International Journal of Livestock Research, Vol. 12 (7) Jul' 2022
http://www.ijlr.org
eISSN: 2277-1964

Original Research

Effect of Dietary Metabolizable Energy and Crude Protein on the Laying Performance, Egg Quality, Hatchability, and Fertility of DZ-White Chickens

Tewodros Fekadu[1]*, Gebreyohannes Berhane[2], Mammo Mengesha[1], Misba Alewi[1]

[1]Ethiopian Institute of Agricultural Research, Debre Zeit Agricultural Research Center, Bishoftu, ETHIOPIA
[2]Addis Ababa University, College of Veterinary Medicine and Agriculture, Bishoftu, ETHIOPIA

*Corresponding Author: tedisha16@gmail.com

How to cite this paper:
Fekadu, T., Berhane, G., Mengesha, M., & Alewi, M. (2022). Effect of Dietary Metabolizable Energy and Crude Protein on the Laying Performance, Egg Quality, Hatchability, and Fertility of DZ-White Chickens. *International Journal of Livestock Research*, 12(7), 37-47.

Received : May 25, 2022
Accepted : Jul 01, 2022
Published : Jul 31, 2022

Abstract

*An experiment was conducted to evaluate the effect of different levels of metabolizeable energy (ME, kcal/kg) and crude protein (% CP) level on the production performance, egg quality, hatchability, and fertility of the DZ-White chicken breed at Debre-Zeit Agricultural Research Center. A total of 594 twenty weeks age DZ-white chickens were randomly distributed to the nine dietary treatments, with 3*3 factorial arrangements, in a Completely Randomized Design. The experimental diets were formulated containing different levels of dietary protein 14.5, 15.5, or 16.5%, and 2850, 2750, or 2650 kcal/kg of ME respectively. Chemical composition of feed ingredients was analyzed and feed intake, egg production, hatchability, fertility, and egg quality parameters were recorded. The results indicated that dietary treatments with varied levels of ME and CP showed significant (P <0.05) effects on the total and percentage of hen-day egg production. However, no significant (P >0.05) effect was detected among the dietary treatments (CP, ME, and their interaction) on hatchability, fertility, and most egg quality parameters. Based on this study it is certainly suggested to economically fed the DZ-white chickens with a layer diet, containing 15.5% CP and 2750 kcal/kg of ME.*

Keywords: Crude Protein, DZ-White Chickens, Egg Production, Fertility, Hatchability, Metabolizeable Energy

Introduction

Poultry product consumption is recently outstripping the growth of all other animal-source foods in all regions of the world (Michael, 2019). However, average *per capita* poultry meat and egg consumption in Ethiopia is about 0.5 and 0.6 kg, respectively, which is the lowest among others in the world. For example, the *per capita*, in Sub-Saharan Africa is 2.3 kg (Robinson and Pozzi, 2011). Collectively, these all might be due to the use of unimproved chicken breeds and traditional management systems. Pagani and Wossene (2008) also reported that traditional poultry production continues to dominate domestic poultry production in Ethiopia. Most chicken production in the country have been practicing backyard farming, using indigenous breeds (Halima *et al.,* 2007).

Literature indicated that different strategies have been implemented so far to improve the production and productivity of the poultry sector in Ethiopia. Among others, different institutions, such as the Ministry of Agriculture (MOA), Research Institutions, Higher Learning Institutions, and NGOs in Ethiopia have introduced and distributed exotic chicken breeds and fertile eggs to the farmers across the country.

The National Poultry Research Program of the Debre-Zeit Agricultural Research Center (DZARC) has developed a synthetic dual-purpose chicken breed known as the DZ-White feather. A DZ-White feather chicken breed was developed from Lohman silver, Potchefstroom Koekoek, and Rhode Island White (RIW) chicken breeds (Mulugeta *et al.,* 2020). The main purpose of crossing the above different chicken breeds was to develop a strain, the so-called DZ-white feather which is supposed to have better productivity and be able to fit the semi-intensive production system that finally contributes to the improvement of living conditions of Ethiopian smallholder farmers (Mulugeta *et al.,* 2020). However, there are some limitations in formulating diets for this synthetic dual-purpose chicken strain, since its nutrient requirements (dietary crude protein and metabolizeable energy) have not been determined.

