



Effect of In-Feed Inclusion of Biochar from Mixture of Wood and Empty Palm Fruit Bunch on Growth Performance of Broiler Chickens

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Abstract

A total of 45, four weeks (28 days) old, unsexed Arbor acre (broiler) chickens were used to determine the growth performance of broiler chickens on feed substitute of biochar produced from pyrolysis of wood and empty palm fruit bunch mixture at the finisher phase (29 – 56 days). The birds were randomly assigned to three feed substitution levels (0, 3 and 6% biochar Kg⁻¹) of the whole diet with fifteen (15) birds per treatment (three replicates of five birds each), in a completely randomized design for four weeks. The final body weight (FBW) and average daily feed intake (ADFI) of the birds showed no significant ($P > 0.05$) differences among the treatments (T1, T2 and T3). However, the average feed intake in the biochar supplemented treatments (T2; 164.30 g and T3; 165.80 g) were higher than the control (T1; 160.40 g). Conversely, the average daily weight gain of broilers on the 3 and 6% biochar kg⁻¹ supplemented diets recorded significant decrease compared with the 0% biochar (T1) group. There was no significant difference between T2 (68.33 g) and T1 (70.48 g) and it also did not differ from T3 (66.33 g). The FCR significantly increased from 2.27 (T1) to 2.40 and 2.50 in T2 and T3 respectively. On cumulative feed intake, the 3% (T2) biochar Kg⁻¹ was significantly ($P < 0.05$) higher than 0% as well as the 6% biochar Kg⁻¹ diet. On the overall, it can be inferred that while 3% biochar kg⁻¹ was tolerable, an inclusion up to 6% depressed production parameters.

Keywords: Biochar, wood, empty palm fruit bunch, Broiler chicken, Performance

Introduction

Notable residues deposited in poultry meat and eggs (Owusu-Doubreh *et al.*, 2023) due to constant use of chemical feed additives to improve production parameters (Hafez and Attia, 2020) have rendered man and the environment vulnerable to the harmful effects of these residues when poultry products are consumed or carelessly deposited in the environment (Bolaji *et al.*, 2019). Therefore, cost-effective, users and environmentally friendly alternatives to the use of these chemical feed additives are advocated. One such alternative is in-feed inclusion of biochar (Lao and Mbega, 2020).

The International Biochar Initiative defined biochar as “the solid material obtained from the thermochemical conversion of biomass in an oxygen-limited environment” (Omar, 2021). Anita (2009) and Almuth (2011) indicated that the process of biochar production from biomass yield two main products, carbon (50%) and biofuel, often syngas which can be employed in several energy application processes. The physicochemical properties of biochar depend on feedstock materials and the thermochemical process (Webber and Quicker, 2018). Lehmann and Joseph (2009), also indicated that depending on the feed materials and pyrolysis condition, biochar

contains (on a w/w basis) 40 – 80% carbon, 0.1 – 0.8% nitrogen, 1 – 2% potassium, 5 – 6% calcium and can have an ion exchange capacity between 25 and 150 cmol⁺/kg. Biochar are often used for carbon sequestration and as a soil ameliorant for improving soil water holding capacity and/or ion exchange capacity and as a recalcitrant carbon, mineral fertilizer, (Lehmann and Joseph, 2009; Wolf *et al.*, 2010; Hagemann *et al.*, 2018; Lehmann and Joseph, 2015).

Biochar is not per se a nutrient but added to feeds to enhance the quality of the nutrients in the feeds thereby promoting digestion, improve animal health, increased feed efficiency, energy absorption through the feed and thus the productivity of the bird, fish and other animals. As an adsorbent, it locks up organic toxins and other compounds such as dioxin, glyphosate mycotoxins in the digestive tract which expectedly would lead to lower mortality rate in poultry, fish and ruminant animals (Gerlach and Schmidt, 2012). Biochar has been produced from different materials and utilized as feed substitute, such as coconut shell (Jiya *et al.*, 2013), Maize cobs and *Canarium schweinfurthii* Engl. Fruit seeds (Kana *et al.*, 2011) oak, maize cob, *canarium* seed, coconut shell, and locally available wood (Prasai, 2013).

