GSAR Journal of Agriculture and Veterinary Sciences
ISSN: 3048-9075 (Online)
Abbreviated key title: Glob.J. Agri.Vet.Sci.
Frequency: Monthly
Published By GSAR Publishers
Journal Homepage Link- https://gsarpublishers.com/journal-gjavs-home/

Broiler Chickens' Response to Dietary Inclusion of Maize Stover as an Alternative Energy Source to Yellow Maize

By

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Article History

Received: 01/08/2025
Accepted: 04/08/2025
Published: 06/08/2025

Vol – 2 Issue –7

PP: -31-37

Abstract

A 49-day feeding trial was conducted to evaluate the response of broiler chickens fed diets in which maize stover partially replaced yellow maize. A total of 144 day-old Abor Acre broiler chicks were randomly allocated to six dietary treatments in a completely randomised design, with three replicates of 8 birds per treatment. Diets 1 (control), 2, 3, 4, 5, and 6 contained 0%, 5%, 10%, 15%, 20%, and 25% maize stover, respectively, as a partial substitute for dietary yellow maize. Birds were provided feed and water ad libitum and reared on wood-shaving litter. Growth performance parameters such as feed intake, weight gain, and feed conversion ratio (FCR) were monitored, while carcass traits and haematological indices were analysed using standard laboratory procedures. Results showed that body weight was significantly affected ($P < 0.05$) by dietary treatments, with birds fed 5% maize stover exhibiting the best FCR. Carcass traits, including back cut, thigh, drumstick, and breast weight, differed significantly ($P < 0.05$) across treatments. Birds on the 5% maize stover diet recorded the highest live weight (1900.00 g/bird) and dressed weight (1266.67 g/bird). Haematological parameters were generally not significantly affected ($P > 0.05$); however, birds fed 15% maize stover recorded the highest values for haemoglobin (8.94 g/dL), mean corpuscular haemoglobin (31.34 pg), mean corpuscular haemoglobin concentration (32.27 g/dL), and packed cell volume (27.67%). In conclusion, maize stover can be used to partially replace yellow maize in broiler diets at inclusion levels of up to 15–20% without adverse effects on growth performance, carcass quality, or haematological health.

***Keywords**: Broiler Chicken, Maize Stover, Broiler Diets and Productive Performance*

INTRODUCTION

In recent years, the rising cost and fluctuating availability of conventional feed ingredients such as yellow maize have posed significant challenges to sustainable poultry production, particularly in developing countries like Nigeria. This situation has necessitated a continuous search for alternative and locally available feed resources that are cost-effective and nutritionally beneficial for livestock. Among the potential alternatives, crop residues have emerged as important feed resources due to their abundance, low or zero acquisition cost, and minimal competition with human food sources.

The primary sources of crop residues in Nigeria include stovers of cereal crops—such as maize (Zea mays), sorghum (Sorghum bicolor), and millet (Pennisetum glaucum)—as well as haulms of leguminous crops like cowpea (Vigna unguiculata), groundnut (Arachis hypogaea), and soybean (Glycine max) (Tang et al., 2006). While these by-products are traditionally used for purposes such as mulch, manure, fuel, bedding material, and staking for yam vines (Heuzé et al., 2017), they hold considerable promise as unconventional feedstuffs in livestock nutrition (Ogundipe & Sanni, 2002; Akinfemi et al., 2009).

Maize stover, in particular, is a readily available crop residue in maize-producing regions and consists of the leaves, stalks, husks, and cobs remaining in the field after maize harvest. It typically constitutes about 50% of the total maize biomass yield. Chemically, maize stover is composed of 37.4% cellulose, 21.1% xylan, 18.0% lignin, 5.2% ash, 3.1% protein, 2.9% arabinan, 2.0% galactan, and 1.6% mannan (Lizotte et al., 2015; Huang et al., 2009). Despite its richness in fibrous carbohydrates, the utilisation of maize stover in poultry diets is limited by its high fibre content and the presence of non-starch polysaccharides (NSPs)—compounds that are not

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easily degraded by the endogenous enzymes of monogastric animals such as broiler chickens (Daliord, 2006). NSPs increase digesta viscosity and hinder nutrient absorption, thus reducing feed efficiency and growth performance.

However, with advancements in feed technology, strategies such as the use of exogenous feed enzymes have been explored to mitigate these anti-nutritional effects and improve the digestibility of high-fibre feed ingredients. Incorporating treated or enzyme-supplemented maize stover in broiler diets could therefore serve as a sustainable approach to lowering feed costs and promoting circular agricultural practices without compromising productivity.

