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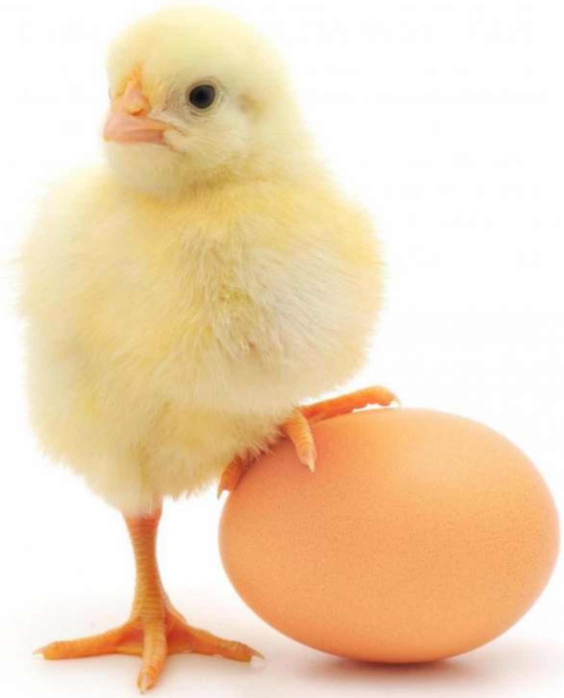

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Response of Commercial Egg-Type Pullets to Diets Varying in Protein and Energy Content in Arid Hot Climate

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Abstract: 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 growing (starter, grower and developer) and their effect on growth and development. 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). Data on phase four (production) are discussed elsewhere. In all phases of growth, control levels of protein and energy were set according to NRC (1994) and the other levels were higher and lower. A total of 9 treatments in all phases of growing were employed and each treatment was replicated three times with ten birds each. Lysine and methionine were added to the diets of all phases to meet levels recommended for birds in each growing phase (NRC, 1994). During the starter period three levels of protein (P1 = 16, P2 = 18 “control” and P3 = 20% CP) and Three levels of energy (E1 = 2650, E2 = 2850 “control” and E3 = 3050 kcal of ME/kg of diet) which equivalent (E1 = 11.1, E2 = 11.9 and 12.8 MJ/kg ME) were used. The same protocol in phase one was continued for the factorial arrangement for the grower period. The levels of energy were not change, but the levels of protein were changed (P1 = 14%, P2 = 16% “control” and P3 = 18%). For the developer period the same protocol in phase one and two was continued, but the levels of both protein and energy were changed (P1 = 13%, P2 = 15% “control” and P3 = 17%) and (E1 = 2700, E2 = 2900“control” and E3 = 3100 kcal of ME/kg of diet) which equivalent (E1 = 11.3, E2 = 12.1, and E3 = 13.0 MJ/kg ME). Body Weights (BW), Body Weight Gain (BWG) and Feed Consumption (FC) were measured and Feed Conversion (FCR) was calculated at the end of each growing phases. Higher protein levels consistently increased BWG of pullets during the starter ($p \leq 0.01$) and grower periods ($p \leq 0.05$). The body weights for pullets fed higher levels of protein (P2 and P3) were consistently higher than those fed lower protein level during all growing phases ($p \leq 0.01$). High protein diets P2 and P3 during starter period resulted in improved FCR of birds compared to those pullets fed the low level of protein diet ($p \leq 0.05$). The best BWG and FCR during starter period were observed for birds fed P2E3 diet ($p \leq 0.01$). BW, BWG and FCR were not influenced by dietary energy levels during all growing periods. The only exception for the BW and BWG during the starter period ($p \leq 0.05$). FC was not affected by dietary protein and energy levels during the growing period. Oviduct development was affected by dietary protein and energy levels during the growing period ($p \leq 0.01$). Ages at first egg and 50% production were advanced ($p \leq 0.05$) due to the use of high protein diets. Thus, based on this study, birds fed high levels of protein diets (P2 and P3) during the early stages of growing period had the best BWG, BW and FCR and had well developed reproductive organs.

