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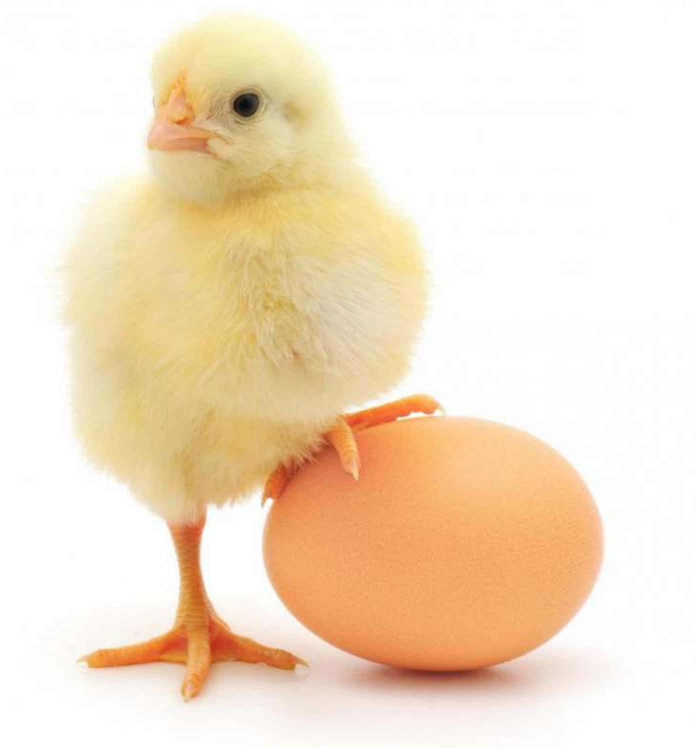

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The Effect of Dietary Protein and Energy Levels During the Growing Period of Egg-type Pullets on Internal Egg Characteristics of Phase One of Production in Arid Hot Climate

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Abstract: A (3 x 3) factorial arrangement was used in a completely randomized design to study the effect of protein and energy levels during the growing period of pullet on subsequent egg production performance. Three levels of protein and three levels of energy during stages of pullet growth (starter 0 to 6 wk, grower 7 to 12 wk and developer 13 to 18 wk of age) and their effect on laying performance (22 to 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 (P2 and E2) and (P3 and E3). A total of 9 treatments in each phase of the growth period were employed (P1 = 18, P2 = 20 and P3 = 22% CP) and (E1 = 3000, E2 = 3100 and E3 = 3200 kcal of ME/kg of diet) starter, (P1 = 16%, P2 = 18% and P3 = 20% CP) and (E1 = 3000, E2 = 3100 and E3 = 3200 kcal of ME/kg of diet) grower and (P1 = 15%, P2 = 17% and P3 = 19% CP) and (E1 = 3050, E2 = 3150 and E3 = 3250 kcal of ME/kg of diet) developer. 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 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 to 36 week of age), 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 was not influenced by dietary protein levels fed to the birds during the growing period. Egg weight and egg mass were not affected by dietary energy levels fed to the birds during the growing period. Internal egg characteristics from 22 to 36 weeks of age were not affected by protein and energy levels during the growing period. The only exception was yolk weight, which was significantly ($p \leq 0.05$) higher for the birds fed the medium protein level (P2). Thus, feeding the higher protein levels (P2 and P3) had the highest egg mass. The best egg mass was recorded with P2E3 diet. There was an interaction effect ($p \leq 0.05$) between protein and energy for yolk weight and height and Haugh units.

Key words: Dietary protein, energy, pullets, growing period, egg characteristics

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. Higher crude protein intake at an early age may improve subsequent egg production for broiler breeders (Hudson *et al*., 2000). 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 very important 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). There is a mature pullet body weight, which the bird should reach before the early stages of reproductive process are initiated with (increase in liver weight, development of the oviduct, etc.). Regardless of diet energy level, pullets were smaller in weight and stature when the protein level decreased (Leeson *et al*., 1998). During the entire 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