This study was therefore undertaken to evaluate the growth performance, carcass characteristics, haematological responses, and economic viability of feeding maize stover as a partial replacement for yellow maize in the diets of broiler chickens.

MATERIALS AND METHODS

Experimental site

The experiment was carried out at the Poultry Unit of the Teaching and Research Farm, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. The area falls within the tropical rain forest zone with an annual rainfall of 2177mm, a temperature range between 20-30^{o}C °C, and with relative humidity of 50-59%, depending on season (NRCRI, 2020).

Source and processing of maize stover

Maize stover was collected from a maize farm in Isiala Ngwa North L.G.A. of Abia State after harvesting was concluded. The stover was chopped into smaller sizes (2-4cm) and sundried. It was taken to the local mill, where it was ground for incorporation in the diets for the experiment. Other ingredients such as maize, soyabean meal, groundnut cake, fish meal(Danish), palm kernel meal, bone meal, oyster shell, vitamin/mineral premix, salt, methionine and lysine were procured from a commercial dealer.

Experimental birds and management

A total of 144-day-old Abor Acre (unsexed) broiler chickens (DOC) were procured from Vertex® HTS Farms in Uyo, Nigeria, for the experiment. The initial weight of the birds was taken, and they were randomly divided into 6 treatment groups with 8 birds per replicate, comprising 24 birds in each treatment group and The birds were brooded with a 60W bulb each in the pens. Each group was raised in floor pens with wood shavings as litter material. Feeders and drinkers were respectively provided for the supply of *ad libitum* feed and water for a duration of seven weeks. Birds were vaccinated against Gumboro disease at 10th and 18th days of life, while the Newcastle vaccine was administered at the 28th day. Coccidiostat was administered in drinking water during the second and third weeks of the experiment.

Experimental diets

Six (6) experimental broiler diets were formulated such that the control diet (T_1) did not contain maize stover, while diets T_2-T_6 contained maize stover at 5%, 10%, 15%, 20% and 25% respectively. The compositions of the broiler diets and calculated analysis are shown in Table 1.

Table 1: Dietary Composition of Broiler diets showing percent substitution of maize stover for yellow maize (0-7 weeks)

Ingredient (%)	T_1(0%)	T_2(5%)	T_3(10%)	T_4(15%)	T_5(20%)	T_6(25%)
Yellow Maize	52.20	49.59	46.98	44.37	41.76	39.15
Maize Stover	0.00	2.61	5.22	7.83	10.44	13.05
Soyabean Meal	15.00	15.00	15.00	15.00	15.00	15.00
Groundnut Cake	15.00	15.00	15.00	15.00	15.00	15.00
Fish Meal (Danish)	4.00	4.00	4.00	4.00	4.00	4.00
Palm Kernel Meal	10.00	10.00	10.00	10.00	10.00	10.00
Bone Meal	2.00	2.00	2.00	2.00	2.00	2.00
Oyster Shell	1.00	1.00	1.00	1.00	1.00	1.00
Premix	0.25	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25	0.25
Methionine DL	0.15	0.15	0.15	0.15	0.15	0.15
Lysine	0.15	0.15	0.15	0.15	0.15	0.15
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis:						
Crude protein %	21.00	20.80	20.60	20.40	20.20	20.00

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ME Kcal/Kg	3000.08	2910.32	2820.55	2730.79	2641.02	2551.25
Analyzed composition:						
Dry matter %	92.46	92.66	92.55	92.50	92.24	92.21
Crude protein %	20.75	20.35	20.15	19.90	19.75	19.50
Crude fibre %	5.84	6.67	7.59	7.64	10.37	11.42
Ether extract %	3.72	3.60	3.52	3.47	3.42	3.40
Moisture %	7.54	7.74	7.45	7.50	7.76	7.79
NFE %	44.49	43.43	42.43	42.01	38.76	37.39
Ash	17.66	18.21	18.86	19.48	19.94	20.55
ME Kcal/kg	2843.85	2815.76	2802.69	2678.99	2661.36	2643.70

*Vitamin-mineral premix supplied the following: Vitamin A 8,000,000 iu, Vitamin D_3 2,000,000, Vitamin E 5,000mg, Vitamin K_3 2,000mg, Folic acid 500mg,

Niacin 15,000mg, Vitamin B_2 8,000mg, Vitamin B_{12} 10,000mg, Vitamin B_1 1,500mg, B6 1,500mg, Biotin 20mg, Calpan 5,000mg.

