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Research Article

Growth and Laying Performance of Local Guinea Fowl on Different Dietary Protein and Energy Levels

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Abstract: Constraints to Guinea fowl (*Numida meleagris*) production include poor growth and low laying performance. However, the lack of standard nutritional requirements significantly hinders commercial indigenous Guinea fowl production in Nigeria. This study aimed to determine the proper levels of crude protein (14, 16, and 18%) and metabolizable energy (2.65, 2.75, and 2.85 Mcal/kg) in the diets of native Guinea fowl in Nigeria. The dietary protein (PL) and energy (EL) levels for the fowl were evaluated in a completely randomized 3 (PL) × 3 (EL) factorial design with three replicates of 10 birds each. Thus, 270 birds with 20 weeks of age were allocated randomly to nine dietary treatments (18P:2.65E, 18P:2.75E, 18P:2.85E, 16P:2.65E, 16P:2.75E, 16P:2.85E, 14P:2.65E, 14P:2.75E and 14P:2.85E). The PL × EL interaction affected Guinea fowl's DFI, DWG, and WWG (p<0.05), while WFI and FCR remained unaffected. The 16:2.85E diet increased the DFI of the birds compared to other diets (p<0.05). The DFI of the 18:2.65, 18:2.75, and 16:2.75E Guinea fowls was higher than those of 18:2.85E, 14:2.65E, 14:2.75E, and 14:2.85 birds (p<0.05). The DWG of fowls improved by the 16:2.85E diet compared to other diets, except for the 18P:2.65E and 16P:2.75E diets (p<0.05). The interaction had a significant impact on the EN, EYH, and EM of the Guinea fowl egg while FCR remained unaffected. The 18P:2.85E diet improved the EN and EM of the birds compared to other diets (p<0.05), The 18P:2.85E also improved the FCR for laying except for 14P:2.85E and 18P:2.75E. The 18P:2.85E diet influenced the YW of the birds compared to other diets (p<0.05), whereas the EW of fowls improved by the 16:2.85E diet compared to other diets except for the 16P:2.65E diet (p<0.05). In conclusion, feeding guinea fowls with a diet comprising 18% protein and 2.85 Mcal/kg metabolizable energy significantly improved egg production and quality.

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1. Introduction

As a major source of protein, the poultry sector is vital to the world's food production (Oghenero et al., 2021). The native guinea fowl (*Numida meleagris*) is a valuable alternative for poultry farming (Baruwa and Sofoluwe, 2016; Shoyombo et al., 2021; Alabi et al., 2023) due to their gamey nature, meat and egg production. However, increasing their productivity demands understanding the connection between dietary nutrients and vital economic indicators like growth, egg production, and egg quality (Ebegbulem, 2018; Yakubu et al., 2022). Thorough management of diet is crucial for successful poultry production. Growth, reproductive efficiency, and product quality can be improved by tweaking the energy and dietary protein levels of poultry feeds based on specific requirements. However, there is no nutritional requirement standard for the native Guinea fowl in Nigeria (Mohammed and Dei, 2017; Rafiu et al., 2021).

Nutritional requirement studies have advanced greatly in relevance, therefore, the current study carefully deployed three energy and three dietary protein levels in a factorial design. The objective of the approach is to examine the effects of these factors, independently and in combination, on growth, egg production, and egg quality. Growth performance impacts meat production, while production and quality of eggs serve as essential aspects of poultry products (Ismoyowati et al., 2022). However, the local guinea fowl hens low laying on the range, and their ability to lay for long periods is dependent on the weather conditions; in harsh weather, they tend not to lay but only occasionally (Alli et al., 2016; Yakubu et al., 2019). Hence, by evaluating the effect of dietary protein and energy on the growth and egg-laying performance of the indigenous guinea fowl, this study's findings could contribute to setting a framework for developing nutritional standards and feed formulations that can improve the indigenous guinea fowl laying capability.

