

Growth Performance, Caeca Microbial Population and Immune Response of Starter Broiler Chicks Fed Aqueous Extract of *Balanites Aegyptiaca* and *Alchornea Cordifolia* Stem Bark Mixture

Musa Bashir¹, John O. Alagbe², Adegbite Motunrade Betty³, E.A. Omokore⁴

¹Department of Animal Science, Kano State University of Science & Tech, Wudil

^{2,4}Department of Animal Science, University of Abuja, Nigeria

³Department of Agricultural Extension, University of Ibadan, Nigeria

Abstract— A total of Two hundred and fifty (250), 1-day old (Cobb) broiler chicks with mixed sex were used to evaluate the the growth performance, caeca microbial population and immune response of starter broiler chicks fed aqueous extract of *Balanites aegyptiaca* and *Alchornea cordifolia* stem bark mixture (BACM). Birds were reared on a deep litter system and randomly divided into five treatments with five replicates consisting of 10 birds each in a completely randomized design. Treatment 1 (T1) were given basal diet + 0 % BACM, T2, T3, T4 and T5 were fed 20, 40, 60 and 80 ml/liter BACM respectively. The experiment lasted for 28 during which clean feed and water were offered ad libitum. The results obtained revealed that the average weight gain (AWG), feed conversion ratio (FCR) and mortality were influenced by the dietary treatments ($P<0.05$). Birds in T5 had the highest AWG and FCR (1159.3 g, 1.57) followed by T4 (1070.2 g, 1.70), T3 (1047.4 g, 1.74), T2 (981.1 g, 1.86) and T1 (850.7 g, 2.14) respectively. Activities of superoxide dismutase (SDA), glutathione peroxidase (GPx), catalase (CAT), malonyldialdehyde (MDA) and antibody titres against Newcastle and gumboro disease were significantly affected by BACM ($P<0.05$). Caeca microbial population of *Escherichia coli* and *Lactobacilli* were significantly different among the treatments ($P<0.05$). *E. coli* count in T1 were higher compared to other treatments ($P<0.05$), *Lactobacilli* population increased in T2, T3, T4 and T5 compared to T1. It was concluded that BACM can be fed to broiler chicks at 80 ml/litre without any negative effect on the performance and immune response of birds.

Keywords— broiler chicks, immune response, performance, antibodies.

I. INTRODUCTION

The use of medicinal plants of high therapeutic value have recently gained interest since the ban on the use of

antibiotics by the European Union in 2006 due to anticipated toxicity, high cost and adverse effect (Adu et al., 2009; Oluwafemi et al., 2020). According to Mahima et al. (2012); Ezekiel et al. (2019), there are over 200,000 species of medicinal plant species where about 800 plant species have been used by different communities for curing different diseases and they contain several minerals, vitamins, protein and essential fatty acids. Among the potential medicinal plants are *Balanites aegyptiaca* and *Alchornea cordifolia*, they contains several bioactive chemicals or phytochemicals which allows them to perform multiple biological activities. The plants are found to contain alkaloids, flavonoids, phenols, saponins, tannins, oxalate, terpenoids, steroids etc. (Alagbe et al., 2020; Abu et al., 2016) which confers them ability to function as an antimicrobial (Ajumobi, 2014), anti-inflammatory (Agyare et al., 2014), antiviral (Adu et al., 2014), antioxidant (Ojo et al., 2006), anti-ulcer, antihelminthic and anti-implantation (Francis et al., 2002; Chothani and Vaghasiya, 2011).

Balanites aegyptiaca belongs to the family Zygophyllaceae. It's found in many parts of Africa (Kenya, Sudan, Somalia, Djibouti, Nigeria and Ethiopia) and Asia (China, India, Pakistan, Afghanistan, Sri Lanka and Bangladesh) (Dubey et al., 2011). The leaves are characterized by dark green or grey green colouration with two firm coriaceous leaflets spirally arranged on the shoots (Chothani and Vaghasiya, 2011). The leaf, stem bark and roots are traditionally used to treat headache, stomach disorder, wound; skin infection and tooth ache (Sunil et al., 2016). Phytochemical evaluation of the stem bark, leaves and roots revealed the presence of appreciable quantity of flavonoids, alkaloids, saponins, phenols, terpenoids, tannins glycosides, amino acids, vitamins, carbohydrates and protein (Sunil et al., 2016).