The study was conducted to determine the growth performance of broiler chickens on feed substitute of biochar produced from pyrolysis of a mixture of wood and empty palm fruit bunch (EPFB).

Materials and Methods

Experimental Location

The study was carried out at the Poultry Unit of the Department of Animal Production, Leventis Foundation, Kano State Agricultural Training School, Panda, Kano State, Nigeria. Kano State is located in the Northern part of

Nigeria. Panda is in the Sahel Savannah Vegetation bounded by Latitude 12⁰N and 14⁰N (Karkana and Mohammed, 2018)

Source of Birds, Housing and Experimental Design

Forty five (45), four weeks (28 days) old unsexed arbor Acre (broiler) chickens that were reared from day-old randomly assigned to three treatments with 15 birds each, and replicated three times in a completely randomized design. Each replicate contained 5 birds. The duration of the experiment was four weeks (29 – 56 days). The birds were moved a week prior to the commencement of the experiment from the brooding/starter house to the experimental pens for acclimation. The birds were assigned to wood shavings littered floor pens of 1.5 m² (1.5 m × 1.0 m) per 5 birds. Standard management practices were employed in the management of the chickens. Water and feed were provided *ad libitum*.

Experimental Diets

The biochar used for the supplementation was produced from incomplete pyrolysis of a mixture of wood and empty palm fruit bunch (EPFB) in a pyrolytic kiln. Dietary treatments included a control group with diet having 0% biochar kg⁻¹ (T1), and two groups with diets supplemented with 3% (T2) and 6% biochar kg⁻¹ (T3). The control group (0% biochar) was fed only the standard commercial broiler finisher crumble ration (Livestock Feeds, Nigeria) with the nutrient composition presented in Table 1, while T2 and T3 were replaced accordingly.



Table 1: Nutrient content of the commercial diet

Nutrients	Composition (%)
	Finisher
Crude Protein (min.)	17.00
Crude Fat (Min.)	4.00
Crude Fibre (Max.)	5.00
Calcium (Min.)	0.85
Average Phosphorus (Min.)	0.42
Lysine (Min.)	0.92
Methionine (Min.)	0.40
Metabolizable Energy (Min.)	3,000kcal/Kg

Evaluation of Production Parameters

The initial weights of the birds were taken at the beginning of the experiment, and thereafter on a weekly basis to determine their growth response and average body weight (ABW) together with average weight

gain and feed conversion ratio (FCR) were estimated on a weekly basis after measuring feed intake upto the end of the study. Feeds were weighed on daily basis, and leftovers weighed on daily basis to obtain the feed intake. These parameters were estimated as follows:

$$\text{Average daily feed intake, ADFI (g/bird/day)} = \frac{\text{Feed Intake Cumulative}}{\text{No. of Birds} \times \text{No. of days}}$$

$$\text{Average daily weight Gain, ADWG (g)} = \frac{\text{Final weight} - \text{initial weight}}{\text{No. of Birds} \times \text{No. of days}}$$

$$\text{Feed Conversion Ratio (FCR)} = \frac{\text{Average daily feed intake, ADFI (g)}}{\text{Average daily weight gain, ADWG (g)}}$$

Statistical Analysis

All data generated were subjected to analysis of variance according to the following experimental model; $Y_i = \mu + T_i + \epsilon_i$

Where Y_i = observed dependent variable; μ = overall mean; T_i = fixed effect of treatment (i = control Vs biochar); and ϵ_i = residual error.

performed using Duncan Multiple Range Test at 95 degrees confidence limit, and differences between treatment means were considered to be significant at ($P < 0.05$), while non-significant ($P > 0.05$) means were designated with the same superscript.

Data analyses were performed using GenStat (General Statistic) version 20, a statistical software tool produced by VSN International UK. Pairwise comparison of means was

Results

Effects of Different Dietary Levels of Biochar on Growth Performance of Finisher Broiler Chickens (29-56 days)

The initial live weight of birds indicated statistical similarity ($P>0.05$) as shown in Table 2. Within the experimental period, the final body weight (FBW) and average daily feed intake (ADFI) of the birds showed no significant ($P>0.05$) differences among the treatments (T1, T2 and T3). Numerically however, the average daily feed intake in T2

(164.30 g) and T3 (165.80 g) were higher than the T1 (160 g).