Table 2: Determined Proximate Composition of Maize Stover

Parameter	% Composition
Dry matter	92.9
Crude protein	6.48
Crude fat	0.50
Crude fibre	31.73
Ash	23.33
Moisture	8.02
Metabolizable energy (Kcal/kg)	972.72

Data Collection

Growth performance

Data on performance characteristics such as average initial weight, average weight, and average feed intake were collected, while average weight gain, feed conversion ratio, protein intake and protein efficiency ratio were calculated.

Carcass evaluation

At the end of the experiment, two (2)birds of similar body weight were selected from the treatment groups, fasted, weighed and slaughtered by severing the jugular vein. They were thoroughly bled and scalded by dipping in hot water of 60 °C and defeathered. The carcass values from head, shank, neck and visceral were removed in order to determine the dressed weight as described by Ojewola and Longe (1999).

$$\text{Dressing \%} = \frac{\text{Dressed weight}}{\text{Live weight}} \times \frac{100}{1}$$

$$\text{Organs} = \frac{\text{Heart/liver/kidney/intestine/proventriculus}}{\text{Live weight}} \times \frac{100}{1}$$

Haematological indices

Blood samples (10mls) were taken from the jugular vein of each of the birds under each of the treatment diets at the end of the experiment using a sterile needle and syringe to withdraw the blood, where 5mls each were kept in a sample containing Ethylene Diamine Tetra Acetic Acid (EDTA), an anti-coagulant to prevent blood clotting. Each of the blood samples collected was put into a properly labelled and sterilised tube and taken to the laboratory for haematological assessment. The following were determined: Packed Cell Volume (PCV), Red Blood Cells (RBC), White Blood Cells (WBC), Haemoglobin (Hb), Mean Corpuscular Volume (MCV), Mean Corpuscular Haemoglobin (MCH), Mean Corpuscular Haemoglobin Concentration (MCHC).

Mean Corpuscular Haemoglobin (MCH)

$$\frac{\text{Hb x 10}}{\text{RBC}}$$

Mean Corpuscular Volume (MCV)

$$\frac{\text{PCV x 10}}{\text{RBC}}$$

Mean Corpuscular Haemoglobin Concentration (MCHC)

$$\frac{\text{Hbx100}}{\text{PCV}}$$

Statistical Analysis

All data generated were statistically analysed using the Analysis of Variance (ANOVA) procedure described by Steel and Torrie (1980) in a Completely Randomized Design (CRD), and significant means were separated using Duncan Multiple Range Test (Duncan, 1995) taking P<0.05 as significance level.

Results and Discussion

The proximate composition of maize stover used in this study is presented in Table 2. It includes the dry matter 92.9%, crude protein 6.48%, crude fat 0.50%, crude fibre 31.73%, ash 23.33%, moisture 8.02% and metabolizable energy 972.72Kcal.kg.

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Growth Performance

The results of broiler chickens fed a maize stover-based diet are presented in Table 3. The result showed the growth performance of broiler chickens fed maize stover diets. Initial weight showed no significant difference (P>0.05) across the treatment groups. Final weight, total weight, average daily weight, FCR, DPI and PER showed significant differences (P<0.05). Final weight 1921.58g/b, total weight 1749.40g/b and average daily weight 38.44g values, respectively, were significantly highest in birds fed 5% maize stover diets among other treatment groups. The lower weight gain value of 1658.33g for birds fed 25% maize stover could be due to the high fibre content of the diet, which could have reached a critical level at this replacement level. Although there are various literature reports on the inclusion level of unconventional and agro-industrial by-products without adverse effects (Duru and Dafwang, 2010). Maikano (2005) recommended15% inclusion level as the highest level of inclusion of maize stover when he experimented with rice offal in poultry feed. Lower inclusion of maize stover in the diet showed that broiler chickens were able to utilise an appreciable amount of insoluble diet without disrupting the digestion and utilisation of soluble maize.