2. Material and Methods

2.1. Experimental design and bird management

The Landmark University Ethics Committee approved the research protocols and experimental birds in this work vide number LUAC/2021/0018A. The research was carried out at the Guinea Fowl Improvement Centre of the Teaching and Research Farm of Landmark University. Two hundred and seventy native Guinea fowls were selected from the grower flock at 20 weeks of age and then were allocated in a completely randomized 3 (protein levels, PL) × 3 (energy levels, EL) factorial design to nine dietary treatments (18P:2.65E, 18P:2.75E, 18P:2.85E, 16P:2.65E, 16P:2.75E, 16P:2.85E, 14P:2.65E, 14P:2.75E and 14P:2.85E) with three replicates of 10 birds each. Birds in each of the replicate pens were homogeneous in terms of live weight (LW) and egg production.

In this study, nine experimental diets (Table 1) were formulated using locally purchased ingredients to contain varying PL and EL. Three PLs (18, 16, and 14% crude protein, CP) were formulated, and three ELs (2.65, 2.75, and 2.85 Mcal/kg) in metabolizable energy (ME) were altered in the high, medium, and low CP diets. Thus, three levels of the energy content of each 18, 16, and 14% CP diet were created by replacing energy sources with protein sources in the layer diet. The Guinea fowls were fed with one of these diets in mash form (20–52 weeks) with ad libitum access to feed and fresh water. The fowls were reared in floor pens (1 × 2.5 m^2) with wood shavings and a lighting program with a minimum light intensity of 1-2 Lux for at least 12 hours, depending on the daily photoperiod, under controlled environmental conditions. The indoor temperature was set at 28°C with a relative humidity of 55% throughout the experiment. In addition, each of the indoor pens was equipped with a perch, individual nests (30 × 45 × 60 cm, 1 nest/5 hens), a drinker, and a red circular poultry feeder plate.

2.3. Data collection

The proximate composition (the percentages of dry matter [DM], ash, ether extract [EE], and crude fiber [CF]) of all diets was determined according to the standard method (AOAC, 2012). These analyses were performed at the Project Research Laboratory I, the College of Agricultural Sciences, Landmark University.

The LW of Guinea fowls was measured using the Ohaus (model PA512) digital sensitive weighing balance at placement and weekly during the experimental period. The daily (DWG) and weekly (WWG) weight gain for each treatment were calculated from these measurements. Feed intake (FI) and egg yield and weights were recorded daily per replicate pen using the Ohaus (model PA512) digital sensitive balance to two decimal places. Egg-laying number (EN) and weight (EW), egg yield per hen (EYH, mm) and week (EYW, mm), egg mass (laying rate × egg weight), daily (DFI) and weakly (WFI) FIs (total FI/number of days or weeks of the trial period) and feed conversion ratio (FCR, g feed: g egg mass) were calculated. Of the eggs produced during the last three days of each 7-day interval, 64 randomly selected eggs (4 from each replicate) were used to determine some egg quality parameters (reference should be given), such as egg weight (EW), egg height (EH), egg width (EWd), yolk height (YH), yolk diameter (YD), yolk weight (YW), shell thickness (ST), egg index (EI, [(egg width/egg height) × 100]): yolk index (YI, [(yolk width/yolk height) × 100]) (Musundire et al., 2017).

2.2. Statistical analysis

All data were subject to two-way analysis of variance using GenStat (2013) statistical package to analyze the effect of dietary PL and EL and their interaction (PL × EL) on growth performance and egg production indices. Differences in mean values were determined using Duncan's multiple comparison test, with a difference level of $p<0.05$ considered. All data in this study are expressed as mean ± SEM.

3. Results

Table 1 presents the composition of the diet formulated for the experiment using the 3 levels of energy and protein. The calculated nutrients are given for ME, CP, Ca, and Available P for all the diets. The analyzed nutrient composition of the diets was not significantly different ($p<0.05$). However, the ash content in interaction 16P:2.65E (5.07) was highest followed by 14P:2.65E (5.00). Interaction 18P:2.75E has the highest moisture content of 10.50% while interaction 16P:2.85E.