Currently, while formulating a diet for this DZ-White chicken strain, the Research Center is using a common formula that is basically used to formulate diets for any commercial-layer chickens, which are completely different from those of these dual-purpose chicken. The fact is that DZ-white chickens are dual purpose and medium-egg-laying strain. Therefore, feeding these breeds with diets that are prepared based on the requirements of commercial layers, may not be economical and cost-effective.

So far, there is no or little information available on the dietary proteins and energy, as nutrient requirement levels for the DZ-white chickens. Therefore, this study was carried out with the objectives of evaluating the effects of different levels of dietary crude protein and energy on the laying performance, egg quality, hatchability, and fertility in DZ-White chickens.

Material And Methods

Description of the Study Area

The experiment was conducted at DZARC which is located about 47 km east of Addis Ababa. It has an altitude of 1920 m a.s.l. and latitude of 8°44’ N and a longitude of 38°38’E. It has a mean annual rainfall of 892 mm and mean temperature of 25°C. The relative humidity ranges from 48% to 68% (DZARC 2017).

Experimental Design and Diets

A Completely Randomized Design (CRD) with 3*3 factorial arrangements was employed in this study. A total of 540, 20 weeks age, DZ-White chickens were randomly distributed to nine experimental diets. Each treatment was replicated four times, having 15 chickens per replicate. This experiment was conducted from 20 weeks of age until the birds reached peak egg production (35 weeks). A layer diet containing different levels of dietary protein (16.5, 15.5, or 14.5% CP) and energy (2850, 2750, or 2650 kcal/kg) were formulated.

Feed ingredients used in the formulation of the experimental rations for this study were maize, wheat middling, soybean meal, Nougseed cake, wheat bran, meat and bone meal, vitamin-mineral premix, salt, limestone, lysine, and methionine. Compositions of feed ingredients used in the experimental diets are described in Table 1.

Table 1: Composition of major nutrients and feed ingredients in layer diets

Ingredients (%)	**Experimental diets**								
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**
Maize	56.5	58.2	59.7	50.75	52	51.25	39.15	44.5	47.5
Nougseed Cake	9	8.5	9	9	8	8.25	9	8.25	8
Wheat Middling	8	8.5	9.5	10.25	10	13	19	15.75	13.5
Soybean Meal	8.5	6.6	5	8	5.15	4.1	7	6	5.25
Wheat bran	6.5	7	7	8	11	13	14	14	14
Meat and Bone Meal	5.55	4.7	3	6	6	3	4.5	4	3
Limestone	4	5	5.3	6.5	6.25	6	6	6	7.25
Salt	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
DL-Methionine	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
DL-Lysine	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Vitamin-mineral premix	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total (~)	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
CP (%)	16.5	15.5	14.5	16.5	15.5	14.5	16.5	15.5	14.5
ME (kcal/kg)	2850	2850	2850	2750	2750	2750	2650	2650	2650

ME = Metabolizeable energy, Kcal = Kilo calorie per kilogram of Dry Matter, CP= Crude protein.

Management of Experimental Birds

The experimental house was prepared and partitioned into 36 pens with enough working space allowances. The house's wall, floor, door, windows, watering and feeding troughs were cleaned, washed and disinfected with savlon and dried before introduction of experimental birds in the house. The chickens were maintained under a partitioned deep litter housing system.

Measured amount of feed was offered twice a day in the morning and in the afternoon with *ad-libitum* water access. To prevent any outbreak of diseases, strict bio-security measurements were maintained. Chickens were vaccinated against Newcastle Disease in every three months.

Laboratory Analysis

Representative samples of the feed ingredients and the treatment diets were taken and subjected to Proximate method of AOAC (2016) to determine dry matter (DM), crude protein (CP), crude fiber (CF), ether extract (EE) and total ash content before the beginning of the experiment at laboratory of Bless Agri food laboratories P.l.c in Addis Ababa, Ethiopia. Besides, Kjeildhal procedure was employed to determine the nitrogen (N) content of each ingredient and the crude protein content was determined by multiplying the N content by 6.25 (Magomya *et al*., 2014). The metabolize energy value was determined according to the method of Wiseman (1987) as follows: ME (Kcal/kg DM) = (3951 + 54.4 EE – 88.7 CF – 40.8 Ash).

