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Research Article
Growth Performance and Carcass Characteristics of Broiler Chickens Fed Diets Containing Differently Processed Finger Millet Supplemented with Enzyme

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Abstract

Objectives: The present study was conducted to assess the performance and carcass characteristics of broiler chickens fed diets containing differently processed finger millet meal supplemented with enzymes. **Materials and Methods:** A total of 150 two-week-old broiler chicks of mixed sexes were randomly allocated to one of four diets in a completely randomized block design. The broiler chicks were allocated one of four diets containing either 0 (Control), uncrushed, roughly crushed, or finely crushed finger millet. The starter diets were isonitrogenous (23% CP) but varied in energy levels from 2,710.00 (Diet A) to 2,726.60 kcal/kg ME (for diets B, C and D respectively). The finisher diet was also isonitrogenous (21% CP) and fed to the birds for 21 days. A total of 37 broiler birds were divided into four groups, each receiving a finisher diet containing 0 (control), uncrushed, roughly crushed and finely crushed finger millet, all (except for control) supplemented with enzyme for 3 weeks. Each diet was replicated thrice with 12 birds each. Some replicates had 13 birds each. Feed and water were made available ad libitum. **Results:** Feed intake was significantly lower ($p<0.05$) for birds fed on diets A (0.51), B (0.47) and C (0.46kg) than those fed on diet D (0.60kg/bird). However, weight gain and feed efficiency were similar across treatment groups. Feed cost per kilogram gain was significantly lower in birds fed on diet A (₦ 58.05/bird) than those fed on diets B (₦ 71.18/bird), C (₦ 70.60/bird) and D (₦ 71.18/bird), respectively. No differences were observed in carcass values except for the relative gizzard weight which was significantly higher ($p<0.05$) for birds fed on diets A (8.76), B (10.71) and C (8.04) than those fed on diet D (6.67%). **Conclusion:** In order to induce an intake response, finger millet can be fed to broiler chickens in finely ground form but it won't affect the weight of the carcass organs. When considered collectively, our results showed that crushing the finger millet was unnecessary because it had no significant impact on the birds' body weight or feed efficiency.

Key words: Broiler chickens, carcass characteristics, crushing, feed cost, Finger millet, poultry feed, weight gain

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

It is well-established that the high cost of conventional feed ingredients and the conflicting demands for industrial and human consumption lead to a significant reliance on non-conventional feed materials in commercial poultry production[1,2]. The unpredictable fluctuations in market prices for feed ingredients force feed manufacturers to constantly alter their diet formulations to maintain a reasonable gross margin. To keep output constant and reduce overall production costs, poultry producers are substituting other grains for conventional ingredients (e.g., maize), such as finger millet, pearl millet and sorghum (which offers comparable nutritional value to maize[3,4].

In recent studies, finger millet (*Eleusine coracana*) appears to be a promising alternative energy source for poultry[3,5,6]. Nigeria and other nations, including India, China, Japan and Malaysia, are major producers of finger millet[7]. Finger millet grains have an exceptional capacity to flourish under unfavourable farming settings, such as uneven weather patterns and soils with low nutrient levels and its inherent resistance to drought greatly increase its acceptability and availability as an energy source in poultry feed[8]. Finger millet is rich in dietary fibre, carbohydrates, protein and minerals, among other important components[7,9]. In addition, finger millet has a nutritional profile similar to maize, with roughly 70% carbohydrate, 7-8% protein, 20% dietary fibre, 2.5-3.5% minerals and 1-2% ether extracts[10].

Numerous studies on poultry feeding have demonstrated that finger millet can effectively replace corn as an energy source without adversely affecting the performance of the birds[11,12]. According to Bot *et al.*[6], feed intake was the poorest when 75% of their diet was black finger millet. In that same study, the cost per kilogram gain increased with increasing quantities of the test diets[6]. Elangovan *et al.*[13] reported that body weight gain and feed efficiency were significantly lower in birds fed finger millet-based diet but were improved when exogenous enzymes were added. Due to high crude fiber content of finger millet, feeding diets containing this grain should include enzymes. It was reported that the millets (pearl, finger, or mogul) can completely replace maize in the diet of layer hens, quail, duck and guinea fowl, 55% of the broiler diet, 40-69% of the laying birds diet[14,15]. Rao *et al.*[16] also reported that finger millet was able to replace yellow maize by 25% and produce similar responses on body weight without affecting weight gain. In that study, adding finger millet beyond 25% decreased thigh fat, liver fat and gizzard fat. This could be attributed to the fact that the gizzard was involved in more grinding activities of feed materials[16].

