

Research Article

Performance Quality, Nutrient Digestibility and Carcass Traits of Broiler Chickens Fed Graded Levels of White Sorghum Soaked in Wood Ash Extract

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Abstract

This study investigated the effects of feeding graded levels of white sorghum soaked in wood ash extract on performance, nutrient digestibility and carcass traits of broiler chickens. One hundred and forty-four day-old broiler chicks were randomly assigned to four experimental diets in a completely randomized design (CRD). Each treatment had 36 birds, divided into three replicates of 12 birds each. At the starter phase, birds fed the control diet (T1) had the highest significant ($p < 0.05$) live weight (733.00g), feed intake (50.80g), weight gain (36.17g) and feed conversion ratio (FCR) OF (1.44). The highest protein efficiency ratio (3.37) was observed in birds fed T2 (25% WSSWAE). Birds fed T4 (75% WSSWAE) had the lowest ($P < 0.05$) live weight, feed intake and weight gain. At the finishing phase, birds fed T1 had the highest ($p < 0.05$) final live weight (2180.00g), body weight gain (51.68g) and feed intake (93.10g). The best feed conversion ratio (1.08) was observed in birds fed T1. Nutrient digestibility was highest ($p < 0.05$) in birds fed T1, with dry matter (92.61%), crude protein (75.70%) and ash (74.88%). The highest (2165.00g) significant ($p < 0.05$) de-feathered weight and 2115.00g eviscerated were observed from birds fed on T3 (50% WSSWAE) while the least value of 1980.00g and 1930.00g were noticed from T4 (75% WSSWAE). Birds on T1 (Control) revealed the highest (8.63g) significant ($p < 0.05$) different while the least value of 8.27g was noticed from T4. Conclusively, white sorghum soaked in the wood ash extract can be replaced maize up to 50% without negative effect on performance, apparent nutrient digestibility, carcass traits and organ weights of the broiler finisher chickens. Therefore, 25% inclusion level of white sorghum soaked in wood ash extract is recommended to substituting maize in broiler chickens diets.

Keywords

Broiler Chickens, White Sorghum, Maize, Performance Quality, Carcass Traits, Organ Weights

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1. Introduction

Poultry farming is one of the keys to global food security, contributing about 40% of agricultural output in industrialized countries and 20% in developing nations like Nigeria [1, 2]. Broiler chicken production constitutes the poultry meat market, accounting for around 90% of total poultry production globally [3]. However, the industry struggles with feed costs, which for 60%–70% of total production expenses [4].

Maize is one of the major sources of dietary convective energy in poultry feed ingredient, but its competition with human consumption and industrial use may limit its future availability in Nigeria. This is because maize is high in energy as compared to other cereal grains such as millet, sorghum etc [5]. As a result of its numerous uses and relatively higher moisture requirement for growth, in comparison to maize, sorghum can be grown successfully on relatively poor soils and with lower moisture condition. Globally, sorghum holds a substantial position as a main animal feed grain [6]. It ranks as the third most widely cultivated cereal in the world, following rice and maize. While its nutritional content falls slightly behind maize, it proves to be more cost-effective and accessible, particularly in African semi-arid regions [7].

Sorghum nutritional profile (3270 kcal/kg metabolizable energy [ME] and 9.5% crude protein [CP]) is comparable to maize (3434 kcal/kg ME and 10% CP) [3], making it a suitable substitute in poultry feed. As a result, sorghum is commonly replaced for maize in poultry nutrition throughout the world, depending on relative prices [5]. It is important to evaluate the feeding and replacement value of sorghum for maize as alter-

native cheap and easily available feedstuffs in the broiler ration. Therefore, this study designed to assess performance, nutrient digestibility and carcass of broiler chickens fed graded levels of white sorghum soaked in wood ash extract.

2. Materials and Methods

2.1. Experimental Site

The feeding trial was conducted at the Livestock Teaching and Research Farm, Faculty of Agriculture, Ambrose Alli University, Ekpoma, Esan West Local Government Area, Edo State, Nigeria. The farm is located in Nigeria's tropical derived savannah rain forest vegetation area between longitudes 6.440N and 6.080NE, with a mean ambient temperature ranging from roughly 26°C in December to 34°C in February and an average relative humidity of 61 percent in January and 92 percent in August.