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production and other internal egg characteristics were not influenced by protein levels during the growing period for white and brown-egg pullets. The body weight is an important consideration and reliable measure for well developed pullet. Leeson *et al.* (2000) revealed that pullets fed lower protein diets were consistently smaller regardless of energy evaluation system. Summers and Leeson (1994) reported that such low protein diets are deleterious to subsequent size of the egg. Many reports indicated that body weight of pullets at the age of housing was positively correlated with egg weight during the egg production cycle (Summers and Leeson, 1983; Keshavarz, 1995). Keshavarz (1998) investigated in another experiment the effect of two dietary levels of energy (2,816 vs 3,036 kcal ME/kg) and two dietary protein sequence (22, 18 and 17% vs 18, 16 and 14% that were used during 0 to 6, 6 to 12 and 12 to 18 week of age), for the White Leghorn pullets during the growing period. He concluded that body weight was not influenced by dietary energy levels during the growing period. On the other hand, body weight was consistently greater throughout the experiment (growing and laying periods) for birds fed high protein sequence during the growing period. Egg weight was not influenced by neither energy nor protein levels during the growing period. Hussein (2000) reported that there were no significant effects of rearing protein-feeding system on egg weight and Haugh unit scores.

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. The objective of the present study was to evaluate the effect of varying energy and protein levels during the growing period on subsequent egg weight and internal characteristics 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 Humboldt (Germany), University of Khartoum (Sudan), Technical University of Munich (Germany) and Veterinary Research Centre (Soba-Sudan).

Birds management and housing: 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, to investigate the effect of feed protein and energy levels during the growing period on pullet growth and laying performance. Before chicks housing, all pens were cleaned, burned, sanitized 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 contains 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 23 h lighting and 1 h dark in the first 48 h. Thereafter, the lighting period was reduced gradually by two hours weekly to 12 h at 6 wk of age and that is equivalent to the day length during summer season in Sudan. 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 h per day at 20 wk of age. The day length during laying period was kept at 16 h 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 to 6 wk, phase two (grower) from 7 to 12 wk, phase three (developer) from 13 to 18 wk and phase four (production).

In all phases of growing, control levels of protein and energy were set to meet 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 for the starter period. Table 1 shows the compositions of the starter diets. A total of 9 treatments were employed and each treatment was replicated three times with ten birds each. 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

Table 1: Composition and calculated nutritional content (% original matter) of experimental diets of starter period (0 to 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; 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)

Table 2: Composition and calculated nutritional content (% original matter) of experimental diets of grower period (7 to 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; 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)

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). Clean water was provided to all groups all the time.

Laying performance: Hen-day egg production was recorded. Sample of 15 eggs from each group of hens were collected at 22, 24 and thereafter every month interval for measuring egg quality.

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 characteristics: 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

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

	3,050 kcal ME/kg (E1)			3,150 kcal ME/kg (E2)			3,250 kcal ME/kg (E3)		
Ingredients and analysis	15% CP (P1)	17% CP (P2)	19% CP (P3)	15% CP (P1)	17% CP (P2)	19% CP (P3)	15% CP (P1)	17% CP (P2)	19% CP (P3)
Sorghum	60.99	43.8	51.00	69.10	57.80	62.88	70.00	73.70	74.00
Groundnut cake	0.10	2.50	50	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	22.5	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; 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)

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)

of egg weight, egg mass, albumen height to calculate Haugh unit for internal egg characteristics. At first egg weight was recorded by sensitive electronic scale. The eggs were broken out and the maximum albumen heights were measured from at least three places in each egg with vernier caliper. The height and yolk diameter were measured using vernier caliper. Yolk index was calculated according to the following formula:

$$\text{Yolk index (\%)} = (\text{Yolk height}/\text{Yolk diameter}) \times 100$$

Individual Haugh unit score was calculated using the egg weight and albumen height. The Haugh unit values were calculated for individual egg using the following formula (Haugh, 1937):

$$HU = 100 \log (H + 7.57 - 1.7W0.37)$$

Where:

HU = Haugh unit

H = Observed height of albumen (mm)

W = Weight of egg (g)

The yolk was then weighed and the weight of albumen was calculated by the difference in egg weight after the yolk and shell weights were recorded by subtraction.

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 tests (Petrie and Watson, 1999).

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

$$Yijklm = \mu + Mi + Pj + Tk + (MP)ij + (MT)ik + (PT)jk + (MPT)ijk + Rijkl + \gamma ijklm$$

Where:

Yijklm = Response variables from each individual replication.

μ = The overall mean.

Mi = The effect of dietary metabolizable energy.
Pj = The effect of dietary crude protein.
Tk = 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.
Rijkl = The experimental unit (replications) error term.
γijklm = The experimental unit error term.

