



Effect of Dietary Supplementation of *Cymbopogon Citratus* Oil on the Performance and Carcass Characteristics of Broiler Chicks

Alagbe J. O.

Department of Animal Nutrition and Biochemistry, Sumitra Research Institute, Gujarat, India

Email: demsonfarms@yahoo.com

Article History

Received: October 5, 2020

Revised: November 15, 2020

Accepted: November 20, 2020

Published: November 22, 2020

Abstract

This study was carried out to determine the effect of dietary supplementation of *Cymbopogon citratus* oil (LGO) on the performance and carcass characteristics of broiler chicks. A total of 250 one-day-old chicks of Ross 308 strain were divided into 5 treatments with 5 replicate per treatment of 10 birds in a completely randomized design. The dietary treatments include a control diet (T1) with no *Cymbopogon citratus* oil (LGO). LGO was supplemented at 0.1%, 0.2 %, 0.3 % and 0.4 % in diets 2, 3, 4 and 5 respectively. The experiment lasted for 56 days; feed and water were administered *ad libitum*. Results obtained revealed that average daily weight gain (ADWG), average daily feed intake (ADFI), average daily water consumption (ADWC) and feed:gain were significantly influenced by LGO ($P < 0.05$). Highest mortality was recorded in T1 (4.15 %) followed by T2 (1.71 %), T3 (0.50 %), none was recorded in T4 and T5 ($P < 0.05$). Dressing percentage, carcass and relative organ weight were significantly different among the treatments ($P < 0.05$). There was no noticeable inflammation observed on the liver, kidney spleen and other internal organs. It was concluded that LGO is rich in phytochemical constituents and can be safely included in the diets of broiler chicks up to 0.4 % level without causing any detrimental effect on the growth performance and carcass of birds.

Keywords: Broiler chicks; *Cymbopogon citratus*; Phytochemical; Performance; Mortality.

1. Introduction

Due to the problems of antibiotics resistant bacteria and antibiotics residues in animal products and the danger posed to human health, there is a renewed and growing interest in quest for alternatives to antibiotics for livestock medication. Recently, essential oils (plant extracts) are being used as feed additives to improve livestock performance, especially under intensive system of management [1]. Among the potential plants with significant therapeutic effect is *Cymbopogon citratus*.

Cymbopogon citratus Stapf belonging to the family Gramineae is a perennial grass widely distributed worldwide and most especially in tropical and subtropical countries [2]. It is commonly referred to as lemon grass and it comprises approximately 500 genus and 8,000 herb species [3]. The leaves are long, green, linear tapering upwards along the margins [4]. It is rich in phytochemical constituents and have been reported to exhibit several pharmacological roles which includes: antimicrobial, anti-inflammatory, hepatoprotective, antifungal, antiviral, antiurolithiatic, antioxidant, anti-nociceptive, antithrombotic and cytotoxic activities [3, 5-9]. Traditionally the plants have been used for the treatment of flu, elephantiasis, malaria, headache, pneumonia, leprosy, cough, gingivitis and vascular disorders [4].

Scientific studies have shown that lemon grass contained several medicinal components which reside in its essential oil, this bioactive chemicals includes: citral, myrcene, α -citral, β -citral, limonene, dipentene, heptenone, borncol, geranial, geraniol, β -myrcene, citronellol, 6-methyl-5-hepten-2-ona and undecan-2-one [6, 10-14]. Their concentrations are dependent on the extraction methods, species of plants, age of plant/maturity stage, geographical location [15, 16].

In view of these potentials, essential oil can be used to bridge the gap between food safety and livestock management which encompass health, housing and feeding. Therefore, this experiment was designed to evaluate the effect of dietary supplementation of *Cymbopogon citratus* oil on the performance and carcass characteristics of broiler chicks.

2. Materials and Methods

2.1. Site of the Experiment

The experiment was carried out at Division of Animal Nutrition, Sumitra Research Institute, Gujarat, India during the month of January to March, 2019.

2.2. Collection and Extraction of Lemon Grass Oil (LGO)

Fresh and mature lemon grass (*Cymbopogon citratus*) leaves were harvested within Sumitra Teaching and Research farm, Gujarat, India and identified by a plant taxonomist (Dr. Sharma Kumar), it was later washed with a running tap water to remove dirt's and air dried for 15 days to maintain the bioactive chemicals in the plant and to prevent the growth of microorganisms until a constant was obtained, thereafter powdered and kept in an air tight well labeled container. *Cymbopogon citratus* essential oil (LGO) was obtained according to the methods outlined by Oluwole, *et al.* [17].

2.3. Management of Experimental Birds

250 –one- day- old (Ross 308) broiler chicks were used for the experiment. The birds were purchased from a commercial hatchery in India and weighed on arrival on the farm to obtain their initial body weight and thereafter weekly. A deep litter pen was used, it was fumigated two weeks prior to the commencement of the study, electrical fittings were properly fixed and foot bath was put in place to ensure proper biosecurity. Birds were divided to five treatments with five replicates of fifteen (10) birds in a completely randomized design. Electric brooders were used and wood shavings serve as the litter material. Vaccines were administered according to the prevailing disease condition in the environment and all other management practices were strictly adhered to throughout the experiment which lasted for 56 days.