Table 1. Ingredients and nutrient composition of the experimental diets (as fed, %)

	Diet								
Ingredient	**18P:2.65E**	**18P:2.75E**	**18P:2.85E**	**16P:2.65E**	**16P:2.75E**	**16P:2.85E**	**14P:2.65E**	**14P:2.75E**	**14P:2.85E**
Maize	50.00	55.00	61.50	52.00	55.00	65.50	49.00	56.00	65.50
SBM, 44 CP %	18.00	18.00	28.50	12.00	13.00	14.50	10.00	11.00	17.00
Groundnut cake	11.00	12.00	0.00	9.00	11.00	10.00	8.00	8.00	0.50
Corn bran	7.00	5.00	0.00	9.00	11.00	0.00	19.00	14.00	7.00
Wheat offal	4.00	0.00	0.00	6.00	0.00	0.00	4.00	1.00	0.00
Bone meal	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05
Limestone	5.80	5.80	5.80	5.80	5.80	5.80	5.80	5.80	5.80
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
L-Lysine	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Methionine DL	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Layer premix[1]	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Choline chloride	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Nutrizyme[2]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Vitamin E	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Calculated nutrient composition									
ME (Mcal kg^{-1})	2.65	2.75	2.85	2.65	2.75	2.85	2.65	2.75	2.85
CP (%)	18.00	18.00	18.00	16.00	16.00	16.00	14.00	14.00	14.00
Ca	3.163	3.155	3.14	3.16	3.159	3.133	3.173	3.159	3.138
Available P	0.933	0.900	0.895	0.933	0.882	0.882	0.901	0.876	0.861
Analyzed nutrient composition (%)									
Moisture	9.83	10.50	10.33	10.17	9.00	8.83	9.00	8.83	10.00
Ash	4.67	4.67	4.87	5.07	4.13	4.00	5.00	4.87	4.93
Crude protein	17.89	17.94	17.89	15.95	15.98	15.96	13.97	13.93	13.95
Ether extract	13.00	13.67	14.00	14.33	14.17	13.33	13.17	13.83	14.50
Crude fiber	4.37	3.10	3.39	4.22	4.00	4.17	4.06	4.41	4.38
N-free extract	50.24	50.13	49.55	50.26	52.72	53.70	50.24	50.13	52.24

[1]Vitamins [A, D3, E, K, pantothenate (B5), pyridoxine (B6), B12, niacin, biotin, and choline], Minerals [calcium, arsenic, magnesium, potassium, copper, iodine, iron, manganese, molybdenum, selenium, and zinc].
[2]Nutrizyme enzyme cocktail: Cellulase, Xylanase, β-glucanase, Mannanase, Protease, Alpha-amylase.

Table 2 presents the impact of dietary PL, EL, and the interaction between them on the growth performance of native Guinea fowls. The DFI, DWG, and WWG of Guinea fowl were affected by the interaction between these factors, while WFI and FCR remained unaffected. The 16P:2.85E diet increased the DFI of the birds compared to other diets (p<0.05). The DFI of Guinea fowls fed on the 18P:2.65E, 18P:2.75E, and 16P:2.75E diets was higher than those of birds fed on the 18P:2.85E, 14P:2.65E, 14P:2.75E, and 14P:2.85 diets (p<0.05). The DWG of fowls improved by the 16:2.85E diet compared to other diets, except for the 18P:2.65E and 16P:2.75E diets (p<0.05). The 18P:2.85E and 16P:2.65E birds had a lower DWG compared with other Guinea fowls, except for 14P:2.85E (p<0.05).

Table 2. Growth performance of local Guinea fowl fed diets with different protein and energy levels

Factor	Parameter				
	DFI (g)	**WFI (g)**	**DWG (g)**	**WWG (g)**	**FCR (g feed: g live weight)**
Protein level (PL, %CP)					
18	11.36	79.54	1.88	13.17	6.12
16	11.78	74.98	1.98	13.83	6.18
14	10.46	73.24	1.91	13.35	5.54
Energy level (EL, Mcal ME kg^{-1})					
2.85	11.28	72.95	1.94	13.55	5.97
2.75	11.11	77.75	1.96	13.69	5.70
2.65	11.21	77.05	1.87	13.11	6.17
PL × EL interaction					
18:2.65E	11.65	81.57	2.08	14.52	5.62
18:2.75E	11.70	81.87	1.97	13.78	5.97
18:2.85E	10.74	75.18	1.60	11.19	6.77
16:2.65E	11.18	73.89	1.58	11.04	7.32
16:2.75E	11.41	79.85	2.00	14.01	5.70
16:2.85E	12.75	71.19	2.35	16.43	5.51
14:2.65E	10.81	75.70	1.97	13.75	5.56
14:2.75E	10.22	71.53	1.90	13.26	5.42
14:2.85E	10.36	72.49	1.86	13.04	5.64
SEM	0.62	1.79	0.11	0.78	0.60
Main effect of					
PL	*	Ns	**	Ns	Ns
EL	*	Ns	*	Ns	Ns
PL × ML	**	Ns	***	**	Ns