RESULTS

Egg weight from 22 to 36 wk of age was not influenced by dietary protein levels during the growing period (Table 5). Egg mass was affected significantly ($p \leq 0.01$) by dietary protein levels fed to the birds during the growing period. Table 5 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). Egg weight and egg mass were influenced by age from 22 to 36 wk of age ($p \leq 0.01$, Table 5). The heavy egg weight was recorded at 36 wk of age whereas no significant differences in egg weight were reported between the others ages. 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. Hen-day egg production has been discussed elsewhere. Egg weight and egg mass during 22 to 36 wk of age were not influenced by dietary energy levels during the growing period (Table 6). There was no interaction between protein and energy during the growing period for egg weight and egg mass from 22 to 36 wk of age (Table 7). The highest egg weight recorded with P2E1 combination between protein and energy followed by P2E3 and the lowest one was observed with P2E2. The highest egg mass was recorded with P2E3 and the lowest one was observed with P1E3. Table 8 shows that the internal egg characteristics from 22 to 36 wk of age were not influenced by dietary protein levels fed to the birds during the growing period. The only parameter affected was yolk weight, which was significantly ($p \leq 0.05$) higher for the birds fed the medium dietary protein level (P2) than those fed others levels. All of the internal egg characteristics shown in Table 8 were significantly ($p \leq 0.01$) affected by age (22 to 36 wk). The only exception was the albumen weight which was not influenced by age. Haugh unit values improved from 22 to 36 week of age scoring the highest value (98.8) at 36 week of age. Similarly albumen height increased with advanced age from 22 to 36 week of age. Yolk weight and yolk height were consistently increased with advanced age. The interaction between protein level and age was not significant ($p \leq 0.05$) for all internal egg characteristics except for yolk weight and yolk width. With

Table 5: The effect of protein levels during the growing period on egg weight and egg mass (22 to 36 wk of age)

---------- Treatment ----------		Egg weight (g)	Egg mass (g)
Protein level	Age (weeks)		
P1	22	50.0	3.4
	24	51.8	20.0
	28	51.0	37.0
	32	53.0	36.0
	36	53.4	34.6
P2	22	52.0	7.5
	24	51.4	28.7
	28	54.2	37.3
	32	51.0	38.0
	36	57.8	38.6
P3	22	51.1	13.9
	24	51.0	30.6
	28	51.6	35.6
	32	52.4	37.4
	36	53.1	34.8
SEM		1.23	1.83
Protein effect		N.S	**
P1		51.9	26.2^{B}
P2		53.3	30.0^{A}
P3		51.8	30.5^{A}
Age effect		**	**
22		51.1^{B}	8.3^{C}
24		51.4^{B}	26.4^{B}
28		52.3^{B}	36.6^{A}
32		52.1^{B}	37.2^{A}
36		54.8^{A}	36.0^{A}
Protein x Age		N.S	*

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

Table 6: The effect of energy levels during the growing period on egg weight and egg mass (22 to 36 wk of age)

---------- Treatment ----------		Egg weight (g)	Egg mass (g)
Energy level	Age (weeks)		
E1	22	52.7	7.8
	24	53.1	30.9
	28	53.7	36.0
	32	51.3	34.2
	36	55.8	35.1
E2	22	50.9	8.1
	24	50.2	22.3
	28	50.1	36.6
	32	51.9	37.6
	36	54.6	37.2
E3	22	49.6	8.8
	24	51.0	26.1
	28	52.1	37.3
	32	53.2	39.7
	36	53.9	35.7
SEM		1.23	1.83
Energy effect		N.S	N.S
E1		53.3	28.8
E2		51.7	28.4
E3		52.0	29.5
Energy x Age		N.S	N.S

NS = Not Significant ($p \leq 0.01$)

P1 and P2 dietary levels of protein during the growing period the yolk weight decreased and thereafter gradually increased with advanced age from 22 to 36 wk of age. Table 9 shows that the internal egg characteristics (22 to 36 wk of age) were not significantly influenced by dietary energy levels fed to the birds during the growing period ($p \le 0.05$). There was no interaction effect of between energy and age on all parameters measured ($p \le 0.01$). Table 10 shows the effect of dietary protein and energy levels during the growing period on internal egg characteristics from 22 to 36 wk of age. There was an interaction effect between protein and energy for yolk weight and height and Haugh unit ($p \le 0.05$, Table 10). With dietary levels of protein (P1 and P3) the Haugh unit decreased when dietary energy concentration increased. However, the Haugh unit increased when the dietary energy concentration increased for the medium protein level (P2). The highest Haugh unit was recorded with P1E1 followed by P2E3 diets. With both higher energy levels E2 and E3 the yolk height increased due to increased protein levels from P2 to P3. Also, with high levels of protein from P2 to P3, the yolk weight decreased due to increasing the energy level from E2 to E3.

