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Evaluating Maize, Sorghum and Millet as Alternative Energy Sources in Broiler Starter Diets: Impacts on Growth, Hematology and Economic Feasibility

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ABSTRACT

Background and Objective: Efficient and cost-effective broiler production is crucial for addressing the rising demand for poultry meat, but the choice of energy sources in starter diets remains a critical factor influencing performance and profitability. This study aimed to evaluate the effects of maize, sorghum and millet as alternative energy sources in broiler starter diets on growth performance, hematological indices and economic viability. **Materials and Methods:** The research was conducted at the Poultry Unit of the Teaching and Research Farm, Department of Animal Health and Production, Binyaminu Usman Polytechnic, Hadejia, Jigawa State, Nigeria. A total of 72 unsexed broiler chicks, sourced from an accredited hatchery, were raised under an intensive management system. Three experimental diets using maize, sorghum and millet as energy sources were formulated and designated as Treatments 1, 2 and 3, respectively. Growth performance, hematological indices, proximate composition of diets and economic analysis were assessed. Data were analyzed using ANOVA, with significant differences determined at $p<0.05$ via Duncan's Multiple Range Test. **Results:** No significant ($p>0.05$) differences were observed among the treatment groups for growth performance and hematological indices, despite numerical variations. Performance parameters were within normal ranges and millet-based diets showed promising numerical trends in some indices. **Conclusion:** Millet was identified as the most economically viable energy source, offering the lowest feed cost per weight gain. This finding highlights millet's potential as a cost-effective ingredient for broiler starter diets, particularly in regions with limited access to conventional feed resources.

KEYWORDS

Maize, sorghum, millet, broiler, growth performance, hematological indices

INTRODUCTION

Poultry is a term used to explain all domestic birds bred for meat and eggs. There is a tendency to restrict this definition to the domestic chicken (*Gallus domesticus*), which dominates the attention of agricultural personnel to the neglect of other species like ducks and guinea fowls. Poultry serves as a rich source of protein which is vital in human nutrition. In Nigeria, the per capita consumption of meat protein is 13 kg[1],

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while that across the African continent is 16 kg, which is less than the recommended minimum of 16.5 kg[2]. The consumption of animal protein is declining, especially in rural areas, where 85% of the extremely poor live[3]. This deficit has led to increased imports of poultry meat from developed countries[4].

Increasing demand for poultry products requires producers to ensure there is enough supply of the products since an increase in poultry weight translates to an increase in poultry production[5]. This study has been conducted in poultry farming to determine the relationship between different poultry feeds and body weight. Also, this statistical research on poultry production has helped farmers and researchers describe and understand biological processes, allowing them to prioritize the research objectives from identifying the study components to evaluating the response variables[6]. Therefore, this study sought to model the weight of broiler chickens fed different energy source diets, such as maize, sorghum and the millet. The objective of this study was to assess the impact of incorporating maize, sorghum and millet as alternative energy sources in broiler starter diets on growth performance, hematological parameters and economic feasibility.

MATERIALS AND METHODS

Study area: This research project was conducted from April to August, 2023. The study was conducted at the Poultry Unit of the Teaching and Research Farm of the Department of Animal Health and Production, Binyaminu Usman Polytechnic, Hadejia, Jigawa State, Nigeria. Hadejia Town is the capital of Hadejia Emirate and is located at the Central Part of the Emirate which lies between Longitude 10°02'28 14"E and Latitude 12°27'12.49"N.

Research protocol: A total of 72 broiler birds were obtained from accredited Hatchery Chikun Company at Hadejia Metropolis, Jigawa State, Nigeria. The birds were raised under an intensive management system. Feed Ingredients used include; maize, sorghum, millet, methionine, lysine, premix, bone-meal, limestone, salt, soybean, groundnut cake and wheat offal. Other experimental materials used were; a weighing balance, grinding mill, 5 mL syringes, microscope, EDTA bottles, cotton wool, methylated spirit, burette, test tubes, distilled water, red blood cell (RBC), white blood cell (WBC) diluting fluids and laboratory oven.