DFI: average daily feed intake, WFI: average weekly feed intake, DWG: average daily weight gain, WWG: average weekly weight gain, FCR: feed conversion ratio, SEM: standard error of the mean.

[a,b,c] Means within a row with different superscripts are significantly different at p<0.05. ns: non-significant (p>0.05), *: p<0.05, **: p<0.01, ***: p<0.001.

Table 3 presents the effect of dietary PL, EL, and their interaction on the laying performance of native Guinea fowls. The EN, EYH, and EM of Guinea fowl were affected by the interaction between these factors, while FCR remained unaffected. The 18P:2.85E diet increased the EN of the birds compared to other diets (p<0.05). The EN of Guinea fowls fed on the 18P:2.65E and 18P:2.75E diets was higher than those of birds fed on the 16P6:2.85E, 16P:2.65E, 1P:2.75E, and 14P:2.65, 14P:2.75E, diets (p<0.05). The EM of fowls improved by the 18:2.85E diet compared to other diets, except for the 18P:2.75E, 18P:2.65E and 14P:2.75E diets (p<0.05). The birds on 14P:2.75E had a lower EM than other Guinea fowls (p<0.05). The FCR for laying was better in diet 18P:2.85E compared to other diets except for 14P:2.85E and 18P:2.75E, however, it was much in diet 14P:2.75E (p<0.05).

Table 4 shows the impact of dietary PL, EL, and the interaction between them on some egg quality traits of native Guinea fowls. The YD and YW of Guinea fowl eggs were affected by the interaction between these factors, while EI and YI remained unaffected. The 18P:2.85E diet influenced the YW of the birds compared to other diets (p<0.05). The YD of Guinea fowls fed on the 16P:2.65E, 16:2.85E, and 16P:2.75E diets was higher than those of birds fed on other diets (p<0.05). The EW of fowls improved by the 16:2.85E diet compared to other diets, except for the 16P:2.65E diet (p<0.05).

Table 3. Laying performance of local guinea fowl fed diets with different protein and energy levels

Factor	Parameter				
	EN	EYH	EM (g)	FCR (g feed: g EM)	LR (%)
Protein level (PL, %CP)					
18	165.70	26.10	831	3.31	54.60
16	65.90	11.10	603	3.97	45.20
14	61.40	9.60	562	3.94	41.10
Energy level (EL, Mcal ME kg^{-1})					
2.85	114.60	17.30	767	3.00	78.90
2.75	92.10	15.40	600	4.25	31.40
2.65	86.30	14.10	629	3.98	30.60
PL × ML interaction					
18:2.65E	138.70^{b}	23.10^{ab}	701^{ab}	3.64	66.00
18:2.75E	163.00^{ab}	27.20^{a}	829^{a}	2.98	77.60
18:2.85E	195.30^{a}	27.90^{a}	964^{a}	2.37	93.00
16:2.65E	72.00^{bc}	12.10^{b}	597^{b}	4.26	34.30
16:2.75E	77.00^{bc}	12.30^{b}	643^{ab}	3.76	36.70
16:2.85E	48.70^{c}	9.00^{bc}	569^{b}	4.73	23.20
14:2.65E	48.30^{c}	7.20^{c}	590^{b}	3.93	23.00
14:2.75E	36.30^{c}	6.70^{c}	326^{c}	5.18	21.30
14:2.85E	99.70^{bc}	15.00^{b}	769^{ab}	2.84	47.50
SEM	17.58	3.07	91.30	0.47	8.16
Main effect of					
PL	*	**	*	Ns	*
EL	*	*	*	Ns	*
PL × ML	**	***	**	**	***

EN: egg number, EYH: average egg yield per hen, TEW: total egg weight, EM: egg mass, LR: laying rate, SEM: standard error of the mean.
[a,b,c] Means within a row with different superscripts are significantly different at p<0.05. *: p<0.05, **: p<0.01, ***: p<0.001.

