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Original Article

Effect of dietary crude protein variations on growth performance, carcass characteristics and organ weights of pigeon squabs

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Abstract

Pigeon farming could alleviate Nigeria's animal protein shortages, but the influence of feed quality on pigeon, particularly dietary crude protein, is largely undefined or limited. A feeding trial was conducted to evaluate the effects of different dietary protein levels on the performance, carcass characteristics, and organ weights of pigeon squabs, aimed at establishing an optimal dietary crude protein requirement for pigeons. Five nearly isocaloric diets (ME: 2864 - 2871 Kcal/kg) containing 12, 14, 16, 18, and 20% CP were formulated and fed to pigeon squabs in a completely randomized experimental design (CRD), replicated three (3) times with four (4) birds per replicate. The results showed significant ($p<0.05$) impacts of dietary crude protein levels on live-weight, weight gain, and feed conversion ratio, with the 16% CP diet showing superior performance. Carcass characteristics were not significantly affected ($p>0.05$) by varying crude protein levels, but the 16% CP diet showed numerically higher live-weight than others. Dietary treatments did not affect relative organ weights except for the spleen and pancreas. The study revealed that 16% is the dietary crude protein level that yielded optimal performance in key growth indicators of pigeon squabs.

INTRODUCTION

With the global population projected to reach a staggering 10 billion by the year 2050, the pressing challenge of ensuring a sustainable and adequate supply of animal protein becomes paramount (Searchinger *et al*., 2018). Pigeon (*Columba livia*) emerges as a potential contributor to meeting this demand, yet it remains an underexplored resource, particularly in the context of animal husbandry Pigeons possess several attributes that make them ideal as an animal protein source. Their adaptability, ease of management, rapid growth, and high protein content could make them attractive to farmers. Despite these attributes, pigeons have been overlooked among other poultry species, especially in Sub-Saharan Africa,

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including Nigeria.

The nutritional needs of pigeons remain inadequately defined, leading to a significant gap in the understanding of their dietary requirements. In the quest to optimize pigeon production, it is crucial to address the limited knowledge on pigeon nutrition and unlock the species' potential as a valuable protein source. As traditional animal protein sources face challenges such as resource scarcity and environmental concerns, embracing the utilization of pigeon meat could offer a more sustainable alternative.

Dietary crude protein plays a pivotal role in the growth, development, and physiological well-being of livestock and poultry. However, the optimal level of dietary crude protein for pigeon squabs remains a subject of investigation (Sales and Janssens, 2003), with limited comprehensive studies addressing its impact on growth performance, and various carcass characteristic and organ parameters. It is important to grasp how the levels of protein in pigeon diets affect these important factors. This understanding is key to creating affordable and healthy diets that can help the pigeon farming to thrive. The dearth of information on pigeon nutrition and its potential contribution to animal protein supply necessitates comprehensive research.

In the specific context of Nigeria and Sub-Saharan Africa, where pigeon farming has not received adequate attention, this research becomes particularly relevant. Investigating the nutritional requirements of pigeons and determining the optimal protein levels for their growth and development can catalyze the inclusion of pigeons in mainstream poultry farming practices. This shift has the potential to enhance the resilience of local food systems, improve livelihoods, contribute to the sustainable production of animal protein in the face of an expanding population, and pave the way for innovative strategies to enhance the efficiency and sustainability of pigeon farming practices.

MATERIALS AND METHODS

The feeding trial was carried out at the Poultry Unit of the Teaching and Research Farm of the Federal College of Agriculture in Akure, Nigeria, while the proximate analysis of the feed was conducted at the Nutrition Laboratory of the Department of Animal Production and Health of the Federal University of Technology, Akure, Nigeria. Akure, the capital of Ondo State, lies in the forested Yoruba Hills, serving as an agricultural trade center. Its climate is tropical wet and dry, with distinct wet and dry seasons. The latitude and longitude coordinates of Akure are approximately 7.2526° N (latitude) and 5.1931° E (longitude) (Mapcarta, 2024).