Maize, sorghum, millet and other feed ingredients were sourced from the Hadejia market and were used in formulating the experimental diet. Individual ingredients were calculated and the quantity of each ingredient was weighed using a weighing balance (for the higher quantity ingredients) and a sensitive weighing balance (for the micro ingredients). Three different diets containing different energy sources were designated as T1, T2 and T3 for maize, sorghum and millet, respectively. The diet was subjected to proximate analysis using the standard method of the Association of Analytical Chemist[7]. Table 1 shows the composition of experimental diets.

A total of 72 day old chicks were purchased and randomly allocated on a weight equalization basis to three dietary groups (each with a different energy source). All sanitary procedures such as cleaning, washing and disinfection of the pen and other equipment were observed. Chicks were managed in a deep litter system and brood for 1 week they were transferred into individual pens. Feed (twice daily, early morning and late evening) and water were provided *ad libitum* throughout the period of the experiment which lasted for six weeks. The chicks were duly vaccinated orally via drinking water and under normal health conditions, multivitamins were administered twice a week.

Experimental design: A Completely Randomized Design (CRD) containing 3 treatment groups with 4 replications consisting of different energy sources in each treatment was used in this experiment.

Table 1: Composition of experimental diets

Ingredient	Diet T1 (Maize)	T2 (Sorghum)	T3 (Millet)
Maize	52.91	-	-
Sorghum	-	56.02	-
Millet	-	-	57.98
Soya bean meal	26.98	29.04	29.04
Wheat offal	5.01	3.98	2.70
GNC	11.00	6.98	6.98
Bone meal	1.50	1.50	1.50
Limestone	1.50	1.50	1.50
Vitamin premix	0.26	0.26	0.26
Methionine	0.26	0.26	0.26
Lysine	0.26	0.26	0.26
Common salt	0.36	0.36	0.36
Total	100	100	100
Calculated nutrients (%) unless otherwise stated			
ME (kcal)	2891	2890	2508
Crude protein (%)	20.90	20.63	21.51
Crude fibre (%)	4.19	5.20	6.99
Calcium	0.99	0.99	0.76
Phosphorus (Av.)	0.54	0.58	0.40
Ether extract	9.50	5.20	9.60
Lysine	1.28	1.27	1.34
Methionine	0.59	0.58	0.34

ME: Metabolizable energy and Av: Average

Data collection

Growth performance: The growth performance of the broiler chickens was monitored and determined by measuring their weights, feed intake, feed conversion ratio (FCR) and body weight gain (g)[8]. The initial body weights of the broiler chicks were recorded on arrival and subsequent body weight gain was recorded at the end of every week for a period of 6 weeks of the experiment. Body weight gain was calculated from the differences between the body weight gain for the given week and the previous week. The final body weights of the birds were recorded at the end of the experiment:

$$\text{Body weight gain (g)} = \text{Final body weight (g)-Initial weight gain (g)}$$

A known quantity of feed was given to the broiler chicken while the leftover of feed was weighed to determine the daily feed intake for each treatment. Feed intake for each week was obtained from the difference between the feed given per week and leftover:

$$\text{Total feed intake (g)} = \text{Daily feed intake} \times 42 \text{ days}$$

Feed conversion ratio (FCR): The feed conversion ratio of the birds was determined by calculating the ratio of their feed intake to weight gain[8]:

$$\text{FCR} = \frac{\text{Total feed intake}}{\text{Total body weight gain}}$$

Hematological indices: On 42 days, 2.5 mL blood samples were collected from one bird in each replicate using a needle and syringe through wing veins directly into EDTA-containing bottles and taken to the laboratory for the determination of hematological Indices.

Ethical consideration: An Institutional Review Board (IRB) before the commencement of the experiment approved the study.

Statistical analysis: Data obtained from the study were subjected to One-way Analysis of Variance (ANOVA) using the General linear model (GLM) procedure of statistical analysis system (SAS®) version 2000[9]. Duncan's Multiple Range Test was used to test the significant difference among treatments at a 5% significance level[10].

RESULTS

The proximate composition of diets containing different energy sources is presented in Table 2. Despite numerical variation among the experimental groups, no significant difference (p>0.05) was observed among all parameters except crude protein. Hence, all the values obtained were within the normal range.

Table 3 shows the result of the growth performance of broiler chicken fed a diet of different energy sources. The result showed a non-significant (p>0.05) difference but numerical variation exists; in terms of final body weight, sorghum (T2) and millet (T3) are superior to maize (T1).

