

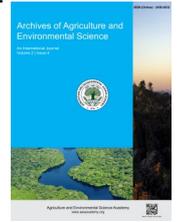


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ORIGINAL RESEARCH ARTICLE



## Dietary crude protein optimization for enhanced growth performance in indigenous chickens during the starter phase

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### ABSTRACT

Formulating diets that meet the nutrient requirements of indigenous chickens during the starter phase is essential for optimal growth, feed efficiency, profitability, and sustainability in poultry production. This study aimed to evaluate the growth response of indigenous chickens to varying crude protein (CP) concentrations in starter diets and to determine the optimal CP requirement during this phase. A total of 240 days-old chicks were randomly assigned to four iso-caloric starter diets containing 16%, 18%, 20%, and 22% CP, with three replicates per treatment. The birds were housed in deep-litter floor pens with 20 birds per pen, provided ad libitum access to feed and water, and monitored for eight weeks. Weekly data collection included body weight (BW) and feed intake, from which average daily gain (ADG) and feed conversion ratio (FCR) were calculated. Results showed that increasing dietary CP significantly improved growth performance. Final body weight, feed intake, and ADG increased with higher CP levels, with the 22% CP diet yielding the highest final weight (380.8 g) and ADG (12.3 g/day). However, the lowest performance was observed with the 16% CP diet. Feed intake peaked at 1300.9 g for the 22% CP diet, and FCR decreased with increasing CP content. Regression analysis suggested that FCR was optimized at 20.5% CP. These findings highlight the importance of precise CP formulations to enhance growth efficiency and profitability in intensive indigenous chicken production systems.

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### INTRODUCTION

The production of indigenous chickens is vital to rural livelihoods in developing countries like Uganda. Traditionally raised in low-input scavenging systems, these chickens are increasingly transitioning to more intensive production systems as small-holder farmers seek to improve productivity and income from poultry. A key challenge in this shift is formulating nutritionally balanced diets that meet the specific nutrient requirements of

indigenous chickens, especially during the starter phase. In poultry diets, protein is essential for muscle and organ development, especially in chick stage. While commercial chicken breeds have well-established nutritional requirements, the optimal crude protein (CP) levels for indigenous chickens during the starter phase remain unclear. Indigenous chickens differ significantly from commercial strains in terms of metabolism and growth, making it necessary to establish specific CP recommendations for these local ecotypes (Beski *et al.*, 2015; Magala *et al.*,

2012). In Uganda, indigenous chickens are central to smallholder farming systems. However, commercial feeds, often formulated for high-performing breeds, are not always suitable or economically viable for use in feeding indigenous birds (Mujyambere et al., 2022). Optimizing CP intake during the starter phase is crucial for improving growth performance, feed efficiency, and profitability. Precision in feed formulation not only boosts profitability (Bamidele et al., 2023) but also reduces environmental impact of chicken production (Bailey, 2020), thereby promoting sustainability of poultry production. Despite some research on CP requirements, most studies have focused on grower and finisher phases, leaving a gap in understanding optimal CP levels during the starter phase (Kpomasse et al., 2023). Among the few authors that have attempted to determine the optimal CP content, none, to the best of our knowledge has employed the use regression analysis to establish the optimal level in indigenous chicken diets. The current study aimed to assess the growth performance of local chicks fed varying levels of dietary CP in the starter phase and to determine the optimal CP requirement of chicks in this stage.

## MATERIALS AND METHODS

### Experimental birds and their management

The experiment was conducted at Mukono Zonal Agricultural Research and Development Institute (MuZARDI). A total of 240 healthy day-old indigenous chicks were used in the study. The chicks were hatched from the hatchery at MuZARDI. The chicks were third-generation birds from a breeding program aimed at improving growth performance in indigenous chickens. The birds were kept in group pens, with 20 chicks per pen. Charcoal in clay pots was used as the main source of heat during the brooding period. Chicks had ad libitum access to clean provided plastic water troughs. Feed was also offered ad libitum to ensure daily refusals throughout the period. All birds were vaccinated following the recommended vaccination schedule. Coffee husks were used as the deep litter material on the pen floors. All the experiments were conducted as per the ethical guidelines and Animal (Preventions and Cruelty) Act of Uganda 2000.