One hundred (100) 4-week-old pigeon squabs, weighing between 200 – 220g, were obtained from a pigeon breeder in Ikirun, Osun State, South-West Nigeria. These squabs underwent a two (2) week acclimatization period, during which they were fed chicken growers mash containing 18% crude protein (CP) and 2800 kcal/kg Metabolizable energy (ME). Additionally, sorghum grains were provided, and clean drinking water was available ad-libitum throughout the acclimatization period. After the two (2) week pre-experimental phase, sixty (60) squabs were randomly selected, weighed, and assigned to five (5) experimental diets. The diets, replicated three (3) times with four (4) birds per replicate, were arranged in a Completely Randomized Experimental Design (CRD). These five (5) diets were almost isocaloric (ME: 2864 - 2871 Kcal/kg) and contained 12, 14, 16, 18, and 20% CP. The gross composition of the experimental diets is presented in Table 1. Each set of four (4) birds per replicate were housed in a modified poultry experimental house, divided into cages measuring 2m in length, 1m in width, and 2m in height (2×1×2m) using wire mesh. The cages were equipped with nests and perches, and the diets were pelletized. Throughout the four (4) week experimental period, feed and water were provided ad-libitum. The experimental pens were well-ventilated, maintaining a mean daily temperature of 23°C.

The proximate composition of the experimental diets was analyzed using the methods outlined by AOAC (2019). Daily feed intakes of the birds were recorded and their live weights were taken at the beginning and end of the experiment. Weight gains were calculated, and feed conversion ratios were determined. At the conclusion of the experiment, three birds per replicate were randomly selected and slaughtered by severing their jugular veins with a sharp knife. The slaughtered pigeons were then scalded in hot water, de-feathered, dressed, eviscerated, and dissected into parts, following the procedures outlined for turkeys by Hahn

Table 1. Gross composition of experimental diets

Ingredients	**%Protein Levels**				
	12	**14**	**16**	**18**	**20**
Maize	65.50	62.50	59.50	58.50	54.30
GNC (45% CP)	1.00	8.40	9.60	9.00	10.00
SBM (44% CP)	4.00	2.00	7.00	13.70	18.80
Vegetable Oil	3.00	3.00	3.00	2.00	2.50
Wheat Offal	20.40	18.00	15.80	12.00	10.80
Bone Meal	2.50	2.50	2.50	2.50	2.50
Oyster Shell	2.30	2.30	1.30	1.00	1.30
Salt	0.30	0.50	0.50	0.50	0.50
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Vitamin/Mineral Premix	0.50	0.50	0.50	0.50	0.50
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Nutrients					
Metabolizable Energy (Kcal/kg)	2869	2866	2871	2864	2865
Crude Protein (%)	12.34	14.04	16.10	18.04	20.10
Calcium (%)	1.77	1.78	1.43	1.34	1.45
Phosphorus (%)	0.52	0.53	0.55	0.56	0.59
Ether Extract (%)	3.51	3.52	3.67	3.76	3.79
Crude Fibre (%)	3.34	3.42	3.50	3.52	3.72
Methionine (%)	0.45	0.47	0.49	0.51	0.53
Lysine (%)	0.67	0.78	0.87	0.98	1.11

* Supplied per kg of diets: Copper, 8 mg; Iodine, 0.4 mg; Iron, 100 mg; Selenium, 0.3 mg; Vitamin A (retinyl acetate), 4540 IU; Vitamin D3, 1543 IU; Vitamin E, 15.4 IU; Choline, 284 mg; Niacin, 34 mg; d-Pantothenic acid, 5.7 mg; Riboflavin, 3.4 mg; Menadione, 0.85 mg; Vitamin B12, 0.01 mg; Biotin, 0.1 mg; Folic acid, 0.5 mg; Thiamine, 0.6 mg

and Spindler (2002). The weights recorded included live weight, dressed weight, eviscerated weight, thigh, drumstick, neck, head, shank, wing, chest, back, liver, heart, gizzard, lungs, spleen, and pancreas. The dressed and eviscerated weights were expressed as percentages of the live weight, while the other organ weights were expressed as grams per kilogram of live weight. All data generated were subjected to one-way analysis of variance (ANOVA) using the general linear model (GLM) procedure of SAS (2005). Significant differences were determined using the New Duncan Multiple Range Test of the same statistical package.

RESULTS AND DISCUSSION

The proximate composition (on an as fed basis) of the experimental diets is presented in Table 2. The analyzed crude protein, ether extract, crude fiber, calcium, and phosphorus contents of the five experimental diets slightly deviated from the calculated composition presented in Table 1. The marginal differences between the calculated and analyzed compositions could be attributed to variations in ingredient sources and potential analytical errors.

The analyzed protein contents for the five experimental diets were 11.87, 14.60, 16.27, 17.80, and 19.61%, while the calculated values were 12.34, 14.04, 16.10, 18.04, and 20.10% for diets 1, 2, 3, 4, and 5, respectively. The protein levels in the diets were within the 12 to 18% range recommended for feeding growing and adult pigeons by Sales and Janssens (2003).