According to Akpet and Ibekwe (2018), inclusion level of cereal offal up to 20-30% in broiler diets had no adverse effects on performance. The results on total feed intake showed that birds fed a 10% maize stover diet had the highest feed intake compared to other treatment groups. Isikwenu *et al.* (2000) attributed high feed intake to high dietary fibre level, which is associated with high heat increment, which contributes to heat stress in warm climates and also affects the physical texture of the rations and increases feed intake of birds in an attempt to satisfy their energy needs. Feed intake decreased numerically by 4057.50g, 4060.83g, and 4052.50g as the level of maize stover increased, and this agrees with the reports of Saadatmand *et al.*(2019), who observed a decrease in feed intake and weight gain when broilers were fed 30% rice hull. The inclusion of hull reduced feed intake and improved feed conversion ratio without affecting the final body weight. (Gonzalez-Alvarado *et al.,* 2007). Feed conversion ratio showed a significant difference (P<0.05) in all the treatment groups. Daily protein intake was highest in the control diet for birds fed 0% maize stover diets and lowest in birds fed 25% maize stover. This agrees with the report of Ani *et al.* (2003) that high fibre in the diets of monogastric animals reduces the utilisation of other nutrients, especially crude protein. Protein efficiency ratio showed a significant difference (P<0.05) with birds fed 10% maize stover diets having the least value of 1.92.

Parameter (g)	T_1(0%)	T_2(5%)	T_3(10%)	T_4(15%)	T_5(20%)	T_6(25%)	SEM
Initial W	37.50	38.33	38.75	37.92	38.33	37.92	0.15
Final W	1786.90^{b}	1921.58^{a}	1741.25^{bc}	1750.00^{bc}	1766.58^{b}	1696.25^{c}	18.03
Total W	1749.40^{b}	1749.40^{a}	1702.50^{bc}	1712.08^{bc}	1728.25^{b}	1658.33^{c}	18.01
ADW	35.70^{b}	38.44^{a}	34.74^{bc}	34.94^{bc}	35.27^{b}	33.84^{c}	0.37
TFI	4296.33	4244.17	4295.83	4057.50	4060.83	4052.50	40.55
ADFI	87.69	86.62	87.67	82.80	82.88	82.70	0.83
FCR	2.46^{ab}	2.25^{c}	2.53^{a}	2.37^{abc}	2.35^{bc}	2.44^{ab}	0.03
DPI	18.42^{a}	18.11^{ab}	18.06^{ab}	16.89^{bc}	16.64^{c}	16.54^{c}	0.22
PER	1.94^{bc}	2.13^{a}	1.92^{c}	2.07^{ab}	2.11^{a}	2.05^{abc}	0.02

Table 3: Performance of Broiler Chickens fed maize stover diets (0-7 weeks)

[a,b,c,] Means within the rows with different superscripts are significantly different (P<0.05); SEM, Standard error of mean. FW: Final Weight; TW: Total Weight; ADW: Average Daily Weight; ADFI: Average Daily Feed Intake; TFI: Total Feed Intake; FCR: Feed Conversion Ratio; PI: Protein Intake; PER: Protein Efficiency Ratio.

Carcass Characteristics

The result of the carcass characteristics of broilers fed maize stover diets is presented in Table 4. The results of carcass characteristics of broiler chickens fed maize stover diets showed significant differences (P<0.05) in live weight, dressed weight, defeathered weight, back cut, drumstick and breast. Live weight, dressed weight, and defeathered weight results followed the same pattern of significance among the

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treatment groups. As the level of dietary maize stover increased, these parameters decreased due to an increase in high fibre content. Dressing percentage recorded higher values, 68.69% in birds fed 25% maize stover. Back cut was higher, 20.87% in birds fed 10% maize stover diets, while thigh, 14.78% and drumstick, 14.47%, wings, 12.02% and breast, 27.27% were higher in birds fed 20% maize stover diets among the treatment groups. The results on cut parts obtained in this study agreed with those of Amaefule *et al.*(2006) and Odeh *et al.*(2016), who observed no significant difference in some of the broiler chickens fed rice milling waste diets.

Table 4: Carcass Characteristics of Broiler Chickens fed maize stover diets (0-7 weeks)

