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Research Article

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

Etalem Tesfaye*, Wondmeneh Esatu, Kasech Melese and Tadios Habte

Debre Zeit Agricultural Research Center, Debre Zeit, Ethiopia

***Corresponding Author:** Etalem Tesfaye, Debre Zeit Agricultural Research Center, Debre Zeit, Ethiopia.

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Abstract

Three phases (starter, grower and laying) trials were performed to evaluate the effects of different levels of energy and protein combinations on the growth and egg production performances of local chickens. A total of 500 chicks (Trial I), 375 growers (Trial II) and 84 + 12 hens and cocks, respectively (Trial III) were used. Improved Horro ecotype chicks, growers and adult chickens were randomly distributed into the respective trials, treatments and replications. Treatments were varying levels of energy (ME in kcal/kg DM) and protein (% crude protein (CP)) combinations at 2950, 21 (T_1), 2800, 20 (T_2), 2650, 19 (T_3), 3150, 23 (T_4), 3000, 22 (T_5) and 2850, 21 (T_6), respectively for Trial I; at 2700, 15 (T_1), 2800, 16 (T_2), 2900, 17 (T_3), 3000, 18 (T_4) and 3100, 19 (T_5), respectively for Trial II; at 2750, 16 (T_1), 2800, 16.5 (T_2), 2900, 17 (T_3) and 2700, 16 (T_4), respectively for Trial III. Feed intake recoded daily for each trial, body weight (BW) weighed every week (Trial I and Trial II) and at the start and end of the period (Trial III) and the change calculated as BW change. Egg weight and egg production record taken daily. Fertility and hatchability tested towards the end of Trial III. Feed consumption at the starter phase did not show a difference ($P > 0.05$) among the treatments but was higher for T_4 in grower phase and was similar with T_1, T_2, and T_3, the same trend also observed with average feed intake. The total feed cost for T_4 and T_5 and net return for T_1 in the grower phase were higher ($P < 0.05$) whereas no difference ($P > 0.05$) were observed in the laying phase in feed consumption. Egg mass was higher ($P < 0.05$) in T_2 which was similar with T_1; feed efficiency higher ($P < 0.05$) for T_1 and T_4 similar with T_3. The egg feed price ratio also higher ($P < 0.05$) for T_2 and T_1, T_3. However, no differences ($P > 0.05$) observed in all the egg quality parameters considered and the fertility and hatchability. The trial considered a varying level of energy-protein combination; however, the variation in the energy content is much smaller and falls within the range considered as the same. As a small gap of the result indicates that the Improved Horro chicken ecotypes seems to be a layer type rather than the meat because their egg production seems better at the lower level of ME and CP considered. Further investigation of energy-protein optimization should be considered by varying the level of energy to put a clear distinction of the chicken as an egg or meat type. To concluded that the higher energy and protein combination are use full during the starter and grower and the lower level combination of energy and protein are important during the laying phases of these local chickens.

Keywords: Energy-Protein Levels; Growth; Local Chickens; Production

Introduction

Poultry production is essentially a conversion of feed into poultry egg and meat products which affected by the feed quality and quantity dictating the level of production and product quality, independent of the production systems. The art of feeding is to supply the vital and productive demands of an animal by giving all the nutritional and natural worth substances that put on the organism. The chemical components which are indispensable for life and play an essential role in the metabolism of animals are called nutrients-the term used for the components of the feed capable of being utilized by animals. Energy and protein feed stuffs are the nutrients and determination of the required amount of energy and protein in feedstuff is probably the most important decision to be made when it comes to feed formulation for poultry. Energy itself comprises 70% of the total cost of feed. The right relation between nutrients in feed formulation requests good knowledge of needed concentrations of energy and proteins, amino acids, minerals and vitamins. In chicken production, it is very important to evaluate the ratio between raw protein level and metabolic energy level in formulation. The recommendation for example is that the ratio between raw proteins (%) and metabolic energy (KJ) is from 1:570 in starter mixture to 1:649 in finisher. In poultry production, the regime of dietary protein and energy were established both in the tropics and temperate climates [1,2]. The performances of broilers were evaluated [3] and reported that 23% crude protein (CP) with either 2800 or 3000 kcal/kg metabolizable energy (ME) was adequate as the requirement for broiler starters, while Onwudike [4] recommended 22% CP and 2900 kcal/kg ME. On the other hand, a range of 23 - 24% CP and 2800- 3000 kcal/kg DM ME for starter broiler and 19 - 21% CP with the same energy level for the finisher phase was recommended [5].

