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Growth performance and nutrient digestibility of broiler chickens fed wood ash-based diets

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Abstract

This study was conducted to determine the growth performance and nutrient digestibility of broiler chickens fed wood-ash based diet. A total of 120 broiler chickens were randomly allocated to four treatments in the completely randomized design. Treatment 1 was the control while Treatments 2, 3, and 4 were Neem ash (NTA), Shea butter ash (SBA) and Locust bean ash (LBA), respectively. Each treatment has three replicates and ten birds per replicate. Data on growth rate, live weight, feed intake and mortality were collected while feed conversion ratio was calculated. Apparent dry matter, crude protein, crude fibre, ether extract and nitrogen free extract retention were also determined. All data collected were analyzed using one-way analysis of variance. Starter phase results shows that birds on SBA ash had the highest final weight (366.00 g), body weight gain (173.71 g) and feed intake (546.03 g) and were significantly higher ($p<0.05$) than the control. At the finisher phase, all ash treatment had higher ($p<0.05$) final, daily weight gain and better ($p<0.05$) feed conversion than the control dietary. The digestibility results indicated birds on LBA diet had the highest crude fibre and ash content. The study showed that wood ash influenced growth performance and nutrient retention of broiler chickens. Chickens on ash-based diets performed better that the control at the finisher phase.

Keywords: Neem, Shea butter, locust, ash

Introduction

Broiler chicken production plays a major role in food security for the rapidly increasing human population. Their short production cycle, and high biomass per unit of agricultural land are particularly attractive for the production systems (Talpur *et al.,* 2012). The present broiler chicken has been genetically selected for rapid growth high feed efficiency, increased muscle mass and heavier breast weight (Garner *et al.,* 2002). These genetic potentials cannot be fully utilized or expressed if the right or optimal nutrient is not provided. This implies that animals should be adequately provided with the right kind of nutrients for the maximum expression of their genetic endowment. Modern broiler strains have very rapid growth for which their requirement for oxygen, nutrients, enzymes, hormones, and growth factors has increased in comparison to earlier strains (Onimisi *et al.,* 2014). Additionally, the supportive systems are challenged to maintain structure, function, and to satisfy demands of tissues during growth. Thus, it is extremely important that their metabolism and bones support the increasingly heavier body weight and muscle mass that are obtained in younger ages as genetic selection for growth progresses. Mineral imbalance, particularly of calcium (Ca) is one of the problems responsible for economic losses to poultry industry (Talpur *et al.,* 2012). Maintenance of calcium and phosphorus (P) ratio at 1:0.5 is essential for performing various functions in the body. Generally, minerals are responsible for proper osmo-regulation in addition to maintaining nervous and muscular coordination and blood coagulation in the animal's body (Adamu *et al.,* 2012). Calcium is the mineral with the highest concentration in the body of poultry, consisting of 1.5 % of its body weight (Pelicia *et al.,* 2011). Calcium plays two important physiological roles in the poultry. First, it provides the structural strength of the poultry skeleton by the formation of calcium salts. Second, it plays

vital roles in many of the biochemical reactions within the body via its concentration in the extracellular fluid (Vahid *et al.,* 2014). Deficiency of calcium, for instance, leads to development of rickets, tibial dyschondroplasia (TD), increased chick's mortality and reduced body weight in older birds (Underwood and Suttle, 2001). Supplying diets with adequate calcium levels is essential for bone formation to support high growth rates in broilers (Costa *et al.,* 2009). Supporting muscles and protects delicate organs and tissues, including the bone marrow, but is also jointed to allow movement, and is malleable to allow growth. There are several studies on the calcium requirements of broilers (Alveset *al.,* 2002; Araujo *et al.,* 2002; Sa *et al.,* 2004; Santos *et al.,* 2011; Tancharoenrat and Ravindran, 2014), out of which some have evaluated calcium sources, such as calcium bicarbonate (Alves *et al.,* 2002), calcium citrate-malate (Henry and Pesti, 2002), and calcitic and dolomitic limestone (Sa *et al.,* 2004). However, there are limited studies on the use of firewood ash as a calcium source for broilers at the finisher phase. The objective of this study was to evaluate effect of firewood ash-based diet on the performance and nutrient digestibility of broilers.

