EFFECT OF DIETARY CHARCOAL ON NUTRIENT DIGESTIBILITY AND GUT MICROBIAL POPULATION OF BROILER CHICKENS

[1]Yunana, Y.L., [2]*Salihu, E.A. and [1]Essien, K.F.

[1]Department of Animal Science, Bayero University, Kano
[2]Department of Animal Science, Ahmadu Bello University, Zaria
*Corresponding Author: salihuezekiel@gmail.com; +234 706 063 8200,

ABSTRACT

This study evaluated the effect of dietary charcoal supplementation on nutrient digestibility and gut microbial population of broiler chickens. A total of 250 one-day-old commercial broiler chicks (Ross 308) were randomly assigned to five dietary treatments, each containing different levels of charcoal supplementation (0, 1.0, 1.5, 2.0, and 2.5% per 100kg diet). The birds were allotted and raised in a deep litter pen in a completely randomized design (CRD), with three replicates of 15 birds. Feed and water were provided ad libitum. All vaccinations and medications, except antibiotics, were administered. A digestibility trial was conducted at the end of the experiment. Additionally, gut microbial analysis was performed on intestinal fluid samples to determine the presence of Salmonella spp., Staphylococcus spp., Escherichia coli, total aerobic plate count (TAPC), and coliform counts. Data were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of SAS. Results revealed significant differences ($p<0.05$) in ether extract (EE) and nitrogen-free extract (NFE) digestibility coefficients, with birds fed 1.0% charcoal diets exhibiting higher digestibility compared to the control and 2.5% charcoal groups. Gut microbial analysis showed that charcoal supplementation reduced coliform and aerobic bacterial counts in treated groups compared to the control. Notably, no Salmonella spp. was detected, while E. coli counts were higher in the treatment groups. The highest bacterial population in the ileum was recorded in birds on 1.5% dietary charcoal inclusion, after which it declined. Findings suggests that dietary charcoal supplementation at 1.0% per 100kg of feed enhances nutrient digestibility and promotes favourable gut microbial population in broiler chickens. Therefore, charcoal inclusion in poultry diets could be recommended as a natural feed additive to improve nutrient utilization and intestinal health.

Keywords: Charcoal supplementation, Nutrient digestibility, Gut microbiota, Broiler chickens, Poultry nutrition

INTRODUCTION

Poultry production is a vital component of the livestock industry, contributing significantly to global food security by providing a readily available source of protein (FAO, 2021). Among poultry species, broiler chickens are important due to their rapid growth rate, efficient feed conversion, and high economic returns. One of the major challenges in poultry production is improving feed efficiency and gut health while minimizing the use of antibiotics due to growing concerns over antimicrobial resistance (Mulvenna *et al*., 2022). Nutrient digestibility plays a crucial role in broiler chicken performance. Poor nutrient digestibility leads to inefficient feed utilization, increased feed costs, and environmental waste. Various feed additives have been explored to enhance nutrient digestion and absorption (Shazali *et al*., 2019). In recent years, the use of natural feed additives such as biochar and activated charcoal has gained attention for their potential benefits in improving digestibility and gut health in poultry production. The intestinal microbiome can influence the efficiency and the health status of its host's digestive system (Borda-Molina *et al*., 2020).

Charcoal is a carbon-rich material with high porosity and adsorption capacity. It has been widely used in livestock nutrition for its ability to bind toxins, improve gut health, and enhance feed efficiency (Hassan *et al*., 2022). When incorporated into poultry diets, charcoal has been reported to promote better nutrient absorption, reduce intestinal pathogens, and improve overall gut integrity (Shazali *et al*., 2019 Salihu *et al*., 2020; Reuben *et al*., 2021). Given the increasing need for sustainable and antibiotic-free poultry production, investigating the effects of charcoal on nutrient digestibility and gut microbial populations is essential. Therefore the study evaluated the effect of charcoal on nutrient digestibility and gut microbial population of broiler chickens.

MATERIALS AND METHODS

Experimental site

The study was conducted at the Poultry Unit of the Research and Experimental farm, Department of Animal Science, Ahmadu Bello University, Zaria. Zaria is located between latitude 11° 14'44'N and longitude 7°38'65'E, at an altitude of 610m above sea level.