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

INTRODUCTION

Pullet's nutrition is very important for layers egg production and quality. Poultry producers who raise their own replacement pullets have better control of their pullet’s growth and development. The producers are putting their fate in the hands of others when they purchase their replacement pullets from commercial pullet growers. There is a direct relationship between the pullet’s development during rearing and subsequent performance during the laying cycle. It is very important to have the correct amount and balance of amino acids, other nutrients and energy in the ration at several stages of the growing period. Pullets should be fed in a manner that will give the great chance for full expression of their growth genetic potential during the growing period. Body weight of pullets at the age of housing has a positive correlation with egg weight during the egg production cycle (Summers and Leeson, 1983; Keshavarz, 1995). It is essential to have the Leghorn pullet reach the target weight, body composition and possibly age, at the onset of laying (Leeson and Caston, 1991). Increasing the energy and protein in the diet from 16-20 wk of age did not improve the body weight of pullets at 20 wk of age and egg size during the early stages of egg production cycle (Summers and Leeson, 1993). Many researches suggest that it might be important to begin manipulation of nutrients in the diet at an earlier age during the growing period to increase the body weight at the age of housing and consequently the early egg size (Summers and Leeson, 1993; Keshavarz and Nakajima, 1995). Keshavarz (1998) reported that body weight at 18 wk of age was increased by using high energy (3,036 v 2,816 kcal ME/kg) or high protein (17.5 vs 14.5%) diets from 8-18 wk of age. Also he revealed that body weight at 18 wk of age increased only due to the use of a high protein sequence (22, 18 and 16% vs 18, 16 and 14% that were used during 0-6, 6-12 and 12-18 wk of age, respectively). However, the length of the small intestine and the weight of different body organs were not affected by energy or protein levels used during the growing period. On the other hand age at first egg and 50% production were not influenced by energy level used during the growing period. However, these ages were advanced by 2 and 4 days respectively, for the birds fed the high protein sequence during the growing period. Sturkie (1990) rvealed that the levels of the plasma lipids are probably influenced by the physiological and nutritional status of the bird.

Although relatively few strains of Leghorn bird are used in Sudan for egg production, there is a surprising lack of information concerning the suitable levels of protein and energy for those birds during the growing period. Also in order to resolve the confounding effect of harsh climatic condition in Sudan on pullets growth and development, it seemed advantageous to study the protein and energy manipulation on pullet growth and development. For these reasons this research was conducted to achieve those goals.

MATERIALS AND METHODS

Two hundred and seventy, one-day-old chicks single comb Leghorn strain (Hisex) were brought from Coral Chick and Feed Production Farms in Khartoum to investigate the effect of feed manipulation during the growing period on pullet growth and laying performance. Before chicks housing, all pens were cleaned, burned, fumigated with formaldehyde solution and washed prior to the commencement of the experiment. The floor of pens was covered with wood shavings. 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 23 h lighting and 1 h dark in the first 48 h. Thereafter, the lighting period was reduced gradually by 2 h 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 remained constant until 18 wk of age. Thereafter the day length was increased by 2 h weekly until reach 16 h per day at 20 wk of age. 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). Data on phase four (production) are discussed elsewhere.

In all phases of growing, control levels of protein and energy were set according to NRC (1994) and the other levels were higher and lower. 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 units. 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 the starter period three levels of protein (P1 = 16, P2 = 18 "control" and P3 = 20% CP) and Three levels of energy (E1 = 2650, E2 = 2850 "control" and E3 = 3050 kcal of ME/kg of diet) which equivalent (E1 = 11.1, E2 = 11.9 and 12.8 MJ/kg ME) were used for the starter period. Table 1 shows the compositions of starter diets. A total of 9 treatments were employed and each treatment was replicated three times with ten birds each. When a bird died, it was replaced with a bird from the extra replicate in order to keep the floor space identical for all groups during the growing period. The same protocol in phase one was continued for the factorial arrangement for the grower period. The levels of energy were not change, but the levels of protein were changed (P1 = 14%, P2 = 16% "control" and P3 = 18%) (Table 2). For the developer period the same protocol in phase one and two was continued, but the levels of both protein and energy were changed (P1 = 13%, P2 = 15% "control" and P3 = 17%) and (E1 = 2700, E2 = 2900"control" and E3 = 3100 kcal of ME/kg of diet) which equivalent (E1 = 11.3, E2 = 12.1, and E3 = 13.0 MJ/kg ME).

