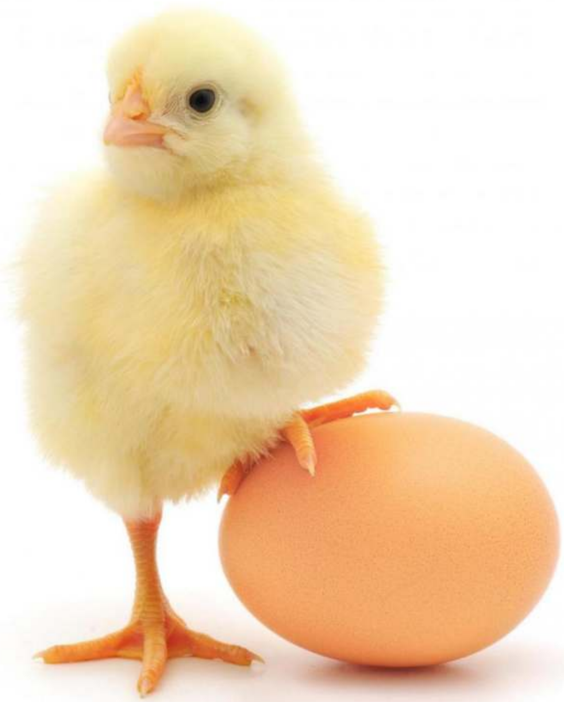

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The Effect of Dietary Protein and Energy Levels During the Growing Period of Egg-type Pullets on Early Egg Production and Egg Weight and Dimensions in Arid Hot Climate

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Abstract: A (3 x 3) factorial arrangement was used in a completely randomized design to study the effect of early nutrition of pullet on subsequent egg production and quality. Three levels of protein and three levels of energy during stages of pullet growth (starter 0-6 wk, grower 7-12 wk and developer 13-18 wk of age) and their effect on laying performance (22-36 wk of age) were evaluated. In all phases of growing period, control levels of protein (P1) and energy (E1) were set according to NRC (1994) and the other levels were higher, for protein in 2% steps (P2 and P3) and for energy by 100 kcal of ME/kg steps (E2 and E3). Each treatment was replicated three times with ten birds each. Treatments in the factorial arrangement were kept the same for bird groups in every phase but at 19 week of age all groups were shifted to the identical layer diet up to the end of the trial. The layer performance of the different treatment groups was evaluated. In phase one of egg production cycle (22-36 week of age), hen-day egg production was influenced ($p \leq 0.01$) by protein levels fed to the birds during the growing period. P2E3 diet had the best hen-day egg production. Egg mass was significantly ($p \leq 0.01$) affected by dietary protein levels fed to the birds during the growing period. The higher dietary protein levels (P2 and P3) fed to the birds during the growing period had higher egg mass than those fed the lowest protein level P1. Egg weight, egg length, egg width and feed consumption were not influenced by dietary protein levels fed to the birds during the growing period. Egg weight, mass, length, width and shape index and feed conversion were not affected by dietary energy levels fed to the birds during the growing period. Thus, feeding the higher protein levels (P2 and P3) had the highest hen-day egg production and egg mass. The best egg mass and egg production were recorded with P2E3 diet, so the feeding of the pullets with P2E3 diet during the growing period will give best hen-day egg production.

Key words: Dietary protein, energy, pullets, growing period, laying performance

INTRODUCTION

Pullet's feeding programs which provide adequate requirements in the growing periods had a pronounced effect on their body weight and at onset of lay and laying performance. Hudson *et al.* (2000) mentioned that providing higher crude protein intakes at an early age may improve subsequent egg production for broiler breeders. There have been many researchers suggesting the adoption of proper levels of dietary nutrient and rearing regime in order to produce pullets that develop into profitable layers. The quality of the bird at the onset of her egg production will greatly determine how profitable she will be during the laying cycle. However, it appeared that there is no best program to follow. There is no consensus on the proper levels of dietary protein and energy required during the growth phase. There appears to be limited agreement that body weight and/or body composition at onset of production are the most important (Leeson and Summers, 1987). It is essential to have the Leghorn pullet reach the target weight, body composition and possibly age, at the onset of laying (Leeson *et al.*, 1991; Leeson and Caston, 1991; Summers *et al.*, 1991). Leeson *et al.* (1998) stated that regardless of diet energy level, pullets were smaller in weight and stature when the protein level decreased. Throughout the laying cycle this weight differential was maintained, during, which there was obvious trend of smaller weight birds to produce smaller eggs. Also, at the same report the egg production and other egg characteristics were not influenced by protein levels during the growing period. Many reports indicated that body weight of pullets at the age of housing was

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positively correlated with egg weight during the egg production cycle (Summers and Leeson, 1983; Keshavarz, 1995). Keshavarz (1998) reported that egg production, egg mass, feed consumption and feed conversion from 18-38 wk of age were not affected by dietary energy and protein levels used for pullets during 8-18 wk of age. Similarly, egg weight and egg size during 20-38 wk of age were not influenced by diet energy and protein levels fed to the birds during 8-18 wk of age. Egg production from 22-66 wk of age was not influenced by energy or protein levels during the growing period. The only exception was for egg production from 34-38 wk of age, which was lower for hens fed high protein sequence during the growing period. Egg weight was not influenced by neither energy nor protein levels during the growing period.