Materials and methods

The study was carried out in the poultry section of the Teaching and Research Farm of the Department of Animal Production, Federal University of Technology, Gidan Kwano Campus, Minna, Niger state. Minna is located between latitude 4° 30 and 9° 37 North and longitude 6°33 and 06°45 East with an altitude of 1475 m above sea level (Niger state Agricultural Development Project; NSADP, 2009). The area falls within the Southern Guinea Savannah vegetation zone of Nigeria with average annual rainfall of between 1100 and 1600 mm and a mean temperature of between 21° and 36.5° C (Ovimap, 2016).

Wood ash, feed ingredients and dietary preparation

Fresh *Azadirachta indica* (Neem), *Parkia biglobosa* (African locust bean) and *Vitellaria paradoxa* (Shea butter tree) woods were collected from within the Gidan Kwano campus. This was because of their abundance, availability and accessibility. The woods including the barks collected were broken into pieces to hasten the drying process and sun dried before burning to ashes. The woods were separately burnt in open air. Ashes produced were collected in plastic bags and taken to the laboratory for storage and subsequent analysis to determine their mineral contents. Use of fuel for burning was avoided to minimize contamination. The ingredients used in the formulation of the feed were purchased from the Minna central market (Kure), Niger state. Four experimental diets were formulated and designated as control, Neem ash (NTA), Shea butter ash (SBA) and Locust bean ash (LBA), respectively. Diet 1 was designated as the control without wood ash while diets 2, 3 and 4 contained 2 % NWA, SWA and LWA, respectively. The wood ash in diets 2, 3 and 4 were used to replace limestone and bone meal which were used in the control diet. The diet compositions of the two phases of the work are shown in Table 1.

The initial live weights of the birds were taken at the beginning of each experiment and at weekly intervals thereafter. Feed intake, weight gain and feed conversion ratio were determined according to the procedures of McDonald *et al.* (2011).

Nutrient retention studies

This was conducted on the 23rd and 49th day of the experiment using total collection technique according to the procedure of Aduku and Olukosi (1990). Two birds were randomly selected from each replicate and kept in the constructed metabolic cages for seven days. Activities involved feeding the broilers with known quantity of feed after allowing three days of acclimatization, followed by four days total faecal collection from each replicate. Faeces were bulked thoroughly mixed and sub-sample taken at the end of the faecal collection. The faeces were weighed and oven dried at 85 °C until a

constant weight was obtained, followed by grounding to a size that could pass through a 2 mm sieve for proximate analysis. The difference between the nutrients in the Feed and faecal sample multiply by 100 gives the apparent digestibility coefficient of the feed.

Table 1: Ingredients and chemical composition of experimental diet (%)

	Starter phase				Finisher Phase			
Ingredients	Control	NTA	SBA	LBA	Control	NTA	SBA	LBA
Maize	50.00	50.00	50.00	50.00	62.00	62.00	62.00	62.00
Maize bran	9.00	9.00	9.00	9.00	5.00	5.00	5.00	5.00
GNC	26.00	26.00	26.00	26.00	20.00	20.00	20.00	20.00
Fish meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
SBM	8.00	8.00	8.00	8.00	6.00	6.00	6.00	6.00
Bone meal	2.00	1.00	1.00	1.00	2.00	1.00	1.00	1.00
Limestone	2.00	1.00	1.00	1.00	2.00	1.00	1.00	1.00
Wood ash	0.00	2.00	2.00	2.00	0.00	2.00	2.00	2.00
Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Premix	0.25	0.25	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	0.25	0.25
Total	100	100	100	100	1 00	100	100	100
Total	100	100	100	100	1 00	100	100	100
CP (%)	22.35	22.35	22.35	22.35	19.39	19.39	19.39	19.39
ME (Kcal/Kg)	2934.00	2934.00	2934.00	2934.00	2939.00	2939.00	2939.00	2939.00

NTA: Neem tree ash; STA: Shea butter tree ash; LTA: Locus beans tree ash
CP: Crude protein; ME: Metabolizable energy

Nutrient digestibility =
Nutrient in feed – Nutrient in faeces x 100
Nutrient in feed

Chemical analysis

Feed and faecal sample of the diet were oven dried until a constant weight is attained. Both the diet as well as the faeces collected from each animal per replicate was chemically analysed according to AOAC (2000) procedure.