Alchornea cordifolia (Euphorbiaceae) is a perennial evergreen tree which measures between 4-8 m high, grows

near river bank or marshy places and it is characterized by unisexual and sessile flowers (Timibitei et al., 2013) and wide spread in Kenya, Senegal, Nigeria, Niger, Cameroon, Tanzania, Angola, Mudagaska, China and some parts of India (Kwabena, 2012). Mamadou et al. (2005); Noundou (2012); Osabe and Okoye (2003) reported that *A. cordifolia* is loaded with several secondary metabolites (terpenoids, alkaloids, phenols, steroids, glycosides, hydroxybenzoic acid, tannins, imidazopyrimidine, alchorneine, namelygallic acid, anthralinic acid, ellagic acid, alchornidine guanidine, nutrients (carbohydrate, protein and amino acids) and have traditionally used to treat rheumatism, arthritis, tooth ache and pile.

Previous studies have shown that the immune system benefit greatly from proper nutrition (phytogenics) of the bird (Gary, 2002; Mahima et al., 2012). Phytogenics is a safe growth promoter without side effects on birds (Alagawany et al., 2016), enhance the modulation of beneficial intestinal microbiota by controlling potential pathogens (Alagbe, 2020; Oyuntsetseg et al., 2014; Farag et al., 2016) and improvement of nutrient absorption and enzyme activity to enhance better weight gain and feed conversion efficiency (Santi and Kim, 2017) due to the presence of several bioactive chemicals.

In view of these potential a synergistic combination of different plants will give better result, especially those that are underexplored. Therefore the experiment was carried out to evaluate the growth performance, caeca microbial population and immune response of starter broiler chicks fed aqueous extract of *Balanites aegyptiaca* and *Alchornea cordifolia* stem bark mixture.

II. PROCEDURE FOR PAPER SUBMISSION EXPERIMENTAL SITE

The experiment was carried at Kano State University of Science and Technology, Wudil, Kano State, Nigeria.

COLLECTION, PROCESSING, PREPARATION OF EXTRACT AND ANALYSIS

Healthy stems of *Balanites aegyptiaca* and *Alchornea cordifolia* were obtained from the Teaching and Research farm of Kano State University, Nigeria. The plant materials were identified and authenticated by a botanist (Dr. Bashir), and thoroughly washed with distilled water to remove soil and other bound particles, air dried separately until a constant weight was obtained and made into powder using a pulverizer. Samples were later stored in a well labeled air tight container and kept for further

analysis. 100 g of each ground sample (*Balanites aegyptiaca* and *Alchornea cordifolia*) were mixed together (1:1) dissolved in 1000 ml water, stirred continuously and kept in the refrigerator for 48 hours. The extract was filtered using What an filter paper No. 1 to obtain filtrate (BACM). Proximate compositions of test material and experiment diet were determined by using official method of analysis by AOAC (2000).

Phytochemical evaluation of tannins, alkaloids, saponins, flavonoids, phenols, oxalate, glycosides, steroids and terpenoids were estimated using methods described by Atamgba et al. (2015), Harbone (1973), Shabbir et al. (2013), Odebiyi and Sofowora (1978), Boham and Kocipai (1974). Mineral analyses were carried out using Atomic Absorption Spectrophotometer (AAS) model 12-0TA.

ANIMALS AND THEIR MANAGEMENT

A total of two hundred and fifty one-day old broiler chicks (Cobb) strain of mixed sex were randomly distributed into five treatments with 5 replicates, each replicates contained 10 birds each in a completely randomized design. Prior to the arrival of the birds the deep litter pen house were properly disinfected and the foot bath is constructed to ensure biosecurity. Birds were weighed on arrival to the farm to determine their initial body weight and weekly thereafter. Wood shavings were used as litter material and lighting was continuous, vaccines were administered according to the prevailing disease condition in the environment and all necessary management practices were strictly adhered to, clean feed and water were offered ad libitum and the experiment lasted for 28 days.

FEED FORMULATION AND EXPERIMENTAL SET UP

A standard starter's ration was formulated to meet the nutritional recommendation of birds by NRC (1994). It was made up of corn –soya meal based diet and it contained 23 % crude protein and 2900 Kcal/kg energy.

Treatment 1- Basal diet + 0 % BACM

Treatment 2 – Basal diet + 20 ml/liter BACM

Treatment 3 – Basal diet + 40 ml/liter BACM

Treatment 4 – Basal diet + 60 ml/liter BACM

Treatment 5 – Basal diet + 80 ml/liter BACM

III. EXPERIMENTAL MEASUREMENTS PERFORMANCE RECORD

Feed intake was recorded daily and body weight gain was recorded weekly, feed conversion ratio was calculated by dividing the total feed intake by weight gain, mortality was also recorded as it occurs.

FATTY ACID OF THE FEED

Fatty acid composition of the feed was carried out using gas liquid chromatography (Model 231 A-01, Punjab, India). Percentage concentrations were evaluated according to the methods outlined by Suriya et al. (2014).