2.4. Experimental Set Up and Diet Formulation

Basal diet was formulated to meet the nutritional requirement of birds according to National Research Council [18]. Treatment 1 (T1) a control diet with no *Cymbopogon citratus* oil (LGO), LGO was included at 0.1 %, 0.2 %, 0.3 % and 0.4 % in diets of T2, T3, T4 and T5 respectively.

2.5. Data Obtained

Weight gain (g) = final weight (FW) – initial weight (IW)

Feed intake (g) = Amount of feed consumed – remaining feed

Average daily gain (ADG) = $\frac{\text{Final body weight} - \text{Initial body weight}}{\text{Total days of the experiment}}$

Feed: gain = feed intake (g)/weight gain (g)

% mortality = number of dead birds/total number of birds × 100

2.6. Carcass Evaluation

At the end of the experiment (56 days), three (3) birds were randomly selected per replicate for carcass evaluation; the birds were feed starved overnight, weighed, slaughtered and manually de-feathered. Weights of internal organs (liver, lungs, spleen, gizzard, heart and intestine) were recorded and the parameters below were estimated:

Dressing % = dress weight/live weight × 100

% organ/ primal cut parts = weight of primal cut or organ/live weight × 100

2.7. Chemical Analysis

Laboratory analysis of the experimental diet was carried out according to the methods outlined by AOAC [19].

2.8. Statistical Analysis

All data were subjected to one -way analysis of variance (ANOVA) using SPSS (18.0) and significant means were separated using Duncan multiple range tests [20]. Significant was declared if $P \leq 0.05$.

Table-1. Chemical composition of experimental diets

Materials	Starter (1-21 days)	Grower (22-35 days)	Finisher (36-56 days)
Maize	50.00	56.00	60.50
Wheat offal	8.00	7.00	8.05
Soya meal	28.55	22.00	21.00
Groundnut cake	10.00	11.55	6.05
Fish meal	2.00	2.00	2.00
Bone meal	0.35	0.40	0.40
Limestone	0.20	0.20	0.20
Lysine	0.15	0.15	0.15
Methionine	0.20	0.20	0.20
Premix	0.25	0.25	0.25
Salt	0.30	0.30	0.30
TOTAL	100.0	100.0	100.0
Determined analysis			
Dry matter (%)	90.10	93.63	92.04
Crude protein (%)	23.08	20.11	19.33
Ether extracts (%)	5.03	4.87	4.28

Crude fibre (%)	3.06	3.95	3.42
Calcium (%)	0.98	1.00	1.10
Phosphorus (%)	0.47	0.40	0.51
Lysine	1.17	1.29	1.60
Meth +Cyst	0.87	0.82	0.51
ME (Kcal/kg)	2936	3000.8	3100.2

*Premix supplied per kg diet: - vit A, 10,000 I.U; vit E, 5mg; vit D3, 3000I.U, vit K, 3mg; vit B2, 5.5mg; Niacin, 25mg; vit B12, 16mg; choline chloride, 120mg; Mn, 5.2mg; Zn, 25mg; Cu, 2.6g; folic acid, 2mg; Fe, 5g; pantothenic acid, 10mg; biotin, 30.5g; antioxidant, 56mg.

Table-2. Vaccination schedule of birds

Vaccine	Day/week	Route of administration
IBD (Gumboro)	Day 5	Via drinking water
Immucox vaccine (Coccidial)	Day 6	Oral
1 st ND (Lasota)	Day 8	Oral
2 nd IBD (Gumboro)	Day 13	Oral
2 nd ND (Lasota)	Day 21	Oral
3 rd ND (Lasota)	Day 28	Oral

Table-3. Performance characteristics of broiler chicks fed diets supplemented with LGO

Parameters	T1	T2	T3	T4	T5	SEM
IW (g)	45.18	45.13	45.09	45.11	45.02	0.01Z
FW (g)	1934.0 ^c	2000.6 ^b	2109.6 ^b	2340.9 ^a	2400.3 ^a	7.84
WG (g)	1888.8 ^b	1955.5 ^b	2064.5 ^a	2295.8 ^a	2355.3 ^a	5.60
ADWG (g)	33.73 ^b	34.92 ^b	36.87 ^b	41.00 ^a	42.10 ^a	0.88
F.I (g)	4000.4 ^a	3900.8 ^b	3900.1 ^b	3889.3 ^b	3880.5 ^b	11.22
ADFI (g)	71.43 ^a	69.66 ^b	69.64 ^b	69.45 ^b	69.29 ^b	0.56
Feed: gain	2.13 ^a	1.99 ^b	1.89 ^b	1.69 ^c	1.65 ^c	0.02
TWC (ml)	21,003	21,000	22,009	22,400	22,000	12.33
ADWC (ml)	375.1	375.0	393.0	400.0	392.9	6.71
Mortality (%)	4.15	1.71	0.50	-	-	0.04

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

IW: initial weight; FW: final weight; WG: weight gain; ADWG: average daily weight gain; F.I: feed intake; ADFI: average daily feed intake; TWC: total water consumption; ADWC: average daily water consumption.