The information pertaining to the effect of dietary levels of energy and protein during the growing period on pullet growth and subsequent production performance in arid hot climate regions of the world, such as that prevailing in Sudan was very scarce. In addition to that the most poultry farms in Sudan used the levels of protein and energy recommended by (National Research Council, 1994) to feed their birds without taking in consideration the high environmental temperature. Although they feed their birds ad libitum but the production always fluctuated. That is why in the current experiment we also used protein and energy levels higher than those recommended by (National Research Council, 1994) for feeding the pullets. The objective of the present study was to evaluate the effect of varying energy and protein levels during the growing period on subsequent egg production performance of white Leghorn pullets raised under Sudan conditions.

MATERIALS AND METHODS

The present study was conducted at the poultry houses of The Department of Poultry Production, Faculty of Animal Production, University of Khartoum to estimate the effect of feed manipulations during growing period on early egg production performance. The chemical analysis was performed for the rations and ingredients in the laboratories of University of Khartoum (Sudan), University of Humboldt (Germany), Technical University of Munich (Germany) and Veterinary Research Centre (Soba-Sudan).

Birds housing and management: Two hundred and seventy, one-day-old chicks single comb white Leghorn strain (Hisex) were brought from Coral Chick and Feed Production Farms in Khartoum. Before chicks housing, all pens were cleaned, burned and washed prior to the commencement of the experiment. The floor of pens was covered with wood shavings 5 cm in depth. The pens measured 100 x 100 x 100 cm and each housed 10 birds. The birds were housed on open sided deep litter system in three rows of pens each one contain nine pens situated on East-West direction facing South and North winds. Birds were kept at these pens throughout the trial. The pullets were exposed to decreasing lighting period by two hours weekly from 23-12 h day length up to the sixth week of age. The lighting period was kept constant until 18 wk of age. Thereafter the day length was increased by two hours of artificial light weekly until it reached 16 hours per day at 20 wk of age. The day length during laying period was kept at 16 hours up to the end of the experiment. A (3 x 3) factorial arrangement was used in a completely randomized design to study three levels of protein and three levels of energy during several stages of pullet growth and their effect on growth and laying performance. The experimental period was divided into four phases. Phase one (starter) from 0-6 wk, phase two (grower) from 7-12 wk, phase three (developer) from 13-18 wk and phase four (production). In all phases of growing, control levels of protein and energy were set according to NRC (1994) and the other levels were higher. A total of 9 treatments in all phases of growing were employed and each treatment was replicated three times with ten birds each. At 1 day old, experimental birds were weighed individually and assigned so as to make no obvious differences in average weight between experimental groups.

Experimental diets and feeding program: All the groups were provided *ad libitum* access to the feed and water throughout the trial. Lysine and methionine were added to the diets of all phases to meet levels recommended for birds in each growing phase (National Research Council, 1994).

During phase one (starter), three levels of protein (P1 = 18, P2 = 20 and P3 = 22% CP) and Three levels of energy (E1 = 3000, E2 = 3100 and E3 = 3200 kcal of ME/kg of diet) were used. Table 1 shows the compositions of the starter diets. In phase two (grower), the same protocol in phase one was continued for the factorial arrangement. The levels of energy were not changed, but the corresponding levels of protein were changed (P1 = 16%, P2 = 18% and P3 = 20%), (Table 2). In phase three (developer), the same protocol in phase one and two was continued, but the levels of both protein and energy were changed (P1 = 15%, P2 = 17% and P3 = 19%) and (E1 = 3050, E2 = 3150 and E3 = 3250 kcal of ME/kg of diet). Table 3 shows the composition of the developer diets. During phase four (production period), all groups were shifted to a standard layer diet from 19 to the end of the experiment (Table 4).

Table 1: Composition and calculated nutritional content (% original matter) of experimental diets of starter period (0-6 wks)

	3,000 kcal ME/kg (E1)			3,100 kcal ME/kg (E2)			3,200 kcal ME/kg (E3)		
Ingredients and analysis	18% CP (P1)	20% CP (P2)	22% CP (P3)	18% CP (P1)	20% CP (P2)	22% CP (P3)	18% CP (P1)	20% CP (P2)	22% CP (P3)
Sorghum	49.30	46.16	41.33	60.80	57.80	53.16	61.40	60.00	61.50
Groundnut cake	7.50	12.21	12.21	3.50	8.70	9.45	5.00	9.40	12.41
Sesame cake	1.01	2.00	10.00	7.04	7.06	13.11	6.34	9.11	13.00
Wheat bran	38.57	36.07	33.17	25.07	23.00	21.30	20.98	16.13	9.39
Dicalcium phosphate	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49
Oyster shell	1.05	1.05	0.80	1.05	0.90	0.53	1.03	0.85	0.50
Sodium chloride	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Lysine	0.44	0.42	0.40	0.48	0.48	0.42	0.49	0.45	0.43
DL-methionine	0.14	0.10	0.10	0.07	0.07	0.04	0.07	0.07	0.05
Vegetable oil	-	-	-	-	-	-	2.70	2.00	0.73
Vitamin-mineral premix[1]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Chemical analysis[2]									
Energy (kcal ME/kg)	3,050.00	3,078.00	3,027.00	3,101.00	3,096.00	3,091.00	3,219.00	3,202.00	3,056.00
Protein	19.53	20.67	22.90	18.34	20.44	22.60	19.02	20.99	23.00

