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Original Research

Effects of Feeding Graded Levels of Dietary Metabolizable Energy and Crude Protein on the Growth Performance of DZ-White Chicken Strain

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Abstract

A feeding trial was conducted to determine an optimum combination of metabolizable energy (ME, kcal/kg) and crude protein (% CP) levels for the DZ-White chicken strain at the Debre-Zeit Agricultural Research Center. The experiment had three phases: starter (0-8), grower (9-14), and pullet (15-19 weeks). The experimental diets were formulated containing different levels of proteins as 19, 18 or 17, 18, 17 or 16, and 17, 16 or 15% CP for starters, growers, and pullets, respectively. Similarly, metabolizable energy was also leveled as 2900, 2750, or 2600 kcal/kg-as feed basis for both starters and growers and 2850, 2750, or 2650 kcal/kg for pullets. A total of 1260 unsexed one-day-old DZ-White chicks were randomly allocated on nine dietary treatments, with 3x3 factorial arrangements, in a Completely Randomized Design (CRD). Chemical compositions of feed ingredients were analyzed and the body weight, feed intake, and feed conversion ratio were recorded. The results indicated that dietary treatments with varied levels of ME and CP showed a significant ($P < 0.05$) effect on the feed intake of chickens at the starter phase, but not at the grower and pullet phases. The growth performance of the chickens was significantly ($P < 0.05$) influenced by dietary proteins and energy in the three experimental phases. The feed conversion ratio and body weight gain were increased in diets containing 19% CP with 2900 kcal/kg of ME in growers and 17% CP with 2750 kcal/kg of ME in pullets. From this study, it can be concluded that for maximum growth and better feed utilization DZ-White chickens need a diet with 19% CP in the starter and 17% CP in grower phases each with 2900 kcal/kg of ME and 17% CP with 2750 kcal/kg of ME in pullet phase.

Keywords: Crude Protein, Feed Intake, Growth, Metabolizable Energy

Introduction

Poultry products consumption is recently outstripping the growth of all other animal-source foods in all regions of the world (Michael, 2017). However, average *per capita* poultry meat and egg consumption in Ethiopia are about 0.5 and 0.6 kg, respectively, which are 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 productions 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 almost across the country.

In parallel to the importation of improved chicken breeds, 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 chicken breeds (DZARC, unpublished). 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 to the semi-intensive production system that finally contributing to the improvement of living conditions of Ethiopian small holder farmers (Mulugeta *et al.*, 2020).

There are some limitations to prepare production package of this breed. One of the contents of this package is specific ration/diet formulation formula which satisfies the minimum nutrient requirements, at least for major nutrients (protein and energy) needs to be determined for these dual-purpose chickens.

Currently, while formulating diet for this DZ-White chicken strain, the Research Center is using a common formula that basically uses to formulate diets for any commercial-layer chickens, which are completely different from these dual-purpose chickens. The fact is that DZ-white chickens are a dual purpose and medium-egg-laying strain. Therefore, feeding these breeds with expensive 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 an optimum combination of dietary proteins and energy, as nutrient requirement levels for dual-purpose chicken breeds, specifically DZ-white chickens. Therefore, this study was carried out with the objectives of determining an optimum and cost-effective combination of dietary crude protein and metabolizeable energy for the newly developed synthetic DZ-White chicken breed.

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 meters above sea level and latitude of 8°44' N and a longitude of 38°38'E. It has a mean annual rainfall of 892 mm and a mean temperature of 25°C). The relative humidity ranges from 48% to 68% (DZARC GIS information).

Experimental Design and Diets

A Completely Randomized Design (CRD) with 3x3 factorial arrangements was employed in this study throughout all experimental phases. A total of 1260 un-sexed DZW day-old chicks were hatched in DZARC and randomly allocated to nine experimental diets. Each treatment was replicated four times, having 35 un-sexed chicks per replicate. Nineteen weeks was the final target while planning to determine the optimal major nutrient (ME and CP) requirements of this study. This trial had three phases, such as starter (0-8), grower (9-14), and pullet (15-19 wks). Whilst trying to satisfy the minimum nutrient requirements, each phase's experimental diets were formulated. Sufficient literature guidance, including NRC (1994) was used at the time of setting the minimum and maximum nutrient levels of these experimental diets. Depending on the age and number of birds, daily required diets were weighed and offered (twice a day) throughout the experimental period.