Data Collection

The experiment was conducted starting from 20 weeks age until the birds reached peak egg production (35 weeks). The following parameters were recorded for the experiment:

Feed intake and Feed conversion ratio

The feed offered and refused were recorded for each pen. Feed intake was calculated by subtracting amount of feed refused from amount of feed offered.

The feed conversion ratio was calculated by using the following formula:

$$\text{FCR} = \frac{\text{Feed intake (g)}}{\text{egg production (g)}}$$

Egg Production and Sexual Maturity

Egg production was recorded on daily basis starting from age at first egg-lay until to peak egg production. Eggs were collected three times a day from each pen. The sum of these 3 collections along with the numbers of hens were recorded and summarized. Average egg weight was computed by dividing the total egg weight to the number of eggs. Egg mass per bird was calculated as total egg mass divided by the number of birds. Hen-day egg production (HDEP) and hen-housed egg production (HHEP), as percentages were determined following the formula given below (Hunton, 1995).

$$\text{HDEP\% (Hen} - \text{day egg production)} = \frac{\text{Number of eggs collected per day}}{\text{number of hens present at that day}} \text{x } 100$$

$$\text{HHEP\% (Hen} - \text{housed egg production)} = \frac{\text{sum of eggs counted}}{\text{number of hens originaly housed}} \text{ x } 100$$

Average egg mass per hen per day (g) = Percent of HDEP x average egg weight (g)

Age at first egg lay was fixed when at least 5% of the flock in each treatment started laying egg.

Egg Quality Parameters

A total of 108 eggs, 12 per treatment (3 eggs per pen) were randomly selected at one time at early laying stage (25 weeks) and again repeated at peak egg production stage (35 weeks) and then averages were computed for each of the following egg quality parameters.

The external egg quality parameters were assessed in terms of egg weight and egg shape index. After breaking the egg, near to the sharpen end, and carefully separating and dropping the contents, internal egg quality measuring parameters were measured, in terms of shell weight, shell thickness, yolk weight, yolk height and yolk color, albumen weight, albumin height and Haugh Unit (HU). Shell thickness was measured by the digital caliper while removing the internal membranes. While measuring thickness, the average value was taken from blunt, middle, and sharp points of the egg (Aberra, 2010). Height of the thick albumen was measured with the micrometer and the Haugh Unit Score was also calculated using the formula (Haugh, 1937):

HU = 100 log (AH-1.7$EW^{0.37}$+7.6) (Haugh, 1937)
Where, HU = Haugh unit,
AH = observed albumen height (mm) and
EW = weight of egg (g).

The yolk color determined by comparing the color of a properly mixed yolk sample placed on a colorless glass with the color strips of Roche color fan measurement, which consists of 1 to 15 strips ranging from pale to orange-yellow. Shape index was computed using the following formula (Panda, 1996):

Egg shape index = (Width of egg/Length of egg) x100

Average egg weight was determined by weighing eggs collected from 40 birds under each treatment.

Hatchability and fertility

A total of 180 eggs (20 eggs per treatment) were collected from each replicate, for seven consecutive days to determine fertility and hatchability. Temperature and relative humidity of artificial incubator was maintained at 37.6^{o}C and 55 – 60% during the first 18 days and 37.3^{o}C and 55 – 70% during the last 3 days, respectively. On the 10th day of incubation, all eggs were candled and the fertile eggs were counted and transferred to the hatching baskets.

Percentage of fertility was calculated as:

$$\text{Fertility (\%)} = \frac{\text{Number of fertile eggs}}{\text{number of egg set}} \text{ x } 100$$

Upon hatch, each day-old chick was weighed and counted. Hatchability parentage of set eggs per treatment was calculated as follows:

$$\text{Hatchability (\%)} = \frac{\text{Number of eggs hatched}}{\text{number of fertile egg set}} \text{ x } 100$$

Dead chickens were recorded as mortality and expressed as percent of mortality at the end of the experiment.

