World Journal of Agricultural Sciences 17 (2): 104-111, 2021
ISSN 1817-3047

DOI: 10.5829/idosi.wjas.2021.104.111

Energy-Protein Optimization Effect on the Growth and Production Performances of Koekoek Chickens

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Abstract: There is a driving force of feed cost regardless of production system that leads to feed chickens critically based on their nutrient requirement. Three trials (Trial I-starter, Trial II- grower and Trial III layer phases) carried out to evaluate the growth and production performances of koekoek dual purpose chicken fed diet with different energy and protein levels; and to determine the optimum energy and protein levels for the breed in Ethiopian condition. The metabolizable energy and crude protein (CP) contents were kept in the treatment rations in the ranges of 2650-3150 kcal/kg DM and 19 - 23%; 2800-2900 kcal/kg DM and 16-18%; 2750-2950 kcal/kg DM and 16-17.5%, respectively in Trial I (comprises 6 treatments), Trial II (comprises 5 treatments) and Trial III (comprises 4 treatments). Feed consumption recorded daily and total and average feed consumptions were calculated in all the trails. Body weight (BW) measurements taken every week for Trial I and Trial II and at the start and end of the trial 23 for Trial III then BW changes calculated. Egg production and quality parameters data were recorded; fertility and hatchability also tested. The partial budget was calculated for each trial. The result obtained at the starter phase revealed that no differences (P>0.05) in feed consumption, only total feed cost was higher (P<0.05) with T_2, T_4 and T_5. The reverse was true for net return and was higher (P<0.05) with T_2, T_4 and T_5. At the grower phase, no difference (P>0.05) again on feed consumption but growth performances in terms of BW changes, average daily BW gains and feed efficiency and were higher (P<0.05) with T_2 and T_3. Besides, the total cost was higher (P<0.05) with T_3 and T_5. The net return in Trial II was higher (P<0.05) with T_3 and T_5. In all parameters considered during the laying phase showed non-significant differences among the treatments. In conclusion, during the growing phases even a small difference in the energy and protein combinations brought differences in performance though not in the laying phase. This implies a further clear investigation that considers daily feed allowance with energy-protein levels combination needed in the diets to demark at what level the breed performs well.

Key words: Energy-Protein Optimization · Growth Performance · Koekoek Chickens · Production

INTRODUCTION

Satisfying the nutritional requirements of a particular class of livestock is rapidly becoming a difficult task. This is due to scarcity and high cost of feed and feed ingredients. Meeting the energy and protein needs of chickens represents a very substantial part of the cost of feeding [1]. Although National Research Council [2] recommended a feeding standard for broilers and layers among other classes of livestock under temperate climatic conditions, this has not been practicable for the local chickens in the tropics for the obvious reasons of environmental differences and type and quality of available feed ingredients and the breed differences too. Efforts have been made to determine feeding standards for broilers under tropical environments [3, 4]. However, due to high cost and scarcity of feed and feed ingredients poultry farmers still occasionally and haphazardly mix one or two ingredients together without due consideration for age and nutrient requirements of the class of birds involved. Potchefstroom Koekoek chickens are a dual purpose chicken imported from South Africa, distributed in almost all the parts of the rural and pre-urban areas of Ethiopia. Most of the farmers in these areas operate with bad and inadequate access to roads and transportation; thus, it is difficult to reach areas where complete feed can easily be found on time. Hence, the practice of on-farm feed production and testing in which level of energy and

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protein combination the breed performs well might be an urge. Thus, the objective of this study was evaluate the growth and production performance of Koekoek dual purpose chicken fed with different energy and protein levels; and to determine the optimum energy and protein level for the breed in Ethiopian condition.

MATERIALS AND METHODS

Experimental Ration and Treatments: These experiments were conducted at Debre Zeit Agricultural Research Center (DZARC), located 47 km southeast of Addis Ababa, Ethiopia. The experimental layouts are presented in Table 1. Samples from the major feed ingredients were analyzed for proximate values (Table 2). The feed ingredients used in the formulation of the different experimental rations were maize, wheat middling, nougseed cake, soybean meal, vitamin-mineral premix, salt, limestone, lysine and methionine (Table 3). All the ingredients except wheat middling, soybean meal, vitamin premix, lysine and methionine were then hammer milled to 3-5 mm sieve size.