Feed ingredients that were 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.

There is no cost-effective diet-formulation, so far for the dual-purpose chickens that to being used as a benchmark However, after reviewing related literatures, levels of the test-nutrients (CP and ME) were firstly set-out ranging from 15-19 (%CP) and 2600-2900 (ME, kcal/kg, as feed basis). Accordingly, the starters, growers and pullets experimental diets contained a graded levels of proteins (19, 18 or 17% CP), (18, 17 or 16% CP) and (17, 16 or 15% CP), respectively. Graded levels of ME (2900, 2750 or 2600 kcal/kg, feed basis) were also used in diets of both starters and growers, and the other ME levels, such as 2850, 2750 or 2650 kcal/kg for pullets were also used for pullets too.

Management of Experimental Birds

The chicks were randomly distributed, with an initial BW (mean ± SD) of 39.14 ± 3.30 g to the respective experimental diets. The chicks were properly brooded and reared under a partitioned experimental pen, with a deep litter system. Chicks were vaccinated with Marek's on the 1st day. New Castle Disease (Lasota and HB1) on the 7th, 21st, 49th, and 98th days. Gumboro was given on the 14th and 28th days for Infectious Bursal Disease. Fowl typhoid on the 42nd and 84th days and Fowlpox on the 56th day.

Laboratory Analysis

Representative samples of the feed ingredients and the treatment diets were taken and subjected to the 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. 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 a day-old age until the birds reached nineteen weeks of age. The following parameters were recorded for the experiment:

Feed Intake, Body Weight Gain, and Feed Conversion Ratio

A measured amount of feed was offered twice a day in the morning and in the afternoon with *ad-libitum* water access throughout the experimental period. The feed offered and refused were recorded for each pen. Feed intake was calculated by subtracting the g amount of feed refused from the amount of feed offered.

Initial body weights of the chickens were taken at the beginning of the experiment. The average body weight gain of the birds in each replication was calculated by subtracting the initial body weight from the final body weight at each experimental phase. The feed conversion ratio was calculated as follows:

$$\mathrm{FCR} = \frac{\text{Feed intake (g)}}{\text{Body Weight gain (g)}}$$

Partial Economic 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 the General Linear Models Procedure of the Statistical Analysis System (SAS, 2008) subjected to the analysis of variance (ANOVA). Significance differences among the treatment means were determined by using Duncan Multiple Range Test (DMRT). Differences between treatment groups were considered statistically significant at $P < 0.05$.

The model for the data analysis was: $Yij = \mu + \alpha i + \beta j + (\alpha\beta)ij + \varepsilon ij$

Where:

Yij = individual observation,

μ = the overall mean,

αi = effect of CP level; i=(1,2 and 3),

βj = effect of ME level; j=(1,2 and 3),

$(\alpha\beta)ij$ = interaction effect between ME and CP; and

εij = error component.

Results

In this study, different growth parameters, such as feed intake, body weight gain, feed conversion ratio and partial economic 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 1.

Table 1: Chemical composition of the feed ingredients

Ingredients (%)	Parameters							
	DM	CP	EE	CF	ASH	Ca	P	ME (Kcal/kg)
Maize grain	89.7	9	4.07	3.54	1.51	0.182	0.3	3325
Niger seedcake	85.76	32	8.03	22.26	5.49	0.26	0.65	2650
Wheat middlings	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, TA = Total ash, Ca = Calcium, P = Phosphorus, ME = Metabolizeable energy kilo calorie per kilogram of Dry Matter.

Feed Intake, Body Weight Gain, and Feed Conversion Ratio of DZ-White Chickens in Starter Phase

Mean values for parameters associated with feed intake (kg/b), initial body weight, final body weight at 8 weeks of age (g/b), body weight gain (g/b), and feed conversion ratio of DZ-White chickens in the starter phase are shown in Table 2.

Different levels of dietary protein and energy showed significant ($P < 0.05$) effects on the feed intake of the chickens at starter phase, but the interaction of energy and protein levels didn't show any significant ($P > 0.05$) difference. The DZ-White chickens fed a diet with 19% CP and 2900 kcal/kg-ME showed the highest feed intake as compared to others.