[1]Vitamin-mineral premix provided the following per kilogram of diet: vitamin A (retinyle acetate), 10,000 IU; cholecalciferol, 2,500 IU; alpha-tocopheryl acetate, 60 mg; mendione sodium bisulfite complex, 15 mg; thiamine hydrochloride, 2 mg; riboflavine, 8 gm; pyridoxine hydrochloride, 4 mg; cyanocobalamin, 0.04 mg; pantothenic acid, 15 mg; nicotinic acid, 40 gm; folic acid, 1.5 mg; biotin, 0.2 mg; choline chloride, 200 mg; iron, 50 mg; manganese, 50 mg; copper, 10 mg; zinc, 50 mg; calcium, 352 mg; iodine, 1.46 mg; cobalt, 0.5 mg; selenium, 0.2 mg. [2]Values and metabolizable energy calculated according to Sulieman and Mabrouk (1999)

Table 2: Composition and calculated nutritional content (% original matter) of experimental diets of grower period (7-12 wks)

	3,000 kcal ME/kg (E1)			3,100 kcal ME/kg (E2)			3,200 kcal ME/kg (E3)		
Ingredients and analysis	16% CP (P1)	18% CP (P2)	20% CP (P3)	16% CP (P1)	18% CP (P2)	20% CP (P3)	16% CP (P1)	18% CP (P2)	20% CP (P3)
Sorghum	53.61	49.60	45.20	65.20	61.80	57.70	65.84	64.30	65.99
Groundnut cake	0.30	4.21	6.70	1.00	4.70	7.45	1.00	5.00	6.41
Sesame cake	0.30	2.16	6.84	1.04	3.06	7.11	1.00	5.11	10.00
Wheat bran	42.37	40.91	38.48	29.37	27.29	24.82	26.14	20.52	14.18
Dicalcium phosphate	1.49	1.40	1.40	1.49	1.40	1.45	1.42	1.4	1.35
Oyster shell	1.05	0.90	0.64	1.05	0.90	0.73	1.04	0.85	0.56
Sodium chloride	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Lysine	0.24	0.22	0.18	0.28	0.28	0.20	0.28	0.25	0.23
DL-methionine	0.14	0.10	0.06	0.07	0.07	0.04	0.08	0.07	0.05
Vegetable oil	-	-	-	-	-	-	2.70	2.00	0.73
Vitamin-mineral premix[1]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Chemical analysis[2]									
Energy (kcal ME/kg)	3,009.00	3,066.00	3,045.00	3,154.00	3,134.00	3,128.00	3,265.00	3,235.00	3,054.00
Protein	15.60	17.67	20.21	15.85	17.95	19.84	15.17	17.81	20.59

[1]Vitamin-mineral premix provided the following per kilogram of diet: vitamin A (retinyle acetate), 10,000 IU; cholecalciferol, 2,500 IU; alpha-tocopheryl acetate, 60 mg; mendione sodium bisulfite complex, 15 mg; thiamine hydrochloride, 2 mg; riboflavine, 8 gm; pyridoxine hydrochloride, 4 mg; cyanocobalamin, 0.04 mg; pantothenic acid, 15 mg; nicotinic acid, 40 gm; folic acid, 1.5 mg; biotin, 0.2 mg; choline chloride, 200 mg; iron, 50 mg; manganese, 50 mg; copper, 10 mg; zinc, 50 mg; calcium, 352 mg; iodine, 1.46 mg; cobalt, 0.5 mg; selenium, 0.2 mg. [2]Values and metabolizable energy calculated according to Sulieman and Mabrouk (1999)

Parameters during production period: Feed consumption was recorded weekly throughout the trial. Egg production was recorded daily. Egg traits were measured and FCR was calculated from the daily feed consumption and the egg mass. Egg mass was calculated by multiplying egg weight by hen-day egg production. Egg production on a daily basis was calculated in hen-day production throughout the laying period. Fifteen eggs from each treatment were collected at the end of week 22, 24 and thereafter every four weeks up to 36 wk of age for measurements of egg weight and egg mass. Yolk index and shape index were calculated. At first egg weight was recorded by sensitive electronic scale. The length and width of egg were determined by vernier caliper and their shape index was determined.

Statistical analysis: Experimental data are presented as mean values ± standard errors of the means. Statistical analyses were carried out by using the SPSS 11.0 program package (SPSS, 2001). The significance of the differences among the groups has been determined by Duncan's multiple range test (Petrie and Watson, 1999).

Table 3: Composition and calculated nutritional content (% original matter) of experimental diets of developer period (13-18 wks)

Ingredients and analysis	3,050 kcal ME/kg (E1) 15% CP (P1)	17% CP (P2)	19% CP (P3)	3,150 kcal ME/kg (E2) 15% CP (P1)	17% CP (P2)	19% CP (P3)	3,250 kcal ME/kg (E3) 15% CP (P1)	17% CP (P2)	19% CP (P3)
Sorghum	60.99	43.80	51.00	69.10	57.80	62.88	70.00	73.70	74.00
Groundnut cake	0.10	2.50	50.00	0.10	2.02	5.50	0.50	4.00	6.50
Sesame cake	0.10	2.50	5.00	0.10	2.31	6.00	0.50	4.00	6.25
Wheat bran	34.36	44.64	35.58	27.55	32.8	22.50	22.61	14.88	10.42
Dicalcium phosphate	1.80	1.60	1.49	1.40	1.40	1.40	1.45	1.35	1.40
Oyster shell	1.80	1.40	1.05	0.90	0.85	0.90	1.50	0.56	0.69
Sodium chloride	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Lysine	0.28	0.49	0.24	0.28	0.25	0.22	0.20	0.23	0.18
DL-methionine	0.07	0.07	0.14	0.07	0.07	0.10	0.04	0.05	0.06
Vegetable oil		2.50			2.00		2.70	0.73	
Vitamin-mineral premix[1]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Chemical analysis[2]									
Energy (kcal ME/kg)	3,084.00	3,141.00	3,078.00	3,179.00	3,226.00	3,139.00	3,281.00	3,241.00	3,208.00
Protein	15.22	17.11	18.50	15.15	16.61	18.66	15.15	17.89	18.78