Experimental materials and management

A total of 250 one-day-old Ross 308 chicks were purchased from Agrited Farm, Ibadan. The birds were raised in a deep litter pen in a completely randomized design, the birds were grouped in five treatments with three replicates with 15 birds. Throughout the experimental period, feed and clean water were provided *ad-libitum*. All

necessary vaccinations and management practices were adhered. Five treatment diets were formulated involving levels of charcoal: 0, 1.0, 1.50, 2.0, and 2.5 % per 100kg diet.

Digestibility trial

A digestibility trial was carried out at the end of the experiment. Two birds per replicate making a total of six per treatment were selected at random. The birds were housed in individual cages, they were given three days adjustment period; trays were placed under each cage for faecal collection for a period of seven days. The faeces were dried and mixed thoroughly; and analyzed for proximate composition using the methods described by AOAC (2010).

Microbial analysis

Each homogenous intestinal sample from each replicate was pooled in one sterile flask containing 100ml of sterile 1% nutrient both. Intestinal fluid samples were taken to the Microbiology Laboratory of the Faculty of Veterinary Medicine Ahmadu Bello University, Zaria for microbial analysis following the indications, standard plate counting plate technique for aerobic, anaerobic, coliform clostridium and salmonella counts (Yardimci and Kenar, 2008).

Data analysis

Data were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of SAS (SAS, 2003). Means were compared using Duncan Multiple Range Test at $P<0.05$.

RESULTS AND DISCUSSION

Effect of graded levels of dietary charcoal on nutrient digestibility of broiler chickens

Table 1 shows the result of apparent nutrient digestibility coefficients of broiler chickens fed diets containing graded levels of charcoal at 56 days of age.

Table 1: Effect of graded levels of charcoal on nutrient digestibility of broiler chickens (at 8weeks)

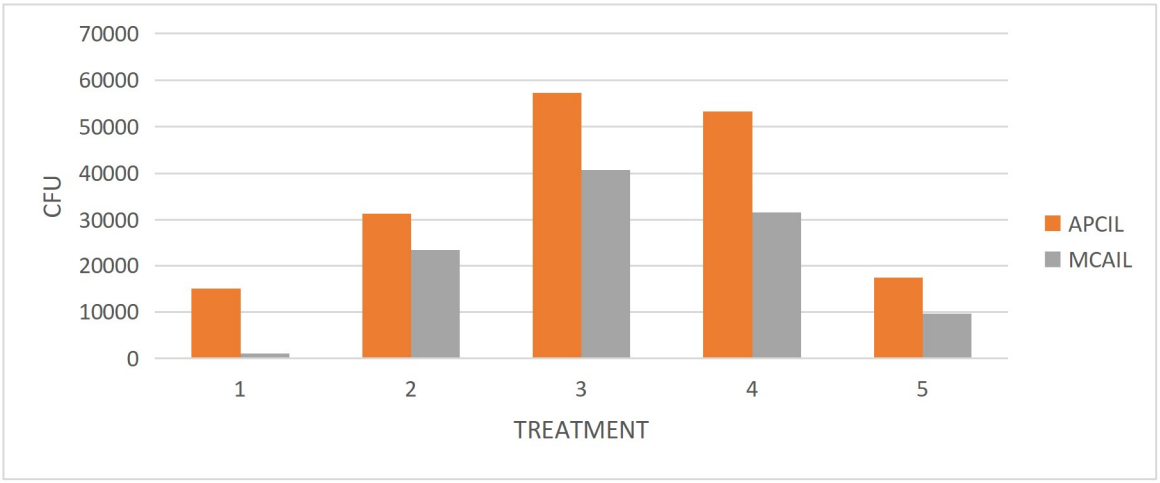
	Levels of charcoal inclusion (%)					
Parameters	**0.0**	**1.0**	**1.5**	**2.0**	**2.5**	**SEM**
Dry matter (%)	68.15^{e}	76.49^{d}	78.38^{c}	79.52^{b}	82.03^{a}	0.27
Crude protein (%)	82.46^{d}	89.13^{a}	86.39^{c}	87.72^{b}	88.14^{b}	0.39
Crude fibre (%)	72.48^{d}	84.94^{a}	82.17^{b}	82.03^{b}	78.49^{c}	0.30
Ether extracts (%)	74.17^{c}	92.36^{a}	90.84^{a}	90.16^{a}	87.58^{b}	1.23
Nitrogen free extracts (%)	68.63^{d}	79.87^{ab}	7.91^{c}	81.00^{a}	78.53^{b}	0.87