The effects of varying crude protein (CP) levels on the performance of pigeon squabs during the growing period (6 to 10 weeks of age) are detailed in Table 3. The final weight and weight gain of the pigeons were significantly ($P<0.05$) influenced by the dietary protein levels. Pigeon squabs fed a diet containing 16% CP exhibited a significantly ($P<0.05$) higher weight gain compared to those fed diets with 12, 14, 18, or 20% CP. A noticeable progressive increase in the final weights of the birds was observed as the level of crude protein increased until the 16% CP diet, beyond which a decrease in final weights occurred. Moreover, pigeons fed diets containing the highest level of CP (20%) had lower feed intake and weight gain compared to those fed diets with other CP levels. This observation suggests that a higher level of protein in the diets (above 16%) may not necessarily lead to higher weight in pigeons. This finding aligns with the research of Abdel-Azeem (1998), who indicated that increasing dietary protein

Table 2. Nutritional composition of diets containing varying levels of dietary crude proteins fed to pigeons

Parameters	Diet I (12% CP)	Diet II (14% CP)	Diet III (16% CP)	Diet IV (18% CP)	Diet V (20% CP)
Moisture Content (g/100g)	11.77	12.70	12.90	13.93	13.30
Crude Protein (g/100g)	11.87	14.60	16.27	17.80	19.61
Ether Extract (g/100g)	3.44	3.55	3.84	3.66	3.99
Crude Fibre (g/100g)	4.49	3.97	3.90	4.55	3.70
NFE (g/100g)	68.44	65.18	63.09	60.05	59.40
Gross Energy (g/100g)	392.06	393.55	397.18	394.63	402.08
Calcium (mg/100g)	1.22	1.66	1.59	1.51	1.44
Phosphorus (mg/100g)	0.33	0.30	0.26	0.37	0.40

NFE = Nitrogen free extract

Table 3. Performance of pigeon squabs fed diets containing varying levels of dietary crude protein for 28 days

Parameters	Diet I (12% CP)	Diet II (14% CP)	Diet III (16% CP)	Diet IV (18% CP)	Diet V (20% CP)	P-Value
Initial weight (g)	236.33±7.06	244.47±3.86	230.70±4.01	240.37±11.22	246.40±13.58	0.250
Final weight (g)	296.00±1.31^{b}	296.43±1.02^{b}	303.47±3.05^{a}	297.20±3.65^{b}	293.50±4.67^{b}	0.026
Weight gain (g)	59.63±6.52^{ab}	51.97±2.84^{b}	72.83±4.25^{a}	56.80±10.04^{b}	47.10±8.91^{b}	0.016
Total feed intake (g)	561.13±12.56	514.20±41.94	506.13±27.62	519.57±20.57	505.70±8.20	0.152
Feed conversion ratio	9.41±0.01^{b}	9.89±0.01^{b}	6.94±0.01^{a}	9.15±0.02^{b}	10.74±0.01^{b}	0.018

^{ab} = Means along the same row with different superscripts are significantly different (p<0.05), N = 4.

levels from 14 to 20% had no significant (P>0.05) effect on weight gain of adult pigeons. Wolter *et al.* (1970) similarly reported that the protein requirement for pigeons is approximately 12.5 to 13%, and higher protein levels did not further improve body weight. Additionally, Little (2004) and Bottcher *et al.* (1985) reported that increasing dietary protein levels did not result in a significant change in body weight for pigeons. On the contrary, Bu *et al*. (2015) and Gunawardana *et al*. (2008) found that increasing both dietary energy and protein levels elevated final pigeon body weight. The recorded low body weight gain with high protein intake in the present study may be attributed to the fixed Metabolizable energy in the diets.

Varying protein levels did not significantly (P>0.05) affect total feed intake, this is consistent with the findings of Abou-Khashaba *et al*. (2008), who reported that differences in live body weight and feed intake during the first and second months of life were not significantly affected when dietary CP levels were increased in pigeons. Squabs fed the highest CP (20%), had lower feed intake compared to those fed diets with lower CP levels. This phenomenon has been previously confirmed for broilers by Aletor *et al.* (2000), who reported a low protein appetite (reduction in feed intake) for broiler chickens fed diets containing higher CP levels. The decreased feed intake with increases in CP may be attributed to the depressing effect of CP/amino acids in excess of dietary requirements. Fancher and Jensen (1989) suggested that specific amino acids, rather than CP per se, play a crucial role in influencing feed intake by chickens.