There is a lack of knowledge on how to process finger millet before feeding it to poultry despite the numerous but inconsistent, studies on its benefits in poultry feeding. In contrast to their pen mates fed crushed forms of grain millet, we hypothesized that birds fed finger millet as a whole grain would have equal or higher cost margins, poor growth and poor carcass characteristics. Therefore, the objective of this study was to investigate the effect of feeding diets containing differently processed finger millet supplemented with enzyme on the growth performance and carcass characteristics of broiler chickens.

MATERIALS AND METHODS

All experimental procedures, animal handling and the collection of samples were reviewed and approved by the institutional animal ethics committee of The Federal College of Animal Health and Production Technology, National Veterinary Research Institute, Vom (Protocol No. vriAUCC F001/15) and in compliance with the Nigerian Animal Diseases (Control) Act. Cap A17 LFN, 2004 and the Veterinary Surgeon Act. Cap V3 LFN 2004.

Study location: The experiment was conducted at the Large Animal Experiment Station, National Veterinary Research Institute, Vom. The farm is located at Vom in Jos South Local Government Area of Plateau State in the Sudan Savanna zone of North Central Nigeria. Vom is located at latitude 80 45'E and longitude 90 43' N, 1280 m above sea level. The mean daily temperatures of Vom vary from 13.9°C in December/January to 28.6°C in June/July with between 1300-1500 mm of rain during the rainy season (late March to early October). Monthly relative humidity at 12.00 GMT is between 14-74%.

Birds and management: A total of 150 one day old broiler chicks, were obtained from a hatchery in Ibadan and enrolled in this study. Chicks were uniform in size and body conformation. They were brooded together for two weeks to normalize the birds and housed in deep litter house partitioned into 12 units with wire mesh to allow for adequate ventilation. There were roughly the same numbers of birds per treatment with 13 birds per unit. Each diet was randomly allocated three units of cages in a completely randomized design. All birds from each unit were weighed at the beginning and weighed weekly for five weeks. The experimental diets were designated A, B, C and D. Diet A contained no finger millet meal. Feed and water were provided *ad libitum* for five weeks.

Table 1: Percent ingredient composition of experimental starter diets for broilers

Ingredients	A	B	C	D
Maize	39.17	17.95	17.95	17.95
Finger millet	0	19.59	19.59	19.59
Soyabean cake	34.13	35.76	35.76	35.76
Fish meal	2.00	2.00	2.00	2.00
Palm kernel cake	10.00	10.00	10.00	10.00
Wheat offal	5.00	5.00	5.00	5.00
Maize offal	5.00	5.00	5.00	5.00
Bone meal	2.50	2.50	2.50	2.50
Limestone	1.50	1.50	1.50	1.50
*Vitamin Premix	0.25	0.25	0.25	0.25
Enzyme	-	+	+	+
Salt	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10
Total	100.00	100.00	100.00	100.00
C.P (%)	23.01	23.01	23.01	23.01
M.E (kcal/kg)	2710.00	2647.74	2647.74	2647.74
Ca (%)	1.71	1.75	1.75	1.75
P (%)	0.72	0.77	0.77	0.77
C.F (%)	4.55	5.39	5.39	5.39
Cost/kg diet (N)	533.98	603.92	603.92	603.92

Hi Nutrient premix supplied the following per 100 kg of diet: Vitamin A: 1,200,000 I.U, Vitamin D_3: 250,000 I.U, Vitamin E: 3,000 I.U, Vitamin K: 200 mg, Thiamin, (B_1): 225 mg, Riboflavin, (B_2): 600 mg, Pyridoxine (B_6): 450 mg, Niacin: 4000 mg, Vitamin B_{12}: 2 mg, Pantothenic acid: 1,500 mg, Folic acid: 150 mg, Biotin: 8 mg, Choline chloride: 30,000 mg, Antioxidant: 12,500 mg, Manganese: 8,000 mg, Zinc: 5,000 mg, Iron: 2,000 mg, Copper: 500 mg, Iodine: 100 mg, Selenium: 20 mg, Cobalt: 50 mg, Key: C.P: Crude protein, M.E, Metabolizable energy, Ca: Calcium, P: Phosphorus, C.F: Crude fibre, A: Control, B: Uncrushed finger millet, C: Roughly crushed finger millet and D: Finely crushed finger millet