2.2. Experimental Diets

Four starter and finisher diets were used (1, 2, 3, and 4). Diet one (1) contained 100% maize as the control, while diets two, three, and four processed sorghum grain was used to replace the percentage proportion of maize at levels of 25, 50, and 75% respectively. The diets were formulated to be iso-nitrogenous (22 and 20% crude protein) and iso-caloric (3000 and 2800kcal/kg) as shown in Tables 1 and 2 respectively.

Table 1. Composition of Experimental Broiler Starter as Affected by Dietary Treatment of White Sorghum Soaked in Wood Ash Extract.

	Inclusion Levels of WSSWAE (%)			
	0	25	50	75
	Dietary Treatments			
Ingredients (%)	1	2	3	4
Maize	58.79	44.09	29.40	14.70
White sorghum	0.00	14.70	29.40	44.09
Soya bean meal	31.27	30.84	30.96	31.10
Fish meal	1.80	2.00	2.00	2.00
Wheat offal	2.64	2.65	2.65	2.65
Bone meal	3.95	4.17	4.04	3.91
Lysine	0.50	0.50	0.50	0.50
Methionine	0.50	0.50	0.50	0.50
Salt	0.30	0.30	0.30	0.30

	Inclusion Levels of WSSWAE (%)			
	0	25	50	75
Dietary Treatments				
Biomix (Broiler)	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00
Calculated analyses (%)				
Crude protein	22.00	22.11	22.32	22.40
Crude fibre	3.50	3.50	3.53	3.57
Ether extract	3.30	3.21	3.11	3.01
Calcium	1.00	1.05	1.03	1.02
ME (Kcal/kg)	3000.00	3000.00	3000.00	3000.00

Broiler premix Vit. A, 10,000 I. U; Vit D 2000 I. U; Vit E 23mg; Vit K, 2mg; Calcium, Pantothenate, 7.5mg B12, 0.015mg, folic acid, 0.75mg; Choline Chloride, 300mg; Vit B, 1.8mg, Vit. B₂, 3mg; Manganese, 40mg; iron, 20mg; Copper, m3g; Iodine, 1mg; cobalt, 0.2mg; Selenium, 0.2mg' Zinc, 50mg. ME= Metabolizable energy, WSSWAE= White sorghum soaked in wood ash extract.

Table 2. Composition of Experimental Broiler Finishers Diets as Affected by White Sorghum Soaked in Wood Ash Extract.

	Inclusion Levels of WSSWAE (%)			
	0	25	50	75
Dietary Treatments				
Ingredients (%)	1	2	3	4
Maize	59.50	44.63	29.75	14.88
White sorghum grain	-	14.88	29.75	44.63
Soya bean meal	21.00	21.00	21.00	21.00
Fish meal	1.00	1.00	1.00	1.00
Wheat offal	14.00	14.00	14.00	14.00
Bone meal	2.50	2.50	2.50	2.50
Lysine	0.50	0.50	0.50	0.50
Methionine	0.50	0.50	0.50	0.50
Salt	0.30	0.30	0.30	0.30
Biomix (Broiler)	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00
Calculated analyses (%)				
Crude protein	20.00	20.01	20.02	20.03
Crude fibre	5.62	6.11	6.50	6.98
Ether extract	3.30	3.21	3.11	3.01
Calcium	1.02	1.05	1.03	1.02
ME (Kcal/kg)	2800.00	2800.00	2800.00	2800.00

Biomix Broiler premix Vit. A, 10,000 I. U; Vit D 2000 I. U; Vit E 23mg; Vit K, 2mg; Calcium, Pantothenate, 7.5mg B12, 0.015mg, folic acid, 0.75mg; Choline Chloride, 300mg; Vit B 1.8mg, Vit. B₂, 3mg; Manganese, 40mg; iron, 20mg; Copper, m3g; Iodine, 1mg; cobalt, 0.2mg; Selenium, 0.2mg' Zinc, 50mg. ME = Metabolizable energy. WSSWAE = White sorghum soaked in wood ash extract.