Statistical analysis

All data collected on growth performance and nutrient digestibility were subjected to one-way analysis of variance (ANOVA) using SAS version 9.2 (SAS, 2013). Where means were significantly different at 5% ($p<0.05$), they were separated using Duncan's Multiple Range Test.

Results and discussion

The results showed that at the starter phase the dietary treatment had effect on the final weight, body weight gain and feed intake (Table 2). The wood ash treatments showed superior results that the control diets with the birds on STA diet performed better ($P<0.05$) than the control treatment. The present results indicate that the final weight had no particular trend. The results showed that the final weight is higher in birds fed STA compared to other treatment. It also indicated that all experimental treatments had similar value compared to the control. However, birds on STA diet had the highest final weight gain. The present result is in agreement with the findings of Atuhene (1998) who observed that inclusion of Shea butter cake (SBC) up to 2.5% in growing broiler chicken diet had no adverse effect on the growth performance. Feed intake had similar trend with body weight gain. The results indicate that birds on STA had higher performance in term of feed intake and weight gain. However, all dietary treatments performed better than the control. The high weight gain recorded could be as a result of feed intake. The

observed decrease in weight gain in the control diet could be attributed to the fact that weight gain in broiler is directly related to feed intake, the quantity of feed as well as how efficiently the bird utilized it. The differences between the experimental diets and the control may be attributed to different source of mineral and the medicinal properties of the wood-ashes. The higher good performance of the experimental diets is in agreement with report of Saccomani *et al.* (2016) who started that firewood ash may be used as calcium source in replacement of limestone in broiler diet at starter phase (1 to 21 days of age) as it had similar performance and bone development as limestone.

Similarly, at the finisher phase, dietary treatments had effect (P<0.05) on the final and daily body weight gain.

Table 2: Effects of wood-ash-based diet on growth performance of broiler chicken at starter phase

Parameters	Control	NTA	SBA	LBA	SEM
Initial weight	57.67	61.00	62.00	63.00	1.18
Final weight	283.67^{b}	330.00^{ab}	366.00^{a}	318.67^{ab}	12.29
Body weight gain	129.33^{b}	153.90^{ab}	173.71^{a}	144.52^{ab}	6.67
Feed intake	447.27^{b}	535.42^{a}	546.03^{a}	498.95^{ab}	15.62
FCR	3.46	3.48	3.27	3.50	0.08
Mortality	1.11	0.00	4.44	4.44	0.83

ab: mean with different superscripts along the row are significantly different at p<0.05, NTA: Neem tree ash; STA: Shea butter tree ash; LTA: Locus beans tree ash , SEM: Standard mean error; FCR: Feed conversion ratio

However, unlike the starter phase, dietary treatment had effect on the feed conversion ratio (Table 3). All the birds on the wood ash-based diets had similar results. Their results were better than those of birds on the control diet. The better performance might be attributed to better absorption of the mineral present in the wood ashes. Okoli *et al.* (2014) indicated that minerals in the ash are easily absorbed by the animal. Contrary to the finding in the present study. Onimisi *et al.* (2014) observed no difference in the growth performance of birds fed different calcium sources. This might be because the authors worked on only calcium and not with the other minerals present in the wood ash such as phosphorus, potassium, aluminium, magnesium, sodium, boron, copper, molybdenum, sulphur and zinc. Furthermore, the similarity in the results of the different wood ashes used might imply that any of the ashes can be substituted for the other and they contained similar minerals. From FCR results, birds on shea butter ash had the highest FCR, the reasons is not well known; it, however, could be due to the fact that shea butter tree is rich in saturated and unsaturated fatty acids with a large fraction of unsaponifiable triglycerides, oleic acid, triterpene alcohols, vitamin E, provitamin A and allantoin. The results of FCR agreed with that of Okoli *et al.* (2014), who reported very high feed efficiency in pullets fed plantain ash supplemented diet.