Highly significant (P<0.05) difference in feed conversion ratio (FCR) was observed in birds fed 16% CP diet compared to birds on other diets. This corroborates the recommendations of Sales and Janssens (2003), who suggested that dietary CP content between 12 and 18% and Metabolizable energy content around 2868 Kcal/kg is ideal for feeding growing and adult pigeons. Similarly, Heuser (2003) had reported that a good pigeon feed typically contains about 13 to 15% crude protein, while Waldie *et al*. (1991) found that a 16% CP diet yielded excellent growth responses for both adult and pigeon squabs.

Table 4 shows the relative carcass weight of pigeon squabs fed diets containing varying levels of dietary crude protein. The effects of dietary treatments did not significantly (P>0.05) impact live weights, percentage dressed weight, percentage eviscerated weight and other relative weights of the carcass cuts. Bostami *et al*. (2009) reported that carcass characteristics are considered a benchmark of nutrient deposition in poultry, with breast/chest and thigh meat yield serving as important standards. **A**verage live weights for pigeons in the present experiment ranged between 269.13g and 299.60g, falling within the 250 to 350g live weight range reported for pigeons by Omojola *et al*. (2012).

The percentage dressed weight exhibited an increase as dietary crude protein levels increased from 12 to 18%, followed by a slight decrease in 20% CP diet. The dressing percentage range of 76.45 to 81.46% observed in the current study surpassed the 62 to 68% range reported by Omojola *et al*. (2012), yet fell slightly below the 82 to 88% values reported by Jiang *et al*. (2009). This discrepancy may stem from variations in management practices; while the former utilized extensively reared pigeons, the latter managed pigeons intensively, similar to the approach taken in the current study.

Numerical values for percentage eviscerated weight did not show any pattern across the different dietary treatments, ranging from 76.45 to 81.46%. In the present study, relative weights of thigh ranged from 52.54 to 64.52g/kg live weight, drumstick from 34.01 to 38.25g/kg live weight, shank from 13.86 to 16.87g/kg live weight, back from 125.85 to 146.56g/kg live weight, wing from 117.28 to 132.17g/kg live weight, chest from 279.31 to 298.63g/kg live weight, and neck from 34.18 to 46.74g/kg live weight. The observed lower relative weights of the shank, chest, and neck in birds fed 12% CP diet may be attributed to low protein content in their diets. This observation is directly related to impaired protein accretion, which affects muscle growth, repair, and maintenance. Insufficient dietary protein limits the availability of amino acids necessary for protein synthesis, leading to decreased muscle mass in these areas. Several studies (Bregendahl *et al*., 2002; Si *et al*., 2001; Jiang *et al*., 2009; Waldroup *et al*., 2005; and Farkhoy *et al*., 2012) have reported impaired weight gain, feed efficiency, and relative carcass weights when broilers were fed low protein diets compared to those fed higher levels of protein in the finisher phase.

The impact of varying levels of dietary crude protein on the relative organ weight of pigeon squabs is outlined in Table 5. No significant effects (p>0.05) were observed on all recorded organ weights, with the exception of the spleen and pancreas. The relative weight of the spleen decreased in

Table 4. Relative carcass weight of pigeon squabs fed diets containing varying levels of dietary crude protein

Parameters	Diet I (12% CP)	Diet II (14% CP)	Diet III (16% CP)	Diet IV (18% CP)	Diet V (20% CP)	P-Value
Live weight (g)	269.13±4.92	284.53±19.91	299.60±23.02	297.33±3.84	286.07±19.15	0.388
DW (%)	86.87±7.90	86.26±9.27	86.20±15.88	84.64±7.33	87.07±16.40	0.386
EW (%)	81.46±4.23	76.45±3.31	79.86±15.01	79.48±4.56	81.10±16.95	0.190
Thigh (g/kg LW)	53.51±1.14	57.74±3.80	64.52±2.42	61.75±1.88	52.54±1.72	0.260
D (g/kg LW)	35.30±0.36	36.90±0.96	38.25±1.32	34.64±0.90	34.01±0.61	0.529
Shank (g/kg LW)	13.86±0.38	16.87±1.04	17.56±0.57	14.46±1.08	16.78±0.61	0.236
Wing (g/kg LW)	132.17±2.19	127.23±5.03	124.37±1.01	117.28±2.71	121.19±2.10	0.788
Chest (g/kg LW)	279.31±2.42	298.63±10.79	287.28±4.42	284.53±2.72	281.15±5.50	0.236
Back (g/kg LW)	125.85±2.30	146.56±9.56	139.72±3.51	129.08±4.64	140.28±4.56	0.366
Head (g/kg LW)	49.16±0.68	54.12±2.62	46.96±1.68	46.18±0.64	50.20±1.52	0.571
Neck (g/kg LW)	34.18±0.95	46.74±3.44	44.96±2.05	39.35±2.27	40.20±3.91	0.496