Partial Budget Analysis

The partial economic analysis was calculated as the difference between the feed costs incurred during the experimental period per bird for birds' sales following the procedures of Miles and Jacob (2000), considering the other costs are similar among the treatments. Net income was assumed to be the difference between the total cost of feeds and total return (sale of birds on a live weight basis). Cost benefit ratio (CBR) was calculated as the ratio of returns over the total feed cost.

Statistical Analysis

Data were statistically analyzed using General Linear Models Procedure of the Statistical Analysis System (SAS, 2008) version 9.1.3 computer software program subjected to the analysis of variance (ANOVA). Significance differences among the treatment means were determined by using Duncan Multiple Range Test (DMRT) as contained in the SAS package (Duncan, 1955). Differences between treatment groups were considered statistically significant at $P < 0.05$.

The model for the data analysis was: $Y_{ij} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ij}$

Where:

Y_{ij} = individual observation,
μ = the overall mean,
α_i = effect of CP level; I = (1,2 and 3),
β_j = effect of ME level; j = (1,2 and 3),
$(\alpha\beta)_{ij}$ = interaction effect between ME and CP; and
ε_{ij} = error component.

Results

In this study, different parameters, such as feed intake, body weight gain, feed conversion ratio, egg production, egg quality, hatchability, fertility and partial budget analysis were evaluated.

Chemical Composition of Experimental Feed Ingredients

The laboratory chemical analysis of the feed ingredients used in this experiment is presented in Table 2.

Table 2: Chemical composition of the feed ingredients

Ingredients (%)	Parameters							
	DM	**CP**	**EE**	**CF**	**ASH**	**Ca**	**P**	**ME (Kcal/kg)**
Maize	89.7	9	4.07	3.54	1.51	0.182	0.3	3325
Nougseed cake	85.76	32	8.03	22.26	5.49	0.26	0.65	2650
Wheat middling	90.2	15.6	0.32	9.2	4.5	0.11	1.15	2515
Soybean meal	91.48	42.29	1.92	3.79	4.42	6.22	0.7	2461
Wheat bran	93.34	15	4.23	43	5.2	0.094	0.92	2200
Meat and Bone meal	95.78	43	15.6	3.54	32.64	7.8	64.2	2750

DM = Dry matter, CP = Crude protein, EE = Ether extract, CF = Crude fiber, Ca = Calcium, P = Phosphorus, ME = Metabolizeable energy kilo calorie per kilogram of Dry Matter.

Egg Production

Effect of differently leveled energy and crude protein on different egg production parameters of DZ-White chickens are presented in Table 3.

Dietary energy and protein had a significant (P <0.05) effect on egg production and HDEP of DZ-White chickens. The highest egg production and % of HDEP was recorded in birds fed a diet with 15.5% CP and 2750 kcal, ME/kg. However, differently leveled proteins, energy and their interactions did not show a significant (P >0.05) effect on AFL, egg mass and % of HHEP of DZ-White chickens.

Table 3: Effects of different levels of CP and ME on egg number/bird, egg-weight (g), age at first egg lay, egg mass and other parameters (20-35 wks)

Factors		Parameters				
CP (%)	**ME (Kcal/kg)**	**EN**	**%HDEP**	**%HHEP**	**EW (g)**	**EM (g)**
14.5		48.02[b]	44.16[b]	33.43	50.07	23.7
15.5		51.43[a]	47.16[a]	36.08	52.52	26.17
16.5		50.67[a]	46.30[a]	35.08	51.81	25.17
	2650	50.72[b]	47.10[b]	35.18	50.97	24.5
	2750	53.43[a]	49.11[a]	36.01	52.5	23.93
	2850	51.77[a]	49.42[a]	36.11	51.92	25.5
P-values:						
CP (%)		0.0472	0.0197	0.3416	0.5583	0.058
ME, kcal/kg		0.031	0.0141	0.0552	0.6306	0.115
CP x ME		0.6187	0.4939	0.1774	0.6091	0.493

[a,b,] means in a column having no common superscripts differ significantly (P <0.05) whereas, within the same column, values with no or same superscripts differ not significantly (P >0.05), EN = amount of eggs/bird until 35 wks age, %HDEP = Percentage of hen-day egg production, %HHEP = Percentage of hen-housed egg production, EW = Egg weight, EM = Egg mass (g/b/d), Kcal = Kilocalorie, Kg = Kilogram, ME = Metabolizeable energy, CP = Crude protein.