Table-4. Carcass and organ characteristics of broiler chicks fed diets supplemented with LGO

Parameters	T1	T2	T3	T4	T5	SEM
Live weight (g)	1922.8 ^c	2150.1 ^b	2200.0 ^b	2290.7 ^a	2400.2 ^a	12.30
Dressed weight (g)	1500.1 ^c	1871.8 ^b	1922.4 ^b	2000.1 ^a	2100.8 ^a	8.22
Dressed %	78.01 ^b	87.10 ^a	87.40 ^a	87.30 ^a	87.50 ^a	2.04
Head (%)	1.98 ^b	2.33 ^a	2.38 ^a	2.41 ^a	2.46 ^a	0.56
Neck (%)	3.90 ^b	4.19 ^a	4.56 ^a	4.71 ^a	4.88 ^a	0.02
Thigh (%)	9.74 ^c	10.34 ^c	11.22 ^b	11.50 ^b	12.04 ^a	1.46
Back (%)	15.43 ^c	17.20 ^b	20.18 ^a	20.55 ^a	21.00 ^a	3.27
Shank (%)	3.88 ^c	4.04 ^b	4.85 ^b	5.67 ^a	6.03 ^a	2.05
Breast muscle (%)	21.10 ^b	21.89 ^b	23.01 ^a	23.40 ^a	23.84 ^a	1.33
Wings (%)	6.33 ^c	8.05 ^b	8.59 ^b	9.01 ^a	9.05 ^a	0.04
Organ performance (%)						
Liver	1.64 ^b	1.82 ^b	2.03 ^a	2.18 ^a	2.30 ^a	0.03
Heart	0.36 ^a	0.38 ^a	0.30 ^b	0.32 ^a	0.35 ^a	0.11
Lungs	0.58 ^b	0.55 ^b	0.63 ^a	0.58 ^b	0.61 ^a	0.60
Spleen	0.20 ^a	0.17 ^b	0.15 ^b	0.23 ^a	0.22 ^a	0.04
Gizzard	2.02 ^b	2.30 ^a	2.44 ^a	2.63 ^a	2.50 ^a	0.01
Intestine	3.54 ^a	3.06 ^b	3.18 ^b	3.90 ^a	3.75 ^a	0.18

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

3. Result and Discussion

3.1. Proximate Composition of Experimental Diet Fed to Broiler Chicks

Broiler starter diet was fed to birds at 1-21 days and it contains crude protein (CP), ether extract (EE), crude fibre (CF), calcium, phosphorus and energy at 23.08 %, 5.03 %, 3.06 %, 0.98 %, 0.47 % and 2936 Kcal/kg. Growers mash was fed at 22 – 35 days and it contained CP (20.11 %), EE (4.87 %), CF (3.95 %), calcium (1.00 %), phosphorus (0.40 %) and energy (3000.8 Kcal/kg) while broiler finisher mash (36 – 56 days) contained CP (19.33 %), EE (4.28 %), CF (3.42 %), calcium (1.10 %), phosphorus (0.51 %) and energy (3100.2 Kcal/kg) respectively. The dry matter value of the experimental diets obtained in this study ranged between 90.10 – 93.63 % which is in conformity with the findings of Olajide, *et al.* [21] and Olafadehan, *et al.* [22]. The crude protein and ether extracts

fall within the recommended ranges by National Research Council [18]. The values for crude fibre obtained in this study were lower than the values reported by Ngouana, *et al.* [23]; Musa, *et al.* [24]; Bento, *et al.* [25]; Amerah, *et al.* [26] but calcium and phosphorus conforms to the findings of Adil, *et al.* [27]; Brenes and Roura [28]; Gerardo, *et al.* [29] when Mexican organo oil was supplemented in the diet of broiler chickens. The energy values were similar to the findings of Pineda, *et al.* [30]; Khattak, *et al.* [31] who evaluated the effects of natural blend of essential oil on the performance of broiler chickens.

3.2. Performance Characteristics of Broiler Chicks Fed Different Level of LGO

The initial body weight (IW), final body weight (FW), weight gain (WG) and average daily weight gain (ADWG) ranged between 45.02 – 45.18 g, 1934.0 – 2400.3 g and 1888.8 – 2355.3 g respectively. WG obtained in this study were highest in T4 and T5, intermediate in T2 and T3 and lowest in T1 ($P < 0.05$). This is in conformity to the findings of Alagbe and Oluwafemi [32]; Alagbe, *et al.* [33]; Cho, *et al.* [34]; El-Ghany and Ismail [35] on the effect of oregano and rosemary essential oil or alpha-tocopheryl acetate on the performance of broilers. The high weight gain in T4 and T5 could be attributed to the presence of phytochemicals in LGO. Scientific studies have shown that phytochemicals contains bioactive chemicals which are capable of performing antimicrobial [36], anti-inflammatory [37, 38], hepatoprotective [39-42], cytotoxic [43, 44], antithrombotic [45], antidiabetic [46], miracidicidal and cercaricidal [47], antioxidant [48, 49], neuroprotective [50] antiplasmodial [51], antifungal [52, 53], cardiovascular [29] and antiviral activities [33, 54]. They also have the ability to reduce the invasion of pathogenic bacteria in the gastro intestinal tracts, thus preventing dysbiosis [15, 55] scavenging free radicals [56-58] and growth improvement in animals [59-61].