The average daily weight gain of broilers on the 3 and 6% biochar supplemented diets recorded significant decrease compared with the 0% biochar (T1) group (Table 2). Nevertheless, T2 (68.33 g) compared statistically with T1 (70.48 g) as well as T3 (66.33 g). The FCR significantly increased from 2.27 (T1) to 2.40 and 2.50 in T2 and T3 respectively.

Table 2: Effects of Diets containing Different Dietary Biochar on Growth Performance of Finisher Broiler Chickens (29-56 days)

Parameters	Biochar replacement levels			P-value	±sem
	T1 (0%)	T2 (3%)	T3 6%		
Initial Body Weight (g)	1186 ^a	1208 ^a	1171 ^a	0.70	30.40 ^{ns}
Final Body Weight (g)	3160 ^a	3121 ^a	3028 ^a	0.14	40.20 ^{ns}
Ave Daily Feed Intake (g)	160.40 ^a	164.30 ^a	165.80 ^a	0.28	2.18 ^{ns}
Ave Daily Weight Gain (g)	70.48 ^a	68.33 ^{ab}	66.33 ^b	0.08	1.05*
Feed Conversion Ratio	2.27 ^b	2.40 ^a	2.50 ^a	0.01	0.03*

^{ab}Means with different superscripts differ significantly ($P<0.05$), ns =not significant, *= $P<0.05$

The effect of diets containing different dietary biochar on weekly growth performance parameters such as average weight gain (AWG), average daily weight gain (ADWG), average feed intake (AFI) and feed conversion ratio (FCR) of finisher broiler chickens is shown in Table 3. AWG of the birds showed no significant ($P>0.05$) differences among treatments at weeks 5, 6 and 7. It however indicated statistical difference at week 8 with significant decline of the 6% supplementation group (T3) by 5.88% of the control group (T1). Apart from the week 5, the Average Feed Intake (AFI) reflected no significant differences among treatments. T2 and T3 (with comparable values) indicated significantly higher feed

conversion ratio (FCR) at week 8 of the feeding trial.

The weight trend of broilers on diet containing different dietary biochar during the entire finisher phase (29-56 days) showed consistent growth of the birds with experimental weeks. While the birds on the control diet (0% biochar) showed relatively highest live weight, this was closely followed by T2 (3% biochar) and T3 (6% biochar) was least in live weight value.

Discussion

The result of the current investigation (3 and 6 % supplementation of Biochar) did not demonstrate the potential of biochar as feed supplement in increasing weight gain and/or

for improving feed conversion as reported by some previous workers. The findings contradict the report of Kutlu *et al.* (2001), Kana *et al.* (2011) and Jiya *et al.* (2013) who found increased daily weight gain and higher final body weight for broilers fed diets amended with 20g/kg – 60g/kg. Nevertheless, the outcomes of the study were in agreement with those of Odunsi *et al.* (2007), Kana *et al.* (2011) and Jiya *et al.* (2013) who had

reported that from 2% and higher levels of inclusion, dietary biochar is capable of depressing growth rates and final body weights of broiler chicken. The result observed in the current study also corroborates that of Evans *et al.* (2015) who reported that inclusion of poultry litter biochar (PLB) at inclusion rate of 6.2 – 6.9% resulted in decreased broiler (Cobb 500) live weight gain.

Table 3: Effects of Diets containing Different Levels of Dietary Biochar on Weekly Growth Performance of Finisher Broiler Chickens (29-56 days)