HAEMAGGLUTINATION INHIBITION TEST

Birds were orally vaccinated against Newcastle on the 5th and 18th day and Gumboro diseases on the 11th and 23rd day. Three birds were randomly selected per replicate to access the antibody response to Newcastle and Gumboro virus on the 20th and 28th days of the experiment. Analysis was done according to the method described by Thayer and Beard (1998).

CAECAL MICROBIAL POPULATION

At the end of the experiment (12 weeks), caeca microbial count was conducted using five (5) grasscutters per treatments, caeca contents were collected from slaughtered animal and 10-fold serial dilution method, in which of 1% peptone solution was mixed with caeca samples and poured on Mac Conkey agar plates and lactobacilli medium III agar plates, was used to determine the colony forming unit (cfu) in each gram of caeca sample by means of pour plate method. Colonies of E. coli and Lactobacilli were enumerated according to the method outlined by Phyto et al. (2017). The microbial counts were determined as colony forming units (Cfu/g) of sample.

ANTIOXIDANT STATUS

Activity of superoxide dismutase (SDA), glutathione peroxidase (GPx), catalase (CAT) and malonyldialdehyde (MLA) were carried out using method outlined by Mahipal et al. (2015).

IV. STATISTICAL ANALYSIS

All data were subjected to one-way analysis of variance (ANOVA) using SPSS (23.0) and significant means were separated using Duncan multiple range tests (Duncan, 1955). Significant was declared if $P \leq 0.05$.

Table 1 Composition of experimental diet

Ingredients	Quantity (kg)
Maize	52.00
Wheat offal	5.24
Soya meal	38.00
Fish meal (72%)	3.00
Bone meal	0.50
Limestone	0.25
Lysine	0.20
Methionine	0.25
Premix	0.25
Salt	0.30
Toxin binder	0.01
Total	100.00

ANALYZED NUTRIENT (%)

Crude protein	23.11
Crude fibre	3.09
Ether extract	5.12
Calcium	0.97
Phosphorus	0.46
Energy (kcal/kg)	2990.7

Table 2 Fatty acid composition of the experimental diet

Fatty Acids	Components(%)
TSFA	51.44
TUFA	45.62
MUFA	38.06
PUFA n-3	1.01
PUFA n-6	10.22
n-3: n-6	10.11
Ant. Index	0.21

¹Total saturated fatty acid= C12:0 + C14:0 + C16:0 + C18:0 + C20:0 + C22:0

²Mono unsaturated fatty acid= C14:1C + C16:1C + C18:1C + C18:1n9t + C18:1n9c + C22:1

³Polyunsaturated fatty acid = C18:2 n6 + C20:5 n3 + C18:3n3 + C20:4n6 + C20:3n6 + C: 22:6n3

⁴n-6: n-3 = (C18:2 n6 + C20:4n 6 + C20:3n 6 / (C20:5n3 + C18:3n 3 + C: 22 6n 3), 5Antherogenic index = (C12:0+ 4×C14:0+ C16)/Σ of UFA

Table 3 Phytochemical composition of Balanites aegyptiaca and Alchornea cordifolia stem bark

Parameters(%)	Balanites aegyptiaca stem bark	Alchornea cordifolia stem bark	Permissible range (%)
Alkaloids	2.33	0.42	9.13
Hydrolysable tannins	3.07	2.44	4.56
Condensed tannins	0.01	0.03	1.88
Flavonoids	5.84	6.10	12.10
Saponins	0.36	0.22	7.02
Phenols	2.88	1.84	-
Terpenoids	0.60	0.93	-
Steroids	1.00	0.04	-
Phytates	0.07	0.15	2.13
Oxalates	0.05	0.02	0.54

Table 4 Performance characteristics of broiler chicks fed different levels of BACM

Parameters	T1	T2	T3	T4	T5	SEM
IBW (g)	41.65	41.03	41.29	41.40	41.00	0.02
FBW (g)	892.3 ^c	1022.1 ^b	1088.7 ^b	1111.6 ^a	1200.3 ^a	0.19
WG (g)	850.7 ^c	981.0 ^b	1047.4 ^b	1070.2 ^a	1159.3 ^a	0.12
ADWG (g)	30.38 ^c	35.04 ^b	37.40 ^b	38.22 ^a	41.40 ^a	0.03
FI (g)	1822.1	1820.9	1820.5	1820.1	1820.0	0.25
ADFI (g)	65.08	65.03	65.02	65.01	65.00	0.06
FCR	2.14 ^a	1.86 ^b	1.74 ^b	1.70 ^b	1.57 ^c	0.052
MORT	3.00	-	-	-	-	-

Means in the same row with different superscripts differ significantly (P<0.05)

IBW: Initial body weight; FBW: final body weight; WG: weight gain; ADWG: average daily weight gain; FI: feed intake; ADFI: average daily feed intake; FCR: feed conversion ratio; MORT: mortality.