Feed intake (F.I) and average daily feed intake (ADFI) ranged between 3880.5 – 4000.4 g and 69.29 – 71.43 g; the values obtained were significant across the treatments ($P < 0.05$). The result showed that T1 consumed 71.43 g of feed daily with poor conversion ratio when compared to birds in T3, T4 and T5 which gave a better feed conversion ratio. Oluwole, *et al.* [17]; María del Carmen, *et al.* [62]; Monteiro, *et al.* [63] reported that LGO contains citral, myrcene, genariol, citronellol, α - oxobisabolene, limonene, humulene, cubebol, elemol, β -eudesmol, α -cadinol, citral acetate, citral diethylacetal, decanal and other secondary metabolites in various proportion and it is capable of improving palatability of feed and promoting nutrient absorption via efficient production of beneficial bacteria such as lactobacilli in the gut. Highest mortality were recorded in T1 (4.15 %) followed by T2 (1.71 %) and T3 (0.50 %) respectively. This could possibly attributed to the presence of terpenoids have been suggested to multiple pharmacological activities such as antimicrobial, antiviral, anticancer and anti-inflammatory activities [64, 65]. Phenols are strong antioxidants giving total protection to the body and its metabolism against free radicals [66, 67]. Water consumption of the birds was not significantly affected among the treatments ($P > 0.05$). According to Alagbe [68], water intakes of animals are influenced by age, weather condition, type of diets fed, breed of animals and its physiological state.

3.3. Carcass and Organ Characteristics of Broiler Chicks Fed Diets Supplemented with LGO

Carcass and organ characteristics of broiler chicks fed diet supplemented LGO is presented in Table 4. Dressed % (78.10 – 87.50 %), head (1.98 – 2.46 %), neck (3.90 – 4.88 %), thigh (9.74 – 12.04 %), shank (3.88 – 6.03 %), breast muscle (21.10 – 23.84 %) and wings (6.03 – 9.05 %). Carcass weights were highest in T2, T3, T4 and T5 and lowest in T1 ($P < 0.05$). Dressed % values are in close agreement with the findings of Jamroz, *et al.* [69]; Tiuhonen, *et al.* [70]; Kirkpınar, *et al.* [71] who accessed the effect of garlic and oregano essential oil on the carcass, organ characteristics of broiler chickens. In all the carcass parameters birds fed diet supplemented with LGO performed better than birds on control diet. Organ weights (expressed as % of DW) revealed that liver, heart, lungs, spleen, gizzard and intestine ranged between 1.64 – 2.30 %, 0.30 – 0.36 %, 0.58 – 0.60 %, 0.17 – 0.23 %, 2.02 – 2.50 % and 3.06 – 3.90 % respectively. Significant differences ($P < 0.05$) were observed among the treatments, the result also indicated that LGO is non-toxic since there was no noticeable inflammation on the internal organs of the birds. This conforms to the findings of Alagbe, *et al.* [72]; Yoo, *et al.* [73]; Jamroz, *et al.* [69]; Abdel Fattah, *et al.* [74] when broiler chicks were fed diets supplemented with organic acids.

4. Conclusion

Out of the over 250, 000 species of medicinal plants reported by WHO, there are several plants that are underexplored, among the potential plants is *Cymbopogon citratus* which is found to be abundant in several bioactive chemicals or phytochemicals, it is also rich in several nutrients; LGO is relatively cheap, safe and effective. It was concluded that LGO can be safely included in the diets of broiler chicks up to 0.4 % level without causing any detrimental effect on the growth performance and carcass of birds.

References

- [1] William, P. and Losa, R., 2001. "The use of essential oils and their compounds in poultry nutrition." *World's Poultry*, vol. 17, pp. 14-15.
- [2] Francisco, Y., Song, M., Che, T. M., Lee, J. J., Bravo, D., Maddox, C. W., and Pettigrew, J. E., 2011. "Dietary plant extracts modulate gene expression profiles in ileal mucosa of weaned pigs after an infection." *Journal of Animal Science*, vol. 92, pp. 2050-2062.