LW = Live weight, DW = Dressed weight, EW = Eviscerated weight, D = Drumstick, N= 3.

the carcass of pigeons fed diets containing 14 to 18% CP. This decline was attributed to the expression of the weights relative to the higher live weights of birds fed diets with 14, 16, and 18% CP. The spleen, being the largest peripheral lymphoid organ in chickens, plays a crucial role in antibacterial and antiviral immune responses against acquired antigens. While there was a significant difference (p>0.05) in the relative weight of the pancreas, it did not follow any pattern in relation to dietary treatments. In poultry, the pancreas is responsible for producing a mixture of digestive enzymes known as pancreatic juice, as well as hormones such as insulin and glucagon that play a role in carbohydrate metabolism (Dingle, 1990).

In this study, relative weights of the heart, lungs, and liver were not significantly (p>0.05) affected by dietary CP levels. These organs are vital for circulating blood, oxygenating tissues, removing carbon dioxide, and managing digestion and metabolism. Compared to the findings of Hena *et al*. (2012), where average relative weights were 10.8, 22.0, and 14.0g/kg LW for the heart, lungs, and liver of adult pigeons, respectively, these organs appeared relatively larger in the present study. The gizzard and proventriculus weights were also unaffected (p>0.05) by dietary treatment. The gizzard aids digestion through particle size reduction, nutrient breakdown, and feed regulation, while the proventriculus serves as an initial storage and digestion site. The absence of significant (p>0.05) dietary effects on weight of these organs suggests that the diets imparts no adverse consequences on their functions.

Table 5. Relative organ weight (g/kg LW) of pigeon squabs fed diets containing varying levels of dietary crude protein

Parameters	Diet I (12% CP)	Diet II (14% CP)	Diet III (16% CP)	Diet IV (18% CP)	Diet V (20% CP)	P-Value
Heart	13.74±0.95	12.05±1.17	11.01±0.17	16.14±0.72	13.98±1.30	0.376
Lung	10.78±0.17	9.95±1.02	8.24±0.47	16.24±0.35	9.79±0.35	0.885
Liver	23.41±1.56	20.38±1.04	21.70±0.61	17.59±1.21	18.42±0.23	0.484
Spleen	$1.60±0.15^{c}$	$0.81±0.11^{ab}$	$0.77±0.06^{ab}$	$0.44±0.06^{a}$	$1.15±0.06^{bc}$	0.030
Pancreas	$3.08±0.32^{ab}$	$5.17±0.21^{a}$	$2.34±0.26^{c}$	$4.14±0.15^{bc}$	$3.95±0.21^{abc}$	0.017
Kidney	2.49±0.29	3.16±0.46	1.67±0.44	1.78±0.59	4.05±0.12	0.304
Gizzard	16.83±0.40	16.17±0.70	16.92±0.12	16.48±0.46	19.12±0.92	0.350
Proventriculus	1.97±0.31	4.22±0.10	2.67±0.44	2.25±0.46	2.80±0.35	0.277

abc = Means along the same row with different superscripts are significantly different (p<0.05), N= 3.

CONCLUSION

This study aimed to improve the growth performance of pigeon squabs by adjusting their diets, with a specific focus on crude protein levels. Findings showed that a 16% dietary crude protein level resulted in optimal weight gain and feed conversion ratio. Interestingly, higher protein levels did not consistently enhance weight gain, highlighting the importance of precise dietary planning. Additionally, variations in protein levels had minimal impacts on carcass characteristics and organ weights, indicating the effectiveness of the diets. These findings will contribute to advancing our understanding of pigeon nutrition and provide valuable insights for optimizing its farming practices.

Conflict of Interest Statement

We confirm that there are no conflicts of interest associated with the publication of this paper. We have no financial or personal affiliations that might influence our research. Our study was conducted with integrity and impartiality.

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