Table 3: Growth performance of broiler chicken fed diets containing different wood ash-based diets at the finisher phase

Parameter	NOA	NTA	SBA	LBA	SEM
Initial weight (g)	286.33	330.00	276.67	316.67	11.43
Final weight (g)	959.17^{b}	1238.15^{a}	1197.38^{a}	1155.95^{a}	37.86
Body weight gain (g)	24.03^{b}	32.43^{a}	32.88^{a}	29.97^{a}	1.27
Average daily Feed intake (g)	88.41	95.04	92.63	93.76	2.24
FCR	3.68^{b}	2.93^{a}	2.84^{a}	3.13^{a}	0.12
Mortality (%)	13.33	13.33	16.67	16.67	3.59

ab=means on the same row bearing different superscript are significantly different (p<0.05), NOA=No ash (control); NTA=Neem tree ash ; SBA=Shea butter ash, LBA=Locust bean ash; FCR=feed conversion ratio ; SEM=Standard error of mean

In term of nutrient retention (Table 4 and 5), birds on control, NTA, and LTA diets had higher (P<0.05) dry matter, ether extract digestibility compared to birds on STA diet at the starter phase. However, at the finisher phase birds on locust bean ash had better crude fibre and ash content digestibility, it might be due to the fact that locust bean tree is very rich in protein, vitamin C, retinol, calcium, crude fibre (Gernah *et al.,* 2005; Ogundun, 2007). It could be because of the elevated mineral content present in locust bean wood ash as compared to shea butter wood ash (Alves *et al*. 2002). Storage, handling, processing procedure and anti-nutritional factor, combustion system and handling of the wood may also be contributing factors (Okoli *et al.,* 2014). The results of growth performance showed that the wood ash-based diets had effect on the daily weight gain, final weight and feed conversion ratio (FCR) of broiler chickens at finisher phase with birds on the wood ash diets performing better than the control. Wood ash-based diets had effect on ash and crude fibre, with the birds of locust bean ash having high digestibility.

Table 4: Effects of wood-ash-based diets on nutrient retention of broiler chicken at starter phase

Parameters	Control	NTA	SBA	LBA	SEM
Dry matter	64.53^{a}	65.03^{a}	55.96^{b}	65.73^{a}	1.71
Ether extract	76.45^{a}	75.59^{a}	57.41^{b}	70.23^{b}	3.18
Ash	15.69	20.73	4.29	19.15	3.86
Crude protein	66.42	63.72	53.83	64.56	2.42
Crude fibre	23.63	28.15	20.90	23.33	1.64
NFE	76.47	75.62	80.55	78.86	0.88

ab: mean with different superscript are significantly different (p<0.05); NTA: Neem tree ash; LTA: Locust bean tree ash; STA: Shea butter tree ash; NFE: Nitrogen free extract

Table 5: Effects of wood-ash-based diets on nutrient retention of broiler chickenat the finisher phase

Parameter	NOA	NTA	SBA	LBA	SEM
Dry matter (%)	90.74	90.88	90.79	91.44	0.21
Crude protein (%)	91.04	93.12	92.46	90.94	0.62
Crude fibre (%)	38.62^{c}	58.81^{b}	53.79^{b}	79.87^{a}	5.63
Ether extract (%)	92.63	92.59	92.11	93.59	0.67
Ash content (%)	65.80^{ab}	64.05^{ab}	52.13^{b}	69.56^{a}	2.96
NFE (%)	97.61	95.35	96.90	96.65	0.44

abc=means on the same row bearing different superscript are significantly different at (p<0.05) NOA=No ash (control)
NTA=Neem tree ash; SBA=Shea butter ash; LBA=Locust bean ash; NFE=Nitrogen free extract; SEM=Standard error of mean

Conclusion

The study showed that wood ash influenced growth performance and nutrient retention of broiler chickens. Chickens on ash-based diets performed better that the control at the finisher phase. From the results of this study, it can be recommended to both small and large scale farmers that any of these wood ash sources (neem tree, shea butter tree and locust bean tree) could be an effective substitute for feed lime stone and bone meal in supplying minerals in poultry diets since wood ash is rich in calcium and easily absorbed, it can be used also to supplement deficiencies in diets that contain ingredients known to be deficient in calcium.

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