Today's trend is to reduce protein and energy in feedstuff and on the other side to maintain an appropriate level of amino acids in order to optimize the performance. When it comes to a rational use of protein from feed it is good to know that animal organisms do not use protein but amino acids. The physiological and practical implications of the interaction between energy intake and protein metabolism and between protein intake and energy metabolism must then be considered when the dietary requirements for either nutrient is assessed. But there is little information about the effects of a varying dietary energy and protein level on local chicken ecotype. The objective is to determine the optimum energy and protein levels that support the growth and production performances of improved Horro chicken ecotype.

Materials and Methods

Experimental ration and treatments

The experiment was conducted at Debre Zeit Agricultural Research Center (DZARC), located at an altitude of 1900 meters above sea level and at 8044'N latitude and 38'Eo longitude. The average annual rainfall is 1100 mm and the average maximum and minimum temperature of the area is 28.3 and 8.9°C, respectively. Three trials were performed to test the performance of the local birds (Improved Horro ecotype) at the starter (Trial I), grower (Trial II) and layer (Trial III) phases.

Samples from the major feed ingredients used for the trials were analyzed for proximate values (Table 1). The treatment set-ups for each trial were presented in table 2. The feed ingredients used in the formulation of the different experimental rations were maize, wheat middling, nougseed cake, Soybean Meal (SBM), meat and bone meal (MBM), vitamin-mineral premix, salt, limestone, lysine and methionine. All the ingredients except wheat middling, SBM, MBM, vitamin premix, lysine and methionine were then hammer milled to 5 mm sieve size and were stored until required for formulation of the experimental rations. Based on the chemical analysis result (proximate values), treatment rations were formulated with different ME and %CP levels among the treatments for each trial (Table 3-5).

Nutrients/Parameters	Corn grain	Noug seed Cake	Wheat middling	SBM	MBM
DM (%)	92.08	94.90	92.87	96.02	92.25
CP (%)	8.40	32.60	15.60	42.19	50.00
CF (%)	2.14	18.20	8.42	6.51	0.00
EE (%)	3.43	7.10	5.41	6.81	14.00
Ash (%)	2.30	8.36	3.98	6.02	12.00
ME kcal/kg DM	3358.00	2400.00	2080.00	2180.00	2830.00
Ca (%)	0.04	0.26	0.11	0.30	10.50
P (%)	0.30	0.65	1.15	0.65	5.20

Table 1: Proximate composition of feed ingredients used to formulate Trial I, Trial II and Trial III chicken ration.
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

Five hundred unsexed day-old Improved Horro ecotype chicks with initial body weight (BW) of 28.65 ± 1.71 gm (mean ± SD) were randomly assigned into six dietary treatments with three replications per treatment (Trial I), thus having 30 chicks per replicate or pen. Three hundred seventy-five mixed sex grower local chicks of the same birds used in Trial I with initial BW of 266.99 ± 5.49 gm (mean ± SD) were randomly divided into five dietary treatments and three replications per treatment, thus having 25 birds per replicate or pen (Trial II). Eighty-four local hens the same eco-

Treatments	Trial I		Trial II		Trial III	
	ME (kcal/kg DM)	%CP	ME (kcal/kg DM)	%CP	ME (kcal/kg DM)	%CP
T1	2950	21	2700	15	2750	16
T2	2800	20	2800	16	2800	16.5
T3	2650	19	2900	17	2900	17
T4	3150	23	3000	18	2700	16
T5	3000	22	3100	19		
T6	2850	21				

Table 2: Treatment set-ups for the three trials (Trial I, II and III) for the different stage of growth of *Improved Horro* chicken ecotype.

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). The basis for setting the ME and CP levels in each treatment is by considering the ranges in between the requirements of layers and broilers breed phases as the experimental birds not specified as egg or meat type.

Ingredients (%)	T_1	T_2	T_3	T_4	T_5	T_6
White maize	48.00	45.00	39.00	46.50	44.00	42.50
Wheat middling	7.00	11.00	23.00	6.00	10.00	16.00
Nougseed cake	12.00	11.00	12.00	9.00	11.00	14.5
SBM	29.00	29.00	22.00	33.50	30.00	23.00
MBM	0.88	0.25	0.25	1.40	1.40	0.40
Vitamin-mineral premix	0.50	0.50	0.50	0.50	0.50	0.50
Salt	0.30	0.40	0.40	0.40	0.40	0.40
Limestone	2	2.58	2.58	2.40	2.40	2.40
L-lysine	0.12	0.15	0.15	0.20	0.20	0.20
DL-methionine	0.10	0.12	0.12	0.10	0.10	0.10
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 (%)	21.78	21.55	19.04	22.67	20.20	20.86
CF (%)	5.69	5.78	4.69	4.14	4.33	6.39
EE (%)	4.98	4.93	4.59	5.04	3.70	4.98
Ash (%)	10.00	10.60	9.90	10.90	10.90	11.50
ME kcal/kg DM	3077	3014	3107	3107	2752	2850
Ca (%)	1.00	1.15	1.07	1.21	1.10	1.10
P (%)	0.54	0.53	0.48	0.56	0.49	0.58