Table 4. Some egg quality traits of local guinea fowl fed diets with different protein and energy levels

Factor	Egg quality trait								
	EW	EH	EWd	YH	YD	YW	ST	EI	YI
Protein level (PL, %CP)									
18	36.77	46.83	36.33	1.39	34.06	16.72	0.30	0.78	0.04
16	41.16	51.03	41.56	1.17	41.85	16.24	0.31	0.82	0.03
14	34.80	46.46	37.60	1.21	36.72	13.10	0.29	0.81	0.03
Energy level (EL, Mcal ME kg^{-1})									
2.85	38.30	49.80	41.62	1.26	38.25	14.58	0.29	0.84	0.03
2.75	36.05	46.16	36.55	1.27	38.37	14.75	0.37	0.79	0.03
2.65	38.38	48.36	37.32	1.25	36.01	16.73	0.24	0.77	0.04
PL × ML interaction									
18:2.65E	36.28^{b}	46.44^{bc}	35.93^{c}	1.28^{bc}	27.30^{c}	18.19^{a}	0.29^{b}	0.77^{c}	0.05^{a}
18:2.75E	34.20^{c}	46.03^{bc}	36.03^{c}	1.53^{a}	37.44^{bc}	15.89^{b}	0.34^{ab}	0.78^{b}	0.04^{b}
18:2.85E	39.83^{ab}	48.02^{b}	37.04^{bc}	1.37^{b}	37.45^{bc}	16.07^{b}	0.28^{b}	0.77^{c}	0.04^{b}
16:2.65E	45.38^{a}	52.12^{ab}	39.82^{b}	1.37^{b}	43.53^{a}	19.11^{a}	0.23^{c}	0.77^{c}	0.03^{a}
16:2.75E	37.92^{b}	46.58^{bc}	37.26^{bc}	0.95^{c}	40.88^{b}	14.36^{bc}	0.33^{bc}	0.80^{ab}	0.02^{b}
16:2.85E	40.18^{ab}	54.39^{a}	47.60^{a}	1.20^{bc}	41.14^{b}	15.26^{b}	0.36^{bc}	0.88^{a}	0.03^{a}
14:2.65E	33.47^{c}	46.52^{bc}	36.22^{c}	1.10^{c}	37.21^{bc}	12.89^{c}	0.21^{c}	0.78^{b}	0.03^{a}
14:2.75E	36.04^{b}	45.88^{c}	36.37^{c}	1.33^{b}	36.79^{bc}	14.00^{bc}	0.45^{a}	0.79^{b}	0.04^{b}
14:2.85E	34.89^{c}	46.99^{bc}	40.23^{ab}	1.20^{bc}	36.17^{bc}	12.40^{c}	0.23^{c}	0.86^{ab}	0.03^{a}
SEM	2.07	1.82	1.44	0.08	1.57	1.40	0.09	0.04	0.003
Main effect of									
PL	*	**	**	Ns	*	**	Ns	*	Ns
EL	*	*	*	Ns	**	**	Ns	*	Ns
PL × ML	**	***	**	Ns	**	**	Ns	*	Ns

EW: egg weight, EH: egg height, EWd: egg width, YH: yolk height, YD: yolk diameter, YW: yolk weight), ST: shell thickness, EI: egg index YI: yolk index, SEM: standard error of the mean.
[a,b,c] Means within a row with different superscripts are significantly different at p<0.05. *: p<0.05, **: p<0.01, ***: p<0.001.