Finger millet: Finger millet was purchased from Bukuru market, Jos South LGA of Plateau State. It was crushed into meal and incorporated into experimental diets free from mold and weevils. They were analyzed for proximate chemical contents[17]. Part of the finger millet was left uncrushed; a part was roughly crushed, while a part was finely crushed and incorporated accordingly.

Experimental diets: Four isonitrogenous (23% CP) starter diets containing 0, (control), uncrushed, roughly crushed and finely crushed finger millet were used in this study (Table 1). The diets were designated A, B, C and D respectively and contained metabolizable energy (ME) levels of 2710.60 kcal/kg for diet A and 2647.74 kcal/kg for diets B, C and D. The finisher diets (Table 2) contained one crude protein level (21% CP) but also contained metabolizable energy levels of 2726.60 kcal/kg for diet A and 2659.71 kcal/kg for diets B, C and D. Diet A (control) had no finger millet. Diets B, C and D contained uncrushed, roughly crushed and finely crushed finger millet respectively and fed *ad libitum* for 3 weeks. For each of the diets (from B to D), exogenous enzyme (Fullzyme^R) was included at 100 g for every 100 kg of feed. Fullzyme^R NSP is a multi-enzyme solution for the optimal and most comprehensive degradation of non-starch polysaccharides present in feed. Fullzyme contains amylase, protease, cellulase, β- glucanese, xylanase, phytase, pectinase, β-mananase, lipase, aspergillus oryzae and aspergillus, yeast culture, yeast cell wall, bacillus, sodium calcium aluminosilicate.

Data collection: The mean body weights and feed intake (weekly) were recorded throughout the experimental period (Late May to early July 2024). From the mean body weight and feed intake, the feed conversion ratio was calculated. The amount of feed fed to the birds in each unit was weighed and a corresponding leftover was also weighed. The difference between the feed given and the leftover was the feed intake. The difference between the initial and the final weight was the weight gain. The feed conversion ratio was calculated as the ratio of the feed intake to the weight gain. Feed cost/kg diet was calculated from the prevailing local market price of feed materials. Feed cost per kilogram gain was calculated by multiplying the feed conversion ratio with the unit cost of feed.

Carcass evaluation: At the end of the 6-week feeding trial, two birds per replicate, (one male and one female) with a live weight as close as possible to the mean of the treatment, were randomly selected. The birds were fasted overnight; weighed

Table 2: Percent ingredient composition of experimental finisher diets for broilers

Ingredients	A	B	C	D
Maize	41.73	19.12	19.12	19.12
Finger millet	0.00	20.87	20.87	20.87
Soyabean cake	27.57	29.31	29.31	29.31
Fish meal	2.00	2.00	2.00	2.00
Palm kernel cake	14.00	14.00	14.00	14.00
Wheat offal	5.00	5.00	5.00	5.00
Maize offal	5.00	5.00	5.00	5.00
Bone meal	2.50	2.50	2.50	2.50
Limestone	1.50	1.50	1.50	1.50
*Vitamin Premix	0.25	0.25	0.25	0.25
Enzyme	-	+	+	+
Salt	0.25	0.25	0.25	0.25
Methionine	0.10	0.10	0.10	0.10
Total	100.00	100.00	100.00	100.00
C.P (%)	21.01	21.01	21.01	21.01
M.E (kcal/kg)	2726.60	2659.71	2659.71	2659.71
Ca (%)	1.70	1.74	1.74	1.74
P (%)	0.69	0.74	0.74	0.74
C.F (%)	4.66	5.99	5.99	5.99
Cost/kg diet (N)	508.34	508.34	508.34	508.34