Table 3: Proportion of ingredients used in formulating Improved Horro chicken ecotype chicks' starter (0-8 weeks of age, Trial I) ration and chemical composition in the ration in an experiment to optimize the energy and protein levels for their performance.

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: 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.

Ingredients (%)	T_1	T_2	T_3	T_4	T_5
White maize	52.50	52.00	55.00	57.00	57.50
Wheat middling	24.50	23.00	15.50	9.50	8.00
SBM	7.00	9.00	16.6	23.50	22.00
Nougseed cake	12.00	12	8.50	6.00	5.50
Meat and bone meal	0.40	0.40	0.80	0.40	3.40
Salt	0.40	0.40	0.40	0.40	0.40
Limestone	2.40	2.40	2.40	2.40	2.40
Vitamin-mineral premix	0.50	0.50	0.5	0.5	0.50
DL-lysine	0.20	0.20	0.20	0.20	0.20
DL-methionine	0.10	0.10	0.10	0.10	0.10
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 (%)	15.54	16.30	17.37	18.44	18.93
CF (%)	5.83	5.82	5.11	4.64	4.34
EE (%)	4.51	4.60	4.57	4.55	4.77
Ash (%)	10.00	10.60	9.90	10.90	10.90
ME kcal/kg DM	2792	2827	2961	3079	3087
Ca (%)	1.05	1.10	1.11	1.07	1.38
P (%)	0.58	0.60	0.55	0.49	0.62

Table 4: Proportion of ingredients used in formulating Improved Horro chicken ecotype growers 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 growth performance.

DM: Dry Matter; CP: Crude Protein; CF: Crude Fiber; EE: Ether Extract; ME: Metabolizable Energy; SBM: Soybean Meal; T_1: 2700 ME in kcal/kg DM and 15% CP; T_2: 2800 ME in kcal/kg DM and 16% CP; T_3: 2900 ME in kcal/kg DM and 17% CP; T_4: 3000 ME in kcal/kg DM and 18% CP and T_5: 3100 ME in kcal/kg DM and 19% CP.

type used in the Trial II with initial BW of 1.05 ± 0.28 kg; mean ± SD) and 12 cocks were randomly divided into four dietary treatments and three replications per treatment (Trial III). All the birds in each trial were vaccinated against Newcastle (HB1 at day 9 and Lasota a booster dose at day 21) and Infectious Bursal Disease (Gumboro) at the age of 7 and 19 days, all given through an eye drop. Other health precautions and sanitary measures were also taken throughout the study period. Before the commencement of the actual experiment, experimental pens, watering and feeding troughs in all the trial phases were thoroughly cleaned, disinfected and sprayed against external parasites. The chicks were brooded (Trial I) using 250 watt infrared electric bulbs with gradual height adjustment as sources of heat and light; fluorescent lamps were placed for the lighting system (Trial II and III) in a deep litter house covered with Teff straw. The birds were fed at 45gm/bird, 70gm/bird and 130 gm/bird per day throughout the experimental periods on average, respectively for Trial I, Trial II and Trial II and clean tap water ad libitum was offered throughout the experimental period of all. All the birds were sourced from DZARC and diets were offered in a round feeder and water in a plastic fountain. The birds were adapted to respective treatment diet for a week before the commencement of the actual data collection in all the trials.