^{abc}Means with different superscript on the same row varies significantly ($P<0.05$), SEM: standard error mean.

The results showed significant differences in all the measured parameters. Ether extracts coefficient of digestibility for birds fed 1.0% charcoal supplemented diets were significantly higher ($p<0.05$) than those fed 2.5% charcoal and the control group but were however similar ($p>0.05$) to birds fed 1.5% and 2.0% charcoal diets. Nitrogen free extract coefficient of birds fed 2.0% charcoal diets were significantly ($p<0.05$) higher than the control group but were however similar ($p<0.05$) to those fed 1.0% charcoal diets. This observation contradicts the findings of Jiya *et al*. (2013) who reported no significant differences in nutrient digestibility coefficients measured except in ash content. The higher coefficients recorded in the treatment groups for EE and NFE could be attributed to charcoals ability to absorb lipids and enhance the digestion process as reported by Kutlu *et al*. (2000) which is a good indicator of efficient feed utilization.

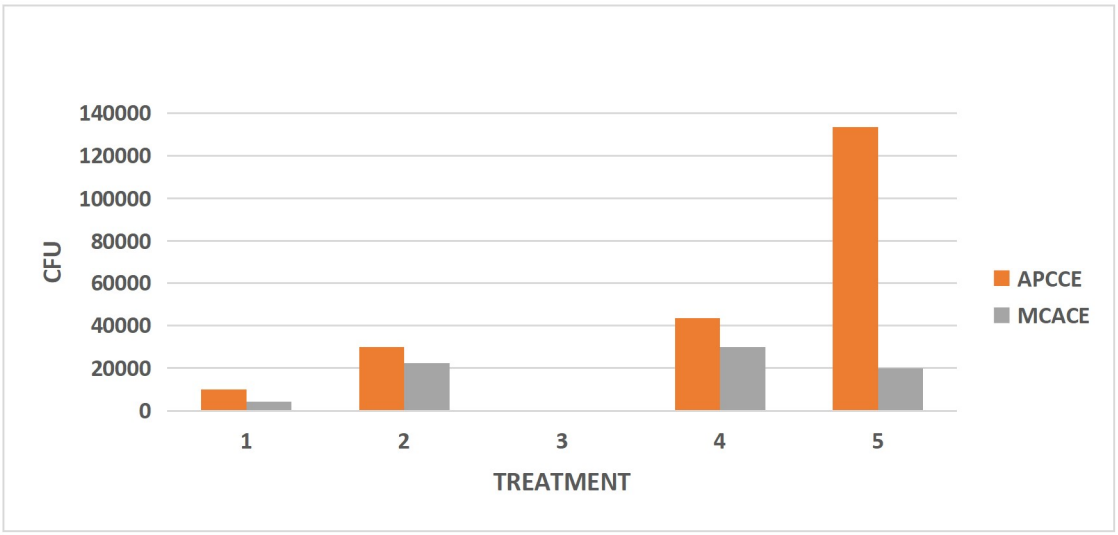
Effect of charcoal on gut microbial population of broiler chickens (at 8 week)

Figure 1 shows the progression of gut microbial population due to charcoal supplementation in broiler chicken diet. The results showed TAPC value range between 0-60 coliform units (cfu) per gram with both coliform and aerobic counts of charcoal treated samples showing lower contamination compared to those of the control group. From Figure 1, the TAPC revealed that birds fed the treatment diets have higher population of bacteria in the ileum than the control group. The population of aerobic bacteria in the ileum rose as the level of charcoal supplementation increased reached the apex at 1.5% charcoal inclusion then began to decline. This is in line with the reports of Falaki *et al*. (2011)that prebiotics increased aerobic count in the crop contents with prebiotic supplementation. Figure 2 shows the progression of bacteria colony forming units (cfu)/g in the cecum. Similarly it increased along with charcoal inclusion levels; no cfu was however detected at 1.5% charcoal inclusion. The population of coliform bacteria was at its peak at 2.5% charcoal inclusion in the cecum.