Hi Nutrient premix supplied the following per 100 kg of diet: Vitamin A: 1,200,000 I.U, Vitamin D3: 250,000 I.U, 300 vitamin E: 3,000 I.U, Vitamin K: 200 mg, Thiamin, (B1): 225 mg, Riboflavin (B2): 600 mg, Pyridoxine (B6): 450 mg, Niacin: 4000 mg, Vitamin B12: 2 mg, Pantothenic acid: 1,500 mg, Folic acid: 150 mg, Biotin: 8 mg, Choline chloride: 30,000 mg, Anti-oxidant: 12,500 mg, Manganese: 8,000 mg, Zinc: 5,000 mg, Iron: 2,000 mg, Copper: 500 mg, Iodine: 100 mg, Selenium: 20 mg, Cobalt: 50 mg, Key: C.P: Crude protein, M.E: Metabolizable energy, Ca, Calcium, P, phosphorus; C.F: Crude fibre, A: Control, B: Uncrushed finger millet, C: Roughly crushed finger millet and D: Finely crushed finger millet

and slaughtered, plucked and dressed. Dressing percentage, prime cuts (drumstick, breast, back, neck, wings and thigh) and visceral organs (heart, gizzard, liver and intestines) were expressed as a percentage of live weight.

Data analysis: Data was analyzed using one-way analysis of variance (ANOVA). In a randomized complete block design, Minitab Software[18] was used to investigate the effect of treatments. Tukey's Honest Significant Difference test was used to compare the means. Values of $p<0.05$ were considered statistically significant, whereas a tendency was declared at $0.05<p>0.10$.

RESULTS AND DISCUSSION

Birds fed on a diet containing finely processed finger millet showed significantly higher feed intake than those fed on control, uncrushed and roughly crushed finger millet diets. Weight gain and feed conversion ratio was not significantly affected by the diets. However, feed cost/kg gain was significantly lower for birds fed on the control diet (A) than those fed on the finger millet diets (B, C and D, Table 3). The initial and final weights were not significantly affected in this study. This result contradict with the findings of Bot *et al.*[6], who worked on finger millet for broiler chickens but agree with the report of Hassan *et al.*[5]. Rao *et al.*[16] reported that 25% of finger millet could replace maize in broiler diet without affecting body weight gain. This study found that body weight gain (at 50% of maize) was not significantly affected, probably because of the differences in climate of study area and the varieties of finger millet used. However, body weight gain and feed efficiency was significantly lower in birds fed finger millet-based diets, which was improved when enzyme was included[13]. This result supports the use of exogenous enzymes when birds fed millet grains.

Enzyme supplementation is quite necessary to break down the non-starch polysaccharides in finger millet. A low viscous digesta will be achieved by solubilizing a high-fiber diet using exogenous enzymes. The results of this study agree with Rao *et al.*[19], who reported that body weight gain and feed conversion efficiency for broiler chickens were not affected by continued feeding until 7 weeks of age but contradict with the report of Bot *et al.*[6]. This is likely due to variation in feed materials and prices. Results of the present study are confirmed by Rao et al.[16] who reported that body weight gain was not affected. However, these results disagree with those of Elangovan *et al.*[13], who recorded similarity in feed intake but feed conversion ratio of birds fed on finger millet was poorer than those fed on the control diet during a 7-week feeding period. This may be due to rice offal that was used in the diet. In that same study, feed efficiency decreased when broiler fed diets containing 75 and 100% finger millet as substitute for yellow maize[13]. This result contradict with the results of the present study. Feed cost/kg gain for birds fed on the control

Table 3: Effects of inclusion levels of differently processed finger millet on parameters measured

Parameters	A	B	C	D	SEM	p-value
Feed intake (kg/bird)	0.51[a]	0.47[a]	0.46[a]	0.60[b]	0.03	0.002
Weight gain (kg/bird)	0.22	0.20	0.23	0.25	0.04	0.696
Feed/gain ratio	2.40	2.38	2.05	2.49	0.50	0.733
Initial weight (kg/bird)	0.37	0.35	0.36	0.37	0.01	0.166
Final weight (kg/bird)	1.48	1.31	1.48	1.48	0.13	0.373
Feed cost/gain (₦)	58.05[a]	71.18[b]	70.60[b]	71.18[b]	5.29	0.040

Means within rows with different superscript letters are significantly different (p<0.05), A: Control; B: Uncrushed finger millet; C: Roughly crushed finger millet and D: Finely crushed finger millet