[1]Vitamin-mineral premix provided the following per kilogram of diet: vitamin A (retinyle acetate), 10,000 IU; cholecalciferol, 2,500 IU; alpha-tocopheryl acetate, 60 mg; mendione sodium bisulfite complex, 15 mg; thiamine hydrochloride, 2 mg; riboflavine, 8 gm; pyridoxine hydrochloride, 4 mg; cyanocobalamin, 0.04 mg; pantothenic acid, 15 mg; nicotinic acid, 40 gm; folic acid, 1.5 mg; biotin, 0.2 mg; choline chloride, 200 mg; iron, 50 mg; manganese, 50 mg; copper, 10 mg; zinc, 50 mg; calcium, 352 mg; iodine, 1.46 mg; cobalt, 0.5 mg; selenium, 0.2 mg. [2]Values and metabolizable energy calculated according to Sulieman and Mabrouk (1999)

Table 4: Composition and calculated nutritional content (% original matter) of experimental standard layer diet

Ingredients	Composition (%)
Sorghum	67.80
Groundnut cake	3.79
Sesame cake	3.36
Wheat bran	12.00
Dicalcium phosphate	0.53
Oyster shell	6.90
Sodium chloride	0.30
Lysine	0.09
DL-methionine	0.03
Vitamin-mineral premix[1]	0.20
Super concentrate	5.00
Chemical analysis[2]	
Energy (kcal ME/kg)	2,832.00
Protein	17.70

[1]Vitamin-mineral premix provided the following per kilogram of diet: vitamin A (retinyle acetate), 10,000 IU; cholecalciferol, 2,500 IU; α-tocopheryl acetate, 60 mg; mendione sodium bisulfite complex, 15 mg; thiamine hydrochloride, 2 mg; riboflavine, 8 gm; pyridoxine hydrochloride, 4 mg; cyanocobalamin, 0.04 mg; pantothenic acid, 15 mg; nicotinic acid, 40 gm; folic acid, 1.5 mg; biotin, 0.2 mg; choline chloride, 200 mg; iron, 50 mg; manganese, 50 mg; copper, 10 mg; zinc, 50 mg; calcium, 352 mg; iodine, 1.46 mg; cobalt, 0.5 mg; selenium, 0.2 mg.
[2]Values and metabolizable energy calculated according to Sulieman and Mabrouk (1999)

The statistical model used for hen-day egg production and egg characteristics was:

$$Y_{ijklm} = \mu + M_i + P_j + T_k + (MP)_{ij} + (MT)_{ik} + (PT)_{jk} + (MPT)_{ijk} + R_{ijkl} + \gamma_{ijklm}$$

Where:

- Y_{ijklm} = Response variables from each individual replication.
- μ = The overall mean.
- M_i = The effect of dietary metabolizable energy.
- P_j = The effect of dietary crude protein.
- T_k = The effect of time period.
- $(MP)_{ij}$ = The effect due to interactions between dietary metabolizable energy and crude protein.
- $(MT)_{ik}$ = The effect due to interactions between metabolizable energy and time period.
- $(PT)_{jk}$ = The effect due to interactions between dietary crude protein and time period.
- $(MPT)_{ijk}$ = The interactions between metabolizable energy, crude protein and time periods.
- R_{ijkl} = The experimental unit (replications) error term.
- γ_{ijklm} = The experimental unit error term.

RESULTS

Hen-day egg production from 22-36 wk of age was significantly influenced ($p \leq 0.01$) by dietary protein levels fed to the birds during the growing period (Table 5). Diets of higher protein levels (P2 and P3) fed to the birds had the highest percentages of hen-day egg production (22-36 wk of age). Hen-day egg production from 22-36 wk of age was significantly influenced ($p \leq 0.01$) by age (Table 5). There was interaction ($p \leq 0.01$) between protein levels fed to the birds during the growing period and age from 22-36 wk of age. With higher dietary protein levels (P2 and P3) the egg production increased with advanced age up to 32 wk of age. Hen-day egg production from (22-36 wk of age) was not influenced by dietary energy used during the growing period (Table 6). There was no interaction effect between protein and energy levels during the growing period on hen-day egg production (Table 7). The highest percentage of hen-day egg production for (22-36 wk of age) was observed with birds fed P2E3 diet during the growing period.