Table 3 shows the composition of developer diets. Two birds from each experimental unit were selected randomly to take the blood samples for total blood lipids. The samples were taken at the end of each growing phase. The blood was collected from each bird into nonheparinized tubes then, the blood serum was taken for total lipids analysis. The total lipid levels were measured by sulfo- phospho-vanillin methods (Frings *et al*., 1972). The determination is based on the colour obtained by phosphor-vanillin reaction. The average body weight, average body weight gain and feed consumption record were measured at the end of each growing phase. Feed Conversion Ratio (FCR) was calculated at the end of each growing phase by dividing grams of feed consumed by grams of live body weight gain. Mortality was recorded as it occurred. At day 172

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

	2,650 kcal ME/kg (E1)			2,850 kcal ME/kg (E2)			3,050 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	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
Calculated analysis[2]									
Energy, kcal ME/kg	2,657	2,658	2,660	2,855	2,856	2,853	3,058	3,054	3,056
Protein	16.70	18.30	20.53	16.70	18.20	20.20	16.50	18.50	20.50
Calcium	0.87	0.90	1.00	1.00	0.90	0.90	0.90	0.94	0.90
Available phosphorus	0.42	0.43	0.44	0.42	0.42	0.43	0.41	0.41	0.41
Lysine	0.89	0.91	0.94	0.87	0.92	0.91	0.87	0.88	0.90
Methionine	0.35	0.33	0.41	0.32	0.33	0.37	0.31	0.35	0.38

[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)

	2,650 kcal ME/kg (E1)			2,850 kcal ME/kg (E2)			3,050 kcal ME/kg (E3)		
Ingredients and analysis	14% CP (P1)	16% CP (P2)	18% CP (P3)	14% CP (P1)	16% CP (P2)	18% CP (P3)	14% CP (P1)	16% CP (P2)	18% 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
Calculated analysis[2]									
Energy, kcal ME/kg	2,660	2,653	2,654	2,852	2,854	2,854	3,050	3,053	3,054
Protein	14.50	16.20	18.20	14.40	16.00	18.00	14.00	16.30	18.10
Calcium	0.80	0.80	0.81	0.83	0.80	0.80	0.80	0.80	0.80
Available phosphorus	0.42	0.41	0.41	0.41	0.40	0.41	0.39	0.39	0.38
Lysine	0.62	0.65	0.66	0.62	0.67	0.64	0.61	0.63	0.63
Methionine	0.32	0.31	0.33	0.25	0.28	0.30	0.26	0.30	0.33

[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)

three birds from each treatment that have body weights close to the average weight of their respective group were subjected to feed withdrawal for 4 h to permit gut clearance and were slaughtered to investigate the development of reproductive organs and carcass traits. The individual live and post-mortem weights were recorded. The birds were feather plucked and head and shanks were weighed together. The weights of abdominal fat pad, oviduct including ovary, gizzard, spleen, heart and the gastrointestinal tract were recorded. All weights were estimated in grams.

Experimental data are presented as mean values ± standard errors of the means. Statistical analysis were carried out using the SPSS 11.0 program package

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

	2,700 kcal ME/kg (E1)			2,900 kcal ME/kg (E2)			3,100 kcal ME/kg (E3)		
Ingredients and analysis	13% CP (P1)	15% CP (P2)	17% CP (P3)	13% CP (P1)	15% CP (P2)	17% CP (P3)	13% CP (P1)	15% CP (P2)	17% 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
Calculated analysis[2]									
Energy, kcal ME/kg	2,751	2,707	2,701	2,901	2,902	2,904	3,099	3,099	3,092
Protein	13.90	15.40	17.00	13.90	15.00	17.00	13.50	15.70	17.00
Calcium	1.20	1.00	0.90	0.70	0.77	0.90	1.00	0.70	0.80
Available phosphorus	0.47	0.45	0.43	0.39	0.40	0.40	0.39	0.37	0.38
Lysine	0.63	0.91	0.68	0.60	0.62	0.62	0.50	0.57	0.55
Methionine	0.24	0.28	0.38	0.24	0.27	0.34	0.21	0.26	0.30

[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)

(SPSS, 2001). The significance of the differences among the groups has been determined by Duncan's multiple range test (Petrie and Watson, 1999).