PARAMETERS	WEEK	BIOCHAR REPLACEMENT LEVELS			P-Value	±SEM
		T1 (0%)	T2 (3%)	T3 6%		
AWG (g)	5	469.30 ^a	447.30 ^a	420.70 ^a	0.16	15.48
	6	916.10 ^a	906.70 ^a	860.70 ^a	0.41	29.10
	7	1451.00 ^a	1400.00 ^a	1384.00 ^a	0.46	37.40
	8	1973.00 ^a	1913.00 ^{ab}	1857.00 ^b	0.08	29.30
ADWG (g)	5	67.05 ^a	63.91 ^a	60.09 ^a	0.16	2.21
	6	65.44 ^a	64.76 ^a	61.48 ^a	0.41	2.08
	7	69.09 ^a	66.68 ^a	65.89 ^a	0.46	1.78
	8	70.48 ^a	68.33 ^{ab}	66.33 ^b	0.08	1.05
AFI (g/bird)	5	933.70 ^b	956.00 ^a	939.70 ^b	0.004	2.94
	6	1058.00 ^a	1095.00 ^a	1095.00 ^a	0.25	16.10
	7	1254.00 ^a	1243.00 ^a	1250.00 ^a	0.80	10.86
	8	1374.00 ^a	1370.00 ^a	1356.00 ^a	0.41	9.00
AFIC (g/bird)	5	933.70 ^b	956.00 ^a	939.70 ^b	0.004	2.94
	6	1992.00 ^a	2051.00 ^a	2035.00 ^a	0.11	16.93
	7	3246.00 ^a	3295.00 ^a	3285.00 ^a	0.39	24.50
	8	4492.00 ^a	4597.00 ^a	4642.00 ^a	0.28	60.60
ADFI (g/bird/day)	5	133.40 ^b	136.60 ^a	134.20 ^b	0.004	0.42
	6	142.30 ^a	146.50 ^a	145.40 ^a	0.11	1.21
	7	154.60 ^a	156.90 ^a	156.40 ^a	0.38	1.17
	8	160.40 ^a	164.20 ^a	165.80 ^a	0.28	2.16
FCR	5	1.99 ^a	2.15 ^a	2.24 ^a	0.17	0.08
	6	2.18 ^a	2.26 ^a	2.37 ^a	0.23	0.07
	7	2.24 ^a	2.35 ^a	2.38 ^a	0.30	0.06
	8	2.27 ^b	2.40 ^a	2.50 ^a	0.01	0.03

^{ab}Means with different superscripts differ significantly (P<0.05). AWG = average weight gain; ADWG = average daily weight gain; AFI = average feed intake; AFIC = average feed intake cumulative; ADFI = average daily feed intake; FCR = feed conversion ratio; T1 = 0% biochar; T2 = 3% biochar; T3 = 6% biochar



Biochar being a feed additive is not per se a nutrient but added to feeds to enhance the quality of the nutrients in the feeds thereby promoting digestion, improve animal health etc. This could result in diminished nutrient value by dilution of the feed in terms of energy and protein content, if applied at a high dose. This can be substantiated by the numerically higher feed intake observed in the biochar included treatment groups; as birds tend to eat to satisfy their energy need. Therefore, the dose of inclusion could have accounted for the divergent reports among workers with biochar in-feed. For example, Jiya *et al.* (2013) reported that the broilers fed activated coconut shell charcoal (unspecified pyrolysis conditions) had significant

References

- Almuth, E. (2011). Biochar a climate solution. International Biochar Initiative. <http://WWW.biochar-international.org>. sourced August 20, 2023.
- Anita (2009). The basics of biochar; Science, Technology, Environment and Resource section. Biochar Science Network (WWW.biochar-science.net). Source August 7, 2023.
- Bolaji O., Okhale, O.E. and Bello-Onaghise, G. (2019). Effects of Water Blends of Three Nigerian herbs on Performance and Some Blood Parameters of Broiler Starter Chickens. *Journal of Soil Science and Plant Physiology* (pubtexto.com) 1(1):101 <https://doi.org/10.36266/JSSPP/101>
- Dim, C.E., Akuru, E.A., Egom, M.A., Nnajofofor, N.W., Ossai, O.K., Ukaigwe, C.G. and Onyimonyi, A.E. (2018) Effect of dietary inclusion of biochar on growth performance, haematology and serum lipid profile of broiler birds *Agro Science* 17(2):8 – 16 DOI: <https://dx.doi.org/10.4314/as.v17i2.2>
- Evans, A. M., Loop, S. A. and Moritz, J. S. (2015). Effect of poultry litter biochar diet inclusion on feed manufacture and 4- to 21- d broiler performance. *Journal of Applied Poultry Research*. 24:380 -386.
- Gerlach, H. and Schmidt, H.P. (2012). Biochar in Poultry Farming. *Ithaka Journal* 1:262-264
- Hafez, H.M. and Attia, Y.A. (2020). Challenges to the poultry industry: current perspectives and strategic future after the COVID-19 outbreak. *Frontiers in Veterinary Science* 7: 516. DOI: <https://www.doi.org/10.3389/fvets.2020.00516>