Measurements

The amount of feed offered and refused per pen was recorded daily in each the trial phases. Feed intake (FI) 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 as average BW (Trial I and II). Body weight change was calculated as the difference between the final and initial BW (Trial I, Trial II and Trial III). Average daily BW gain (ADG) was calculated as the ratio of BW change to the number of experimental days. Feed efficiency was computed as the ratio of gm total FI/gm total BW gained (Trial I and II). Mortality was recorded when occurred and general health status was monitored throughout the experiment. From each pen eggs were collected three times a day at 0800, 1300,

Ingredients (%)	T_1	T_2	T_3	T_4
White maize	51.00	53.00	57.00	51.00
Wheat middling	14.50	11.00	6.00	13.00
SBM	14.80	18.00	19.00	14.80
Nougseed cake	10.00	7.80	6.00	11.00
MBM	0.40	0.00	2.80	0.00
Salt	0.40	0.40	0.40	0.40
Limestone	9.00	9.00	9.00	9.00
*Vitamin-mineral premix	0.50	0.50	0.50	0.50
DL-lysine	0.20	0.20	0.20	0.20
DL-methionine	0.10	0.10	0.10	0.10
Total	100.00	100.00	100.00	100.00
Nutrient Contents				
DM (%)	92.40	92.86	91.20	93.00
CP (%)	16.11	17.18	17.16	16.27
CF (%)	5.05	5.65	5.66	5.15
EE (%)	4.22	4.57	4.59	4.24
Ash (%)	10.00	10.60	9.90	10.90
ME kcal/kg DM	2749	2890	2921	2751
Ca (%)	3.53	3.53	3.82	3.53
P (%)	0.48	0.54	0.55	0.40

Table 5: Proportion of ingredients used in formulating *Improved Horro* chicken ecotype ration (24-36 weeks of age, Trial III) and chemical composition in the ration in an experiment to optimize the energy and protein levels for egg performance.

DM: Dry Matter; CP: Crude Protein; CF: Crude Fiber; EE: Ether Extract; ME: Metabolizable Energy; SBM: Soybean Meal; T_1: 2750 ME in kcal/kg DM and 16.5% 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: 2700 ME in kcal/kg DM and 16% 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; iodium, 200 mg; selenium, 80 mg; Ca, 27.8%; antioxidant (butylated hydroxytoluene), 500 mg.

and 1700 hours. The sum of the collections and the number of birds alive on that day were registered and summarized at the end of the period. Eggs collected daily were weighed immediately after collection for each pen and average egg weight was computed by dividing the total egg weight to the number of eggs. Egg mass per hen was calculated as total egg mass divided by number of hens. Hen-day egg production (HDEP) as a percentage was determined.

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

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 day interval from the freshly laid eggs. The external egg quality parameters were assessed in terms of egg weight and shape index. 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 − 1.7 w0.37), 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:

$$\text{Egg shape index} = \frac{\text{Width of egg}}{\text{Length of egg}} \times 100 \text{ and}$$

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

The eggs for incubation were collected one week before the end of the experiment and stored at cool temperature (10-14^{o}c). Thirty average-sized eggs for each replication were selected and used for incubation (incubated). By candling the incubated eggs on the 9th day of incubation, fertility was checked in the dark room with an egg Candler and then the infertile were taken out from the setting tray. The total number of eggs found fertile during candling, the number of eggs set during incubation and the number of chicks hatched were used to calculate the average percentage hatchability and fertility.

Egg: feed price ratio (EFPR) used to calculate the ratio between the revenue from egg sale and cost incurred on the feed.

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

Statistical analysis

The collected data were analyzed using one-way ANOVA of the general linear model procedures of Statistical Analysis Systems software [8] with the model consisting of treatments. Tukey Kramer test was used to separate the differences between treatments means.