The statistical model used for body weight, body weight gain, feed consumption, feed conversion ratio, age at onset of egg, age at 50% egg production, slaughter parameters and total lipids for each period as follows:

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

Where:

Y_{ijkl} = Response variable from each individual replication

μ = The overall mean

M_i = The effect of dietary metabolizable energy

P_j = The effect of dietary crude protein

$(MP)_{ij}$ = The effect due to interaction between metabolizable energy and crude protein.

R_{ijk} = The experimental unit (replications) error term

γ_{ijkl} = The experimental unit error term

The statistical model used for total lipids of growing period 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 AND DISCUSSION

Body weight gain of pullet fed the higher levels of protein P2 and P3 were greater than those fed low level of protein P1 at starter period ($p \leq 0.01$), with no differences in feed consumption (Table 4). High protein diets P2 and P3 during starter period resulted in improved feed conversion ratios of birds compared to those pullets fed the low level of protein diet ($p \leq 0.05$). Body weight gain was affected significantly by protein levels during the grower period ($p \leq 0.05$). There was significant difference ($p \leq 0.05$) between P3 and P1 levels of protein, but there were no significant differences between P2 level of protein and the both two levels P3 and P1 in their effects on body weight gain during the grower period. Feed conversion ratio was not influenced by protein levels used during grower period (Table 4). Body weight gain, feed consumption and feed conversion ratio were not significantly ($p \leq 0.05$) affected by protein levels fed to the pullets during developer period. Feed consumption, feed

Table 4: The effect of the energy and protein levels on performance of pullets during starter, grower and developer periods

		Feed consumption (g/bird)			Weight gain (g)			FCR (g:g)(%)		
Treatment	(kcal/kg)	Starter period	Grower period	Developer period	Starter period	Grower period	Developer period	Starter period	Grower period	Developer period
Protein	**Energy**									
P1	E1	1233.6	1692.3	2850.2	232.6	260.9	314.7	5.3	6.5	9.1
	E2	1214.0	1553.5	3010.9	208.9	264.8	236.4	5.8	6.1	12.8
	E3	1025.7	1770.3	3067.9	164.9	303.4	261.3	6.2	5.8	12.0
P2	E1	1062.4	1770.3	2742.8	249.7	283.1	253.0	4.3	6.3	11.2
	E2	1103.3	2153.9	2749.6	181.8	299.3	358.3	6.1	7.2	7.8
	E3	1081.0	1757.7	3032.4	257.7	298.0	304.5	4.2	6.0	10.1
P3	E1	1290.8	1846.4	2941.2	227.1	324.8	287.4	5.7	5.7	10.3
	E2	1182.3	1738.3	2790.4	234.0	336.1	236.0	5.1	5.2	11.8
	E3	1137.7	1937.4	3085.4	244.1	306.7	266.9	4.7	6.3	11.6
SEM		25.0	53.8	62.6	3.3	7.2	8.3	0.1	0.2	0.3
Protein effect		NS	NS	NS	**	*	NS	*	NS	NS
P1		1157.8	1672.0	2976.32	202.2^{B}	276.4^{b}	270.8	5.8^{a}	6.1	11.3
P2		1082.2	1894.0	2841.61	229.7^{A}	293.4^{ab}	305.3	4.8^{b}	6.5	9.7
P3		1203.6	1840.7	2938.99	235.1^{A}	322.5^{a}	263.4	5.2^{b}	5.7	11.2
Energy Effect		NS	NS	NS	*	NS	NS	NS	NS	NS
E1		1195.6	1769.7	2844.7	236.5^{a}	289.6	285.0	5.1	6.2	10.2
E2		1166.5	1815.3	2850.3	208.2^{b}	300.1	276.9	5.7	6.1	10.8
E3		1081.5	1821.8	3061.9	222.2^{ab}	302.7	277.6	5.0	6.0	11.2
Protein x energy		NS	NS	NS	**	NS	*	**	NS	*