Table 5 Caeca microbial population of broiler chicks fed different levels of BACM

Parameters Cfu/g	T1	T2	T3	T4	T5	SEM
E. coli	17.80 ^a	12.04 ^b	10.28 ^b	9.14 ^c	9.01 ^c	0.45
Lactobacilli	20.01 ^c	29.18 ^b	30.16 ^a	33.45 ^a	35.02 ^a	1.57

Means in the same row with different superscripts differ significantly (P<0.05)

SEM: Standard error of mean

Table 6: Antioxidant status of broiler chicks fed different levels of BACM

Parameters	T1	T2	T3	T4	T5	SEM
MLA (U/mg Hb)	1.03 ^c	2.11 ^b	2.16 ^b	3.00 ^a	3.03 ^a	0.01
SDA (U/mg Hb)	21.5 ^b	24.1 ^b	30.0 ^a	33.8 ^a	35.0 ^a	2.04
GPx (U/mg Hb)	14.5 ^b	16.1 ^b	23.6 ^a	24.0 ^a	28.1 ^a	1.51
CAT (U/mg Hb)	41.0 ^a	38.1 ^b	30.8 ^b	30.0 ^b	29.5 ^b	1.94

Means in the same row with different superscripts differ significantly (P<0.05)

SOD, superoxide dismutase; CAT, catalase; MLA, malondialdehyde; GSH, reduced glutathione

SEM: Standard error of mean

Table 7 Antibody titres of broiler chicks fed different levels of BACM

Parameters	Day	T1	T2	T3	T4	T5	SEM
Newcastle (Log ₂)	5	2.4 ^c	3.6 ^b	4.0 ^a	4.2 ^a	4.3 ^a	0.05
	18	3.0 ^c	4.0 ^c	6.0 ^b	6.4 ^b	7.1 ^a	0.28
Gumboro (Log ₂)	11	1.7 ^b	2.0 ^a	2.6 ^a	2.8 ^a	3.0 ^a	0.03
	23	2.5 ^c	3.9 ^b	4.2 ^b	5.5 ^a	5.0 ^a	0.37

Means in the same row with different superscripts differ significantly (P<0.05)

SEM: Standard error of mean

IV. RESULTS

PROXIMATE AND FATTY ACID COMPOSITION OF EXPERIMENTAL DIET

The chemical composition of experimental diet is presented in Table 1. Result revealed the presence of crude protein (23.11 %), crude fibre (3.07 %), ether extract (5.12 %), calcium (0.97 %), phosphorus (0.46 %) and energy (2990.7 Kcal/kg). Similarly, total saturated fatty (TSFA) 51.44 %, total unsaturated fatty acid (TUFA) 45.62 %, mono saturated fatty acid (MUFA) 38.06 %, omega 3 fatty acid (n-3) 1.01 %, omega 6 fatty acid (n-6) 10.22 %, n-3 : n-6 (10.11 %) and antherio genic index (0.21 %) is presented in Table 2.

PHYTOCHEMICAL ANALYSIS OF BALANITES AEGYPTIACA AND ALCHORNEA CORDIFOLIA STEM BARK

Phytochemical composition of Balanites aegyptiaca and Alchornea cordifolia stem bark is presented in Table 3. Balanites aegyptiaca stem bark contained alkaloids (2.33 %), hydrolysable tannins (3.07 %), condensed tannins (0.01 %), flavonoids (5.84 %), saponins (0.36 %), phenols (2.88 %), terpenoids (0.60 %), steroids (1.00 %), phytates (0.07 %) and oxalates (0.05 %) while Alchornea cordifolia

stem bark posses alkaloids, flavonoids, saponins, condensed tannins, hydrolysable tannins, phenols, steroids, oxalates and phytates at 0.42 %, 6.10 %, 0.22 %, 0.03 %, 2.44 %, 1.84 %, 0.04 %, 0.02 % and 0.15 % respectively.

PERFORMANCE CHARACTERISTICS OF BIRDS FED DIFFERENT LEVEL OF BACM

Performance characteristics of the experimental birds are presented in Table 4. IBW values ranged between (41.00 – 41.65 g), FBW (892.3 – 1200.3 g) and WG (850.7 – 1159.3 g) were higher (P<0.05) in T5 than in T4, T3, T2 and T1. FI values ranged between (1820 – 1822 g) and ADFI (65.0 – 65.08 g), however, no significant differences were observed among the treatments (P>0.05). Mortality were highest for T1 and none was recorded in the other treatments (P<0.05).