The FCR was significantly ($P < 0.05$) influenced by dietary treatments and the interaction of protein and energy levels. A diet containing 2900 kcal /kg- ME, with 19% CP had better FCR as compared to the diet containing 2600 kcal /kg- ME, with 17 and 18% CP. However, there were no significant ($P > 0.05$) differences in FCR values between diets containing 17 and 18% CP with any ME levels at the starter phase (shown in Table 2).

Table 2: Effects of different levels of CP and ME on the growth performance of DZ-White chickens in the starter phase (0- 8 weeks of age)

Factors	Parameters				
CP (%) ME(Kcal/kg)	**FI (0-8 wks)**	**IBW**	**FBW (At 8 wks)**	**BWG (0-8 wks)**	**FCR (0-8 wks)**
17 2600	1.31[b]	39.25	364.10[de]	324.85[e]	4.09[a]
2750	1.31[b]	42.75	379.93[de]	337.18[de]	3.89[a]
2900	1.34[ab]	35.75	380.07[de]	344.32[de]	3.89[a]
18 2600	1.29[c]	37.00	366.90[e]	329.90[e]	3.91[a]
2750	1.33[ab]	40.00	390.08[d]	350.08[d]	3.80[a]
2900	1.33[ab]	38.50	391.46[d]	352.96[d]	3.77[a]
19 2600	1.32[b]	37.75	407.39[c]	369.64[c]	3.57[b]
2750	1.33[ab]	40.75	442.11[b]	401.36[b]	3.31[c]
2900	1.36[a]	40.50	456.16[a]	415.66[a]	3.27[c]
Pooled SEM	0.0072	8.25	19.74	14.95	0.016
Main effects					
17	1.32[b]	39.25	383.37[b]	344.12[b]	3.84[a]
18	1.31[b]	38.50	390.48[b]	351.98[b]	3.72[b]
19	1.34[a]	39.67	441.89[a]	402.23[a]	3.33[c]
2600	1.30[c]	38.00	384.47[b]	346.47[b]	3.75[a]
2750	1.32[ab]	41.18	415.37[a]	374.19[a]	3.53[b]
2900	1.34[a]	38.25	415.90[a]	377.65[a]	3.51[b]
P-values:					
CP%	0.0379	0.6076	<.0001	<.0001	<.0001
ME, kcal/kg	0.0059	0.0611	<.0001	<.0001	<.0009
CP x ME	0.1181	0.1374	<.0001	<.0001	<.0124

[a,b,c,d,e] 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), SEM = pooled standard error of mean. FI = cumulative feed intake of the birds up to 8 weeks age (kg/b), IBW = Initial body weight (g/b), FBW = Final body weight at 8 weeks age (g/b), BWG = Body weight gain (g/b), FCR = Feed conversion ratio (feed intake per weight gain), b = Bird, Kcal = Kilocalorie.

The effect of varying levels of dietary energy, protein, and their interactions on the final body weight at 8 weeks of age and body weight gain of the birds showed significant (P <0.05) effects among all treatment groups in this phase. A similar trend continued until the end of this experiment, where it was found that higher protein and energy levels had a positive effect on body weight. For birds fed on a diet, containing 19% CP with 2900 kcal, ME/kg achieved the highest BWG, but for birds on diet, with 18% CP and 2600 kcal, ME/kg had the lowest BWG.

Feed Intake, Body Weight Gain, and Feed Conversion Ratio in Grower Phase

Results of feed intake (kg/b), body weight (g/b), body weight gain (g/b), and feed conversion ratio at growers' phase (9 to 14Wks) is presented in Table 3.

Dietary levels of protein, energy and their interactions did not show significant (P > 0.05) effects on the feed intake of DZW chickens at grower phase. Even though there was no significance difference found in feed intake, chickens fed on 16% CP and 2600 kcal, ME/kg showed higher feed intake compared to the others. There was significant (P < 0.05) difference in FCR between birds fed a grower diet during this phase. Accordingly, birds fed on diets, with 17% CP with 2900 kcal /kg ME were significantly (P > 0.05) efficient in feed utilization.

Due to varying levels of dietary energy, protein, and their interactions significant (P < 0.05) difference was observed in the final body weight at 14 weeks and body weight gain of the chickens in the grower phase. Growing chickens (both males and females) fed diets, containing 17% CP with 2900 kcal/kg-ME showed higher body weight at 14 weeks and achieved higher body weight gain than the other level of CP and ME. Birds fed on diets, with 16% CP and 2600 kcal/kg ME showed lower body weight gain. It was observed that the final bodyweight of the birds at 14 weeks of age and body weight gains increased as the levels of energy and protein increased. The average body weight of DZ-White chickens at 14 weeks of age was 1.01 Kg and 0.89 Kg for both males and females respectively.