Based on the chemical analysis result (proximate values), six treatments (Table 3), five treatments (Table 4) and four treatments (Table 5) rations, respectively for Trial I, Trial II and Trial III were formulated with different ME and % CP levels among the treatments as shown in treatments layouts (Table 2). The basis for setting the treatments is by considering the ranges in between the requirements of layers and broilers chicken breeds as the experimental birds specified as a dual purpose type.

Management of Experimental Birds: Four hundred-fifty unsexed day-old Potchefstroom Koekoek chicks sourced from DZARC, with initial body weight (BW) of 37.18±1.91 gm (mean ± SD) were randomly divided into 6 dietary treatments and 3 replications per treatment, thus having 25 chicks per replicate in a pen (Trial I). At the age of 10 weeks, the same birds used in the first trial, with initial BW of 266.99±45 gm (mean ± SD), were randomly divided into five dietary treatments and three replications per treatment, thus having 30 grower chicks per replicate or pen (Trial II). For the third trial 84 koekoek hens the same birds that used in Trial II, (with initial BW of 1.38±0.09 kg; mean ± SD) and 12 cocks were randomly divided into 4 dietary treatments and 3 replications per treatment. Wire-mesh-partitioned deep litter floor house covered with disinfected teff straw litter material was used for the study. Before the commencement of the actual experiment, the experimental pens, watering and feeding troughs and laying nests were thoroughly cleaned, disinfected and sprayed against external parasites. The birds were vaccinated against Newcastle disease (HB1 at day 9 and Lasota a booster at day 21) and Infectious Bursal Disease (Gumboro) at the age of 7 and 19 days, all were given through an eye drop. Other health precautions and sanitary measures were also taken throughout the study period. Feed at 45, 75 and 130 gm / bird on average in Trail I, Trail II and Trail III, respectively and clean tap water *ad libitum* was offered throughout the experimental period for each trial.

Measurements: The amount of feed offered and refused per pen was recorded daily during the respective trial phases. Feed intake was determined as the difference between the feed offered and refused. Birds were weighed weekly in a group per pen and pen average was calculated (Trial I and Trial II). Body weight measured at the start and end of the trial (Trial III) and BW changes calculated as the difference between the final and initial BWs in each trial. Average daily BW gain (ADG) calculated as the ratio of BW change to the number of experimental days. Feed efficiency computed as the ratio of gm total feed intake/gm total BW gained (Trial I, Trial II) and kg feed consumed by dozen eggs/total egg produced in Trial III. Mortality was registered as it occurred and general health status was monitored throughout the trial periods. Eggs were collected 3 times a day from each pen at 0800, 1300 and 1700 hours (Trial III) and the sum of these collections along with the number of birds alive on each day were recorded and summarized at the end of the period. Eggs collected daily were weighed immediately for each pen and average egg weight was computed by dividing the total egg weight to the number of eggs. Hen-day egg production (HDEP) as a percentage was determined. Average egg mass per hen per day in grams calculated as percent HDEP by average egg weight in grams [5].

$$\text{HDEP} = \frac{\text{Total number of eggs produced on a day}}{\text{Total number of hens present on that day}} \times 100$$

Feed efficiency was determined as:

$$\text{FCR (per dozen eggs)} = \frac{\text{Kg of feed consumed}}{\text{Total eggs produced}} \times 12$$

For the measurement of egg quality, 4 eggs per replicate were randomly taken at a 15-d interval from the freshly laid eggs. The external egg quality parameters were assessed in terms of egg weight and shape index.