Table 2: Proximate composition of experimental diet containing different energy sources

	Dietary treatment		
Parameter	T1	T2	T3
Ash (%)	5.53^a	5.18^a	5.08^a
Moisture (%)	3.50^a	4.06^a	4.02^a
Dry matter (%)	96.61^a	96.04^a	95.99^a
Crude fibre (%)	7.84^a	5.89^a	6.73^a
Ether extract (%)	4.38^a	4.17^a	4.52^a
Crude protein (%)	21.25^a	20.23^b	19.42^b
Nitrogen free extract (%)	7.48^a	3.66^a	5.48^a

[a,b]Means with the same superscript along the row are not significant (p<0.05)

Table 3: Growth performance of broiler chicken fed diet containing different energy sources

	Treatment			
Parameter	T1	T2	T3	SEM
IBW (g)	270.80	291.60	291.70	0.23
FBW (g)	1500	1529	1479	0.79
BWG/bird (g)	1204	1237	1187	0.75
TFI/bird (g)	3282	3487	3458	0.89
DWG/bird (g)	0.26	0.26	0.25	0.81
DFI/bird (g)	93.00	99.60	98.80	0.96
FCR	1.22	1.23	1.24	0.60

IBW: Initial body weight, FBW: Final body weight, BWG: Body weight gain, TFI: Total feed intake, DWG: Daily weight gain, DFI: Daily feed intake and FCR: Feed conversion ratio

Table 4: Haematological parameters of broiler chicken fed diets containing different energy sources

	Treatment			
Parameter	T1	T2	T3	F-value (ANOVA)
RBC (10^6/μL)	2.98	2.89	2.95	0.99
WBC (10^3/μL)	111	122	108	0.68
HB (g/dL)	21.03	19.93	20.73	0.92
MCV (g/dL)	108.70	109.00	110.00	0.91
MCH (g/dL)	68.17	68.80	70.37	0.64
MCHC (g/dL)	62.80	63.23	68.87	0.23
LYM	10.23	9.80	11.10	0.23
PCV (%)	33.62	31.46	32.47	0.89

WBC: White blood cells, RBC: Red blood cells, HB: Haemoglobin, MCV: Means corpuscular volume, PCV: Pack cells volume, MCH: Means cells haemoglobin and MCHC: Mean Corpuscular haemoglobin concentration and LYM: Lymphocyte

Table 5: Economic analysis of broiler chickens fed diets containing different energy sources

	Treatment			
Parameter	T1	T2	T3	
Feed cost (#/kg)	528	497	487	0.33
Feed cost per weight (#/bird)	1204	1237	1187	0.75
Cost of feed consumed/bird	1706	1813	1800	0.49
Mortality (%)	0.00	0.00	0.00	0.00

Table 4 shows the result of hematological parameters of a broiler chicken-fed diet containing different energy sources. The results showed non-significant ($p>0.05$) differences among the test materials and for all the energy sources, the values of hematological parameters were within the normal range.

Table 5 shows the result of the economic analysis of broiler chickens fed a diet containing different energy sources. The results showed a non-significant ($p>0.05$) difference but numerical variation exists.

DISCUSSION

Efficient and cost-effective broiler production was essential in meeting the increasing demand for poultry meat and the selection of energy sources in starter diets played a pivotal role in influencing performance and profitability. The impact of using maize, sorghum and millet as alternative energy sources in broiler starter diets on growth performance, hematological parameters and economic feasibility was studied.

Ahmed *et al.*[11] reported that sorghum has a similar nutritional value to maize. The metabolizable energy (ME) of sorghum was 14.40 MJ/kg while the metabolizable energy of millet was 14.17 MJ/kg[12]. Therefore, because of their similar compositions, sorghum and millet can be used as a source of energy in poultry diets. The amino acid composition of the two cereals revealed that the content is fairly distributed. Sorghum contains a low level of lysine but the high level of tryptophan content relative to maize[13]. Studies reported that maize, millet and sorghum have the main limiting indispensable amino acids (arginine, lysine, methionine, cysteine and tryptophan)[14,15]. The crude protein (CP) of the three test materials (maize, sorghum and millet) revealed significant variation ($p<0.05$) in which the CP content of T1 appears to be higher than that of T2 and T3, this might be attributed to the fact that maize contained a reasonable amount of protein compared to sorghum and millet[2]. The ether extract (EE) showed significant variation ($p<0.05$) in the three experimental diets. The EE content of treatment 3 was higher compared to other experimental diets. These findings are in agreement with the previous of results Rosebrough and Steele[15] that reported, the EE content of millet is considerably higher than those of maize, cassava and sorghum. However, this is contrary to the findings of Elkin *et al.*[16], who reported a higher amount of EE in maize than millet.