Table 7: The effect of protein and energy levels during the growing period on egg weight and egg mass (22 to 36 wk of age)

----------- Treatment ----------		Egg weight (g)	Egg mass (g)
Protein level	Energy level		
P1	E1	51.8	26.7
	E2	51.9	26.1
	E3	51.9	25.8
P2	E1	56.2	29.1
	E2	51.6	28.5
	E3	52.1	32.5
P3	E1	51.9	30.6
	E2	51.7	30.5
	E3	51.9	30.3
SEM		0.95	1.42
Protein x Energy		NS	NS

$^{*}p \le 0.05$, $^{**}p \le 0.01$. NS = Not Significant

DISCUSSION

In the present study, egg weight was not affected by dietary protein level during the growing period. In contrast, the egg mass was significantly influenced by dietary protein levels during the growing period. These results might be attributed to the hen-day egg production from 22 to 36 wk of age which might be influenced by protein levels during the growing period. 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

Table 8: The effect of protein levels during the growing period and age on internal egg characteristics (22 to 36 wk of age)

------------ Treatment -----------		Albumen wt (g)	Albumen height (mm)	Yolk wt (g)	Yolk height (mm)	Yolk width (mm)	Yolk index	Haugh unit
Protein level	Age (weeks)							
P1	22	29.0	7.5	14.6	12.4	43.4	29.0	89.1
	24	32.7	7.0	12.7	13.3	39.7	33.5	85.3
	28	32.6	7.4	12.2	13.3	39.9	33.4	87.8
	32	32.8	9.0	13.9	16.6	40.2	41.4	95.8
	36	30.2	10.0	15.6	18.8	40.9	46.1	100.2
P2	22	30.1	7.2	15.8	12.3	43.3	28.5	86.8
	24	32.3	6.8	12.9	11.9	39.6	30.0	84.8
	28	34.0	7.6	13.5	12.4	40.5	30.6	87.9
	32	31.1	8.9	13.8	17.4	39.7	43.9	96.1
	36	33.6	9.3	17.2	18.8	41.8	45.0	96.4
P3	22	32.9	6.4	12.2	12.9	40.2	32.1	82.4
	24	31.8	6.6	12.8	12.9	40.1	32.0	83.1
	28	31.5	6.9	13.9	14.3	41.3	34.8	84.6
	32	32.3	8.4	14.0	16.8	40.8	41.2	93.1
	36	32.0	9.8	14.4	18.9	40.4	45.1	99.9
SEM		1.12	0.41	0.61	0.72	0.68	1.94	2.18
Protein effect		NS	N.S	*	N.S	N.S	N.S	N.S
P1		31.5	8.2	13.8^{b}	14.9	40.8	36.7	91.6
P2		32.2	8.0	14.6^{a}	14.6	41.0	35.6	90.4
P3		32.1	7.6	13.5^{b}	15.0	40.6	37.0	88.6
Age effect		NS	**	**	**	**	**	**
22		30.6	7.0^{C}	14.2^{B}	12.5^{C}	42.3^{A}	29.8^{C}	86.1^{C}
24		32.3	6.8^{C}	12.8^{C}	12.7^{C}	39.8^{C}	31.8^{C}	84.4^{C}
28		32.7	7.3^{C}	13.2^{BC}	13.3^{C}	40.6^{BC}	32.9^{C}	86.8^{C}
32		32.1	8.8^{B}	13.9^{B}	17.0^{B}	40.3^{BC}	42.2^{B}	95.0^{B}
36		31.9	9.7^{A}	15.7^{A}	18.6^{A}	41.0^{B}	45.4^{A}	98.8^{A}
Protein x Age		NS	N.S	*	N.S	*	N.S	N.S

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

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

Table 9: The effect of energy levels during the growing period and age on internal egg characteristics (22 to 36 wk of age)