Table 3: Effects of different levels of CP and ME on the birds' growth (9- 14 weeks) performance

Factors	Parameters				
CP (%) ME (Kcal/kg)	FI (9-14wks)	BWG (9-14wks)	FCR (9-14wks)	FBW (at 14 wks of age) Females	Males
16 2600	2.42	486.33^{bcd}	4.98^{a}	850.43^{c}	883.28^{cd}
2750	2.43	499.21^{bc}	4.87^{a}	879.14^{b}	915.05^{c}
2900	2.45	502.09^{bc}	4.87^{a}	882.16^{b}	988.9^{bc}
17 2600	2.44	486.66^{bcd}	5.01^{a}	853.56^{c}	889.56^{c}
2750	2.39	505.95^{bc}	4.72^{bc}	896.03^{b}	929.65^{c}
2900	2.39	584.39^{a}	4.09^{e}	975.85^{a}	1060.06^{ab}
18 2600	2.42	488.07^{bcd}	4.96^{a}	895.86^{b}	963.68^{bc}
2750	2.38	507.94^{bc}	4.69^{bc}	950.05^{a}	101.15^{b}
2900	2.39	537.97^{b}	4.44^{d}	994.13^{a}	1152.65^{a}
Pooled SEM	0.32	9.99	0.09	8.76	5.30
Main effect					
16	2.43	491.54^{b}	4.94^{a}	871.91^{b}	952.41^{b}
17	2.41	497.33^{b}	4.85^{b}	901.81^{a}	987.09^{b}
18	2.39	504.66^{a}	4.74^{b}	916.55^{a}	1068.49^{a}
2600	2.43	483.35^{b}	5.01^{a}	869.82^{b}	952.51^{b}
2750	2.41	488.03^{b}	4.94^{b}	878.40^{b}	972.29^{b}
2900	2.40	529.15^{a}	4.54^{c}	945.05^{a}	1067.20^{a}
P-values:					
CP%	0.2537	<.0008	<.0012	<.0001	0.0261
ME, kcal/kg	0.5170	<.0001	<.0001	<.0001	0.0001
CP x ME	0.7152	<.0001	<.0001	<.0001	0.0267

^{a,b,c,d,e} 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), SEM = pooled standard error of mean. FI = Feed intake (kg/b), FBW = Final body weight at 14 weeks *age (g/b), BWG = Body weight gain (g/b), FCR = Feed conversion ratio (feed intake per weight gain), b = Bird, Kcal = Kilocalorie.*

Feed Intake, Body Weight Gain, and Feed Conversion Ratio in Pullet Phase

Mean values for FI (kg/b), BWG (g/b), FCR, and Final BW at 19 wks age (g/b) of the dietary treatments are presented in Table 4.

Table 4: Effects of different levels of CP and ME on the growth performance at the pullet phase (15- 19 weeks)

Factors		Parameters			
CP (%)	ME (Kcal/kg)	FI	BWG	FCR	FBW at 19 wks
Main effect					
15		2.70	474.57^{b}	5.62	1349.12^{b}
16		2.71	480.37^{b}	5.59	1383.88^{b}
17		2.72	530.21^{a}	5.42	1446.75^{a}
	2650	2.70	488.91^{b}	5.68^{a}	1358.73^{b}
	2750	2.67	527.67^{a}	5.17^{b}	1406.07^{a}
	2850	2.66	527.81^{a}	5.77^{a}	1414.96^{a}
Pooled SEM		1.91	16.26	0.31	17.51
P-values:					
CP%		0.8938	0.0068	0.4919	0.0003
ME, kcal/kg		0.5061	0.0087	0.0295	0.0262
CP x ME		0.4538	0.0649	0.0567	0.6066

[a,b,c,d,e] 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), SEM = pooled standard error of mean. FI = Feed intake from 15 to 19 weeks (kg/b), FBW = Final body weight at 19 weeks age (g/b), BWG = Body weight gain (g/b), FCR = Feed conversion ratio, b = Bird, Kcal = Kilocalorie.*

The effect of different levels of dietary protein, energy, and their interactions on the feed intake of DZ-White chickens from 15-19 weeks of age did not show a significant (P > 0.05) difference. Even though there was no significant difference among treatments in feed intake of the birds, it was observed that when the energy level in the diet increased the feed intake decreased in grower chickens at 15 to 19 weeks of age. The feed conversion ratio was significantly (P < 0.05) influenced by dietary energy in the diet. However, dietary protein and the interaction of CP and ME didn't affect (P > 0.05) the FCR of chickens in this experimental phase. Birds reared on 2750 kcal ME/kg showed the highest FCR, compared to the other energy levels. The lowest FCR was observed in a diet, containing 2850 kcal /kg-ME.