APCIL: aerobic plate count in ileum, MCAIL: MacConkey agar count in ileum

Figure 1: Effect of Charcoal on gut microbial count in the ileum



APCCE: aerobic plate count in cecum, MCACE: MacConkey agar count in cecum

Figure 2: Effect of Charcoal on gut microbial count in the cecum

CONCLUSION AND APPLICATION

Charcoal inclusion in broiler chickens' diet at 1.0% per 100kg of feed improved nutrient digestion and gut microbial populations. Based on the findings of this study, charcoal in broiler chickens diet is recommended to farmers at both starter and finisher phases to improve nutrient utilization and gut microbiota at 1.0%.

REFERENCES

Borda-Molina, D., Mátis, G., Mackei, M., Neogrády, Z., Huber, K., Seifert, J., & Camarinha-Silva, A. (2020). Caeca Microbial Variation in Broiler Chickens as a Result of Dietary Combinations Using Two Cereal Types, Supplementation of Crude Protein and Sodium Butyrate. *Frontiers in Microbiology*, 11, 617800. https://doi.org/10.3389/fmicb.2020.617800.

Falaki, M., Shargh, M. S., Daster, B., Zerehdaran, S. and Khoimariri, M. (2011). The investigation of intestinal microflora and growth response of young broilers given feed supplemented with different levels of probiotic and prebiotic. *Journal of Animal and Veterinary Advances,* 10(3):385-390.

Jiya, E.Z., Ayanwale, B. A., Ijaiya, A. T., Ugochukwu, 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 Sciences and Technology* 3 (2): 268-276.

Kutlu, H.R., Unsa, I. and Gorgulu, M. (2000). Effects of providing dietary wood (oak) charcoal to broiler chicks and laying hens. *Animal Feed Science Technology Elsevier,* 90 (3-4)213-226.

Mulvenna, C. C., McCormack, U. M., Magowan, E., McKillen, J., Bedford, M. R., Walk, C. L., Oster, M., Reyer, H., Wimmers, K., Fornara, D. A., & Ball, M. E. E. (2022). The Growth Performance, Nutrient Digestibility, Gut Bacteria and Bone Strength of Broilers Offered Alternative, Sustainable Diets Varying in Nutrient Specification and Phytase Dose. *Animals*, 12(13): 1669. https://doi.org/10.3390/ani12131669.

Reuben, R. S., Onimisi, P. A., Sekoni, A. A. and Salihu, E. A. (2021). Growth performance, carcass characteristics and villi morphometry of broiler chickens fed diets containing *Mentha piperita* and *Adansonia digitata* leaves meals as phytobiotics. *Nigerian Journal of Animal Production*, 48(6): 217– 228.

SAS (2003). SAS User's guide. Version ^.11. SAS Institute, Inc. Cary, NC.

Salihu, E. A., Onimisi, P. A., Omage, J. J., Afolayan, M., Moses, O. and Reuben, R. S. (2020). Evaluation of Ocimum gratissimum and Ocimum canum as natural growth promoters on the growth performance, intestinal microbiota and villi morphometry of broiler chickens. *Nigerian Journal of Animal Production*, 47(1):186 – 196.

Shazali, N., Loh, T. C., Foo, H. L., & Samsudin, A. A. (2019). Gut Microflora and Intestinal Morphology Changes of Broiler Chickens Fed Reducing Dietary Protein Supplemented with Lysine, Methionine, and Threonine in Tropical Environment. *Revista Brasileira de Zootecnia*, 48. https://doi.org/10.1590/rbz4820170265.

Yardimci, M. and Kenar, B. (2008). Effect of stocking density on litter microbial load in broiler chickens. *Archivo Zootechnica*, 11: 75-81.