------------ Treatment ------------		Albumen wt (g)	Albumen height (mm)	Yolk wt (g)	Yolk height (mm)	Yolk width (mm)	Yolk index	Haugh unit
Energy level	Age (weeks)							
E1	22	31.4	7.3	14.9	12.7	14.9	30.0	87.2
	24	33.3	7.2	13.1	12.2	13.1	30.6	86.3
	28	33.7	7.0	13.6	13.5	13.6	33.2	85.0
	32	31.3	8.5	13.7	16.5	13.7	41.4	94.2
	36	32.3	9.3	16.3	18.6	16.3	45.8	96.9
E2	22	31.2	7.1	13.4	12.2	13.4	29.5	87.0
	24	32.0	6.9	12.1	12.7	12.1	32.5	85.6
	28	31.1	7.5	13.7	13.8	13.7	34.1	88.9
	32	31.6	8.7	14.3	17.4	14.3	43.2	94.2
	36	32.5	10.2	14.8	18.9	14.8	45.3	100.7
E3	22	29.3	6.7	14.3	12.6	14.3	30.0	84.2
	24	31.5	6.3	13.3	13.1	13.3	32.4	81.2
	28	33.2	7.2	12.3	12.6	12.3	31.4	86.5
	32	33.4	9.1	13.6	17.0	13.6	42.0	96.6
	36	31.0	9.7	16.1	18.4	16.1	45.1	98.9
SEM		1.12	0.41	0.62	0.72	0.62	1.94	2.18
Energy effect		N.S	N.S	N.S	N.S	N.S	N.S	N.S
E1		32.4	7.9	14.3	14.7	40.8	36.2	89.9
E2		31.7	8.1	13.7	15.0	40.7	36.9	91.3
E3		31.7	7.8	13.9	14.7	40.9	36.2	89.5
Age effect		N.S	**	**	**	**	**	**
Energy x Age		N.S	N.S	N.S	N.S	N.S	N.S	N.S

A-CMeans in a column and treatment variable with no common superscript differ significantly ($p \leq 0.01$). *$p \leq 0.05$; **$p \leq 0.01$

Table 10: The effect of protein and energy levels during the growing period on internal egg characteristics (22 to 36 wk of age)

------------ Treatment ------------		Albumen wt (g)	Albumen height (mm)	Yolk wt (g)	Yolk height (mm)	Yolk width (mm)	Yolk index	Haugh unit
Protein level	Energy level							
	E1	30.9	8.5	14.0	15.0	41.1	36.6	93.6
P1	E2	32.0	8.2	13.5	14.5	40.2	36.2	91.9
	E3	31.5	7.8	14.0	15.2	41.2	37.3	89.4
	E1	33.8	7.3	16.0	15.3	41.2	37.3	86.2
P2	E2	31.2	8.3	13.8	14.6	41.0	35.7	92.2
	E3	31.7	8.4	14.0	13.7	40.7	33.8	92.9
	E1	32.6	7.8	13.0	13.9	40.0	34.7	90.0
P3	E2	31.9	7.8	13.7	15.9	40.8	38.9	89.7
	E3	31.8	7.3	13.7	15.3	40.9	37.5	86.2
SEM		0.87	0.32	0.48	0.56	0.53	1.50	1.69
Protein x Energy		N.S	N.S	*	*	N.S	N.S	*

*$p \leq 0.05$

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 to 6, 7 to 14 and 15 to 18 week of age, respectively. These results are also coinciding with the finding of Keshavarz (1998) who revealed that egg weight during 22 to 38 wk of age was not influenced by protein level 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 during 22 to 36 wk of age are conflicting with Keshavarz (1998) who reported that egg mass was not influenced by dietary protein level during the growing period. The egg production might be influenced by protein levels during the growing period and this will consequently affect the egg mass, because it has been calculated using the egg production and egg weight. Our findings agreed with the results of Hussein (2002), who reported that two protein sequence regimens (semi-constant protein sequence and decreasing protein sequence) fed to local pullets during their rearing period, did not affect Haugh unit scores at 21 to 40 weeks of age. Egg weight and egg mass during 22 to 36 week of age were not affected by dietary energy levels used during the growing period. The results concerning egg weight, mass and other internal traits are consistent with results reported by Keshavarz (1998) who revealed that egg weight from 22 to 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 from 18 to 38 wk of age was 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 during the first 16 weeks following the photo stimulation was 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 and egg mass from 22 to 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 to 36 wk of age).

Based on this study, feeding the higher protein levels (P2 and P3) had the highest egg mass. Thus, it is very important to supply pullets with high protein levels 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 to 14 wks of age. Although, egg weight was not influenced by protein and energy levels used during the growing period, the egg mass was influenced by protein levels during the growing period and the best one was observed with P2E3 diet. The P2E3 diets may have provided energy to protein ratio which give the best protein and energy utilization for birds reared in hot arid conditions like Sudan, so it is advisable to be adopted.

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