Dietary energy and protein had significant (P <0.05) effects on the BWG and final body weight of chickens at 19 weeks of age. It was found that birds reared on a diet containing 2850 and 2750 kcal/kg of ME and 17% CP attained the highest body weight compared to the other level diets. However, there were no significant differences in the final body weight at 19 weeks of age and body weight gain of the birds fed diets with 2750 and 2850 kcal/kg of ME. The interaction of dietary energy and protein didn't show a significant (P > 0.05) difference in the BWG, FCR, and final bodyweight of the birds.

Mortality

Varying levels of ME and CP, in the diets, had no significant impact (P > 0.05) on the mortality of birds, over the experimental phases.

Partial Budget Analysis

The results of the partial budget analysis of different diets, with varied levels of ME and CP, are presented in Table 5. During the analysis, it was assumed that the cost of feed and the sale of live birds at the end of the experimental period were the sources of costs and profits respectively. The market price of live birds at the end of the feeding trial was determined by negotiation between seller and buyer and it was estimated that the 2 kg of birds were sold for 360 birrs. Thus, the market price of the bird at the time of the experiment was calculated to be 180 birr/kg. The other costs such as purchasing chicks, labor, and transportation costs were considered as similar among all treatments. Accordingly, there was a significant (P <0.05) difference among the treatments in economic analysis. There was a significant (P <0.05) difference in net income (NI) between treatments, and the highest net profit per bird was found on a diet containing 17% CP and 2750 kcal/kg of ME but statistically similar to a diet containing 17% CP and 2900 kcal/kg of ME.

Discussion

Feed Intake, Body Weight Gain, and Feed Conversion Ratio

In the present study, dietary treatments with varied levels of ME and CP had significant (P <0.05) effects on the feed intake of chickens in a starter phase (0-8wks) but not in grower and pullet phases (9 to 19 weeks). The feed intake was higher among the chickens' receiving diets with higher levels of CP (19 %) and ME (2900 kcal/kg) in the starter phase. This finding disagreed with Etalem *et al.* (2019), who reported that chickens at the age of 10-22 wks consume more feed when supplied a feed with a higher level of ME (3150 kcal/kg) and CP (23% CP) than lower levels (2650 ME in kcal/kg and 19% CP). The present result is inconsistent with the work of Nahashon *et al.* (2007) who reported that ME and CP didn't affect the FI of birds and (Nahashon *et al.*, 2007; Perez -Bonilla *et al.*, 2012) who reported that increasing the ME levels in a diet decreases the FI of the birds.

FCR was significantly (P <0.05) influenced by varying levels of dietary protein, energy, and their interactions in starter and grower experimental phases. Chickens fed diets, with higher protein and energy levels (19% and 17% CP each with 2900 kcal/kg, ME) in starter and grower diets, respectively utilized feed more efficiently than those treatments with lower protein and energy levels. The present result is in agreement with Kumar *et al.* (2009), who reported that chicks fed on diets, with higher protein (22% CP) and energy (2900 kcal/kg ME) were more efficient in feed utilization and with Lotfi *et al.* (2018), who reported that feed efficiency was improved, with increasing dietary concentrations of energy in the diets. However, contrary to this finding, Nsoso *et al.* (2012) reported that FCR was decreased with increasing ME from 2400 to 2700 kcal/kg. The differences in FCR values between the present and previous studies may be due to differences in diets, ages, and management conditions.