^{A,B}Means in a column and treatment variable with no common superscript differ significantly ($p\le0.01$),

^{a,b}Means in a column and treatment variable with no common superscript differ significantly ($p\le0.05$), $^{*}p\le0.05$, $^{**}p\le0.01$

conversion ratio and body weight gain were not influenced by energy levels used during the whole growing period (Table 4). The only exception was the body weight gain during starter period, which was greater for pullets fed E1 level from those fed E2 level of energy ($p\le0.05$). There were no significant differences ($p\le0.05$) between the effect of E3 from E2 and E1 levels of energy on body weight gain during starter period.

Table 4 shows that there was a significant ($p\le0.01$) interaction between protein and energy levels for body weight gain during starter period. With high energy levels (E2 and E3), the weight gain significantly increased due to the use of high protein levels (P2 and P3) during the starter period. Table 4 showed that the best body weight gain during starter period resulted from combination P2E3 between protein and energy levels ($p\le0.01$). On the other hand the lowest body weight gain ($p\le0.01$) on starter period resulted from the combination of P1E3. There was an interaction between protein and energy during starter period which significantly affected the feed conversion ratio ($p\le0.01$, Table 4). P2E3 combination had the best feed conversion at the same time the inferior feed conversion was recorded with P1E3 combination ($p\le0.01$, Table 4). During developer period there was interaction between protein and energy which was affected significantly the body weight gain ($p\le0.05$, Table 4). Table 4 shows that the best combination resulted in the best body weight gain was P2E2. Feed conversion ratio at developer period was influenced significantly ($p\le0.05$) by the interaction between protein and energy (Table 4). The best combination between protein and energy which gave the best feed conversion was P2E2 but in contrast the inferior feed conversion was recorded with P1E2 (Table 4). Body weights were affected significantly ($p\le0.01$) by protein levels at starter period (Table 5). 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). At developer period the similar results which have been recorded were performed on pullet's body weights fed several levels of protein ($p\le0.01$). Table 5 showed that there were significant ($p\le0.01$) effects of protein on pullets body weight during grower period. Table 5 showed that at the grower period there were significant differences ($p\le0.01$) between the different levels of protein P3, P2 and P1 which gave higher, medium and lower weights, respectively. Pullets body weights were not influenced significantly ($p\le0.05$) by the variable energy levels during the growing period (Table 5). 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. It is well documented that dietary energy composition has a major effect on the composition of the chicken body (Collin *et al*., 2003). Waldroup *et al*. (1990) reported that increasing dietary energy promoted the growth rate. The interaction between protein and energy levels for body weight were significant ($p\le0.01$) at starter period. With high energy levels (E2 and E3), the body weight

Table 5: The effect of the energy and protein levels on pullets body weight during growing period

Treatment (%)	(kcal/kg)	Body weight 6 wk	12 wk	18 wk
Protein	**Energy**			
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 ($p \leq 0.05$). *$p \leq 0.05$, **$p \leq 0.01$

increased due to the use of high protein levels (P2 and P3) during the starter period. Table 5 shows that the highest body weight was achieved by P2E3 combination and the lowest body weight were performed by P1E3.