- [3] Barbosa, L. C. A., Pereira, U. A., Martinazzo, A. P., and Melo, E. C., 2008. "Evaluation of the chemical composition of Brazilian commercial cymbopogon citratus samples." *Molecules*, vol. 13, pp. 1864-1874.
- [4] Karkala, S. D. and Bhushaa, K., 2014. "Phenolic content and antioxidant activity of Olive extracts." *Food Chemistry*, vol. 73, pp. 73-84.
- [5] Amit, K. T. and Anushree, M., 2010. "Liquid and vapourphase antifungal activities of selected essential oils against candida albicans: microscopic observations and chemical characterization of Cymbopogon citratus." *Complementary and Alternative Medicine*, vol. 10, pp. 1-11.
- [6] Costa, C. A., Kohn, D. O., de Lima, V. M., Gargano, A. C., Flório, J. C., and Costa, M., 2011. "The GABAergic system contributes to the anxiolytic-like effect of essential oil from Cymbopogon citratus (lemongrass)." *Journal of Ethnopharmacology*, vol. 137, pp. 828-836.
- [7] Dharmendra, S., Suman, P. S. K., Atul, P. K., Subhash, C. G., and Sushil, K., 2001. "Comparative antifungal activity of essential oils and constituents from three distinct genotypes of Cymbopogon spp." *Current Science*, vol. 80, pp. 1264-1266.
- [8] Fandohan, P., Gnonlonfin, B., Laleye, A., Gbenou, J. D., Darboux, R., and Moudachirou, M., 2008. "Toxicity and gastric tolerance of essential oils from Cymbopogon citratus, Ocimum gratissimum and Ocimum basilicum in Wistar rats." *Food and Chemical Toxicology*, vol. 46, pp. 2493-2497.
- [9] Silva, C., Guterres, S. S., Weisheimer, V., and Schapoval, E. E., 2008. "Antifungal activity of the lemon grass oil and citral against Candida spp." *Brazilian Journal of Infectious Disease*, vol. 12, pp. 1-8.
- [10] Meevatee, U., Boontim, S., Keereeta, O., Vinitketkumnuen, U., and Oariyakul, N., 1993. *Antimutagenic activity of lemon grass*, in: *Boon-in S. (Ed.), Man and Environment*. Chiang Mai: University Press. p. 346.
- [11] Mirghani, M. E. S., Liyana, Y., and Parveen, J., 2012. "Bioactivity analysis of lemongrass (Cymbopogon citratus) essential oil." *International Food Research Journal*, vol. 12, pp. 1-4.
- [12] Onawunmi, G. O., Yisak, W. A., and Ogunlana, E. O., 1984. "Antibacterial constituents in the essential oil of Cymbopogon citratus (dc.) Stapf." *Journal of Ethnopharmacology*, vol. 12, pp. 274-286.
- [13] Olorunisola, S., Zadeh, Z. T., Torshizi, M. A. K., and Rokni, H., 2014. "Effect of three herbal extracts on growth performance, immune response, blood factor and intestinal selected bacteria population in broiler chickens." *Journal of Agricultural Science and Technology*, vol. 13, pp. 527-539.
- [14] Shigeharu, J. A., Morel, P. C., Wilkinson, B. H., and Purchas, R. W., 2001. "Preliminary investigation of the effects of low level dietary inclusions of fragrant essential oil and oleoresins on pig performance and pork quality." *Journal of Meat Science*, vol. 75, pp. 350-355.
- [15] Akintayo, B., Omolere, M., and Alagbe, J. O., 2020. "Probiotics and medicinal plants in poultry nutrition: A review." *United International Journal for Research and Technology*, vol. 2, pp. 7-13.
- [16] Oluwafemi, R. A., Isiaka, O., 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*, vol. 4, pp. 5-11.
- [17] Oluwole, S. O., Funmilayo, E. A., David, T. A., and Kehinde, A. O., 2019. "Phytochemistry and pharmacological activities of Cymbopogon citratus: A review." *Scientific African*, vol. 6, pp. 1-11.
- [18] National Research Council, 1994. *Nutrient requirement of poultry*. 9th ed. Washington D.C.: National Academy Press.
- [19] AOAC, 2000. "Association of official analytical chemists." In *Official Methods of Analysis 19th Edition Washington, D.C.* pp. 69-77.
- [20] Duncan, D. B., 1955. "Multiple range and multiple F-test." *Biometrics*, vol. 11, pp. 1-42.
- [21] Olajide, A., Asaniyan, E. K., and Akintola, K. A., 2013. "Performance and blood parameters of ross broiler chicks fed graded levels of beniseed cake as substitute for full fat soya meal." *Tropical Animal Production Investigation*, vol. 18, pp. 26-33.
- [22] 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*, vol. 1, p. 4.
- [23] Ngouana, T. R., Kana, J. R., Necdem, T. B., Yemdjie, M. D., Doriane, M. K., Hervé, K. S., Tegui, A., and Meimandipour, A., 2017. "Performances of broiler chickens fed on diet supplemented with thyme and oregano essential oils stabilized in a plant charcoal matrix." *J. World Poult. Res.*, vol. 7, pp. 79-87.
- [24] Musa, B., Alagbe, J. O., Adegbite, M. B., and Omokore, E. A., 2020. "Growth performance, caeca microbial population and immune response of broiler chicks fed aqueous extract of Balanites aegyptiaca and Alchornea cordifolia stem bark mixture." *United Journal for Research and Technology*, vol. 2, pp. 13-21.
- [25] Bento, N., Gee, O. M., and Alagbe, J. O., 2011. "Studies on growth performance, nutrient utilization and haematological characteristics of broiler chickens fed different levels of Azolla-Moringa oliferamixture." *Greener Journal of Agricultural Sciences*, vol. 7, pp. 145-156.
- [26] Amerah, A. M., Péron, A., Zaefarian, F., and Ravindran, V., 2011. "Influence of whole wheat inclusion and a blend of essential oils on the performance, nutrient utilisation, digestive tract development and ileal microbiota profile of broiler chickens." *British Poultry Science*, vol. 52, pp. 124-132.
- [27] Adil, S., Banday, T., Ahmad Bhat, G., Salahuddin, M., Raquib, M., and Shanaz, S., 2011. "Response of broiler chicken to dietary supplementation of organic acids." *Journal of Central European Agriculture*, vol. 12, pp. 498-508.
- [28] Brenes, E. and Roura, M. K., 2010. "Proximate composition and some nutritionally valuable minerals of two varieties of Capsicum annum." *Discovery Innovations*, vol. 12, pp. 75-81.