2.3. Experimental Birds, Design and Management

A total of 144 day-old broiler chicks were obtained from a reputable hatchery, weighed, and randomly assigned to four experimental diets. In a totally randomized design, each treatment was allocated thirty six (36) birds in three (3) replicates of twelve (12) birds each. Before the arrival of the birds, the house was cleaned and disinfected using IZAL. Throughout the trial, the chicks were given access to the treatment diets and water *ad libitum*. The birds were fed experimental starter diets from the first day of brooding till twenty eight (28) days (four weeks), with the finisher phase beginning on the 29th day (fifth week) as shown in the [Tables 1 and 2](#) respectively and lasting for 56th day (eight weeks). Routine medications, vaccination and adequate spaces were provided.

2.4. Data Collection

2.4.1. Performance Quality

During the feeding trial, the broiler chicks were weighed at the beginning of the experiment and then weekly. Weekly weight changes and feed consumption were recorded, and weight increase, feed intake, feed conversion ratio (FCR), and protein efficiency ratio (PER) were determined to evaluate the birds' growth performance. Weight increase was measured by subtracting the final weight from the initial weight. FCR and PER were calculated using the formulae:

$$FCR = \frac{\text{Feed intake (g)}}{\text{Weight gain (g)}}$$

$$PER = \frac{\text{Weight gain / week (g)}}{\text{Protein intake / week (g)}}$$

2.4.2. Apparent Nutrient Digestibility Study

Four birds were selected at random for each replicate and kept separately in a metabolic cage on the last week of the starter and finisher phases (4th and 8th weeks). The selected chicks were allowed three days adaptation period, followed by a five day total collection of droppings on a pre-weighed aluminum foil. The birds were fed a specific quantity of treatment diets for the period. The collected droppings were sun dried and later oven dried at 70°C for 24 hours, bulked and representative samples were taken for proximate analysis according to [8]. Thereafter, the results of the proximate analysis of the test diets and faeces were used to estimate the apparent digestibility of each nutrient as follow;

Apparent Nutrient Digestibility

$$= \frac{\text{Nutrient in feed} - \text{Nutrient in faeces}}{\text{Nutrient in feed}} \times \frac{100}{1}$$

2.4.3. Carcass Traits and Internal Organ Weights

At the conclusion of the 8 weeks feeding trial, birds were starved overnight and their live weight was recorded early morning (7: 00 am) in the following morning, three birds that closely to the mean average weights were selected at random from each replication for carcass analyses. The birds were slain by cutting the jugular vein and bled completely before being de-feathered and their plucked weights were recorded, eviscerated, cut into different parts (head, neck, shanks, thigh, drumstick, back, and breast and wings), weighed, recorded and expressed as percentages of live weight of the birds for evaluation of carcass yield. The gizzard, liver, heart, lungs, kidney, and crop were carefully exercised and blotted free of blood. Each organ weight was measured using a sensitive measuring scale and then related to their body weight.

2.5. Statistical Analysis

Data collected were subjected to one-way Analysis of Variance (ANOVA) by using [9]. Duncan multiple range test of the same software was used to differentiate significant ($p < 0.05$) means between variables [10].

3. Results

3.1. Performance Quality

Broiler performance characteristics during the starter phase as shown in [Table 3](#). Statistical table revealed significantly ($P < 0.05$) effect by the dietary treatments. Birds fed diet T₁ had the highest ($P < 0.05$) average live weight (733.00g) but statistically similar to those fed T₃ (730.16g), while those fed T₂ and T₄ had comparable ($P > 0.05$) values of 707.33 and 718.33 g respectively. Average daily feed intake followed the same pattern with the values of 50.80 and 48.50g/bird, 40.15 and 39.50g/bird obtained in broiler chicken that had T₁ and T₃, T₂ and T₄ respectively and statistically similar to one another. Average daily weight gain was better ($P < 0.05$) in broiler chickens fed T₁ (36.17g/bird) but compared favourably with (36.07g/bird) recorded in birds that fed T₃, followed by 35.65g/bird in T₂ and least (35.26g/bird) in T₄. The feed conversion ratio was better ($P < 0.05$) in broilers chickens fed T₄ (1.35) but compared favourably with 1.36 in T₂ followed by comparable values of 1.44 and 1.40 respectively obtained in

T₃ and T₁. Protein efficiency ratio of broiler chicken was significantly ($P < 0.05$) better in T₂ (3.37) but not significantly

($P > 0.05$) different from 3.37 in T₄, followed by 3.25 in T₃ which compared favourably with 3.24 in T₁.