These findings of the protein effects on body weight and body weight gain are in agreement with the results of Keshavarz (1998) who reported that body weight at 18 wk of age was increased due to the use of high protein sequence (22, 18 and 16% vs 18, 16 and 14% that were used during 0-6, 6-12 and 12-18 wk of age, respectively. The protein in these findings affected significantly the body weight during the all growing periods, body weight gain during starter and grower periods and improved the feed conversion during the starter period. Thus it is better to use the high protein levels during the early growing periods (starter and grower) without insistence of using high protein levels during developer period. Because depending upon current report which showed that no effect of protein levels on body weight gain during the developer period which is also consistent with Keshavarz and Nakajima (1995) who reported that no beneficial effect at 18 wk body weight was observed when pullets were fed an 18% as compared to a14% crude protein diet from 14-18 wk of age. Moreover, Summers and Leeson (1993) did not observe improvement in body weight of pullets at 20 wk of age due to increased protein and energy in the diet from 16-20 wk of age. Although energy has a significant effect on body weight and body weight gain only during the starter period but the interaction between energy and protein should be considered especially during the starter period because 90% of the frame size of the body and the vital organs will be achieved during the first 12 wk of age. Table 6 shows the effect of energy and protein levels during the growing period on pullet's carcass characteristics. The weights of different organs were not influenced by protein levels during the growing period. The only exception was recorded for the oviduct weight ($p \leq 0.01$) and spleen weight ($p \leq 0.05$, Table 6). The larger oviduct weights of birds were observed ($p \leq 0.01$) for the higher levels of protein P2 and P3 than those of birds fed the lowest protin level P1. In contrast the lowest protein level P1 had the highest weight of spleen ($p \leq 0.05$). The higher protein level P2 and P3 had lower spleen weight without significant difference among them ($p \leq 0.05$). The similar results were observed for the energy effect on the weight of various organs of the birds which were obviously showed that there were no significant influences of different energy levels. The only exception was that the significant effect on oviduct ($p \leq 0.01$) and spleen ($p \leq 0.05$) weights. The energy levels E1 and E3 fed to the birds were resulted in increasing of oviduct weights than those fed E2 energy level ($p \leq 0.01$, Table 6). The energy level E2 fed to the birds was significantly higher for the spleen weight than those fed the energy level E1, while there were no significant differences between the weights of spleen for birds fed level E3 and the those fed the others two levels E1 and E2 ($p \leq 0.05$). Table 6 shows the interaction between protein and energy levels. The interaction between protein and energy for oviduct, heart and pancreas weights were significant ($p \leq 0.05$). With increasing the level of energy above E1 level the oviduct weight were increased for the all levels of protein. The largest weight of the oviduct was recorded in the combination of P3E3, while the lowest weight of it was resulted of the P1E2 combination (Table 6). The heart weight was significantly the best for birds consumed diet contained P2E3 combination during the growing period (Table 6). Pancreas was relatively well developed for the birds supplied with P3E2 combination diet (Table 6). With increasing the level of energy from E1-E2 level the pancreas weights were decreased by increasing the protein levels (from P1-P2), then started to increased for E3 level. However, with increasing the level of energy the pancreas weights increased and then started decreasing with the highest level of protein (P3). Previous report of Keshavarz (1998) who revealed that the length of the small intestine and the weight of different organs were not influenced by energy and protein levels used during the growing period, our results were not congruence with those results which indicated that there were significant effects on oviduct weight when high protein levels (P2 and P3) and high level of energy (E3) were used during the growing period. These results indicated that it is advisable to use the high levels of energy and protein, because

Table 6: The effect of the energy and protein levels on carcass characteristics of pullets at 172 day of age