Egg Quality Parameters

Data obtained on the different egg quality parameters is shown in Table 4. Variations in protein level between diets didn't show significant (P >0.05) effects on most egg quality parameters (shape index, albumin index and yolk index). A significant (P <0.05) difference was found in egg weight and HU due to dietary energy, but not due to protein or ME and CP interactions. The lower egg weight was found in diet with 2650 kcal/kg of ME however, there were no statistical difference between diets containing 2750 and 2850 kcal/kg of ME. The higher HU was found in diet with 2650 kcal/kg of ME, but statistically similar with diet containing 2750 kcal/kg of ME. The lower HU was found on diets with 2850 kcal/kg of ME.

Table 4: Effects of metabolizeable energy and protein levels on egg quality parameters.

Factors		Parameters							
CP (%)	**ME Kcal/kg)**	**EW (g)**	**AH (mm)**	**AW (g)**	**YW (g)**	**ESI**	**ST (mm)**	**HU**	**YI**
14.5		53.14	6.18	29.24	16.24	77.48	0.30	80.33	0.46
15.5		53.84	6.19	29.64	16.29	78.11	0.31	79.48	0.47
16.5		53.96	6.36	29.65	16.53	77.08	0.31	78.68	0.46
	2650	51.36	6.24	28.01	16.54	77.57	0.31	81.32	0.46
	2750	55.31	6.15	29.78	16.54	77.81	0.31	79.39	0.46
	2850	53.48	6.05	29.74	16.09	77.28	0.30	77.84	0.46
P-values:									

CP	0.720	0.432	0.4576	0.280	0.542	0.283	0.383	0.450
ME	0.066	0.065	0.0554	0.144	0.849	0.572	0.076	0.520
CP x ME	0.838	0.414	0.9490	0.250	0.502	0.508	0.630	0.092

CP = Crude protein, ME = Metabolizeable energy, EW = Egg weight (g), AW = Albumin weight (g), AH = Albumin height (mm, AW = Albumin weight (g), YW = Yolk weight (g), ESI = Egg shape index, EST = Egg shell thickness (mm), HU = Haugh unit, YI = Yolk index, AW = Albumin weight (g), AH = Albumin height (mm), YW = Yolk weight (g), Kcal = Kilocalorie, Kg = kilogram, g = gram, mm = millimeter.

Hatchability and Fertility

There were no significant (P > 0.05) differences observed between treatments in percentage of fertility and hatchability. In the present study, the highest percentage of fertility and hatchability was found in birds fed on diet, with 16.5% CP while the lowest was for 15% CP, however, there was no significant (P > 0.05) difference among the treatments. It was observed that fertility and hatchability generally increased with increasing protein and energy levels in the diet. The average percentages of fertility and hatchability from both fertile eggs and total egg set were 75.5%, 79.56% and 63.75% respectively.

Table 5: Effects of diet, containing graded levels of energy and protein on fertility and hatchability of egg.

Factors		Parameters		
CP (%)	**ME (Kcal/kg)**	**Fertility (%)**	**Hatchability (%) from fertile egg**	**Hatchability (%) from total egg set**
14.5		76.92	78.07	61.83
15.5		77.08	79.74	65.67
16.5		79.83	83.53	66.08
	2650	72.75	79.10	59.92
	2750	74.92	80.37	62.42
	2850	77.17	84.57	65.25
P-values				
CP		0.1146	0.4790	0.1452
ME		0.3964	0.3092	0.0951
CP x ME		0.2784	0.6538	0.1012

ME = Metabolizeable energy, CP = Crude protein, Kcal = Kilo calorie, Kg = Kilogram.