Table 1: Proximate composition of feed ingredients used to formulate starter chicks ration

Nutrients/Parameters	Corn grain	Nougseed Cake	Wheat middling	SBM
DM (%)	92.08	94.90	92.87	96.02
CP (%)	8.40	32.60	19.16	42.19
CF (%)	2.14	23.20	8.42	6.51
EE (%)	3.43	7.10	5.41	6.81
Ash (%)	2.30	8.36	3.98	6.02
ME kcal/kg DM	3458	2450	2080	2230
Ca (%)	0.04	0.26	0.11	0.30
P (%)	0.30	0.65	1.15	0.65

CP= crude protein; CF= crude fiber; DM= dry matter; EE= ether extract; ME= metabolizable energy; MBM= Meat and bone meal; SBM= soybean meal. Management of experimental birds

Table 2: Treatment set-ups for the three trials (Trial I, II and III) for the different stage of growth of koekoek dual purpose chicken

	Trial I		Trial II		Trial III	
Treatments	ME (kcal/kg DM)	%CP	ME (kcal/kg DM)	%CP	ME (kcal/kg DM)	%CP
T1	2950	21	2800	16	2750	16
T2	2800	20	2800	17	2800	16.5
T3	2650	19	2900	17	2900	17
T4	3150	23	2900	18	2950	17.5
T5	3000	22	2850	17		
T6	2850	21				

ME= metabolizable energy; CP= crude protein; Treatments= diet formulated to contain such respective trials ME (kcal/kg DM) and %CP. Trial I= starter phase trial (0-8 weeks of age); Trial II= grower phase trial (10-22 weeks of age) and Trial III= layer phase trial (24-36 weeks of age).

After breaking and separating each of the components, the internal egg quality parameters were also assessed in terms of shell weight, shell thickness, yolk color, yolk weight, yolk length, yolk height, yolk index, albumen weight, albumen heights and Haugh unit. Eggs were broken on a flat glass to measure the quality parameters. The shell, albumen and yolk were carefully separated and were weighed individually using a sensitive balance of 0.01 g of precision. Shell weight and thickness were taken by removing the internal membrane. The shell thickness measured was the average of the blunt, middle and sharp points of the egg and was measured using a digital micrometer. Albumen and yolk height were measured by tripod micrometer. Haugh unit was calculated according to Haugh [6] using the formula 100 log10 $(h + 7.57 - 1.7w^{0.37})$, where h = observed albumen height (mm) and w = weight of egg (g). The yolk color was determined by comparing the color of a properly mixed yolk sample placed on white paper with the color strips of Roche color fan measurement, which consists of 1 to 15 strips ranging from pale to orange-yellow in color. The length and width of the egg and the length and height of the yolk were measured by using digital caliper and the egg and yolk shape indexes were computed [7]. The formula used to determine egg shape index and yolk index are:

$$\text{Egg shape index} = \frac{\text{Width of egg}}{\text{Length of egg}} \text{ x100}$$

and,

$$\text{Yolk index} = \frac{\text{Yolk height}}{\text{Yolk length}}$$

The eggs for incubation were collected toward the end of the study (35 wk of age) and stored for 7 days till incubation at a temperature of 10 to 14°C. Medium- or average-sized eggs (30 eggs for each replication) graded using an egg grader were selected and used. Fertility was checked by candling the incubated eggs on the 9^{th} day of incubation in the dark room with an egg Candler powered by electricity; infertile clear eggs were taken out from the setting tray. Average percentage fertility was determined by dividing the total number of eggs found fertile at candling by the total number of eggs set. Average percentage hatchability of the fertile eggs was computed by dividing the number of chicks hatched by the number of fertile eggs. Egg: feed price ratio (EFPR) used to find out the ratio between the receipt from egg and expenditure on feed.

$$\text{EFPR} = \frac{\text{Total value of egg produced}}{\text{Total value of feed consumed}}$$

The net income (NI) was calculated by subtracting total cost (TC) from the total return (TR).