Treatment		Live wt	Post mortem	Carcass	Oviduct	Abdominal fat pad	Gizzard + proventri-culus	Intestine	Liver	Heart	Pancreas	Spleen	Head and shanks
(%)	(Kcal/kg)						(g)						
P1	E1	1296.7	1130	832.3	42.5	30.7	42.3	70.4	28.4	5.3	2.9	1.3	78.0
	E2	1153.3	976.7	793.3	8.6	10.7	43.3	58.8	24.7	5.5	2.0	2.2	81.5
	E3	11.3	956.7	775.0	13.2	12.2	47.7	57.8	25.4	4.8	2.8	1.8	76.9
P2	E1	12.80.0	1069	806.7	39.1	21.8	35.6	73.1	27.3	5.7	3.2	1.3	80.8
	E2	1220.0	1036.7	813.3	24.3	32.5	46.1	61.0	29.4	5.4	2.3	1.5	78.1
	E3	1253.3	1113.3	730.0	38.6	13.8	33.8	60.7	21.0	7.9	2.8	1.1	78.9
P3	E1	1260.0	1123.3	823.3	39.9	23.2	38.2	72.5	29.7	6.7	1.9	1.3	81.7
	E2	1260.0	1126.7	833.3	34.6	27.3	40.9	72.7	25.3	5.4	3.3	1.4	79.2
	E3	1313.3	1110.7	840.0	49.4	19.0	38.1	60.8	27.0	4.9	2.2	1.3	77.9
SEM		19.8	21.9	15.7	1.8	1.9	1.2	2.1	1.1	0.2	0.1	0.1	1.1
Protein effect		NS	NS	NS	**	NS	NS	NS	NS	NS	NS	*	NS
P1		1211	1021	797.2	21.4^B	17.9	44.4	62.3	26.2	5.2	2.6	1.8^a	78.8
P2		1251	1073	783.3	34.0^A	22.7	38.5	65.0	25.9	6.3	2.8	1.3^b	79.3
P3		1278	1120	832.2	41.3^A	23.2	39.1	68.7	27.3	5.6	2.5	1.3^b	79.6
Energy effect		NS	NS	NS	**	NS	NS	NS	NS	NS	NS	*	NS
E1		1279	1108	817.8	40.5^A	25.3	38.7	72.0	28.4	5.9	2.7	1.3^b	80.2
E2		1211	1047	813.3	22.5^B	23.5	43.4	64.1	26.5	5.4	2.5	1.7^a	79.6
E3		1250	1060	781.7	33.7^A	15.0	39.8	59.8	24.5	5.8	2.6	1.4^{ab}	77.9
Protein x Energy		NS	NS	NS	*	NS	NS	NS	NS	*	*	NS	NS

^{A,B}Means in a column and treatment variable with no common superscript differ significantly ($p\leq0.01$).
^{a,b}Means in a column and treatment variable with no common superscript differ significantly ($p\leq0.05$). *$p\leq0.05$, **$p\leq0.01$

good production of eggs is depending upon the well developed oviduct. Although there was no significant effect of protein levels during the growing period on shanks and head weights, there were relatively higher for (P2 and P3) levels of protein which in part, due to the larger size of combs and wattles resulting from good development of the oviduct.

Table 7 shows the results of total blood lipids as influenced by protein and energy levels. Total blood lipids at starter period was not significantly influenced by protein and energy levels ($p\leq0.05$). At grower period the total blood lipids was affected significantly ($p\leq0.05$) by diet protein levels. Higher levels of protein (P2 and P3) decreased pullets total blood lipids than those pullets consumed the lower protein level P1 ($p\leq0.05$). At developer period no significant effect of several protein levels on pullets total blood lipids ($p\leq0.05$). Pullets total blood lipids was not significantly influenced by energy levels at different growing periods ($p\leq0.05$). There was no interaction between protein and energy levels ($p\leq$ 0.05) for the total blood lipids. Table 8 shows the influence of protein and energy levels on total blood lipids in the whole growing period. Energy and protein levels had no significant effect ($p\leq0.05$) on total blood lipids at the whole period of growing. The different ages of birds during the growing period had highly significant effect ($p\leq0.01$) on total blood lipids which is obviously observed in Table 8. The highest level of total blood lipids was recorded during the developer period whereas the lowest level was observed at the starter period ($p\leq0.01$). All of growing periods were differ significantly ($p\leq0.01$) from each other in their effect on total blood lipids. These results confirm the observation

Table 7: The effect of energy and protein levels on total blood lipids of pullets during the growing period

Treatment (%)	(kcal/kg)	Total blood lipids (mg/100 ml) Starter period	Grower period	Developer period
Protein	**Energy**			
P1	E1	348.4	518.0	563.9
	E2	344.0	478.0	569.4
	E3	391.7	488.0	488.9
P2	E1	274.6	417.6	740.8
	E2	341.8	457.0	449.9
	E3	342.9	469.6	574.3
P3	E1	305.1	442.1	566.3
	E2	295.9	421.1	480.1
	E3	331.1	494.5	516.6
SEM		11.1	6.1	35.6
Protein effect		NS	*	NS
P1		361.4	494.7^a	540.7
P2		319.8	448.1^b	588.3
P3		310.7	452.6^b	521.0
Energy Effect		NS	NS	NS
E1		309.4	459.2	623.6
E2		327.2	452.1	499.8
E3		355.2	484.0	526.6
Protein x energy		NS	NS	NS