- [29] Gerardo, M. Z., Lorenzo, A. D. M., Michael, E. H., and Ramón, S. V., 2017. "Performance, blood parameters, and carcass yield of broiler chickens supplemented with Mexican oregano oil." *Revista Brasileira de Zootecnia*, vol. 46, pp. 515-520.
- [30] Pineda, L., Chwalibog, A., Sawosz, E., Lauridsen, C., Engberg, R., Elnif, J., Hotowy, A., Sawosz, F., Gao, Y., *et al.*, 2012. "Effect of silver nanoparticles on growth performance, metabolism and microbial profile of broiler chickens." *Archives of Animal Nutrition*, vol. 66, pp. 416-429.
- [31] Khattak, F., Ronchi, A., Castelli, P., and Sparks, N., 2014. "Effects of natural blend of essential oil on growth performance, blood biochemistry, cecal morphology, and carcass quality of broiler chickens." *Poultry Science*, vol. 93, pp. 132-7.
- [32] Alagbe, J. O. and Oluwafemi, R. A., 2019. "Performance and haematological parameters of broiler chicks gives different levels of dried lemon grass (*Cymbopogon citratus*) and garlic (*Allium sativum*) extract." *Research in: Agricultural and Veterinary Sciences*, vol. 3, pp. 102-111.
- [33] Alagbe, J. O., Eimoga, A. A., and Alagbe, O. O., 2017. "Growth response and carcass characteristics of weaner grass cutters fed diets supplemented with Polyalthia longifolia seed oil as a natural growth promoter." *Greener Journal of Agricultural Sciences*, vol. 7, pp. 112-119.
- [34] Cho, J. H., Kim, I. H., and Kim, I. J., 2014. "Effects of phytogetic feed additive on growth performance, digestibility, blood metabolites, intestinal microbiota, meat color and relative organ weight after oral challenge with clostridium perfringens in broilers." *Livestock Science*, vol. 160, pp. 82-88.
- [35] El-Ghany, W. A. A. and Ismail, M., 2013. "Tackling of experimental colisepticaemia in broiler chickens using phytobiotic essential oils and antibiotic alone or in combination." *Iranian Journal of Veterinary Research*, vol. 15, pp. 110-115.
- [36] Ambade, S. V. and Bhadbhade, B. J., 2015. "In-vitro comparison of antimicrobial activity of different extracts of *Cymbopogon citratus* on dental plaque isolates." *Int. J. Curr. Microbiol. Appl. Sci.*, vol. 4, pp. 672-681.
- [37] Alagbe, J. O., Sharma, R., Eunice, A. O., Shittu, M. D., and Bello, K. A., 2020. "Chemical evaluation of the proximate, minerals, vitamins and phytochemical analysis of *Daniellia oliveri* stem bark." *International Journal of Biological, Physical and Chemical Studies*, vol. 2, pp. 16-22.
- [38] Colotta, F., Allavena, P., Sica, A., Garlanda, C., and Mantovani, A., 2009. "Cancer-related inflammation, the seventh hallmark of cancer: links to genetic instability." *Carcinogenesis*, vol. 30, pp. 1073-1081.
- [39] Chukwuocha, U. M., Fernández-Rivera, O., and Legorreta-Herrera, M., 2016. "Exploring the antimalarial potential of whole *Cymbopogon citratus* plant therapy." *J. Ethnopharmacol.*, vol. 193, pp. 517-523.
- [40] 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*, vol. 4, pp. 97-104.
- [41] Piarua, S. P., Perumala, S., Caia, L. W., Mahmuda, R., Abdul Majida, A. M., Ismailb, S., and Manc, C. N., 2012. "Chemical composition, anti-angiogenic and cytotoxicity activities of the essential oils of *Cymbopogon citratus* (lemon grass) against colorectal and breast carcinoma cell lines." *J. Essent. Oil Res.*, vol. 24, pp. 453-459.
- [42] Tajjadin, N. E., Ahmad, S. H., Rosenani, A. B., Azimah, H., and Munirah, M., 2012. "Chemical composition and citral content in lemongrass (*Cymbopogon citratus*) essential oil at three maturity stages." *Afr. J. Biotech.*, vol. 11, pp. 2685-2693.
- [43] Aftab, K., Ali, M. D., Aijaz, P., Beena, N., Gulzar, H., and Sheikh, K., 2011. "Determination of different trace and essential element in Lemon grass samples by X-Ray fluorescence spectroscopy technique." *Intern. Food Res. J.*, vol. 18, pp. 265-270.
- [44] Chowdury, M. I., Debnath, M., Ahmad, M., Alam, M., Saleh, A., Chowdhury, S., and Kama, A. H., 2015. "Potential phytochemical, analgesic and anticancerous activities of *Cymbopogon citratus* leaf." *Am. J. Biomed. Res.*, vol. 3, pp. 66-70.
- [45] Carlson, L. H., Machad, C. B., Pereira, L. K., and Bolzan, A., 2001. "Extraction of lemongrass essential oil with dense carbondioxide." *J. Supercritical. Fluids.*, vol. 21, pp. 33-39.
- [46] Coelho, M., Rocha, C., Cunha, L. M., Cardoso, L., Alves, L., Lima, R. C., and Pintado, M., 2016. "Influence of harvesting factors on sensory attributes and phenolic and aroma compounds composition of *Cymbopogon citratus* leaves infusions." *Food Res. Int.*, vol. 89, pp. 1029-1037.
- [47] Ajayi, G. O., Awujo, N. C., and Abulu, L. E., 2002. "The miracidicidal and cercaricidal activity of the methanolic extracts of *Lagenaria breviflora* Robert family Cucurbitaceae fruit on *Schistosoma mansoni*." *Nig. Q. J. Hosp. Med.*, vol. 12, pp. 57-9.
- [48] Balakrishnan, B., Paramasivam, S., and Arulkumar, A., 2014. "Evaluation of the lemongrass plant (*Cymbopogon citratus*) extracted in different solvents for antioxidant and antibacterial activity against human pathogens." *Asian Pacific Journal of Tropical Disease*, vol. 11, pp. 1-8.
- [49] Jayasinha, P., 2001. *Lemon grass: A literature survey. Medicinal and aromatic plant series no. 9.* Baudhaloka Mawatha, Colombo, Sri Lanka: industrial technology institute.
- [50] Ntonga, P. A., Baldovini, N., Mouray, E., Mambu, L., Belong, P., and Grellier, P., 2014. "Activity of *Ocimum basilicum*, *Ocimum canum*, and *Cymbopogon citratus* essential oils against plasmodium falciparum and mature stage larvae of *Anopheles funestus*." *Parasite*, vol. 21, pp. 33-35.
- [51] Kpoviessi, S., Bero, J., Agbani, P., Gbaguidi, F., Kpadonou-Kpoviessi, B., Sinsin, B., and Leclercq, J., 2014. "Chemical composition, cytotoxicity and in vitro antitrypanosomal and antiplasmodial activity of the essential oils of four *Cymbopogon* species from Benin." *J. Ethnopharmacol.*, vol. 151, pp. 652-659.