CAECA MICROBIAL POPULATION OF BROILER CHICKS GIVEN BACM

Caeca microbial population of birds fed BACM is presented in Table 5. E. coli values ranged between (9.01 – 17.80 Cfu/g) and lactobacilli (20.01 – 35.02 Cfu/g). E. coli were lowest in T5, T4, T3 and T2 and highest in T1 (P<0.05). Lactobacilli count were highest in T4 and T5 and lowest in T1 (P<0.05).

IMMUNE AND ANTIOXIDANT STATUS OF BROILER CHICKS FED BACM

The antioxidant status of the experimental birds is presented in Table 6. Whereas MLA (1.03 – 3.03 U/mgHb), SDA (21.5 – 35.0 U/mgHb) and GPx (14.5 – 28.1 U/mgHb) were lowest (P<0.05) for T1. CAT (29.5 – 41.0 U/mgHb) were highest (P<0.05) for T1 relative to other treatments.

The antibody titre as influenced by BACM is presented in Table 7. Newcastle antibody titre in day 5 ranges between 2.44 – 4.33 (Log₂) while day 18 3.03 – 7.11(Log₂). Parameters were significantly different among the treatments (P<0.05). Gumboro antibody titers on day 11 ranges between 1.78 – 3.00 (Log₂) while on day 23 (2.56 – 5.05) (Log₂) were affected by feeding BACM to birds (P<0.05).

V. DISSCUSSION

The chemical composition of experimental diet is in agreement with the nutritional requirement of birds according to NRC (1994); Aduku (2004). This is an

indication that the feed contains the entire nutrients necessary for optimum growth and immunocompetency of animals (Butcher and Miles, 2002; Makhosazana, 2015). Phytochemical composition of *Balanites aegyptiaca* and *Alchornea cordifolia* stem bark reveals the presence of several bioactive chemicals or secondary metabolites which performs multiple biological activities. The present findings coincides with other research findings from Ngaha et al. (2016); Audu et al. (2018); Onyema et al. (2017). The presence of alkaloids confers the stem bark ability to function as an antibacterial, anti-malarial and anticancer; this supports the earlier findings of Eldin et al. (2016). Flavonoids play a pivotal role as an anti-inflammatory, anti-allergic and anti-plasmodic (Dubey et al., 2011; Sunil et al., 2016). Saponin performs both antibacterial and antifungal activities (Adeshina et al., 2012; Alagbe, 2020). Phenols are strong antioxidants which prevents the entry of diseases (Ezeokeke et al., 2015; Alagbe, 2019). Terpenoids has high therapeutic value and function as antimicrobial, anticarcinogenic and anti-diuretic (Ismaila et al., 2012; Kamenan et al., 2013). Steroids play a major role in fertility of animals (Atamgba et al., 2015; Alagbe, 2019). Tannins have found therapeutic application as antiviral and antibacterial (Adisa et al., 2010). Phytate are antioxidant compounds capable of binding minerals (Maisarah et al., 2014; Akpabio and Ikpe, 2013). Bioactive chemicals in plants vary according to species, age, soil type, geographical area and method of extraction (Omokore and Alagbe, 2019). Olanipekun et al. (2016) reported a higher value of 6.78 % (alkaloids) and 2.79 % (saponins) in *Morinda lucida* stem bark. Enin et al. (2014) also reported a lower value of 0.60 % (tannins), 0.52 % (alkaloids), 0.31 % (flavonoids), 0.65 % (saponins), 0.14 % (oxalate) and 0.21 % (phytate) in *Sida acuta*. However, all the values obtained in this study were within the tolerable level reported by Olafadehan et al. (2020); Alagbe and Oluwafemi (2019).

The fatty acid in the diet shows that it's loaded with poly unsaturated fatty acid; this removes the risk of cardiovascular infection and ensures food safety (meat). Feeding animals with the experimental diet and BACM will improve the nutritive value of the meat, since phytochemicals in plants can function as modulators, this result is consistent with the reports of Suriya et al. (2014); Alagbe (2020). Low atherogenic index reduces the risk of arteriosclerosis (Kholif et al., 2017). Omega -3 and

omega - 6 polyunsaturated fatty acid ratios was within the range recommended by Simopoulos (2001).