NI = TR-TC; TC = FC/bird = (TFI x cost/Kg),
where, TFI= Total feed intake and FC = feed cost

Table 3: Proportion of ingredients used in formulating koekoek chick starter ration (0-8 weeks of age, Trial I) and chemical composition in the ration in an experiment to optimize the energy and protein levels for the support of growth performance

Ingredients (%)	T_1	T_2	T_3	T_4	T_5	T_6
White maize	57.55	57.00	56.00	59.00	60.00	59.00
Wheat middling	7.00	6.50	7.30	2.50	3.42	3.10
Noug seed cake	6.80	7.00	6.50	4.50	3.78	6.00
SBM	25.00	25.68	26.44	30.62	29.00	28.05
Vitamin-mineral premix*	0.50	0.50	0.50	0.50	0.50	0.50
Salt	0.30	0.30	0.30	0.30	0.30	0.30
Limestone	2.40	2.40	2.46	2.20	2.25	2.25
DL-lysine	0.30	0.37	0.30	0.20	0.35	0.30
DL-methionine	0.15	0.25	0.20	0.18	0.40	0.50
Total	100.00	100.00	100.00	100.00	100.00	100.00
Nutrient Contents						
DM (%)	92.40	92.86	91.20	93.00	91.10	93.45
CP (%)	19.46	19.58	19.49	19.46	20.20	20.07
CF (%)	4.70	4.68	4.67	4.14	4.33	4.62
EE (%)	3.80	3.79	3.78	3.70	3.70	3.79
Ash (%)	10.00	10.60	9.90	10.90	10.90	11.50
ME kcal/kg DM	2732	2735	2727	2775	2752	2741
Ca (%)	1.12	1.12	1.12	1.08	1.10	1.12
P (%)	0.5	0.5	0.51	0.48	0.49	0.50

DM=dry matter; CP=crude protein; CF=crude fiber; EE=ether extract; ME= metabolizable energy; SBM=soybean meal; T_1: 2950 ME in kcal/kg DM and 21% CP; T_2: 2800 ME in kcal/kg DM and 20% CP; T_3: 2650 ME in kcal/kg DM and 19% CP; T_4: 3150 ME in kcal/kg DM and 23% CP; T_5: 3000 ME in kcal/kg DM and 22% CP and T_6: 2850 ME in kcal/kg DM and 21% CP. *Vitamin trace minerals premix contained: vitamin A, 2, 000, 000 IU; vitamin D3, 400, 000 IU; vitamin E, 1, 000 mg; vitamin K3, 400 mg; vitamin B1, 300 mg; vitamin B2, 1, 000 mg; vitamin B3, 1, 800 mg; vitamin B6, 600 mg; vitamin B12, 2 mg; pantothenic acid, 6, 000 mg; folic acid, 200 mg; choline chloride, 40, 000 mg; iron, 9, 000 mg; copper, 1, 000 mg; manganese, 12, 000 mg; cobalt, 200 mg; zinc, 14, 000 mg; Sodium, 200 mg; selenium, 80 mg; Ca, 27.8%; antioxidant (butylated hydroxytoluene), 500 mg.

Table 4: Proportion of ingredients used in formulating koekoek chick grower ration (10-22 weeks of age, Trial II) and chemical composition in the ration in an experiment to optimize the energy and protein levels for the support of growth performance

Ingredients (%)	T_1	T_2	T_3	T_4	T_5
White maize	62.20	62.00	60.00	60.00	60.00
Wheat middling	14.00	10.45	16.35	12.37	15
Noug seed cake	5.00	4.85	4.00	5.00	5.00
SBM	15.20	19.00	16.00	19.00	16.45
Vitamin-mineral premix*	0.50	0.50	0.50	0.50	0.50
Salt	0.30	0.30	0.30	0.30	0.30
Limestone	2.60	2.48	2.40	2.38	2.30
DL-lysine	0.10	0.27	0.30	0.30	0.33
DL-methionine	0.10	0.15	0.15	0.15	0.12
Total	100.00	100.00	100.00	100.00	100.00
Nutrient Contents					
DM (%)	92.40	92.86	91.20	93.00	91.10
CP (%)	19.46	19.58	19.49	19.46	20.20
CF (%)	4.70	4.68	4.67	4.14	4.33
EE (%)	3.80	3.79	3.78	3.70	3.70
Ash (%)	10.00	10.60	9.90	10.90	10.90
ME kcal/kg DM	2732	2735	2727	2775	2752
Ca (%)	1.12	1.12	1.12	1.08	1.10
P (%)	0.5	0.5	0.51	0.48	0.49