Table 5: Partial budget analysis of DZ-White chicken production

Items	Experimental Diets								
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**
Feed cost/Kg ration (birr)									
Starter	15.08	14.68	14.02	14.38	14.27	13.73	14.07	13.79	13.23
Grower	14.78	14.28	13.85	13.96	13.95	13.41	13.80	13.57	12.97
Pullet	14.78	14.28	13.77	13.96	13.96	13.41	13.80	13.57	12.97
Feed consumed (Kg)									
Starter	1.36a	1.33^{ab}	1.34^{ab}	1.33^{ab}	1.33^{ab}	1.31^{b}	1.32^{b}	1.29^{c}	1.33^{ab}
Grower	2.39	2.39	2.45	2.38	2.39	2.45	2.42	2.44	2.42
Pullet	2.73	2.66	2.68	2.74	2.69	2.77	2.86	2.76	2.67
Total feed cost (b/bird)	332.36^{a}	325.71^{b}	317.15^{cd}	320.23^{bc}	320.07^{bc}	311.18^{de}	316.02^{cd}	307.46^{e}	298.49^{f}
Starter	20.55^{a}	19.52^{b}	18.72^{cd}	19.16^{bc}	18.90^{cd}	17.98^{e}	18.53^{d}	17.48^{e}	17.52^{e}
Grower	35.24^{a}	34.14^{ab}	33.89^{b}	33.16^{bc}	33.38^{bc}	32.55^{c}	33.36^{bc}	33.09^{bc}	31.37^{d}
Pullet	40.55^{a}	38.42^{ab}	36.21^{c}	35.77^{c}	37.54^{bc}	37.08^{bc}	39.43^{ab}	37.60^{bc}	34.58^{cd}
LW of pullets at sale**	1.49^{a}	1.41^{bc}	1.35^{d}	1.47^{a}	1.4^{bc}	1.35^{d}	1.39^{bc}	1.35^{d}	1.34^{d}
LW of males at sale*	1.15^{a}	1.06^{b}	0.99^{bc}	1.01^{c}	0.93^{cd}	0.92^{cd}	0.96^{c}	0.89^{cd}	0.88^{cd}
Bird sale (Price/Kg)	180	180	180	180	180	180	180	180	180
Total Return	475.2^{a}	444.6^{b}	421.2^{bc}	446.4^{b}	419.4^{bc}	408.6^{c}	423^{bc}	403.2^{c}	399.6^{c}
NI (Birr)	142.84^{a}	118.89^{bc}	104.05^{cd}	126.17^{ab}	99.33^{d}	97.42^{d}	106.98^{cd}	95.74^{d}	101.11^{cd}
CBR	1.43^{a}	1.37^{b}	1.33^{bc}	1.39^{ab}	1.31^{c}	1.31^{c}	1.34^{bc}	1.31^{c}	1.34^{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 the mean. NI = Net income, CBR = Cost-benefit ratio,* LW * = LW taken at14 wks of age for males and LW** = LW taken at 19 wks of age for females.

It was found that higher proteins and energy levels had a positive effect (P <0.05) on the final BW and BWG of DZ-White chickens in all experimental phases. The lower levels of protein and energy were found inadequate for optimum BWG. Chickens fed a diet containing 19% CP in the starter and 17% CP in grower phases each with a higher level of energy (2900 kcal/kg) and 17% with 2750 kcal/kg of ME in pullets phase gained maximum growth.

In agreement with this finding Tuan *et al.* (2010) reported that increasing dietary CP significantly increases the growth performance of chicks, where BW was closely related to protein contents in the diets and (Hussein *et al.*, 2010; Kumar *et al.*, 2009) reported that diets having higher levels of ME had better effects on BWG than lower levels. However, contrary to this finding other scholar (Novak *et al.*, 2006; Sohail *et al.*, 2003) investigated and reported that increasing the levels of proteins in the diets did not influence the overall BWG and final live weight of chickens.

Sexual Maturity

Even though there was no statistical difference observed in AFL, pullets received a diet containing 16.5% CP with 2850 kcal/kg ME reached to sexual maturity at an earlier age (144 days) than those fed diet containing lower levels of CP (14.5 or 15.5 %) and ME (2650 or 2750 kcal/kg). In the previous study by Harms *et al.* (2000) late point of first egg-lay was observed in diets with lower levels of CP (11 or 14% CP) as compared to the higher levels (17 or

20% CP) in white leghorn chickens.

Conclusion

Based on this study it could be suggested /recommend to economically feed the DZ-White chickens with diets containing 19% CP in the starter, 17% CP in grower phases each with 2900 kcal/kg of ME, and also 17% CP with 2750 kcal/kg of ME in pullet phase.

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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.

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