- Hagemann, N., Spokas, k., Schmidt, H-P., Kagi, R., Bohler, M. and Bucheli, T. (2018). Activated biochar and charcoal: Linkages and synergies across pyrogenic carbon's ABCs, Water. 10:182 10-3390/w1002018224.
- Jiya, E.Z., Ayanwale, B.A., Ijaiya, A.T., Ugochuku, A. and Tsado, D. (2013). Effect of activated coconut shell charcoal meal on growth performance and nutrient digestibility of broiler chickens. *British Journal of Applied Science and Technology*. 3(2):268-276.
- Kana, J.R., Tegua, A., Mungfu, B.M. and Tchoumboue, J. (2011). Growth performance and carcass characteristics of broiler chicken diets supplemented with graded levels of charcoal from maize cob or seed of canarium. *Tropical Animal Health and Production*. 43(1):51-56.
- Karkana, M.Z. and Mohammed, S. (2018). Vegetation density and diversity in the dryland of Northwestern Nigeria. *Dutse Journal of Pure and Applied Sciences (DUJOPAS)* 4(1):195-208
- Kutlu, H.R., Unsal, I. and Gorgulu, M. (2000). Effects of providing dietary wood (oak) charcoal to broiler chicks and laying hens. *Animal Feed Science and Technology* 90:213-226
- Lao, E.J. and Mbega, E.R. (2020). Biochar as a feed additive for improving the performance of farm animals. *Malaysian Journal of Sustainable Agriculture*, 4(2):86-93.
- Lehmann, J. and Joseph, S. (2009). Biochar for Environmental Management: an introduction In: Lehmann J, Joseph S. editors. Biochar for Environmental Management: Science and Technology. London.
- Lehmann, J. and Joseph, S. (2015). Biochar for Environmental Management: an introduction. *Biochar for Environmental Management: Science, Technology and Implementation*. Second Edition ed. London
- Odunsi, A.A., Oladele, T.O., Olaiya, A.O. and Onifade, O.S. (2007). Response of Broiler Chickens to Wood Charcoal and Vegetable Oil Based Diets. *World Journal of Agricultural Sciences*, 3(5):572-575.
- Omar, A.A. (2021). The role of Biochar in Agriculture. *Field Crop*. DOI: [10.13140/RG.2.2.30319.25760](https://doi.org/10.13140/RG.2.2.30319.25760)
- Owusu-Doubreh, B. Appaw, W.O. and Abe-Inge, V. (2023). Antibiotic residues in poultry eggs and its implications on public health: A review. *Scientific African* 19 e01456.
- Prasai (2013). Double Green Chickens Produce Carbon-Smart Poo. *Sustainability Matters* 6(4):939-948. farrowmedia/docs/sm_febmar_13_issue.
- Prasai, T.P., Walsh, K.B., Midmore, D.J. and Bhattarai, S.P. (2018). Effect of biochar, zeolite and bentonite feed supplements on egg yield and excreta attributes. *Animal Production Science* 58:1632-1641.
- Teleb, H.M., Hegazy, A.A. and Hussein, Y.A. (2004). Efficiency of kaolin and activated charcoal to reduce the toxicity of lower level of aflatoxin in broilers. *Scientific Journal of King Faisal University*.5(1):1425.
- Webber, K. and Quicker, P. (2018). Properties of biochar. *Fuel*, 217:240-261.
- Wolf, D., Amonette, J.E., Street-perrott, F.A., Lehmann, J. and Joseph, S. (2010). Sustainable biochar to mitigate global climate change. *Nat. Commun.*, 1:1 - 10.1038/ncomms 1011.