### Experimental design and diets

A completely randomized design (CRD) experimentation was used for the study. Four experimental treatment groups based on the different levels of CP content were formed. A total of 240

birds were assigned to one of the four experimental diets. Each treatment was replicated three times, with pens of 20 birds each, making a total of 60 birds per treatment. Four experimental diets were formulated to be isocaloric (3000 kcal/kg DM metabolizable energy) with varying crude protein compositions. The diets were based on maize as the main energy source, as well as soybeans and fish as the main protein sources. The ingredients used in the formulation of the experiment diets are presented in Table 1.

### Data collection

The initial body weight of the day-old chicks was measured as a group using a digital platform weighing scale. The live body weight of the chickens in each pen was subsequently measured on a weekly basis. Body weight gain was calculated as the difference between the average final and initial body weights of the birds at the end of the trial. Daily feed intake was measured as the difference between the amount of feed offered and the refusal per pen. Feed conversion ratio was calculated as the ratio of total weight gain to the total amount of feed consumed per group from start to the end of the feeding trial (Nampijja et al., 2023). Mortalities were recorded daily as they occurred.

### Feed chemical feed analysis

Feed chemical analysis was conducted at the Livestock Nutrition Laboratory of the National Agricultural Research Organisation (NARO). Standard procedures of the Association of the Official Analytical Chemists (AOAC, 1990), were used to determine dry matter (930.15), ash (942.05), crude protein using the automatic Kjeldahl (method 976.05), ether extracts (method 920.39) and crude fibre (method 962.09). The chemical composition of the treatment diets is presented in Table 2.

### Statistical data analysis

All the data were analysed using SAS statistical software. Data were analysed as a completely randomized design using the general linear model. The Tukey HSD test was used for mean separation whenever differences were significant. In all cases, means were considered statistically significant at  $P < 0.05$ . A quadratic polynomial regression was fitted to the FCR data, and the resulting equation was differentiated to determine the optimal level of dietary crude protein required to meet the nutrient requirements for the chicks. Graphs were created using the ggplot2 package in R and Microsoft Excel spreadsheets.

**Table 1.** Ingredient composition of the experiment diets.

Ingredient (%)	D16	D18	D20	D22
Broken maize	22.5	20	13	12
Maize bran	58	53	53	44
Roasted whole soyabeans	5	12	20	26
Silver fish meal	10	10	10	10
Sunflower cake	3	3.5	3	7
Feed grade lime	0.6	0.7	0.3	0.3
Salt	0.3	0.3	0.3	0.3
Vitamin-mineral premix	0.5	0.5	0.4	0.4

D16 Starter diet of 16% CP, D18 starter diet of 18% CP, D20 starter diet of 20% CP, D22 starter diet of 22% CP level.

**Table 2.** Analysed nutrient composition (% DM basis) of experimental diets.

DM (%)	D16	D18	D20	D22
Energy (Kcal/kg DM)	3040.3	3059.1	3079.3	3094.8
Crude protein (%)	16.5	18.2	20.2	22.2
Crude fibre (%)	3.38	3.5	3.3	4.6
Calcium (%)	1	1	0.9	0.9
Phosphorus (%)	0.5	0.5	0.5	0.5
Methionine (%)	0.2	0.3	0.3	0.3
Lysine (%)	0.7	0.8	1.0	1.1

D16 Starter diet of 16% CP, D18 starter diet of 18% CP, D20 starter diet of 20% CP, D22 starter diet of 22% CP level.