Parameters (%)	**T_1(0%)**	**T_2(5%)**	**T_3(10%)**	**T_4(15%)**	**T_5(20%)**	**T_6(25%)**	**SEM**
Live Weight (g/b)	1890.00^{a}	1900.00^{a}	1750.00^{b}	1736.67^{ab}	1736.67^{ab}	1703.33^{b}	21.00
Defeathered Weight (g/b)	1733.33^{a}	1716.67^{a}	1670.00^{ab}	1643.33^{b}	1610.00^{b}	1603.33^{b}	14.10
Dressed Weight (g/b)	1276.67^{a}	1266.67^{a}	1186.67^{b}	1183.83^{b}	1156.67^{b}	1170.00^{b}	13.14
Dressing %	67.53	67.26	67.83	68.15	67.77	68.69	0.33 NS
Back cut	20.12^{bc}	20.21^{b}	20.87^{a}	19.55^{c}	19.86^{bc}	19.52^{c}	0.13
Thigh	13.61^{b}	13.61^{b}	14.38^{a}	14.54^{a}	14.78^{a}	14.28^{a}	0.13
Drumstick	13.41^{b}	13.56^{b}	14.33^{a}	14.31^{a}	14.47^{a}	13.74^{b}	0.13
Wings	11.69	11.82	11.77	11.89	12.02	12.00	0.08 NS
Breast	24.74^{c}	25.64^{bc}	26.13^{ab}	25.89^{bc}	27.27^{a}	26.68^{ab}	0.23

[a,b,c,] Means within the rows with different superscripts are significantly different ($P<0.05$); SEM-Standard Error of the mean

Haematological Indices

The results of the carcass characteristics of broilers fed a maize stover diet are presented in Table 5. Haematological parameters are usually related to the health status of the birds and are of diagnostic importance in clinical evaluation of their state of health. They are good indicators of the physiological, nutritional and pathological status of the animal. The results of haematological indices of broiler chickens fed maize stover diets showed that there were no significant differences ($P>0.05$) in all the parameters. The dietary treatment did not adversely affect the birds. All the haematological parameters RBC, WBC, Hb, MCV, MCH, MCHC and PCV are within the normal ranges. The RBC values were similar, 3.10µl, 3.10µl in the control group and the birds fed 5% maize stover diets. The increase in RBC was brought about by the increase in feed intake as a result of fibre in the diet (Esonu *et al.*, 2003). WBC value was the highest, 2.93µl at birds fed 5% maize stover diet, showing the birds' ability to fight and withstand infections. Haemoglobin value was highest 8.94g/dl in 15% maize stover inclusion across the treatment groups and increased as the level of maize stover increased in the diet and this agrees with IFST report (2001), which shows that fibre could be a source of minerals, vitamins, prebiotics and unidentified growth promoters all of which brings about increase feed intake. Aderemei and Alabi (2013) also reported that high Hb values imply high oxygen carrying capacity, and this would not allow the birds to succumb to respiratory stress. MCV had similar values in 98.41fl and 98.40fl in birds fed maize stover diets 20 and 25% respectively. MCH which is the expression of the average haemoglobin content of the RBC or the mean mass of haemoglobin per red blood cell in a given sample of blood according to Jaime (2001) was highest 31.34pg in birds fed 15% maize stover diets while MCHC and PCV values 32.27g/dl and 27.67g/dl were also highest in 15% respectively. The values fell within the physiological range obtained by Nyaulingo (2013).

Table 5: Haematological indices of Broiler Chickens fed maize stover diets (0-7 weeks)

Parameters	**T_1(0%)**	**T_2(5%)**	**T_3(10%)**	**T_4(15%)**	**T_5(20%)**	**T_6(25%)**	**T_1(0%)**
RBC ($\times10^6$/ µl)	3.10	3.10	2.67	2.85	2.82	2.65	0.07
WBC ($\times10^3$/µl)	2.54	2.93	2.73	2.65	2.69	2.55	0.11
Hb (g/dl)	7.46	8.26	7.88	8.94	8.58	7.92	0.21
MCV (fl)	84.22	83.32	98.07	96.98	98.41	98.40	2.41
MCH (pg)	24.04	29.92	29.74	31.34	30.65	30.03	0.98
MCHC (g/dl)	28.79	31.93	30.47	32.27	31.19	30.52	0.58
PCV (%)	26.00	25.83	25.83	27.67	27.50	26.00	0.42

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[a,b] Means within the rows with different superscripts are significantly different (P<0.05); SEM-Standard Error of the mean. PCV: Packed Cell Volume; Hb: Haemoglobin; RBC: Red Blood Cell; WBC: White Blood Cell; MCV: Mean Cell Volume; MCH: Mean Cell Haemoglobin; MCHC: Mean Cellular Haemoglobin Concentration.

CONCLUSION

The present findings suggest that maize stover diets can replace yellow maize up to 20% as it was found to cause a significant increase in growth performance, better feed efficiency, higher haematological values and reduced cost of feed.

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