Results and Discussion

Total feed intake as well as average feed intake in chicks (0-8 weeks of age –Trial I Table 6) the present study showed a non-significant difference (P > 0.05) among the treatments. The differences observed in feed efficiency, cumulative mortality and total return was insignificant (P > 0.05). However, there was a difference observed among the treatments in growth performances and the net return. In this respect birds fed treatment diets that contained a ME of 3000 kcal/kg DM and CP of 22% (T_5) and ME of 2850 kcal/kg DM and CP of 21% was higher and similar with T_4 (3150 ME in kcal/kg DM and 23% CP) both in average BW as well as BW change. In this study of Trial II (Table 7) that birds fed treatment diets of different energy and protein levels among treatments at the age of 10-22 weeks showed a difference in total and average feed intake. Birds fed at 3150 ME in kcal/kg DM and 23% CP (T_4) energy-protein levels consume more feed than birds fed 2650 ME in kcal/kg DM and 19% CP (T_3); and were similar with the rest of the treatments. As expected, the total cost of the feed formulated with the higher energy and protein levels showed a higher price rather the lower price in total cost observed in treatment diets that formulated with the lower energy-protein levels. As a result, the net return also lowers for T_4 and T_5. In Trial III (Table 8) that birds fed different energy-protein levels among the treatments at the age of 24-34weeks showed a non-significant (P > 0.05) change in total and average feed intake, BW changes, total egg production and HDEP. Whereas the egg mass, feed efficiency and EFPR showed a significant (P < 0.05) differences among the treatments and a higher value observed in T_4 for egg mass that was similar with T_1 also while a lower value for T_3 and T_4 similar with T_1.Feed efficiency in birds under the treatment showed a higher value in T_1 and T_4 and similar with T_3 and lower in T_2. The egg to feed price ratio (EFPR) also showed a higher value at T_2 similar with T_1 and T_3 and lower at T_4 that was similar with T_1 and T_3 too. In all the egg quality parameters considered in Trial III were showed a non-significant (P > 0.05) differences among the treatments. Also, no difference (P > 0.05) observed in fertility and hatchability of eggs incubated from hens that fed different levels of energy and protein among treatments. The results of the present study are in agreement to the findings of Murakami., *et al.* [9], Rosa., *et al.* [10], Yung., *et al.* [11] and Wu., *et al.* [12] who reported also a non-significant difference in weight gain, feed consumption and FCR with increasing the protein and energy ratio in commercial breeder pullet diets at growing phase. Similar to the present findings, Anjum and Khan [13] adds a conformation to that the higher energy and protein levels combination didn't bring a difference in feed consumption and growth performance of the Desi Native chickens.

Parameters	Treatments							
	T_1	T_2	T_3	T_4	T_5	T_6	SE	P-value
Number of observations = 18								
Total FI(g/bird)	1390.06	1354.97	1368.53	1437.02	1425.33	1408.63	35.78	NS
Average FI(g/bird)	24.37	23.77	24.01	25.21	25.01	24.71	0.63	NS
Average BW(g/bird)	320.93^{c}	331.60^{bc}	331.10^{bc}	361.16^{ab}	379.81^{a}	383.68^{a}	10.44	**
Body weight change (g/bird)	283.27^{c}	291.44b^{c}	293.95^{bc}	317.74^{ab}	334.92^{a}	337.13^{a}	9.69	**
FE (g total FI/g total BW gained)	0.20	0.21	0.22	0.22	0.24	0.24	0.01	NS
Cumulative Mortality Rate	3.33	3.33	1.00	1.33	0.67	1.67	0.87	NS
Total Cost	10.56^{b}	10.65^{b}	10.65^{b}	11.73^{a}	11.70^{a}	11.27^{a}	0.28	*
Total Return	90.00	90.00	90.00	90.00	90.00	90.00	0.00	NS
Net Return	79.44^{a}	79.35^{a}	79.35^{a}	78.27^{b}	78.30^{b}	78.73^{a}	0.29	*

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

Means within a row with different superscripts are significantly different; **= P < 0.01; 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.

Parameters	Treatments						
	T_1	T_2	T_3	T_4	T_5	SE	P-value
Number of observations = 18							
Total FI (g/bird)	6736.16[ab]	6822.53[ab]	6629.96[b]	6910.54[a]	6779.91[ab]	49.62	*
Average FI (g/bird)	118.18[ab]	119.69[ab]	116.31[b]	121.24[a]	118.95[ab]	0.87	*
Initial BW (g/bird)	267.10	237.50	266.97	313.06	250.34	23.05	NS
Final BW (g/bird)	1098.17	1192.46	1224.34	1107.44	1224.49	50.77	NS
Body weight change (g/bird)	831.07	954.96	957.37	794.38	974.15	58.05	NS
FE (g total BW gained/ g total FI)	0.12	0.14	0.14	0.12	0.14	0.01	NS
Cumulative Mortality Rate	14.33	19.00	15.33	13.00	16.67	1.96	NS
Total Cost	54.32[c]	48.31[b]	47.20[b]	50.45[a]	50.65[a]	0.36	**
Total Return	120.00	120.00	120.00	120.00	120.00	0.00	NS
Net Return	75.68[a]	71.69[b]	72.80[b]	69.55[c]	69.35[c]	0.36	**

Table 7: Least squares means for feed intake and body weight change performances of *Improved Horro* growers (10-22 weeks of age, **Trial II**) in an experiment to optimize the energy and protein levels for the support of growth performance.

Means within a row with different superscripts are significantly different; *: $P < 0.05$; **: $P < 0.01$; 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 minus total cost.