DM=dry matter; CP=crude protein; CF=crude fiber; EE=ether extract; ME=metabolizable energy; SBM=soybean meal; T_1: 2950 ME in kcal/kg DM and 21% CP; T_2: 2800 ME in kcal/kg DM and 20% CP; T_3: 2650 ME in kcal/kg DM and 19% CP; T_4: 3150 ME in kcal/kg DM and 23% CP; T_5: 3000 ME in kcal/kg DM and 22% CP and T_6: 2850 ME in kcal/kg DM and 21% CP. *Vitamin trace minerals premix contained: vitamin A, 2, 000, 000 IU; vitamin D3, 400, 000 IU; vitamin E, 1, 000 mg; vitamin K3, 400 mg; vitamin B1, 300 mg; vitamin B2, 1, 000 mg; vitamin B3, 1, 800 mg; vitamin B6, 600 mg; vitamin B12, 2 mg; pantothenic acid, 6, 000 mg; folic acid, 200 mg; choline chloride, 40, 000 mg; iron, 9, 000 mg; copper, 1, 000 mg; manganese, 12, 000 mg; cobalt, 200 mg; zinc, 14, 000 mg; Sodium, 200 mg; selenium, 80 mg; Ca, 27.8%; antioxidant (butylated hydroxytoluene), 500 mg.

Table 5: Proportion of ingredients used in formulating koekoek chicken ration (24-36 weeks of age, Trial III) and chemical composition in the ration in an experiment to optimize the energy and protein levels to support layer performance

Ingredients (%)	T_1	T_2	T_3	T_4
White maize	59.00	60.64	61.00	61.00
Wheat middling	13.60	10.00	10.00	9.00
SBM	12.00	12.23	11.90	12.43
Nougseed cake	4.00	5.40	5.30	6.00
MBM	3.50	4.00	4.10	4.00
Salt	0.40	0.40	0.40	0.40
Limestone	6.80	6.65	6.60	6.50
*Vitamin-mineral premix	0.50	0.50	0.50	0.50
DL-lysine	0.15	0.15	0.18	0.15
DL-methionine	0.05	0.03	0.02	0.02
Total	100.00	100.00	100.00	100.00
Nutrient Contents				
DM (%)	92.40	92.86	91.20	93.00
CP (%)	16.02	15.86	15.76	16.02
CF (%)	4.02	3.99	3.96	4.02
EE (%)	4.24	4.22	4.23	4.24
Ash (%)	10.00	10.60	9.90	10.90
ME kcal/kg DM	2700	2690	2696	2700
Ca (%)	3.03	3.08	3.07	3.03
P (%)	0.64	0.65	0.65	0.64

DM=dry matter; CP=crude protein; CF=crude fiber; EE=ether extract; ME=metabolizable energy; MBM=Meat and bone meal; SBM=soybean meal; T_1: 2750 ME in kcal/kg DM and 16% CP; T_2: 2800 ME in kcal/kg DM and 16.5% CP; T_3: 2900 ME in kcal/kg DM and 17% CP and T_4: 2950 ME in kcal/kg DM and 17.5% CP. *Vitamin trace minerals premix contained: vitamin A, 2, 000, 000 IU; vitamin D3, 400, 000 IU; vitamin E, 1, 000 mg; vitamin K3, 400 mg; vitamin B1, 300 mg; vitamin B2, 1, 000 mg; vitamin B3, 1, 800 mg; vitamin B6, 600 mg; vitamin B12, 2 mg; pantothenic acid, 6, 000 mg; folic acid, 200 mg; choline chloride, 40, 000 mg; iron, 9, 000 mg; copper, 1, 000 mg; manganese, 12, 000 mg; cobalt, 200 mg; zinc, 14, 000 mg; Sodium, 200 mg; selenium, 80 mg; Ca, 27.8%; antioxidant (butylated hydroxytoluene), 500 mg.