Table 5: The effect of protein levels during the growing period and age on hen-day egg production (22-36 wk of age)

Treatment: Protein (%)	Age (weeks)	Hen-day egg production (%)
P1 18-16-15	22	6.8
	24	38.3
	28	72.5
	32	68.0
	36	64.7
P2 20-18-17	22	14.7
	24	56.0
	28	68.7
	32	74.4
	36	66.9
P3 22-20-19	22	27.3
	24	60.3
	28	68.9
	32	71.7
	36	65.7
SEM		3.29
Protein effect		**
P1		50.1^{B}
P2		56.1^{A}
P3		58.8^{A}
Age effect		**
22		16.3^{C}
24		51.5^{B}
28		70.0^{A}
32		71.3^{A}
36		65.8^{A}
Protein x Age		**

$^{A-C}$Means in a column and treatment variable with no common superscript differ significantly ($p \leq 0.01$). **$p \leq 0.01$

Table 6: The effect of energy levels during the growing period and age on hen-day egg production (22-36 wk of age)

Treatment: Energy (kcal/kg)	Age (weeks)	Hen-day egg production (%)
E1 3000-3000-3050	22	15.1
	24	58.9
	28	67.1
	32	66.9
	36	63.2
E2 3100-3100-3150	22	16.0
	24	44.4
	28	71.3
	32	72.5
	36	68.4
E3 3200-3200-3250	22	17.7
	24	51.2
	28	71.8
	32	74.6
	36	66.0
SEM		3.29
Energy effect		NS
E1		54.2
E2		54.5
E3		56.3
Energy x Age		NS

Egg (weight, length and width) and feed consumption from 22-36 wk of age were not influenced by dietary protein levels during the growing period (Table 8).

Table 7: The interaction effect of protein and energy levels during the growing period on hen-day egg production (22-36 wk of age)

Treatment: Protein level	Energy level	Hen-day egg production (%)
	E1	51.3
P1	E2	49.8
	E3	49.1
	E1	52.2
P2	E2	54.7
	E3	61.6
	E1	59.1
P3	E2	59.0
	E3	58.2
SEM		2.55
Protein x Energy		NS

Increasing the dietary protein levels (P2 and P3) improved significantly the feed conversion for hens during 22-36 wk of age compared to pullets fed the low protein level (P1) during the growing period ($p \leq 0.01$). Egg mass was affected significantly ($p \leq 0.01$) by dietary protein levels fed to the birds during the growing period. Table 8 shows that pullets fed the higher dietary protein levels (P2 and P3) had higher egg mass than those birds fed the lower dietary protein level (P1). The dietary protein level during the growing period has a significant ($p \leq 0.01$) effect on egg shape index. The highest shape index was recorded for the medium protein level (P2) and there was no difference between the higher and lower protein levels (Table 8). Egg weight, egg mass and egg width were influenced by age from 22-36 wk of age ($p \leq 0.01$, Table 8). The heavy egg weight was recorded at 36 wk of age whereas no significant differences in egg weight were reported between the others ages. Likewise, the egg widths were affected by age from 22-36 wk of age. Egg mass were increased with advanced ages and that is because egg mass is a consequence of egg production, which was increased when the age advanced (Table 5). Egg length and shape index were not influenced by age during 22-36 wk of age. Feed consumption was increased ($p \leq 0.01$) from 22-36 wk of age. Feed conversion was significantly improved ($p \leq 0.01$) from 24-36 wk of age. The interaction between protein and age for the egg mass was significant ($p \leq 0.05$). With advanced age the egg mass was increased due to the use of high dietary protein level during the growing period. Egg weight, mass, length and width and shape index and feed conversion during 22-36 wk of age were not influenced by dietary energy levels during the growing period (Table 9). Table 9 shows that feed consumption was influenced by energy level during the growing period ($p \leq 0.01$). Birds fed diets containing the lowest energy level (E1) consumed significantly ($p \leq 0.01$) more feed than the medium energy level (E2). Table 9 shows that birds fed the highest energy level (E3) consumed more feed ($p \leq 0.01$) than those birds fed medium energy levels (E2). There was no interaction

Table 8: The effect of protein levels during the growing period on feed consumption, feed conversion and egg characteristics (22-36 wk of age)

Treatment: Protein level	Age (weeks)	Egg weight (g)	Egg mass (g)	Feed consumption (g/hen/day)	Egg length (mm)	Egg width (mm)	Shape index	Feed conversion (g:g)
P1	22	50.0	3.4	93.9	54.4	41.0	75.4	43.7
	24	51.8	20.0	93.1	55.3	41.1	74.4	5.3
	28	51.0	37.0	87.8	54.1	41.2	76.1	2.4
	32	53.0	36.0	101.3	54.6	41.9	76.7	2.9
	36	53.4	34.6	110.8	55.8	42.4	76.1	3.3
P2	22	52.0	7.5	91.2	55.1	41.7	75.8	14.0
	24	51.4	28.7	95.2	53.7	41.3	76.9	3.5
	28	54.2	37.3	87.2	55.1	42.0	76.3	2.5
	32	51.0	38.0	107.1	54.3	41.0	75.5	2.8
	36	57.8	38.6	107.9	53.8	42.6	79.9	2.8
P3	22	51.1	13.9	96.9	55.0	41.0	74.7	8.3
	24	51.0	30.6	99.1	54.3	40.9	75.4	3.3
	28	51.6	35.6	87.3	55.8	41.6	74.8	2.5
	32	52.4	37.4	102.3	54.9	41.4	75.5	2.8
	36	53.1	34.8	107.5	56.0	42.1	75.3	3.1
SEM		1.23	1.83	2.52	0.66	0.34	0.83	3.60
Protein effect		NS	**	NS	NS	NS	**	**
P1		51.9	26.2^{B}	97.4	54.8	41.5	75.7^{B}	11.5^{B}
P2		53.3	30.0^{A}	97.2	54.4	41.7	76.9^{A}	5.1^{A}
P3		51.8	30.5^{A}	98.6	55.2	41.4	75.1^{B}	4.0^{A}
Age effect		**	**	**	NS	**	NS	**
22		51.1^{B}	8.3^{C}	94.0^{C}	54.8	41.2^{B}	75.3	22.0^{B}
24		51.4^{B}	26.4^{B}	95.8^{C}	54.4	41.1^{B}	75.6	4.0^{A}
28		52.3^{B}	36.6^{A}	87.4^{D}	55.0	41.6^{B}	75.7	2.5^{A}
32		52.1^{B}	37.2^{A}	103.6^{B}	54.6	41.4^{B}	75.9	2.8^{A}
36		54.8^{A}	36.0^{A}	108.8^{A}	55.2	42.4^{A}	77.1	3.1^{A}
Protein x Age		NS	*	NS	NS	NS	NS	**