The improved the final live weight, total weight gain and average daily gain of birds in treatment 4 and 5 compared to the other treatments could be attributed to efficient feed utilization as a result of various phytochemicals in BACM, these bioactive chemicals also enhanced feed conversion ratio (FCR) in the group. The result obtained is in accordance with the reports of Fascina et al. (2017); Ahsan et al. (2018) when phytochemical additives were fed to broiler chickens. Similar observation was recorded by Dingfa et al. (2017) when turmeric rhizome extract was supplemented of Wenchang broiler chickens. According to Krishnan et al. (2015), intestinal microorganisms play a key role in nutrient absorption and modulating the immune system and metabolic signaling pathways. Hyun et al. (2018); Michiels et al. (2010) and Kim et al. (2013); Shittu et al. (2020) reported that phytochemical feed additives can reduce the activity of pathogenic bacteria by competitive exclusion due to the presence of phenols, alternation of bacteria cells and preventing the development of virulence structures in pathogenic microorganisms. This could be one of the reasons why mortality was not recorded in treatments fed BACM, the test material have also proven its ability to repopulate the beneficial bacteria (*Lactobacilli*) to maintain dysbiosis. This result is in consonance with the findings of Han et al. (2016); Noohi et al. (2014) and Torok et al. (2011) on the influence of antimicrobial feed additives on broiler commensal post hatch gut microbiota development.

According to Pérez and Aguilar (2013) oxidation occurs during the transfer of electrons from one atom to the other essential for cell metabolism with oxygen as an electron acceptor releasing energy in the form of Adenosine triphosphate. Free radicals are generated during a break in the process predisposing animals to stress and disease but are naturally scavenged from cells by serum antioxidant enzymes i.e., superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx) (Hou et al., 2013; Omar, 2013). Phytochemicals have been reported to contain antioxidants (phenol and flavonoids) giving total protection to the body and its metabolism against free radicals in the body, thus improving the health status of birds (Olafadehan et al., 2020; Alagbe, 2020). These phytochemicals are also responsible for the rise in serum antibody titres and hormonal immunity especially among birds in T4 and T5. This result in this study is in

accordance with the work of Fuluyi and Agbede (2018); Olugbemi et al. (2010).

VI. CONCLUSION

The use of phytogenic feed additives are one of the ways to ensure food safety, maximize potential and put an end to the leading worrying increase in cases of antibiotic resistance diagnosed in animals and humans through direct contact, environmental contamination and feed consumption. Medicinal plants are of high therapeutic value, relatively cheap, safe and effective. It was concluded from this experiment that BACM can be fed to broiler chicks at 80 ml/liter of water without any deleterious effect on the performance and health status of animals.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest..

REFERENCES

- [1] Kholif, A.E., Gouda, G.A., Olafadehan, O.A and Abdo, M.M. (2017). Effect of replacement of Moringa olifera for berseem clover in the diets of Nubian goats on feed utilisation, milk yield composition and fatty acid profile. *The Animal Consortium Journal* 12 (5): 964-972
- [2] Alagbe, J.O., Shittu, M.D and Ajagbe, K.D. (2020). Albizia lebeck stem bark aqueous extract as an alternative to antibiotic feed additives in broiler chicks: performance and nutrient retention. *Drug Discovery*. 14(34):265-275.
- [3] Hyun, L., Yanhong, L., Sergio, C., Mariano, E.O., Fang, C., Ron, L.C., Sungtaek, O and Cyril, G.G. (2018). Phytochemical as antibiotic alternatives to promote growth and enhance host health. *Journal of Biomedical Sciences* 10 (18): 49-76.
- [4] A.O.A.C. (2000). Association of Official Analytical Chemists. *Official Methods of Analysis* 19th Edition Washington, D.C Pages 69-77.
- [5] Fascina, V.B., Pasquali, G.A., Carvalho, F.B., Vercese, F., Aoyagi, M.M., Pezzato, A.C., Gonzales, E and Sartori, J.R (2017). Effects of phytogenic feed additives and organic acids alone or in combination on the performance, intestinal quality and immune responses of broiler chickens. *Brazilian Journal of Poultry Science*, 19(3):497-508.
- [6] Ashan, U., Kufer, F., Roza, F., Koksai, B.H., Cengiz, M., Kizanlik, P.K, Kaya, M and Sevim, O (2018). Dietary supplementation of different levels of phytogenic feed additive in broiler diets: the dynamics of growth performance, caecal microbiota and intestinal morphometry. *Brazilian Journal of Poultry Science*, 20(4): 737-746.
- [7] Adisa, R.M., Choudhary, E.A., Adenoye, G.A. and Olorunsogo, O.O. (2010). Hypoglycaemic and biochemical properties of *Cnestis ferruginea*. *African Journal of Traditional Complementary and Alternative Medicine*, 7: 185-194.
- [8] Dingfa, W., Huifang, H., Luli, Z., Wei Li., Hanlin, Z., Guanyu, H and Lin, H (2017). Effects of dietary supplementation with turmeric rhizome extract on growth performance, carcass characteristics, antioxidant capacity and meat quality of Wenchang broiler chickens. *Italian Journal of Animal Science*, 14:3, 3870.
- [9] Olanipekun, M.K., Adewuyi, D and Adedeji, D.E (2016). Ethnobotanical importance and phytochemical analyses of some selected medicinal plants in Ado-Ekiti Local Govt. Area. *Journal of Herbal Medicine Research*, 1(3):0007-0016.
- [10] Suriya, K.R., Idrus, Z., Nordiana, A.A., Mahdi, E and Goy Y.M. (2014). Effects of two herbal extracts and Virginiamycin supplementation on the growth performance, intestinal microbial population and fatty acid composition of broiler chickens. *Asian Australian Journal of Animal Science* 27(3): 375-382.
- [11] Simopoulos, A.P. (2001). N-3 fatty acids and human health: defining strategies for public policy. *Journal of Animal Science* 36(1): 83-89.
- [12] Olugbemi, T.S., Mutayoba, S.K and Lekule, F.P (2010). Effect of Moringa oleifera inclusion in cassava based diets fed to broiler chickens. *International Journal of Poultry Science*, 9:363-367.
- [13] Enin, G.N., Antia, B.S and Enin, F.G (2014). Chemical assessment of the proximate, minerals and antinutrients composition in *Sida acuta* leaves. *Journal of Organic Chemistry*, 7(14): 24654-24660.
- [14] Faluyi, O.B and Agbede, J.O (2018). Immunomodulatory activity of aqueous leaf extract of Moringa oleifera in broiler chickens. *International Journal of Environment, Agriculture and Biotechnology*, 3(1):49-54.
- [15] Omokore, E.O and Alagbe, J.O. (2019). Efficacy of dried *Phyllanthus amarus* leaf meal as an herbal feed