Table 3. Performance Quality of Broiler Starter Fed Experimental Diets.

Parameters	Inclusion levels of WSSWAE (%)				SEM
	0	25	50	75	
	Dietary Treatments				
	1	2	3	4	
Initial live weight (g/bird)	53.13	53.06	53.01	53.01	0.54
Final live weight (g/bird)	733.00a	718.33b	730.16a	707.33b	28.71
Ave feed intake (g/bird)	50.80a	48.15b	50.50a	47.50b	1.19
Ave weight gain (g/bird)	36.17a	35.65c	36.07a	35.26b	3.37
Feed conversion ratio	1.44a	1.35b	1.40a	1.37b	0.10
Protein efficiency ratio	3.24b	3.37a	3.25b	3.37a	0.13

^{abcde} mean with different superscript along same row shows significant difference ($P < 0.05$)

Ave= Average; SWAS = Sun dried wood ash extract; SME= Standard error of means; WSSWAE= White sorghum soaked in wood ash extract.

The performance quality of broiler finishers given graded levels of sorghum soaked in wood ash extract is shown in [Table 4](#). All parameters studied were significantly ($P < 0.05$) affected by the dietary treatments. The average final body weight was significantly ($P < 0.05$) highest in birds fed T₁ (2180.00 g), but comparable to the value obtained in T₃ (2175.00g) and T₂ (2100.00g) and lowest in T₄ (1990.52g). Similarly, the average daily weight gain was significantly ($P < 0.05$) highest in birds fed T₁ (51.68g), but comparable to those fed T₃ (51.49g/bird) followed by those fed T₂

(48.83g/bird), while birds fed T₄ had the least value (44.87g/bird). The average daily feed consumption was greatest ($P < 0.05$) among birds fed T₁ (93.10g/bird) which is comparable to those fed T₃ (90.10g/bird) and T₂ (87.20g/bird) while birds fed T₄ had the least (85.00g/bird) value but was comparable with T₂ and T₃. Birds fed T₄ had the highest FCR (1.89), followed by those fed T₂ (1.80) which was comparable to T₂ (1.79) and T₄ (1.89) while the least (1.75) FCR was obtained in birds fed T₃ but also comparable to T₂ (1.97). Protein utilization was significantly ($P < 0.05$) better in broiler chickens that consumed T₃ (2.86%) but favourable compared with 2.80 and 2.78% in T₂ and T₁ respectively while the least (2.64%) was recorded in T₄.

Table 4. Performance Quality of Broiler Finisher Fed Experimental Diets.

Parameters	Inclusion levels of WSSWAE (%)				SEM
	0	25	50	75	
	Dietary Treatments				
	1	2	3	4	
Average Final body weight (g)	2180.00a	2100.00a	2175.00a	1990.52b	23.96
Average daily weight (g/bird)	51.68a	48.83b	51.49a	44.87c	2.29
Average daily feed intake (g/bird)	93.10a	87.20bc	90.10ab	85.00d	3.13
Feed conversion ratio	1.08a	1.79b	1.75b	1.89ab	0.14

Parameters	Inclusion levels of WSSWAE (%)				SEM
	0	25	50	75	
	Dietary Treatments				
	1	2	3	4	
Protein efficiency ratio	2.78a	2.80a	2.86a	2.64b	0.22

abcd: Means in the same row with varying superscripts differ significantly ($P < 0.05$), SEM \pm : standard error of mean; WSSWAE= White sorghum soaked in wood ash extract.