- [52] Ibrahim, T. A., Ibo, D., and Adejare, A. R., 2010. "Comparative phytochemical properties of crude ethanolic extracts and physicochemical characteristics of essential oils of *Myristical fragrans* (nutmeg) seeds and *Zingiber officinate* (ginger) roots." *Electronic Journal of Environmental, Agricultural and Food Chemistry*, vol. 9, pp. 1110-1116.
- [53] León-Anzueto, E., Abud-Archila, M., Dendooven, L., Ventura-Canseco, L. M. C., and Gutiérrez-Miceli, F. A., 2011. "Effect of vermicompost, worm-bed leachate and arbuscular mycorrhizal fungi on lemongrass (*Cymbopogon citratus* (DC) Stapf.) growth and composition of its essential oil." *Electronic Journal of Biotechnology*, vol. 14, pp. 1-11.
- [54] Adedapo, A. A., Jimoh, F. O., Afolayan, A. J., and Masika, P. J., 2009. "Antioxidant activities of the methanol extracts of the leaves and stems of *Celtis Africana*." *Rec Nat Prod.*, vol. 3, pp. 23-31.
- [55] Haung, J. T. and Lee, M., 2018. "Proximate nutrient composition of sickle pod (*Cassia obtusifolia*) leaves and seeds." *Plant Products Research Journal*, vol. 8, pp. 13-17.
- [56] Lee, M., Sharma, F., and Alagbe, J. O., 2011. "Effect of feeding different levels of Tridax procumbens meal on the performance, carcass characteristics and blood profile of growing cockerels." *Scholarly Journal of Agricultural Science*, vol. 7, pp. 20-26.
- [57] Yu, M., Vasudevan, M. D., and Sreekumari, S., 2012. *Textbook of biochemistry for medical students*. 5th ed. New Delhi, India: Jaypee Brothers Medical Publishers Ltd., pp. 283-287.
- [58] Zhou, N., Yu, H., Sing, O., and Alagbe, J. O., 2016. "Nutrient evaluation of sweet orange (*Citrus sinensis*) fruit peel as a replacement for maize in the diets of weaner grass cutters." *Scholarly Journal of Agricultural Science*, vol. 6, pp. 277-282.
- [59] Hernandez, I. W., Audu, B. S., and Suleiman, Y., 2004. "Phytochemistry and proximate composition of root, stem bark, leaf and fruit of *Balanites aegyptiaca*." *The Journal of Phytopharmacology*, vol. 7, pp. 464-470.
- [60] Mansoub, T. W., Nachana, T., and Attama, C., 2009. "Phytochemical screening, elemental and proximate analysis of *Maerua angolensis* stem bark." *International Journal of Biochemistry Research and Review*, vol. 27, pp. 1-10.
- [61] Mohammed, I. E., Obasi, N. A., and Ugbogu, A. E., 2016. "Nutritional and chemical value of *Amaranthus hybridus* leaves from Afriko Nigeria." *African Journal of Biotechnology*, vol. 6, pp. 2833-2839.
- [62] María del Carmen, V.-B., Luis, R. H., and José Ángel, G.-B., 2015. "Physicochemical and Antioxidant Properties of *Cymbopogon citratus* Essential Oil." *Journal of Food Research*, vol. 4, pp. 36-45.
- [63] Monteiro, O. O., Souza, A. A., Soledade, L. L., Queiroz, N. N., Mouchrek Filho, V. V., and Vasconcelos, A. A., 2011. "Chemical evaluation and thermal analysis of the essential oil from the fruits of the vegetable species *Pimenta dioica* Lindl." *Journal of Thermal Analysis and Calorimetry*, vol. 106, pp. 595-600. Available: <http://dx.doi.org/10.1007/s10973-011-1438-4>