$^{A-D}$Means in a column and treatment variable with no common superscript differ significantly ($p \le 0.01$). *$p \le 0.05$.; **$p \le 0.01$

Table 9: The effect of energy levels during the growing period on feed consumption, feed conversion and egg characteristics (22-36 wk of age)

Treatment: Energy level	Age (weeks)	Egg weight (g)	Egg mass (g)	Feed consumption (g/hen/day)	Egg length (mm)	Egg width (mm)	Shape index	Feed conversion (g:g)
E1	22	52.7	7.8	95.0	55.2	41.5	75.1	18.9
	24	53.1	30.9	96.3	55.3	41.4	74.9	3.2
	28	53.7	36.0	88.9	55.4	41.8	75.5	2.6
	32	51.3	34.2	106.1	54.2	41.3	76.1	3.2
	36	55.8	35.1	108.1	53.5	42.7	80.5	3.1
E2	22	50.9	8.1	90.4	54.5	41.3	75.7	15.6
	24	50.2	22.3	90.6	54.2	40.7	75.1	4.5
	28	50.1	36.6	84.4	53.9	41.3	76.7	2.4
	32	51.9	37.6	98.1	55.0	41.4	75.3	2.6
	36	54.6	37.2	107.4	56.4	42.2	74.9	2.9
E3	22	49.6	8.8	96.6	54.7	41.0	75.0	31.5
	24	51.0	26.1	100.5	53.8	41.3	76.8	4.5
	28	52.1	37.3	88.9	55.9	41.7	74.9	2.4
	32	53.2	39.7	106.5	54.7	41.7	76.3	2.7
	36	53.9	35.7	110.7	55.7	42.2	75.9	3.1
SEM		1.23	1.83	2.52	0.66	0.34	0.83	3.6
Energy effect		NS	NS	**	NS	NS	NS	NS
E1		53.3	28.8	98.9^{A}	54.7	41.7	76.4	6.2
E2		51.7	28.4	94.2^{B}	54.8	41.4	75.5	5.6
E3		52.0	29.5	100.6^{A}	55.0	41.6	75.8	8.8
Energy x Age		NS	NS	NS	*	NS	**	NS

^{A,B}Means in a column and treatment variable with no common superscript differ significantly ($p \le 0.01$). *$p \le 0.05$; **$p \le 0.01$

between protein and energy during the growing period for egg weight, mass and length and feed conversion from 22-36 wk of age (Table 10). The highest egg weight recorded with P2E1 combination between protein and energy followed by P2E3. The highest egg mass was recorded with P2E3 and the lowest one was observed

Table 10: The effect of protein and energy levels during the growing period on feed consumption, feed conversion and egg characteristics (22-36 wk of age)

Treatment				Feed				Feed
Protein level	Energy level	Egg weight (g)	Egg mass (g)	consumption (g/hen/day)	Egg length (mm)	Egg width (mm)	Shape index	conversion (g:g)
P1	E1	51.8	26.7	97.8	55.2	41.4	75.0	9.2
	E2	51.9	26.1	97.1	54.2	41.5	76.6	7.7
	E3	51.9	25.8	97.2	55.1	41.7	75.6	11.7
P2	E1	56.2	29.1	99.1	53.9	42.5	79.3	5.5
	E2	51.6	28.5	90.6	54.9	41.2	75.2	5.2
	E3	52.1	32.5	103.4	54.5	41.4	76.2	4.6
P3	E1	51.9	30.6	99.6	55.0	41.3	75.0	3.9
	E2	51.7	30.5	94.8	55.3	41.4	74.8	3.9
	E3	51.9	30.3	101.4	55.2	41.6	75.5	4.2
SEM		0.95	1.42	1.95	0.51	0.27	0.64	2.37
Protein x Energy		NS	NS	*	NS	*	**	NS

*$p \leq 0.05$; **$p \leq 0.01$

Table 11: The effect of the energy and protein levels on pullets body weight during growing period

Treatment		Body weight		
Protein (%)	Energy (kcal/kg)	6 wk	12 wk	18 wk
P1	E1	297.63	598.73	925.67
	E2	278.93	568.80	848.07
	E3	232.90	569.73	877.33
P2	E1	320.33	654.73	987.23
	E2	252.13	598.27	999.67
	E3	329.00	637.40	1010.43
P3	E1	294.80	691.13	1050.73
	E2	304.30	689.77	989.33
	E3	316.13	665.40	985.60
SEM		3.10	7.33	12.02
Protein effect		**	**	**
P1		269.82^{B}	579.09^{C}	883.69^{B}
P2		300.49^{A}	630.13^{B}	999.11^{A}
P3		305.08^{A}	682.10^{A}	1008.56^{A}
Energy effect		*	NS	NS
E1		304.27^{a}	648.20	987.88
E2		278.46^{b}	618.94	945.69
E3		292.68^{ab}	624.18	957.79
Protein x Energy		**	NS	NS

$^{A-C}$Means in a column and treatment variable with no common superscript differ significantly ($p \leq 0.01$).