- additive on the growth performance, haematology and serum biochemistry of growing rabbits. *International Journal of Academic Research and Development*. 4(3): 97-104.
- [16] Oluwafemi, R.A., Isiaka Olawale and Alagbe, J.O. (2020). Recent trends in the utilization of medicinal plants as growth promoters in poultry nutrition- A review. *Research in: Agricultural and Veterinary Sciences*. 4(1): 5-11.
- [17] Olafadehan, O.A., Oluwafemi, R.A and Alagbe, J.O. (2020). Performance, haemato-biochemical parameters of broiler chicks administered Rolfe (*Daniellia oliveri*) leaf extract as an antibiotic alternative. *Advances in Research and Reviews*, 2020, 1:4.
- [18] A.O.A.C.(2000). Association of Official Analytical Chemists. *Official Methods of Analysis 19th Edition* Washington, D.C Pages 69-77.
- [19] Aduku, A.O (2004). Animal nutrition in the tropics: Feeds and feeding in monogastric and ruminant nutrition. *Journal of Applied Poultry Research*, 13: 628-638.
- [20] Duncan, D.B. (1955). Multiple range and multiple F-test. *Biometrics* 11(1):1-42.
- [21] National Research Council (1994). Nutrient requirement of poultry 9th Rev Edn, Washington D.C. National Academy Press.
- [22] Olafadehan, O.A., Oluwafemi, R.A and Alagbe, J.O (2020). Carcass quality, nutrient retention and caeca microbial population of broiler chicks administered Rolfe (*Daniellia oliveri*) leaf extract as an antibiotic alternative. *Journal of Drug Discovery*. 14(33):146-154.
- [23] Butcher, G.D. and Miles, R.D. (2002). Interrelationship of nutrition and immunity. Available from: <http://edis.ifas.ufl.edu/vm104>
- [24] Alagbe, J.O. (2019). Haematology, serum biochemistry, relative organ weight and bacteria count of broiler chicken given different levels of *Luffa aegyptiaca* leaf extracts. *International Journal of Advanced Biological and Biomedical Research*. 7(4):382-392.
- [25] Boham, B. A. and Kocipai, A. C. (1974). Flavonoids and condensed tannins from leaves of Hawaiian *vaccinium vaticulatum* and *V. calycinium*. *Pacific Sci*. 48: 458-463.
- [26] Harborne, J. D. (1973). *Phytochemical methods: A guide to modern techniques of plant analysis*. Chapman and Hall, London. 279.
- [27] Odebiyi, A. and Sofowora, A. E. (1978). *Phytochemical Screening of Nigerian Medicinal Plant*. Part III, *Lloydia*, 41, 234- 246.
- [28] Atamgba, A.A., Margret, A.A., Kayode, D and Amonor, J.W. (2015). The biomedical significance of the phytochemical, proximate and mineral composition of the leaf, stem bark and roots of *Jatropha curcas*. *Asian Pacific Journal of Tropical Biomedicine*. 5(8):650-657.
- [29] Shittu, M.D., Adejumo, D.O., Ewuola, E.O., Alaba, O., Alagbe, J.O and Ojebiyi, O.O. (2020). Gut morphometric characteristic and ecological response of broiler starter fed varied levels of protein. *Asian Journal of Animal Science*, 14(1):33-39.
- [30] Hou, Y-J., Zhao, Y-Y., Xiong, B., Cui, X-S., Kim, N-H., Xu, Y-X. and Sun, S-C.(2013). Mycotoxin-containing diet causes oxidative stress in the mouse. *PLoS ONE*, 8(3): e60374
- [31] Alagbe, J.O., Shittu, M.D and Eunice Abidemi Ojo (2020). Prospect of leaf extracts on the performance and blood profile of monogastric – A review. *International Journal of Integrated Education*. 3(7): 122-127.
- [32] Alagbe, J.O. (2020). Performance, hematology and serum biochemical parameters of weaner rabbits fed different levels of fermented *Lagenaria brevifera* whole fruit extract. *Advances in Research and Reviews*, 2020, 1:5.
- [33] Omar, H.E.M. (2013). Mycotoxins-induced oxidative stress and disease. In *Mycotoxins and Food Safety in Developing countries*. Makun H.A. (ed.). Available from <http://dx.doi.org/10.5772/51806> (accessed January 2014).
- [34] Pérez, J.A. and Aguilar, T.A. (2013). Chemistry of natural antioxidants and studies performed with different plants collected in Mexico. Available from: <http://dx.doi.org/10.5772/52247> (Accessed May 2014).
- [35] Shabbir, M., Khan, M.R., Saeed, N (2013). Assessment of phytochemicals, antioxidants, anti-lipid peroxidation and anti-hemolytic activity of extract and various fractions of *Maytenus royleanus* leaves. *BMC Complementary Alternative Medicine*, 13:143.