4. Discussion

Guinea fowl though a domesticated game bird (Alabi et al., 2023), also experience significant dietary changes as they move into the egg-laying phase. A greater requirement marks this change for dietary protein to sustain the development of egg-laying cells and improve egg production and quality. Heo et al. (2023) noted that a sufficient provision of dietary protein is crucial to attaining better growth rates and egg production in poultry. As in the present study, when PL decreased from 18% to 14%, the DFI and DWG reduced without affecting FCR. However, FCR improves as protein levels decline due to more effective feed utilization at lower PLs. This case shows that not only PL but also EL of the diet plays an important role. Indeed, in the current study, the PL × EL interaction effect on the parameters examined was significant. Based on our results, providing the optimum energy levels in Guinea Fowl diets is vital because low dietary energy may result in the utilization of dietary protein for energy rather than protein synthesis as noted by Musigwa et al. (2021).

Our results indicate that dietary manipulations critically affected egg yield and quality traits during the early stages of the egg production cycle. Oke et al. (2020) reported that increasing dietary protein from 16% to 18% considerably enhanced egg production, as found herein. However, the results on the laying performance concluded that the PL or EL of the diet at the onset of egg production is not the only factor determining laying hen performance (Bryden et al., 2021). On the other hand, if the EL of the diet was a limiting factor for optimizing egg weight, then one should expect to observe a beneficial effect on egg weight due to increasing the EL of the diet (Mikulski et al., 2020). As known, laying hens have retained the ability to adjust feed intake to dietary energy, and a decrease in dietary energy content leads to increased feed intake. This acceptance may alter the differences in environmental conditions, diet composition, energy-to-protein ratio, egg production, hens' genotype, and age (Mikulski et al., 2020; Bryden et al., 2021). This information may explain the effect of the PL × EL interaction on egg yield and quality.

Our study showed that FCR was better at EL of 2.65 Mcal kg^{-1}, indicating a reduced efficient feed conversion as energy increased. The interaction effects of the PL × EL highlight their collective effect on growth parameters. The highest ADG was observed at 18% PL in combination with EL of 2.85 Mcal kg^{-1} and 2.75 Mcal kg^{-1}, showing weight gains of 81.87 g and 81.57 g respectively. However, at 2.65 Mcal kg^{-1} energy level at the same 18% protein inclusion showed a significantly reduced growth rate. At 16% inclusion, the responses were mixed but in particular, the interaction with 2.85 Mcal kg^{-1} energy showed a significant rise in growth rates. The growth rates observed across different ELs at 14% protein content were generally low. The FCR plays a pivotal role in laying performance, however, the best FCR recorded was 5.42 evidence that nutrient requirements during egg-laying, heat generation, and biological processes significantly impact FCR, further emphasizing the intricacy of dietary administration for the native guinea fowl in the egg-laying phase. A study by Kleyn et al., (2022) found that diets with higher CP content may require more energy consumption, depending on the energy system employed for formulation. Interestingly, the study also revealed that reducing energy levels per dietary protein composition may not provide any significant benefits.