Statistical Analysis: Data were analyzed using the general linear model procedures of Statistical Analysis Systems software [8] with the model consisting of treatments. Differences between treatment means were separated using Tukey Kramer test.

RESULTS AND DISCUSSION

The effect of feeding koekoek chick starter ration (Trial I) of different energy and protein levels among the treatments on feed consumption, growth performances and net returns were presented in Table 6. The result revealed that the feed consumption and growth performance parameters were not affected by the treatments whereas the total cost of feed and the net return was showed a difference ($P<0.05$) among the treatments and birds fed at energy and protein levels of 2850 kcal/kg DM and 21% (T_6) costs more than birds fed 2950 kcal/kg DM and 21% (T_1); 2650 kcal/kg DM and 19% (T_3) and it was similar with treatments T_2, T_4 and T_5. On the reveres, a higher net return was obtained from birds that fed T_1 and T_3 which was similar also with T_2, T_4 and T_5. In the grower phase trial to optimize the energy and protein levels for the support of growth performance (Trial II) results were presented in Table 7. In the present study, parameters considered for feed consumption showed a no differences ($P>0.05$) among the treatments while BW changes, gains and FE were affected and a heavier BW change observed in T_1 and T_5 which was also statistically not different ($P>0.05$) with T_2 and T_3. Result revealed in this study on average daily BW gain, FE and net return were also followed the same trend as that of the BW change. Effect of different levels of energy and protein levels in the growth and egg laying performance of koekoek chicken were also tested (Trial III) and results presented in Table 8. As the result showed that parameters considered testing the effect of different levels of energy and protein combination did not ($P>0.05$) bring any change on FI, BW changes and laying performances of the hens considered, the same observed in egg quality parameters and fertility and hatchability.

The present study is in agreement with the findings [9] that the high-energy feed blend resulted in a higher BW gain between the 7th and 28th day of breeding. The same to the overall results of this study, Solangi *et al.* [10] concluded that the influence of different protein levels in feed on broiler breeding groups were fed a feed with 17%, 20%, 23% and 26% CP that there was a statistically

Table 6: Least squares means for feed intake and body weight change performances of koekoek chicks (0-8 weeks of age) in an experiment to optimize the energy and protein levels for the support of growth performance

	Treatments							
Parameters	T_1	T_2	T_3	T_4	T_5	T_6	SE	P-value
Number of observation= 75								
Total FI(gm/bird)	1531.99	1540.01	1523.33	1530.24	1528.09	1550.63	39.90	NS
Average FI(gm/bird)	29.46	29.61	29.30	29.43	29.39	29.82	0.67	NS
Average BW(gm/bird)	278.02	308.51	233.48	255.57	306.64	273.98	34.21	NS
BW change (gm/bird)	246.05	275.36	200.07	219.46	275.93	237.44	34.05	NS
FE (gm total BW gain/gm total FI)	0.16	0.18	0.13	0.14	0.18	0.15	0.02	NS
Cumulative Mortality Rate	4.67	3.33	2.33	6.00	5.33	7.00	1.30	NS
Total Cost	12.10^{b}	12.69^{ab}	12.32^{b}	12.54^{ab}	13.32^{ab}	13.69^{a}	0.28	*
Total Return	90.00	90.00	90.00	90.00	90.00	90.00	0.00	NS
Net Return	77.90^{a}	77.31^{ab}	77.68^{a}	77.46^{ab}	76.68^{ab}	76.31^{b}	0.28	*

Means within a row with different superscripts are significantly different; *= P<0.05; NS= Non-significant; SE= Standard error; BW= body weight; FE= feed efficiency; FI= feed intake; T_1: 2950 ME in kcal/kg DM and 21% CP; T_2: 2800 ME in kcal/kg DM and 20% CP; T_3: 2650 ME in kcal/kg DM and 19% CP; T_4: 3150 ME in kcal/kg DM and 23% CP; T_5: 3000 ME in kcal/kg DM and 22% CP and T :$_6$2850 ME in kcal/kg DM and 21% CP. Total Cost= feed cost/bird by total feed intake; Total Return= bird sale; Net Return= the difference in total return and total cost