- [36] Chothani, D.L., Vaghasiya, H.U (2011). A review on *Balanites aegyptiaca* phytochemical constituents, traditional use and pharmacological activity. *Pharmacological Review*, 5:55-62.
- [37] Sunil, K., Sangeetha, B., Suchitra, P, Ravisankar, B (2016). Pharmacognosy and quality characterization of *Balanites aegyptiaca* fruits. *Indian Journal of Natural Products and Resources*, 7:40-45.
- [38] Alagbe, J.O and Akintayo-Balogun, O.M (2020). Effect of dietary supplementation of *Albizia lebbek* seed oil on the fatty acid composition of weaned rabbits. *Biochemistry and Biotechnology Research*, 8(2):29-33.
- [39] Audu, I.W., Audu, B.S and Suleiman, Y (2018). Phytochemistry and proximate composition of root, stem bark and fruit of desert date, *Balanites aegyptiaca*. *Journal of Phytomedicine Research*, 7(6):464-470.
- [40] Dubey, P.K., Yogi, M., Bharadwaj, A., Soni, M.L and Sachan, A.K (2011). *Balanites aegyptiaca* A semi arid forest tree :A review. *Academic Journal of Plant Sciences*. 4(1):12-18.
- [41] Ezekiel, T.W., Nachana, T and Attama, C. (2019). Phytochemical screening, elemental and proximate analysis of *Maerua angolensis* stem bark. *International Journal of Biochemistry Research and Reviews*. 27(4)1-10.
- [42] Francis, G, Kareem, Z., Makkar, H.P and Becker, K (2002). The biological action of Saponin in Animal Systems: a review. *British Journal of Nutrition*, 88:587-605.
- [43] Onyema, A, Chinedu, O.J., Ahmad, M.S (2017). Evaluation of *Balanites aegyptiaca* stem bark. *American Journal of Chemistry and Applications*, 4:11-15.
- [44] Ojo, O.O., Nadro, M.S, Tella, I.O. (2006). Protection of rats by extracts of some hepatotoxicity. *African Journal of Biotechnology*, 5:755-760.
- [45] Ngaha, N.M., Dahlan, I., Massoma, L., Yusuf, A (2016). Comparative analysis of leaves and bark of *Alchornea cordifolia*. *Journal of Agriculture and Environmental Sciences*, 5(1):84-90.
- [46] Agyare, C., Ansah, A, Ossei, P., Apenteng, J (2014). Wound healing properties of *Alchornea cordifolia*. *Medicinal Chemistry* 4:533-539.
- [47] Makhosazana, L.D (2015). Application of some target formulations of active herbal plant components in reducing animal exposure to mycotoxins. An Unpublished MSc dissertation submitted to the faculty of Science, University of Johannesburg, South Africa.