^{a,b}Means in a column and treatment variable with no common superscript differ significantly ($p\leq0.05$), *$p\leq0.05$

of Sturkie (1990) who reported that the blood lipids concentration is influenced by age, sex, nutrition, state of health, energy needs and other factors. The blood lipids in the current results was higher in the developer period and that is may be due to the lipoprotein complexes that transport the lipids synthesized in the liver to the ovary where they are deposited intact in the follicles.

Table 8: The effect of energy and protein levels on total blood lipids of pullets at the whole growing period

Treatment	Total blood lipids (mg/100 ml)
Protein effect	NS
P1	465.6
P2	452.0
P3	428.1
Energy effect	NS
E1	464.1
E2	426.4
E3	455.3
Age effect	**
Starter	330.6[C]
Grower	465.1[B]
Developer	550.0[A]
Protein x Energy	NS
Age x Protein	NS
Age x Energy	NS
Age x Protein x Energy	NS
SEM of Model	12.6

[A,C]Means in a column and treatment variable with no common superscript differ significantly ($p \le 0.01$). **$p \le 0.01$

Table 9: The effect of the energy and protein levels on age at first egg and 50% production

Treatments		Age at first egg	Age at 50% production
(%)	(kcal/kg)	------------- (days)	-------------
Protein	**Energy**		
Protein effect		*	*
P1		146[a]	164.8[a]
P2		146[a]	159.8[a]
P3		138[b]	153.3[b]
	Energy effect	NS	NS
	E1	145.3	159.0
	E2	142.7	161.2
	E3	142.9	157.7
Protein x energy		NS	NS

[a,b]Means in a column and treatment variable with no common superscript differ significantly ($p \le 0.05$). *$p \le 0.05$

Table 9 shows the results of the effect of the energy and protein levels during the growing period on age of the first egg and 50% production. Age at first egg and 50% production of hens were not influenced significantly ($p \le 0.05$) by energy levels during the growing period. However, these ages were affected significantly ($p \le 0.05$) by protein levels during the growing period. Age at first egg was postponed by about 8 days for the birds fed P1 and P2 than those fed P3 level of protein ($p \le 0.05$). Age at 50% production for birds fed P3 level of protein was advanced by 6 and 11 days from those fed P2 and P1 levels of protein, respectively, whereas there was no noticeable difference in ages between birds fed P1 and P2 levels of protein. These results are consistent with a previous report of Keshavarz (1998) who revealed that energy level used during the growing period had no effect on the age at first egg or 50% production. However, these ages were advanced for the birds fed the high protein sequence. The results of the current experiment are in agreement with the finding of EL-Zubeir and Mohammed (1993) which explain that the ages of birds at the point of lay and at 50% egg production were decreased by increasing the dietary protein level. The best combination resulted in early age of onset of egg was P3E1 followed by P3E3, whereas P1E1 resulted in late onset of egg. The pullets fed P3E3 during the growing period resulted in early age of 50% production. The result of this experiment indicated that increasing the dietary protein levels during the growing period can increase pullet body weight. Birds fed high levels of protein diets (P2 and P3) during the early stages of growing period had the best BWG, BW and FCR and well developed reproductive organs. Energy levels fed to the birds during the growing period had no effect on FC and FCR. Energy levels fed to the pullets had significant effects on BW and BWG during grower and developer periods. Thus, it is better to use the higher dietary protein level at the early stage o growing period to fulfil the needs of pullets specially at that time. That is because body weight at 6 wk of age has been shown to be positively correlated with laying performance and 90% of the frame size of the body will develop during the first 12-14 wk of age. The interaction between dietary protein and energy levels should be considered.

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