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Effect of dietary supplementation of cymbopogon citratus oil on the performance and carcass characteristics of broiler chicks

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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 was 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

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 (William and Losa, 2001) [21]. Among the potential plants with significant therapeutic effect is Cymbopogon citrates. Cymbopogon citratus Stapf belonging to the family Gramineae is a perennial grass widely distributed worldwide and most especially in tropical and subtropical countries (Francisco *et al*., 2011). It is commonly referred to as lemon grass and it comprises approximately 500 genus and 8,000 herb species (Barbosa *et al*., 2008) [46]. The leaves are long, green, linear tapering upwards along the margins (Karkala and Bhushaa, 2014). 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, amti-nociceptive, antithrombotic and cytotoxic activities (Barbosa *et al*., 2008 [46]; Silva *et al*., 2008 [47]; Amit and Anushree, 2010 Dharmendra *et al*., 2001; Fandohan *et al*., 2008 [53]; Costa *et al*., 2011) [51]. Traditionally the plants have been used for the treatment of flu, elephantiasis, malaria, headache, pneumonia, leprosy, cough, gingivitis and vascular disorders (Karkala and Bhushaa, 2014). Scientific studies have shown that lemon grass contained several medicinal components which reside in its essential oil, this bioactive chemicals includes: citral, myrcene, ά-citral, β-citral, limonene, dipentene, heptenone, borncol, geranial, geraniol, β-myrcene, citronellol, 6-methyl-5-hepten-2-ona and undecan-2-one (Onawunmi *et al*., 1984 [56]; Meevatee *et al*., 1993 [54]; Shigeharu *et al*., 2001 [57]; Costa *et al*., 2011 [51]; Olorunisola *et al*., 2014; and Mirghani *et al*., 2012) [55]. Their concentrations are dependent on the extraction methods, species of plants, age of plant/maturity stage, geographical location (Oluwafemi *et al*., 2020 [5, 7]; Akintayo and Alagbe, 2020) [15].

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.

Materials and methods
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.

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.* (2019) [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.

Experimental set up and diet formulation

Basal diet was formulated to meet the nutritional requirement of birds according to NRC (1994). 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.

Data obtained

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

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

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

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

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

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

Chemical analysis

Laboratory analysis of the experimental diet was carried out according to the methods outlined by AOAC (2000) [41].

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 (Duncan, 1955) [78]. 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
1st ND (Lasota)	Day 8	Oral
2nd IBD (Gumboro)	Day 13	Oral
2nd ND (Lasota)	Day 21	Oral
3rd 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	0.01
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)

Result and Discussion

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*. (2013) [1] and Olafadehan *et al.* (2020) [7, 5]. The crude protein and ether extracts fall within the recommended ranges by NRC (1994). The values for crude fibre obtained in this study were lower than the values reported by Ngouana *et al*. (2017) [58]; Musa *et al*. (2020) [8]; Bento *et al*. (2013); Amerah *et al*. (2011) but calcium and phosphorus conforms to the findings of Adil *et al*. (2011); Brenes and Roura (2010); Gerardo *et al*. (2017) [65] when Mexican organo oil was supplemented in the diet of broiler chickens. The energy values were similar to the findings of Pineda *et al*. (2012) [64]; Khattak *et al*. (2014) [63] who evaluated the effects of natural blend of essential oil on the performance of broiler chickens.

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 (2019) [6]; Alagbe *et al*. (2017) [12]; Cho *et al*. (2014) [14]; El-Ghany *et al*. (2013) [68] and Basmacioğlu *et al*. (2004) 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 (Ambade *et al*., 2015) [33], anti-inflammatory (Collota *et al*., 2009; Alagbe *et al*., 2020) [6], hepatoprotective (Omokore and Alagbe, 2019 [9]; Piarua *et al*., 2012 [30]; Tajidin *et al*., 2012 [29]; Chukwuocha *et al*., 2016) [11], cytotoxic (Aftab *et al*., 2011 [27]; Chowdury *et al*., 2015) [26], antithrombotic (Carlson *et al*., 2001) [28], antidiabetic (Coelho *et al*., 2016) [24], miracicidal and cercaricidal (Ajayi *et al*., 2002) [72], antioxidant (Jayasinha, 2001 [23]; Balakrishnan *et al*., 2014) [14], neuroprotective (Ntonga *et al*., 2014 [36]; Ferdousy *et al*., 2017), antiplasmodial (Kpoviessi *et al*., 2014) [35], antifungal (Nishijima *et al*., 2014; Leon *et al*., 2011; Ibrahim *et al*., 2010) [38], cardiovascular (Garodia *et al*., 2007) and antiviral activities (Escandefi *et al*., 2007; Adedapo *et al*., 2009 [71]; Alagbe, 2017) [12]. They also have the ability to reduce the invasion of pathogenic bacteria in the gastro intestinal tracts, thus preventing dysbiosis (Akintayo and Alagbe, 2020 [15]; Huang and Lee, 2018), scavenging free radicals (Yu *et al*., 2012; Zhou *et al*., 2016; Lee *et al*., 2011 and Basedovsky *et al*., 1991) [62] and growth improvement in animals (Mohammed *et al*., 2016 [20]; Hernandez *et al*., 2004 and Mansoub *et al*., 2011).

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*. (2019) [3]; Maria *et al*. (2015); Monteiro *et al*. (2011) reported that LGO contains citral, mycrene,

genariol, citronellol, ά - oxobisabolene, limonene, humulene, cubebol, elemol, β-eudesmol, ά-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, antiviral, anticancer and anti-inflammatory activities (Ojewumi and Dedeke, 2020 [17]; Rani *et al*., 2011) [18]. Phenols are strong antioxidants giving total protection to the body and its metabolism against free radicals (Kavita *et al*., 2014; Joy *et al*., 2019) [20]. Water consumption of the birds was not significantly affected among the treatments (P>0.05). According to Alagbe (2019) [30], water intakes of animals are influenced by age, weather condition, type of diets fed, breed of animals and its physiological state.

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*. (2005) [61]; Tiihonen *et al*. (2010) [70]; Kirkpinar *et al*. (2014) [69] 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*. (2018) [20]; Yoo *et al*. (2004) [62]; Jamroz *et al.* (2005) [61]; Abdel *et al*. (2008) [59] when broiler chicks were fed diets supplemented with organic acids.

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.

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