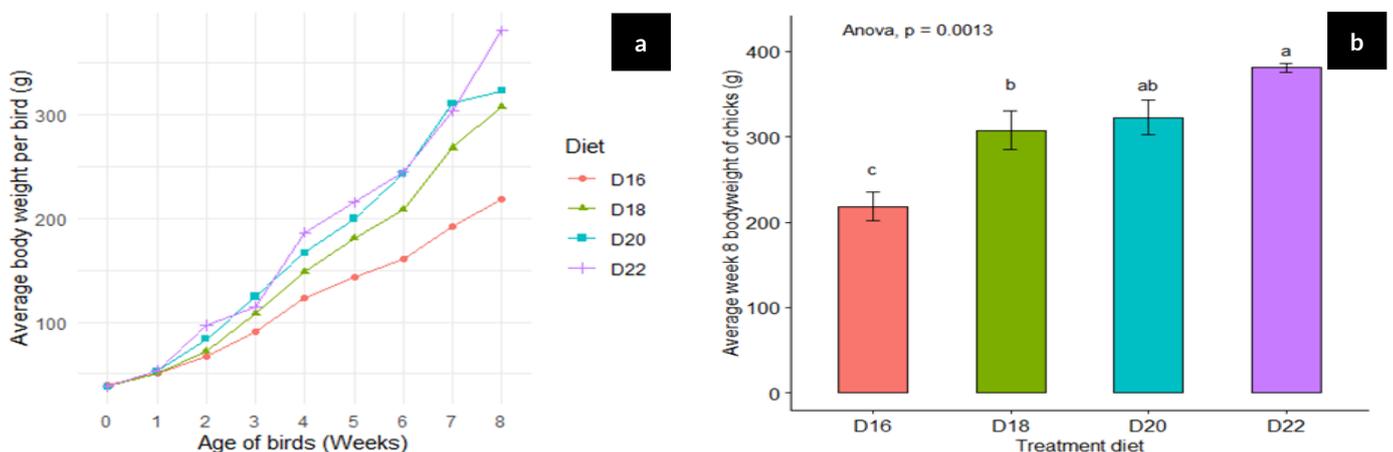
## RESULTS AND DISCUSSION

The average weekly live body weight of birds fed the treatment diets over the eight-week trial period is illustrated in Figure 1a. The highest growth performance was observed for birds fed the 22% CP diets while the lowest performance was observed for birds fed the 16% CP diets. This demonstrates that dietary CP significantly influences the growth performance of indigenous chicks during the starter phase of local chickens (Table 3). These findings underscore the importance of developing tailored feed rations specifically for indigenous chickens, rather than relying on more expensive commercial diets formulated for high performing commercial chicken breeds and strains which have greater nutrient requirements. The linear increase in body weight with increasing dietary CP in the study highlights the critical role of protein during the starter phase, where it is one of most limiting nutrients due to the high demand for tissue synthesis, organ development, and muscle accretion (Beski *et al.*, 2015).

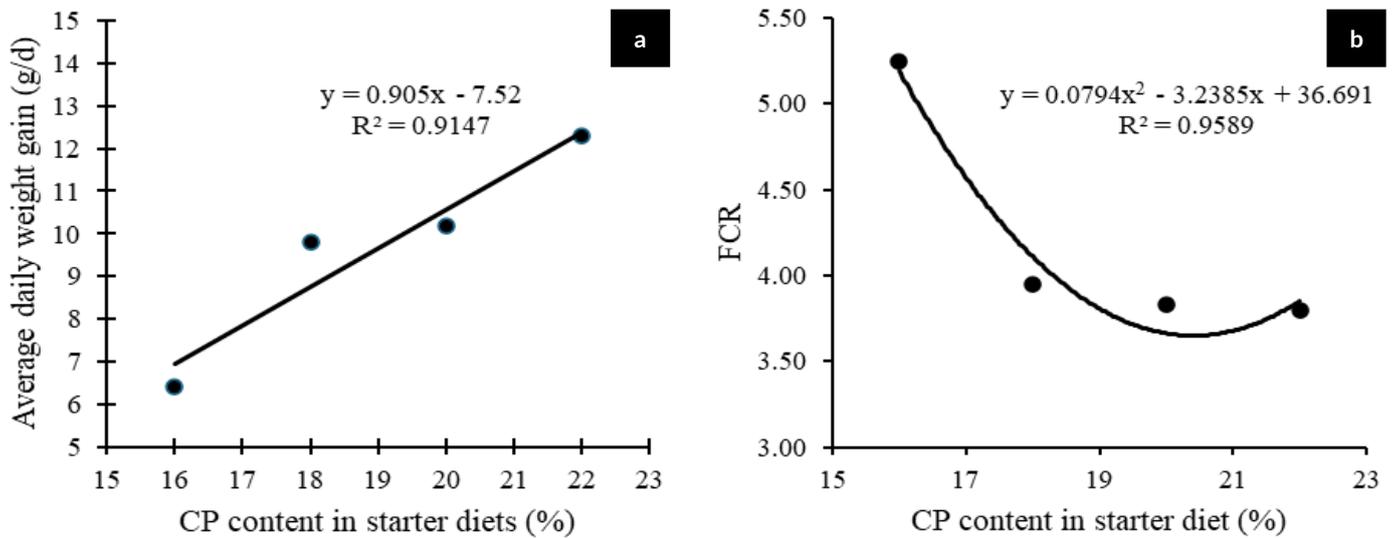
Figure 1b shows average live bodyweight of chicks fed the experimental diets. The highest final bodyweight was recorded for chicks fed the ration with 22% CP and lowest for chicks fed the 16% CP ration. Meanwhile, there were no significant differences in final bodyweight among chicks fed rations with 18% and 20% CP. The final body weight of birds at 20% CP reported in this study is lower than the estimated bodyweight of indigenous chicken ecotypes in Ethiopia as reported by Muluneh *et al.* (2024) and Sanusi & Oseni (2020) in Fulani chickens raised under comparable intensive production system at the same CP level. Similar results have been reported at 22% CP inclusion in