In this study, the impact of varying PL and ELs, in the diet of the native guinea fowl was examined on some egg quality parameters. For the egg weight (EW) being the basis of a good egg, the PLs at 18% and 16% showed positive effects resulting in heavier eggs compared to the 14% level. This finding agrees with the submission of Heo et al. (2023) that higher protein diets enhance egg weight in poultry species. The EW in our study was higher than those of other studies on native guinea fowls (Veckic et al.,2018; Mohsenpour et al., 2020; Zeleke et al., 2020). However, it differed from the reported 53.63 g by (Gwaza and Elkana, 2017). The difference may be due to the interplay of genetic factors as they worked on the improved French-dual purpose breed and environmental factors that impact egg weight. These reports suggest that dietary intervention could directly impact egg weight and the prevailing ecological factor in the region. Yolk Quality (YH, YD, YW): Remarkably, the medial PL (16%) appears to give a balance, producing optimum yolk height, diameter, and weight. It could suggest an optimal protein threshold where further increases might not significantly enhance these yolk parameters (Kazemi et al., 2022). The interaction effect was significant in yolk height at 18: 26E, however, the results were to some extent lower than those reported by Mohsenpour (2020) and Vekic et al. (2018). This may imply that even though there is an apparent effect, it possibly may not be as obvious as observed in the aforementioned studies. The yolk height is a vital variable determining the nutritive content of the egg (Da Nóbrega et al., 2022) and the observed values highlight the complex interaction between dietary effects and environmental factors. Yolk weight as the source of essential nutrients was impacted by the dietary interaction, with the 16:2.6E (19.11 g) and 18E:2.6E (18.19 g) interactions showing higher values than the 12.74 g and 11.00 g recorded by Mohsenpour et al. (2020) and Zeleke et al. (2020), This underlines the implication of energy content in the diet in enhancing yolk weight (Kazemi et al., 2022) and, in addition, the nutritional value of the egg. The 16: 26E interaction showed a higher yolk diameter of 43.53 mm, which was significant to other interactions. It could be linked with the higher protein level, signifying a possible path for definite dietary interventions to stimulate specific egg features (Karakolev et al., 2022). The eggshell thickness regulates the quality of the egg in terms of breakage, storage, and protection against bacterial infection (Kocetkovs et al., 2022), and in this study, at a higher energy level (2.85 Mcal kg^{-1}), the shell appears to be thicker, emphasizing the importance of energy intake in shell formation. This finding points to the potential role of energy supplementation in bolstering shell strength, and consequently, egg quality. However, the interaction effect on shell thickness was significant across all diets, with the highest value of 0.45mm recorded in 14: 27E. It was, however, lower than the 0.49mm reported by Veckic et al. (2018). It demonstrates that the level of inclusion did not show an apparent effect on shell thickness. Therefore, understanding the intricacies of shell thickness is central to enhancing egg value and can form a basis for future approaches in native guinea fowl nutrition. The protein and energy levels interaction is such that it affected both egg and yolk indices, indicative of a likelihood for more even and better eggs. This intricate relationship emphasizes the complexity of factors affecting egg shape. The Indigenous Guinea fowl egg-laying cycle may have been significantly impacted by factors such as growth rate, weather conditions, and human activities that affect wild animals, as reported by Soara et al. (2020) and Portillo-Salgado et al. (2022). These findings align with the current study observation that a correlation exists between egg count and diet given. Increased egg production metrics were observed at a higher protein level of 18% compared to 14% CP. with egg number, average egg/hen, total egg weight, and average egg/week all showing a pattern of improvement. Similarly, an energy level of 2.85 Mcal kg^{-1} slightly correlates with increased egg production indices compared to 2.65 Mcal kg^{-1}. It validates other research that demonstrates the effect of energy in supporting reproductive performance in poultry (Kazemi et al., 2022). The interaction effects reveal mixed effects on egg production metrics, with some showing synergistic effects that improve egg production indices against projections from individual effects. For example, the combination of 18% CP with medium energy at 2.75 Mcal kg^{-1} shows better egg production indices when compared to other interactions. It indicates the importance of understanding the interplay between protein and energy to optimize egg production in the indigenous guinea fowl. More importantly, it is worthy of note that, in the current study, the birds entered into lay at the peak of the dry season in January to buttress the fact that nutrition and management systems were factors that can affect the bird's performance and egg production, this is consonant with the report of Wasti and Mishra (2020), who observed that environmental conditions could seriously influence egg production. Consequently, careful consideration of the nutritional requirements of the birds is vital, coupled with good management practices to enhance egg production in different seasons.

Conclusion

The outcomes of this study highlight the importance of species-specific dietary considerations for indigenous Guinea fowl, mainly in enhancing egg production and quality. Based on the results obtained, a feed comprising 18% crude protein (CP) and 2.85 Mcal kg^{-1} is recommended, as it was found to significantly improve laying capacity. However, it is important to stress the need for more research to corroborate these findings across seasons (rainy and dry seasons) and to address limitations in the current study.

Ethical Statement

Ethical approval for this study was obtained from the Landmark University Ethics Committee vide number LUAC/2021/0018A.

Conflict of Interest

The Authors declare that there are no conflicts of interest.

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Cyril Abang: Investigation, Formal analysis, Data curation;

Arije Olaniyi Damilare: Investigation, Methodology, Formal analysis, Data gathering

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