Parameters	Treatments					
	T_1	T_2	T_3	T_4	SE	P-value
Number of observations = 12						
Total FI (g/bird)	6825.70	6942.30	6623.50	6812.60	253.79	NS
Average FI (g/bird)	75.01	76.29	72.79	74.86	2.79	NS
Initial BW (g/bird)	1024.42	1031.55	1065.98	1075.57	52.70	NS
Final BW (g/bird)	1497.90	1384.90	1603.30	1585.80	128.47	NS
Body weight change (g/bird)	473.50	353.30	537.40	510.20	129.38	NS
Total number of eggs produced	188.33	220.00	184.00	172.67	6.94	NS
HDEP	49.93	55.75	55.07	46.71	3.98	NS
Average egg weight (g)	44.35	45.02	44.73	44.70	0.53	NS
Egg mass (g)	8362.00[ab]	9907.70[a]	8168.70[b]	7719.70[b]	359.94	*
Feed efficiency	0.44[a]	0.38[b]	0.43[ab]	0.47[a]	0.02	*
Cumulative Mortality Rate	2.33	1.33	2.33	1.33	0.60	NS
EFPR	13.28[ab]	15.15[a]	13.20[ab]	12.07[b]	0.59	*

Table 8: Feed intake, BW change, and egg laying performances of 24-34wks-old **(Trial II)** Improved Horro ecotype hens fed a ration containing different energy and protein levels in an experiment to determine the optimum energy and protein level for the performance.

Means within a row with different superscripts are significantly different; **: $P < 0.01$; NS: Non-significant; SE: Standard error; BW: Body Weight; EFPR: Egg Feed Price Ratio; FE: Feed Efficiency; FI: Feed Intake; T_1: 2750 ME in kcal/kg DM and 16.5% 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: 2700 ME in kcal/kg DM and 16% CP. Total Cost=feed cost/bird by total feed intake; Total Return= spent hen and egg sale; Net Return= total return minus total cost.

Parameters	Treatments					
	T_1	T_2	T_3	T_4	SE	P-value
Number of observations = 12						
Sampled egg weight (g)	46.74	47.43	47.32	46.61	0.72	NS
Egg length (mm)	58.45	52.48	53.12	50.33	2.53	NS
Egg width (mm)	46.98	42.42	40.83	39.29	3.28	NS
Egg shape index	0.80	0.81	0.76	0.78	0.03	NS
Shell thickness (mm)	0.32	0.35	0.33	0.28	0.02	NS
Shell weight (g)	5.82	6.18	6.05	5.82	0.19	NS
Albumen height (mm)	6.67	7.17	6.44	5.56	0.48	NS
Albumen weight (g)	24.46	25.23	23.88	23.73	1.03	NS
Yolk weight (g)	15.40	16.80	16.38	16.38	0.54	NS
Yolk height (mm)	17.56	17.73	17.89	17.78	0.15	NS
Yolk length (mm)	39.00	37.87	39.50	38.52	0.87	NS
Yolk index	0.45	0.47	0.45	0.46	0.01	NS
Yolk color (RCF)	1.00	1.00	1.00	1.00	0.00	NS

Table 9: Egg quality characteristics of 24-36wk-old (Trial III) Improved Horro ecotype hens fed a ration containing different energy and protein levels in an experiment to determine the optimum energy and protein level for the performance.

T_1: 2750 ME in kcal/kg DM and 16.5% 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: 2700 ME in kcal/kg DM and 16% CP. NS: Non-Significant (P > 0.05); RCF: Roche color fan.

Parameters	Treatments					
	T_1	T_2	T_3	T_4	SE	P-value
Number of observations = 12						
Fertility (%)	94.67	90.67	93.33	88.00	3.46	NS
Hatchability (%)	86.33	95.33	87.00	77.67	4.30	NS

Table 10: Fertility and hatchability of 35-36-wk-old (Trial II) *Improved Horro* ecotype hens fed a ration containing different energy and protein levels in an experiment to determine the optimum energy and protein level for the performance.

T_1: 2750 ME in kcal/kg DM and 16.5% 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: 2700 ME in kcal/kg DM and 16% CP; NS= non-significant.

Conclusions and Applications

The experiment attempted to indicate the right energy–protein combination (s) that lead to a higher response in BW at least cost of production possible. The trial considered a varying level of energy-protein combination; however, the variation in the energy content is much smaller and falls within the range considered as the same. A small gap of the result indicates that the Improved Horro chicken seems to be a layer type rather than the meat because their egg production seems better at the lower level of ME and CP considered. Further investigation of energy-protein optimization warranted to be considered by varying the level of energy to put a clear distinction of the chicken as an egg or meat type.

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