- [64] Ojewumi, A. W. and Dedeke, G. A., 2020. "Evaluation of nutritional and phytochemical properties of *Eucalyptus camaldulensis*, *Hibiscus sabdariffa* and *Morinda lucida* from Ogun State, Nigeria." *Journal of Stress Physiology and Biochemistry*, vol. 16, pp. 45-56.
- [65] Rani, P. M. I., Kannan, P., and Kumaravel, S., 2011. "Screening of antioxidant activity, total phenolics and gas chromatograph and mass spectrometer (GC-MS) study of *Delonix regia*." *African Journal of Biochem. Res.*, vol. 5, pp. 341-347.
- [66] Joy, S., Rahmat, A., Mohammed, A. K., Mahbubar, R., Sakhawat, H., and Khurshid, A., 2019. "The plant *Aerva sanguinolenta*: A review on traditional uses, phytoconstituents and pharmacological activities." *Pharmacognosy Reviews*, vol. 13, pp. 89-92.
- [67] Kavita, N. Y., Prasad, V. K., Jigna, A. P., and Manohar, J. P., 2014. "Strychnos potatorum: Phytochemical and pharmacological review." *Pharmacognosy Reviews*, vol. 8, pp. 61-66.
- [68] Alagbe, J. O., 2019. "Role of *Moringa olifera* leaf meal on the growth performance of Poultry/African catfish – A review." *International Journal of Advanced Biological and Biomedical Research*, vol. 7, pp. 249-257.
- [69] Jamroz, D., Wertelecki, T., Houszka, M., and Kamel, C., 2005. "Influence of diet type on the inclusion of plant origin active substances on morphological and histochemical characteristics of the stomach and jejunum walls in chicken." *Journal of Animal Physiology and Animal Nutrition*, vol. 90, pp. 255-268.
- [70] Tiisonen, K., Kettunen, H., Bento, M. H., Saarinen, M., Lathinen, S., Ouwe-hand, A. C., Sculze, H., and Rautonen, N., 2010. "The effect of feeding essential oils on broiler performance and gut microbiota." *British Poultry Science*, vol. 51, pp. 381-392.
- [71] Kırkpınar, F., Ünlü, H. B., Serdaroglu, M., and Turp, G. Y., 2014. "Effects of dietary oregano and garlic essential oils on carcass characteristics, meat composition, colour, pH and sensory quality of broiler meat." *British Poultry Science*, vol. 55, pp. 157-166.
- [72] Alagbe, J. O., Soares, D. M., and Eimoga, M. M., 2018. "Efficacy of Shea butter (*Butryospermum parkii*) – Neem (*Azadirachta indica*) leaf meal mixture on performance and carcass characteristics, immune response and blood parameters in broiler chickens." *Greener Journal of Agricultural Sciences*, vol. 8, pp. 42-51.
- [73] Yoo, D. H., Nam, D. S., Kim, D. H., and Lee, C. Y., 2004. "Influence of essential oil components on growth performance and the functional activity of the pancreas and small intestine in broiler chickens." *Asian-Australian Journal of Animal Science*, vol. 17, pp. 394-400.
- [74] Abdel Fattah, S. A., El-Sanhoury, M. H., El-Mednay, N. M., and Abdel-Azem, F., 2008. "Tyroid activity, some blood constituents, organs morphology and performance of broiler chicks fed supplemental organic acids." *International Journal of Poultry Science*, vol. 7, pp. 215- 222.