Partial Budget Analysis

The economic returns in terms of partial budget from layers reared under different diet having different levels of ME and CP is presented in Table 6. The results of the partial budget analysis of different diets with varied levels of ME and CP from 20 to 35 weeks of the experimental period are presented in Table 6. During the analysis, it was assumed that the cost of feed and the sale of eggs were the source of costs and profits respectively. The other costs such as purchasing of chickens, labor and transportation costs were considered similar among all treatments. Accordingly, there was a significant (P <0.05) difference among the treatments in economic analysis.

Generally, the highest feed cost per bird was recorded on concentrate diets with higher levels of CP (16.5 %) and ME (2850 kcal/kg) and the lowest feed cost was on low concentrated diets (14.5% CP and 2650 kcal/kg, ME). There was significant (P <0.05) difference in net income (NI) between treatments, and the highest net profit per bird was found in a layer diet with 15.5% CP with 2750 kcal/kg of ME.

Table 6: Partial budget analysis of DZ-White chicken production

Items	Experimental Diets								
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**
Feed cost/Kg	14.67	14.27	13.81	14.06	13.94	13.41	13.72	13.49	12.97

ration (Birr)									
Cumulative feed intake (Kg)	19.2	19.15	19.1	19.89	19.18	19.39	19.38	19.14	19.1
Total feed cost (Birr/Kg)	274.06	268.82	260.71	261.63	263.11	256.21	260.4	252.75	245.01
Egg produced (No./bird)	50.25^{bc}	50.98^{bc}	51.07^{bc}	50.61^{bc}	54.69^{a}	52.33^{a}	48.15^{bc}	49.96^{bc}	49.67^{bc}
Egg price (Birr/egg)	6	6	6	6	6	6	6	6	6
Return from egg sales	301.50	305.88	306.42	303.66	328.14	313.98	294.90	302.76	301.02
NI (Birr)	27.60^{f}	37.50^{de}	44.90^{d}	39.52^{de}	64.98^{a}	57.40^{b}	28.38^{f}	46.83^{d}	52.86^{bc}
CBR	1.10^{d}	1.14^{cd}	1.17^{bc}	1.15^{cd}	1.25^{a}	1.22^{bc}	1.11^{cd}	1.19^{bc}	1.20^{bc}

^{a,b,c,d,e,f,} *Means in a row having no common superscripts differ significantly (P <0.05) whereas, within the same column, values with no or same superscripts differ not significantly (P >0.05). SEM = Pooled standard error of mean. NI = Net income, CBR = Cost benefit ratio, T1-T4 = treatments containing each 2850 kcal/kg, ME with 16.5, 15.5 or 14.5% CP respectively, T4-T6 Treatments containing each 2750 kcal/kg, ME with 16.5, 15.5 or 14.5% CP and T5-T9= Treatments containing each 2650 kcal/kg, ME with 16.5, 15.5, 14.5% CP.*

Discussion

Egg Production

In this study it was observed that egg production per hen and % of HDEP were influenced (P <0.05) by differently leveled experimental diets. These results are in line with the previous findings by Rao *et al.* (2011) and Perez-Bonilla *et al.* (2012) who observed significance (P <0.05) difference in egg production among dietary treatments range from 2350 to 2600 kcal/kg ME in White Leghorn layers and from 2650 to 2850 kcal/kg ME in Brown hens. However, contrary to this finding (Etalem *et al.*, 2019; Zeweil *et al.*, 2011) reported that levels of dietary energy and protein didn't have significant (P >0.05) effects on the total egg production and percentage of HDEP.

From this study the highest egg production and % of HDEP was recorded in birds fed a diet with 15.5% CP and 2750 kcal, ME/kg. In the present study there was no ME and CP interaction effects on egg production of DZ-White chickens, which is in agreement with the previous studies (Byerly *et al.*, 2008 and (Novak *et al.*, 2008) who reported that interaction of CP and ME had no effects on egg production.

Egg Quality Traits

Variation in crude protein and metabolizeable energy levels between diets didn't have a significant (P >0.05) effect on most egg quality parameters. Consistently Novak *et al.* (2008) reported that the internal and external egg quality parameters were not influenced by variations of CP and ME in the diet.