3.2. Nutrient Digestibility

Table 5 shows the effect of soaking sorghum in wood ash extract on nutrient digestibility of boiler chickens. The results revealed no significant ($P > 0.05$) difference on digestibility of crude fibre, ether extract and nitrogen free extract (NFE). Dry matter for T1 was significantly higher (92.61%) than the remaining treatment diets, similar trend were observed from T2 and T3, while the least (89.10%) was obtained from T4. Crude

protein values followed the same trend with dry matter. However, Crude fibre and ether extract were not significantly ($P > 0.05$) different, values were (75.5 and 77.29%) in T1, T2 (75.00 and 74.21%), T3 (74.50 and 76.31%), T4 (73.00 and 75.02%) and was decreased with increasing levels of inclusion levels of the test diet. Ash content was ($P < 0.05$) higher (74.88%) in T1 while the least value of 72.22% was noticed from T4. The nitrogen free extract (NFE) was highest ($P < 0.05$) in T1 (89.54%) while the least value of 84.50% was recorded from T4.

Table 5. Nutrient Digestibility of Boilers chickens Fed Graded Level of Sorghum Soaked in Wood Ash Extract.

Parameters (%)	Inclusion Levels of WSSWAE (%)				SEM \pm
	0	25	50	75	
	Dietary treatments				
	1	2	3	4	
Dry Matter	92.61a	92.10bc	92.29b	89.10d	1.05
Crude Protein	75.70a	75.26bc	75.36b	73.70d	0.48
Crude Fibre	75.50	75.00	74.50	73.00	0.77
Ether Extract	77.29	74.21	76.31	75.02	0.82
Ash	74.88a	74.28bc	74.38b	72.22d	0.96
NFE	89.54	88.10	88.50	84.50	1.97

abcd: Means in the same row with varying superscripts differ significantly ($P < 0.05$) SEM: standard error of mean; WSSWAE= White sorghum soaked in wood ash extract.

3.3. Carcass Traits

Results on the carcass traits of boiler finisher fed graded level of sorghum soaked in wood ash extract (Table 6) revealed that final live weight, de-feathered and eviscerated weights as well as relative weight of wings were significantly

($P < 0.05$) affected by the dietary treatments. While dressing percentage, relative weight of head, neck, shanks, drum sticks, breasts, back and thigh were not significantly ($P > 0.05$) affected. Final live weight of bird was highest (2180g/bird) in birds fed T1 and while the least live weight was obtained in broilers placed on T4(1990.00g/bird). De-feathered weight was higher ($P < 0.05$) in broiler chicken placed on T3

(2,165.00g/bird) but similar ($P>0.005$) with T1 (2,160.00g/bird) while T4 (1980.00g/bird) had the least value. Eviscerated weight had similar trend with de-feathered weight, the highest ($P<0.05$) value recorded from boiler chicken fed T3 (2115.00g/bird) followed by T1 (2110.00 g/bird) while the least value (1930.00g/bird) was observed from T4. The dressing percentage ranged from 96.79% to 97.24%, T1 had the highest value of 97.24% while the least value of 96.79% was

obtained from T1. The highest (8.63%) significant ($P<0.05$) wing was observed from T1 while the least (8.27%) was observed from T4. The non-significant ($P>0.05$) gizzard relative weights values of 4.00, 2.93, 3.50 and 3.01% were observed from the birds placed on T1, T2, T3 and T4 respectively. Values of 3.60, 3.75, 4.54, and 3.89% weights were observed from shank placed on T1, T2, T3 and T4 respectively.

Table 6. Carcass Traits and Organs Weight of Broiler Finisher Fed Graded Levels of White Sorghum Soaked in Wood Ash Extract.

Parameters	Inclusion levels of WSSWAE (%)				SEM±
	0	25	50	75	
	Dietary treatments				
	1	2	3	4	
Live Weight (g/bird)	2180.00a	2100.00a	2175.00b	1990.00b	23.96
De-feathered weight (g)	2160.00a	2083.00b	2165.00a	1980.00bc	12.50
Eviscerated weight (g)	2110.00a	2033.00b	2115.00a	1930.00bc	1.05
Dressing (%)	96.79	96.81	97.24	96.99	0.43
Cut parts (%)					
Head	2.51	2.47	2.47	2.84	0.20
Neck	4.72	4.29	4.78	4.12	0.17
Shank	3.60	3.75	4.54	3.89	0.12
Drumstick	10.62	10.09	10.34	9.89	0.24
Breast	20.24	17.95	19.83	17.86	0.33
Back	16.22	15.51	16.00	15.00	0.28
Thigh	10.48	10.36	10.38	9.89	0.16
Wing	8.63a	8.35ab	8.40a	8.27b	0.24
Organ weights (%)					
Heart	0.57	0.51	0.73	0.63	0.01
Gizzard	4.00	2.93	3.50	3.01	0.09
Liver	2.79	2.52	2.76	2.24	0.05
Intestine	4.55	4.99	5.07	5.37	0.05
Lungs	0.61	0.63	0.72	0.68	0.03

ab: Means in the same row with varying superscripts differ significantly ($P<0.05$)