starter diets for Horasi chickens in Tanzania (Mpemba *et al.*, 2022). In contrast, week 8 final bodyweight of birds at 22% CP in this study was higher than for native chicken ecotypes from Sudan as reported by Binda *et al.* (2012). This variance in final bodyweight may be related to the genotype of the birds, since the energy and CP contents of the diets were comparable.

Average daily weight gain (ADG) increased linearly with increasing levels of crude protein (CP) in diets (Figure 2a). The ADG reported in this study at 18% CP in the diet is higher than that for Savana (3.2 g/d) and Forest (2.9 g/d) local chicken ecotypes in Benin even at the same CP level in the diet. While this may partly be attributed to differences in energy content of the diets, it also demonstrates that the Ugandan chicken ecotypes may have better productivity than the Benin chickens studied above. Average daily weight gain (ADG) also increased with higher CP levels, further emphasizing the importance of adequate protein for muscle development in poultry. This observation aligns with the findings that demonstrated a positive relationship between dietary CP and growth performance in local Nigerian chickens (Oleforuh-Okoleh *et al.*, 2016). Regression analysis showed a curvilinear relationship between FCR and the level of CP in the diet (Figure 2b). Differentiation of the quadratic equation revealed that the optimal CP level in the diets should be approximately 20.5%. The optimal CP level determined in this study exceeds the 18% recommended by Nakkazi *et al.* (2015). This discrepancy likely stems from differences in the methods used to determine optimal CP levels. While polynomial regression analysis was used in the current study, Nakkazi *et al.* (2015) selected the best performing diet from the experimental diets evaluated in their study.



**Figure 1(a).** Impact of dietary crude protein on average weekly bodyweight of local chickens during the starter phase, **(b)** shows the effect of varying crude protein on final bodyweight of chicks.



**Figure 2(a).** Effect of varying crude protein content in starter diet on ADG of chicks, **(b)** effect of varying crude protein content of local chicken starter diets on feed conversion ratio.

**Table 3.** Effect of dietary CP on intake and growth performance of indigenous chicken chicks during the starter phase.

	Level of dietary CP (%)				SEM	Significance	
	16	18	20	22		Lin	Quad
Initial weight (g)	38.9	38.2	37.7	37.8	2.56	nd	nd
Final weight (g)	218.5	307.5	322.8	380.8	17.56	<0.001	ns
ADG (g/day)	6.4	9.8	10.2	12.3	0.59	<0.001	ns
Intake (g)	925.1	1056.1	1086.8	1300.9	40.19	<0.001	ns
FCR	5.2	3.9	3.8	3.8	0.36	<0.001	0.014

ADG Average daily weight gain, FCR Feed conversion ratio

## Conclusion

The findings of this study demonstrate that CP levels significantly influence the growth performance of indigenous chicks during the starter phase. Higher CP levels were associated with increased final body weight, ADG, and improved FCR. Polynomial regression analysis indicated that the optimal CP level for maximizing FCR is approximately 20.5%. Future research should focus on determining the amino acid requirements of indigenous chickens during this phase to further optimize dietary formulations.

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## DECLARATIONS

### Author contribution

Conceptualization, M.K, W.H.K, and M.A.H; methodology, M.K, W.K.H and Z.N.; validation, H.A.M., Z.N and Z.N.; formal analysis, M.K.; investigation, M.K., Z.N and R.L.; resources, H.A.M and M.K.; data curation, M.K, Z.N., and R.L.; writing original draft

preparation, M.K, and Z.N.; writing review and editing, M.K, Z.N, H.A.M, Z.N, W.K.H., R.N., K.K., R.L.; visualization, M.K.; supervision, H.A.M.; project administration, H.A.M and R.N.; funding acquisition, H.A.M. All authors have read and agreed to the published version of the manuscript.

**Conflicts of interest:** The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

**Ethics approval:** All animal use, care and handling during data collection was undertaken in compliance with statutory animal care, welfare and prevention of cruelty under the Animal (Preventions and Cruelty) Act of Uganda 2000.

**Consent for publication:** All co-authors gave their consent to publish this paper in AAES.

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