From the present study the HU values of eggs obtained from all experimental diets ranged between 76.61 to 81.66 and then these eggs can be classified as best quality eggs "AA" (72 to100). This classification is based on the United States Department of Agriculture (USDA). Similarly, Oluyemi and Robert (2000) reported also Haugh unit score of 72 and above had been graded as the best quality. The higher the HU, the more desirable is the egg quality (Fayeye *et al.*, 2005). The present result on Haugh unit is in agreement with previous findings (Sehu *et al*, 2005; Ding *et al*., 2016; Junqueira *et al.*, 2006), who reported that the Haugh unit were not affected by dietary ME and CP levels.

Eggshell strength and eggshell thickness are the two important indicators for reflecting eggshell quality. In present study the value of shape index was ranged between 76.22 and 78.87 mm, which indicate the quality of eggs. This study showed that eggshell thickness was not significantly (P >0.05) affected by dietary treatments with varied levels of CP, ME and their interactions, which is consistent with other reports (Sehu *et al.*, 2005; Junqueira *et al.*, 2006; Almeida *et al*., 2012) that shell thickness was not affected by either protein or energy variations in the diet. But contrary to this finding Lofti *et al. (*2018) reported increasing ME and CP level in a diet resulted increment in egg shell thickness and egg shell strength.

Egg shape index, albumin index and yolk index were not significantly (P >0.05) influenced by the dietary treatments (CP, ME and their interaction). The present result on albumin and shape index of eggs disagreed with the previous finding by Lotfi *et al.* (2018) reported that albumin and shape index of eggs were increased with increasing the energy and protein levels in a diet.

The present result on egg weight is contradict with previous finding of Hassan *et al.* (2013) who found higher egg weight on diets with higher levels of ME (2800 kcal, ME/kg).

Hatchability and Fertility

Statistical analysis indicated that there were no significant differences (P >0.05) observed between dietary treatments due to variations in ME, CP and their interaction, on the percentage of fertility and hatchability of eggs. The preset result on fertility and hatchability is consistent with Etalem *et al.* (2019) who reported dietary energy and protein didn't have a significant (P >0.05) effect on fertility and hatchability of eggs. However, contrary to the present finding Marie *et al.* (2009) and Lotfi *et al.* (2018) reported that the high-energy diet fed to hens, had significantly higher egg fertility than those fed with the lower energy levels.

Although there were no significance differences in fertility and hatchability of eggs, linear increases in fertility and hatchability with increase in ME and CP levels was observed. According to Hassan *et al.* (2000) and Kingori *et al.* (2010) fertility and hatchability of eggs are mainly affected by genetic and environmental conditions such as nutrition, breed, egg quality, storage conditions and duration rather than diets. Diet mainly affects the number and size of eggs rather than their composition (Hassan *et al.*, 2000; Kingori *et al.*, 2010).

Partial Budget Analysis

There was a significant (P <0.05) difference among the treatments with different levels of CP and ME in economic analysis. It is observed that as the level of protein and energy in the diets increased, the cost of experimental ration also increased. The result indicated that feeding of the experimental birds on layer diet containing 15.5% CP with 2750 kcal/kg of ME found to have comparatively lower production cost as compared to other diets. There was also significant (P <0.05) difference in net income (NI) among the treatments and the highest net profit per bird was found on a diet with 15.5% CP with 2750 kcal/kg, ME.

Conclusions

The current result revealed that egg production performance of DZ-White chickens was significantly influenced by dietary treatments with differently leveled proteins and energy. Based on this it can be concluded that for better egg production the DZ-White chickens need a layer diet with 15.5% CP and 2750 kcal/kg of ME.

In this study the percentages of hatchability, fertility and most egg quality parameters were not significantly influenced by dietary treatments containing different levels of dietary energy and protein.

Acknowledgments

We express our sincere gratitude to the Ethiopian Institute of Agricultural Research for covering the research cost and poultry research program technical assistants involved in data collection.

Authors would like to highly acknowledge researchers that did a lot and make their papers available online.

Conflict of Interests

There is no conflict of interest. Contribution of Authors During the writing of the manuscript, all of the authors contributed equally. They read the final manuscript and gave it their approval for publishing.

Funding

This project was funded by the Ethiopian Institute of Agricultural Research, Debre Ziet Agricultural Research Center.

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