Table 7: Least squares means for feed intake and body weight change performances of koekoek grower chicks (10-16 weeks of age) in an experiment to optimize the energy and protein levels for the support of growth performance

Parameters	T_1	T_2	T_3	T_4	T_5	SE	P-value
Number of observation = 90							
Total FI (gm/bird)	3680.98	3693.58	3627.37	3654.10	3654.66	43.96	NS
Average FI (gm/bird)	73.62	73.87	72.55	73.08	73.09	0.88	NS
Initial BW (gm/bird)	267.00	240.50	266.97	300.06	250.94	14.96	NS
Final BW (gm/bird)	979.44	886.01	919.87	881.18	942.16	21.72	NS
Body weight change (gm/bird)	712.44^{a}	648.51^{ab}	652.90^{ab}	568.13^{b}	691.82^{a}	23.16	*
Average daily BW gain(gm/bird)	14.54^{a}	13.23^{ab}	13.33^{ab}	11.59^{b}	14.12^{a}	0.47	*
FE (gm total weight gain/gm total FI)	0.19^{a}	0.18^{ab}	0.18^{ab}	0.17^{b}	0.19^{a}	0.01	*
Cumulative Mortality Rate	10.00	10.00	10.67	12.00	13.00	1.72	NS
Total Cost	24.74^{b}	26.48^{a}	25.68^{ab}	26.34^{a}	25.88^{ab}	0.31	*
Total Return	120.00	120.00	120.00	120.00	120.00	0.00	NS
Net Return	95.26^{a}	93.52^{b}	94.32^{ab}	93.66^{b}	94.12^{ab}	0.31	*

Means within a row with different superscripts are significantly different; *= P<0.05; NS= Non-significant; SE= Standard error; BW= body weight; FE= feed efficiency; FI= feed intake; T_1: 2950 ME in kcal/kg DM and 21% CP; T_2: 2800 ME in kcal/kg DM and 20% CP; T_3: 2650 ME in kcal/kg DM and 19% CP; T_4: 3150 ME in kcal/kg DM and 23% CP; T_5: 3000 ME in kcal/kg DM and 22% CP and T_6: 2850 ME in kcal/kg DM and 21% CP. Total Cost= feed cost/bird by total feed intake; Total Return= bird sale; Net Return= total return by total cost.

Table 8: Feed intake, BW change and egg laying performances of 24-34wks-old koekoek chickens fed a ration containing different energy and protein levels in an experiment to determine the optimum energy and protein level

	Treatments					
Parameters	T_1	T_2	T_3	T_4	SE	P-value
Number of observation = 24						
Total FI (gm/bird)	7837.20	7856.60	7721.10	7927.60	120.25	NS
Average FI (gm/bird)	93.30	93.53	91.92	94.38	1.43	NS
Initial BW (gm/bird)	1376.63	1370.24	1341.83	1442.20	29.69	NS
Final BW (gm/bird)	1964.59	1994.28	1856.20	2037.44	65.15	NS
Body weight change (gm/bird)	588.00	624.00	514.40	595.20	74.15	NS
Total number of egg produced	295	335.33	317.00	319.67	22.50	NS
HDEP	56.24	64.42	65.49	62.01	4.06	NS
Average egg weight (gm)	47.56	48.21	47.08	48.03	0.52	NS
Egg mass (gm)	14038.00	16166.00	14929.00	15354.00	1108.78	NS
Feed efficiency	0.32	0.29	0.29	0.30	0.02	NS
Cumulative Mortality Rate	0.33	0.33	1.00	1.00	0.47	NS
EFPR	19.73	22.21	21.37	21.11	1.31	NS

Means within a row with different superscripts are significantly different; *= P<0.05; NS= Non-significant; SE= Standard error; BW=body weight; FE= feed efficiency; FI=feed intake; T_1: 2750 ME in kcal/kg DM and 16% CP; T_2: 2800 ME in kcal/kg DM and 16.5% CP; T_3: 2900 ME in kcal/kg DM and 17% CP and T_4: 2950 ME in kcal/kg DM and 17.5% CP. Total Cost=feed cost/bird by total feed intake; Total Return= spent hen and egg sale; Net Return= total return minus total cost.