Table 4: Carcass characteristics of broiler chickens fed diets containing differently processed finger millet supplemented with enzyme

Parameters	A	B	C	D	SEM	p-value
Live weight (kg)	1.37	1.40	1.24	1.50	0.19	0.472
Bled weight (kg)	1.29	1.35	1.20	1.44	0.14	0.299
Plucked weight (kg)	1.21	1.30	1.09	1.30	0.15	0.113
Carcass weight (kg)	1.13	1.19	0.98	1.20	0.16	0.141
Dressing (%)	70.12	65.10	61.08	68.00	5.82	0.366
Thigh (kg)	0.14	0.14	0.11	0.14	0.01	0.060
Drumstick (kg)	0.14	0.13	0.11	0.14	0.02	0.385
Breast (kg)	0.32	0.31	0.32	0.33	0.04	0.883
Back (kg)	0.19	0.20	0.13	0.19	0.05	0.402
Neck (kg)	0.09	0.09	0.06	0.06	0.01	0.079
Relative organ weight as a percentage of live weight (%)						
Intestine	15.95	17.77	18.85	12.23	4.63	0.375
Heart	3.99	4.05	4.02	3.56	0.59	0.720
Liver	5.37	4.73	4.02	6.67	2.09	0.085
Gizzard	8.76[b]	10.71[b]	8.04[b]	6.67[a]	1.44	0.049

Means within rows with different superscript letters are significantly different (p<0.05), A: Control, B: Uncrushed finger millet, C: Roughly crushed finger millet and D: Finely crushed finger millet

diet was significantly lower than those fed on diets containing finger millet. In contrast, Elangovan *et al.*[13] and Bot *et al.*[6], observed a higher feed cost/kg gain who fed diet containing finger millet to broilers under the same climate. The erratic changes in the price of feed materials on the market may have contributed to these results. However, it warrants further investigation why birds fed the control diet consumed less feed than those fed the finger millet diet.

Table 4 shows that carcass measurements, including live weight, bled weight, plucked weight, carcass weight, prime cuts (back, breast, thigh, drumstick) and relative organ weights (intestine and heart), were not significantly influenced by the diets. However, the weight of the liver and neck were influenced by the diet. Birds fed finely crushed finger millet had significantly lower gizzard weight than those fed the control and the other finger millet diets. Rao *et al.*[16] and Rao *et al.*[19] reported that, increasing the percentage of finger millet in the diet decreased abdominal fat but increased the relative weight of the gizzard and intestines, likely due to the higher crude fiber content in finger millet. This contradicts the present study in which the reduced gizzard weight was observed (Table 4). The reason for this reduction is unclear, however we speculate that it is due to the finely crushed finger millet reducing the grinding time and activities of the gizzard in those birds fed this test diet. Previous studies[13,16] had reported no significant effects of diets containing sorghum, finger millet and maize on carcass values, giblets, liver, heart and gizzard, which partially confirms the findings of the present study. Yunusa *et al.*[20] found that diets containing sorghum or millet had no significant effect on the carcass or gut characteristics which align in part with the observations of the present study. Similar results were reported by Rao *et al.*[16] who observed that ready-to-cook yield and relative weights of giblet, liver, intestine and length of intestine were not significantly affected when evaluated at day 42.

LIMITATIONS OF THE STUDY

In contrast to 8 weeks, a small sample size was used over a short period (5 weeks) for broiler feeding. Consistent fluctuations in feed and material costs may have affected the duration of feeding and the results presented here.

CONCLUSION

Adding enzymes to finger millet is crucial for breaking down its non-starch polysaccharides. Exogenous enzymes solubilize a high-fiber diet, resulting in a low viscous digesta. Birds fed finely crushed finger millet meal supplemented with enzymes had significantly higher feed intake than those fed the control or other processed diets. However, weight gain, feed efficiency and feed cost was not significantly affected. Carcass characteristics were similar across the experimental diets, except for gizzard weight, which was significantly lower in birds fed finely crushed finger millet meal supplemented with enzymes compared to the control and other diets. Based on these findings, we conclude that finger millet meal supplemented with enzymes, whether crushed or uncrushed can replace up to 50% of maize in broiler chicken diets without negatively impacting their growth performance.

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