^{a,b}Means in a column and treatment variable with no common superscript differ significantly ($p \leq 0.05$). *$p \leq 0.05$, **$p \leq 0.01$

with P1E3. There was interaction between energy and protein levels during the growing period for the feed consumption ($p \leq 0.01$) during 22-36 wk of age (Table 10). With increasing the energy level from E2 to E3 the feed consumption increased with increasing levels of protein. The dietary protein and energy levels fed to the birds during the growing period had interaction for the egg width. Increasing the energy level from E2 to E3 egg width increased with increasing levels of protein. Body weights were affected significantly ($p \leq 0.01$) by protein levels at all phases of growth (Table 11). High levels of protein (P2 and P3) scored higher body weights of pullets than those body weights of pullets fed low level of protein (P1). Pullets body weights were not influenced significantly ($p \leq 0.05$) by the variable energy levels during the growing period (Table 11). The only exception was body weight at the starter period which was greater for the pullets provided by lower level of energy E1 than those supplied by E2 level of energy. On the other hand no significant difference between pullet's body weights fed E3 level of energy which represents the highest level of energy and E1 and E2.

DISCUSSION

In the present study hen-day egg production from 22-36 week of age was affected significantly ($p \leq 0.01$) by dietary protein levels used during the growing period and hen age. Diets of higher protein levels (P2 and P3) had the highest hen-day egg production. These results disagree with the findings of Keshavarz (1998), who reported that egg production was not influenced by low protein sequence (18-16-14) and high protein sequence (22-18-16) fed to the birds during the growing period. The only exceptions were egg production from 18-22 wk of age, which was greater for birds fed the high protein sequence and from 34-38 wk of age, which was lower for birds fed the high protein sequence during the growing period. The results of the current study are in line with those findings of Nahashon *et al.* (2007), who reported that the hen-day egg production was higher for birds fed higher protein levels 22 and 24% than those fed 20% crude protein diets used during the 0-8 wk of age. Birds fed P2 and P3 exhibited higher body weight during the growing period than on lower protein level P1 (Table 11). Leeson *et al.* (1997) reported that regardless of strain, pullets with smaller body weight matured more slowly and produced less total egg mass to 70 wk of age. Cheng *et al.* (1991) reported that birds with heavier body weights at 20 week of age had better laying performance than birds with lighter body weights ($p<0.05$). Hen-day egg production had significantly positive correlation ($p \leq 0.05$) with egg mass (0.96) (Nahashon *et al.*, 2007). Hen-day egg production was not influenced by dietary energy used during the growing period. Keshavarz (1998) revealed that the egg production was not influenced by energy levels (2,816 vs 3,036 kcal of ME/kg of diet) fed to the birds during the growing period and no interaction effect was recorded between energy and protein levels, which is concur with the current study.

Although, egg weight was not affected by dietary protein level during the growing period in this study, the egg mass in contrast was significantly influenced by dietary protein levels during the growing period. The egg mass was calculated (egg weight x egg production), so these results may be due to the hen-day egg production from 22-36 wk of age which was influenced ($p \leq 0.01$) by protein levels during the growing period (Table 5). These results are in line with the findings of Hussein *et al.* (1996) who stated that egg weight during the first 16 weeks following the photo stimulation was not influenced by protein levels during the growing period when using 13.5, 15.8 and 18.9% for increasing protein treatment; 15.8, 15.8 and 15.8% for constant protein treatment and 18.9, 15.8 and 13.5% from 2-6, 7-14 and 15-18 week of age, respectively. There was reduction in feed intake during the early stage of egg production. This reduction is a normal phenomenon which happens as pullets approach the onset of egg and at the second stage of sexual maturity, so body reserves (body weight) are very important for the pullets coming into production. Nutrient intake at that time will not be probably sufficient to meet the needs for maintenance and egg production, especially if birds are coming into production in hot weather when where feed intake will be further reduced by high environmental temperature. The high value of feed conversion ratio at 22 wk of age was due to the low egg production by which the feed conversion has been calculated.