SEM: standard error of mean; WSSWAE= White sorghum soaked in wood ash extract.

4. Discussion

The results showed that birds fed 0% sorghum (control diet) had the highest live weight, feed intake, and weight gain at

both phases of the study. At starting phase of the study, best (least) feed conversion ratio (FCR) was noticed from T2 (25%) while T1 (control) showed also the least at finishing phase of the study. This study indicate that birds at T2 (starting phase) and T1 (finishing phase) birds were converted feed into body

muscle than other treatment groups. This suggest that replacing maize with soaked sorghum in wood ash extract may negatively impact broiler performance at both starting and finishing phases of the study, except at 0% level of the inclusion. The reduced performance at higher sorghum levels could be due to anti-nutritional factors like tannins in sorghum, which can reduce nutrients digestibility and utilization [11]. Soaking sorghum in ash may not have been sufficient to eliminate these anti-nutritional factors. Similar studies have reported decreased performance in broilers fed sorghum based diets [12]. The fluctuation in results at 25, 50 and 75% replacement levels may be due to variation and gut health.

Dry matter content was significantly ($P < 0.05$) higher in the control diet (T1) than all test diets, indicating a lack of comparability across treatments. This aligns with [13], who reported significant impact of varying maize-sorghum levels on the apparent digestibility of dry matter, protein and ash in broiler finisher finishers. The lower dry matter, crude protein and ash values observed in the test diets containing 25, 50 and 75% sorghum, relative to the 0% (control), would be as a result of anti-nutrients (tannin) content of the sorghum. This study suggests that soaked sorghum in ash water was not enough to reduce anti-nutrients in the test ingredient to the minimum level that broilers can tolerate to improve availability of the nutrients. This shown that ash water used as medium to reduced anti-nutrients content of sorghum did not reduced the level of the ANFS to the level birds can tolerate therefore, the nutrient profiles observed from this study was inferior to those of the control group. Moreover, sorghum may reveal relatively lower digestibility coefficients for starch compared to maize. Ingredients with such characteristics, characterized by limited starch digestion, tend to reside in the small intestine of birds for prolonged periods [14] The cut parts and organ weights of finishing broiler chickens in this study showed no significant differences in dressed percentage, head, neck, shank, heart, drumstick, breast, back, spleen, back, wings, liver, gizzard, lung and intestine across treatment groups. The similar organ weights suggest that the birds had adequate nutrients to support normal organ function and development, as insufficient amino acid supply can inhibit tissue and organ [15]. This implies that the dietary treatments did not adversely affect organ development or function.

5. Conclusion

Based on the outcome of this finding, white sorghum soaked in the wood ash extract can be replaced maize up to 50% inclusion level without negative effect on the performance, apparent nutrient digestibility, carcass traits and organ weights of the broiler finisher chickens. Therefore, 25% inclusion level of white sorghum soaked in wood ash extract is recommended to substitute maize in the broiler chickens nutrition.

Abbreviations

Ave	Average
CRD	Completely Randomized Design
DMRT	Duncan Multiple Range Test
FCR	Feed Conversion Ratio
Kcal/kg	Kilocalories per Kilogramme
ME	Metabolizable Energy
N	North
NE	North East
PER	Protein Efficiency Ratio
SEM	Standard Error of Mean
T1 to 4	Treatments 1 to 4
WSSWAE	White Sorghum Soaked in Wood Ash Extract

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Bamgbose Adeyemi Mustafa: Methodology, Supervision

Data Availability Statement

The data is of this finding will be available from the corresponding author upon request.

Conflicts of Interest

There was no conflict of interest throughout this study.

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