Table 3 shows the result of growth performance. The average feed consumption was high for birds fed a diet containing millet as the source of energy. This result agrees with the findings of Adamu *et al.*[10], who replaced yellow sorghum for maize and found a significant difference in the daily feed intake. The total feed intake in T2 (3382 g) was higher than those of the other treatments this is attributed to high CP (13%) high oil content (5-6%) and a lower portion of less digestible prolamines[2,14]. During the starter phase, the average daily feed intake was not significantly affected across the dietary treatment. This is in agreement with the finding of Cerrate *et al.*[18], who replaced millet with maize. Similarly, a research study replaced quality protein maize for normal maize and found no statistical difference in the daily feed intake[17,18]. This result agrees with the findings of Pour-Reza and Edriss[19], who stated that all dietary maize portions can be replaced with low-tannin sorghum in broiler diets without adverse effects on feed intake. In all treatment groups, no significant ($p>0.05$) difference was observed in the feed conversion ratio, the best feed conversion ratio was seen in diet 3 (1.24). In diet 1, the poor FCR could be due to the presence of tannin, which reduces the utilization of energy, protein and specific amino acids[20]. Deficiencies in crude protein and anti-nutritional factors in maize-based diets may impair nutrient digestion, absorption and utilization[21]. A better feed conversion ratio in millet based diet was also reported by Attia and Hassan[3].

Table 4 shows the result of hematological parameters. The highest value of RBC was observed in T1 (2.98 µ:). As reported by Peters *et al.*[22] the value of RBC was within the normal range for adult chickens. Similarly, according to Caldas *et al.*[23], the RBC values of the experimental birds were within the normal range ($1.5\text{-}3.5\times10^6/\mu L$). The result for PCV showed no statistical ($p>0.05$) difference but numerical variation exists between the treatment groups. The T1 (33.62%) showed the highest percentage followed by T3 and T2. The normal value for PCV ranges from 22-43%[24]. The values for mean corpuscular hemoglobin concentration showed no significant variation ($p>0.05$). Also, the values for mean corpuscular hemoglobin concentration observed in the present study (60-70 g/dL) was similar to the normal range as reported by Peters *et al.*[22]. Haemoglobin and Mean Corpuscular Hemoglobin (MCH) are major indices for evaluating circulatory erythrocytes and are significant in the diagnosis of anaemia and also serve as useful indices for the evaluation of the bone marrow capacity to produce red blood cells in mammals[25].

Table 5 shows the result of the economic analysis. A significant cost reduction was observed when sorghum was replaced for maize in broiler diets[2]. Numerically, the result contradicts Adam[13], who found total cost of feed (TCF) and total weight gain per weight of feed (TWG) which showed the reduction in the cost of production when sorghum is used in place of maize.

CONCLUSION

The different energy sources used in this study did not significantly affect the general performance parameters evaluated. However, no mortality was recorded and values obtained for haematological indices were within the recommended range which indicates the safety of the diets and good management. Based on the economic analysis, millet is recommended being the cheapest in terms of feed cost and feed cost per weight of bird.

SIGNIFICANCE STATEMENT

This study highlights the potential of utilizing alternative energy sources in poultry diets without compromising performance parameters, safety or health, as evidenced by stable hematological indices and zero mortality. Millet, identified as the most cost-effective energy source, offers a sustainable option for reducing feed costs in poultry production. Future research should explore the long-term effects of these diets on productivity, environmental impact and consumer health. Additionally, investigations into optimizing millet-based diets and their feasibility in diverse agroecological zones can expand the scope of sustainable poultry nutrition.

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