Table 9: Egg quality characteristics of 24-36wk-old koekoek chicken fed a ration containing different energy and protein levels in an experiment to determine the optimum energy and protein level

	Treatments					
Parameters	T_1	T_2	T_3	T_4	SE	P-value
Number of observation = 12						
Sampled egg weight (gm)	48.52	49.45	48.94	48.96	1.35	NS
Egg length (mm)	41.89	49.12	41.08	39.94	3.49	NS
Egg width (mm)	31.53	37.04	28.63	26.73	3.05	NS
Egg shape index	0.65	0.75	0.58	0.55	0.06	NS
Shell thickness (mm)	0.36	0.34	0.34	0.33	0.02	NS
Shell weight (gm)	5.94	6.14	6.12	6.20	0.20	NS
Albumen height (mm)	6.00	6.00	6.33	5.44	0.35	NS
Albumen weight (gm)	25.76	26.32	26.47	26.36	1.04	NS
Yolk weight (gm)	16.09	15.75	15.59	15.93	0.43	NS
Yolk height (mm)	17.44	17.22	17.34	17.56	0.37	NS
Yolk length (mm)	38.90	36.21	37.87	38.79	1.20	NS
Yolk index	0.40	0.49	0.46	0.45	0.03	NS
Yolk color (RCF)	1.00	1.00	1.00	1.00	1.00	NS

T_1: 2750 ME in kcal/kg DM and 16% CP; T_2: 2800 ME in kcal/kg DM and 16.5% CP; T_3: 2900 ME in kcal/kg DM and 17% CP and T_4: 2950 ME in kcal/kg DM and 17.5% CP; RCF = Roche color fan.

Table 10: Fertility and hatchability of 35-36-weeks-old koekoek hen fed a ration containing different energy and protein levels in an experiment to determine the optimum energy and protein level

	Treatments					
Parameters	T_1	T_2	T_3	T_4	SE	P-value
Number of observation = 24						
Fertility (%)	85.33	90.67	81.33	86.67	4.52	NS
Hatchability (%)	80.00	77.33	73.33	77.33	3.27	NS

T_1: 2750 ME in kcal/kg DM and 16% CP; T_2: 2800 ME in kcal/kg DM and 16.5% CP; T_3: 2900 ME in kcal/kg DM and 17% CP and T_4: 2950 ME in kcal/kg DM and 17.5% CP

significant link between body mass and the increasing levels of proteins in feed. There was no significant difference among the treatments groups when the biological parameters were considered. This might have been caused by the feed rations or the treatments that contain more or less similar energy and crude protein levels. Although critical, major parameters such as feed efficiency and body weight did not vary among all treatment rations. Total cost and net return showed inverse relationship lower total cost of production was associated with higher net return and higher total cost resulted in lower net return.

CONCLUSIONS

The present research results point to a different influence of energy and protein levels on the examined chicken characteristics. Better weight and mass gain were achieved in the groups fed the feed with a higher content of energy and crude protein. In the current study, although significant differences in biological parameters have not been realized, differences were observed in some parameters regarding profitability. Economics is a driving force in poultry enterprises, but biological parameters are important too. Further investigation of energy-protein optimization is important to determine how insignificant biological variation could lead to significant differences along with the other nutrients that contribute an effect on the energy-protein metabolism. Feed allowance on the daily basis should be also addressed together to control the energy-protein intake compensation.

Conflicts of Interest: The authors declare no conflicts of interest.

ACKNOWLEDGMENT

The authors express their gratitude to DZARC for covering the research expenses; from the poultry research case team a special thank goes to Mr. Biniyam Abebe who duly and carefully recording all the data considered.

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