These results are coinciding with the finding of Keshavarz (1998) who revealed that egg weight during 22-38 wk of age was not influenced by protein level fed to the birds during the growing period. He also reported that feed consumption during 18-38 wk of age was not influenced by protein levels fed to the birds during the growing period. The results of the current study pertaining to the effect of dietary protein levels on egg mass and feed conversion during 22-36 wk of age are conflicting with Keshavarz (1998) who reported that egg mass and feed conversion were not influenced by dietary protein level during the growing period. The effect of protein on egg mass might be attributed to the egg production which was influenced by dietary protein levels. This will consequently affect the egg mass because it has been calculated using the egg production and egg weight. Egg weight, mass, length and width and shape index and feed conversion during 22-36 week of age were not affected by dietary energy levels used during the growing period. Birds fed diets containing the lowest energy level (E1) consumed more feed than those fed medium energy level (E2). Although all birds fed during the laying period the same diets which presented in Table 4 and no variations of feed consumption were expected, but that was may be due to the variation between weights of birds and the needs of more diet to fulfil their genetic potential weights that were not scored during the growing period. Previous report of Golian and Maurice (1992) and Leeson *et al.* (1993) that birds consume feed to meet their energy requirement. When birds fed high energy diets, often due to high fat content, the passage rate of the digesta through the intestinal tract will be reduced and consequently the feed intake will be reduced (Sturkie, 1990). Veldkamp *et al.* (2005) reported that feed consumption decreased linearly as dietary energy increased. Table 9 shows that birds fed the highest energy level (E3) consumed more feed ($p \leq 0.01$) than those birds fed medium energy levels (E2). These results contrast with suggestions of Golian and Maurice (1992) and that may be due to the harmful weather effect from July to November during which this parameter was measured. The results concerning egg traits are consistent with results reported by Keshavarz (1998) who revealed that egg weight from 22-38 wk of age was not influenced by dietary energy (2,816 vs 3,036 kcal ME/kg) fed to the birds during the growing period. He also reported that egg mass and feed conversion from 18-38 wk of age were not affected by dietary energy levels used during the growing period. These findings also agree with those of Hussein *et al.* (1996) who reported that egg weight and feed conversion during the first 16 weeks following the photo stimulation were not influenced by dietary energy (3.09 vs 2.78 Mcal AMEn/kg) used during the growing period. The information provided by this experiment indicates that there was no interaction between protein and energy during the growing period for egg weight, mass and length and feed conversion from 22-36 wk of age (Table 10). Although the combination P2E3 was not observed as the one gave the highest egg weight but had the highest egg mass and that is because of its highest hen-day egg production (22-36 wk of age).

Based on this study, feeding the higher protein levels (P2 and P3) had the highest hen-day egg production and egg mass. Thus, it is very important to supply pullets with high protein levels above the recommended level by (National Research Council, 1994) during the growing period, because high protein level will give good body weight and consequently high percentage of egg production. Body weight at 6 wk of age has been shown to be positively correlated with performance and 90% of the frame size of the body will develop by 12-14 wks of age. Egg weight was not influenced by protein and energy levels used during the growing period. The best egg mass and egg production was observed with P2E3 diet. Table 5 and 6 show how much the level of protein

(P2) and the level of energy (E3) gave good results. The P2E3 diets may have provided energy to protein ratio that provided the better protein and energy utilization for birds reared in hot arid conditions like Sudan, so it is advisable to be adopted.

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REFERENCES

Cheng, T.K., A. Pequri, M.L. Hamre and C.N. Coon, 1991. Effect of rearing regimens on pullet growth and subsequent laying performance. Poult. Sci., 70: 907-916.

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.

Hudson, B.P., R.J. Lien and J.B. Hess, 2000. Effects of early protein intake on development and subsequent egg production of broiler breeder hens. J. Appl. Poult. Res., 9: 324-333.

Hussein, A.S., A.H. Cantor, A.G. Pescatore and T.H. Johnson, 1996. Effect of dietary protein and energy levels on pullet development. Poult. Sci., 75: 973-978.

Keshavarz, K., 1995. Further investigations on the effect of dietary manipulations of nutrients on early egg weight. Poult. Sci., 74: 50-61.

Keshavarz, K., 1998. The effect of light regimen, floor space and energy and protein levels during the growing period on body weight and early egg size. Poult. Sci., 77: 1266-1279.

Leeson, S. and J.D. Summers, 1987. Effect of immature body weight on laying performance. Poult. Sci., 66: 1924-1928.

Leeson, S. and L. Caston, 1991. Growth and development of Leghorn pullet subjected to abrupt changes in environmental temperature and dietary energy level. Poult. Sci., 70: 1732-1738.

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

Leeson, S., J.D. Summers and L.J. Caston, 1998. Performance of white and brown egg pullets fed varying levels of diet protein with constant sulfer amino acids, lysine and tryptophan. J. Appl. Poult. Res., 7: 287-301.

Leeson, S., L. Caston and J.D. Summers, 1991. Significance of physiological age of Leghorn pullet in term of subsequent reproductive characteristics and economic analysis. Poult. Sci., 70: 37-43.

Leeson, S., L. Caston and J.D. Summers, 1997. Layer performance of four strains of Leghorn pullets subjected to various rearing programs. Poult. Sci., 76: 1-5.

Nahashon, S.N., N. Adefope, A. Amenyenu and D. Wright, 2007. Effect of varying metabolizable energy and crude protein concentrations in diets of Pearl Grey guinea fowl pullets. 2. egg production performance. Poult. Sci., 86: 973-982.

NRC, 1994. Nutrient Requirements of Poultry. National Academy Press, Washington, DC.

Petrie, A. and P. Watson, 1999. Statistics for Veterinary and Animal Science. Blackwell Sci., Malden, MA.

SPSS, 2001. 11.0. SPSS for Windows. SPSS, Chicago, IL.

Sturkie, P.D., 1990. Avian physiology, 3rd Edn., Springer verlag New York Inc. New York, USA.

Sulieman, Y.R. and A. Abd/Ra. Mabrouk, 1999. The Nutrient Composition of Sudanese Animal Feeds (Bulletin 111). Animal Production Research Centre Publications. Khartoum North, Sudan.

Summers, J.D. and S. Leeson, 1983. Factors influencing early egg size. Poult. Sci., 62: 1155-1159.

Summers, J.D., D. Spratt and J.L. Atkinson, 1991. Delaying sexual maturity of pullets by nutrient restriction at the onset of production. Can. J. Anim. Sci., 71: 1215-1221.

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.