**Premix supplied per kg diet: - vit A, 13,000 I.U; vit E, 5mg; vit D3, 3000I.U, vit K, 3mg; vit B2, 5.5mg; Niacin, 25mg; vit B12, 16mg; chorine chloride, 120mg; Mn, 5.2mg; Zn, 25mg; Cu, 2.6g; folic acid, 2mg; Fe, 5g; pantothenic acid, 10mg; biotin, 30.5g; antioxidant, 56mg.*

MEASUREMENTS

Performance parameters

Feed intake (g) was determined by subtracting feed left over from feed served, it was estimated for each of the replicate daily.

Weight gain (g) = final weight - initial weight

Feed to gain ratio = feed intake (g)/weight gain (g)

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

$$\text{Average total feed intake (ADFI)} = \frac{\text{Feed intake}}{\text{Total days of the experiment}}$$

Caecal microbial enumeration

On the 56th day of the experiment, 6 birds were randomly selected per treatment for caecal microbial enumeration (*E. coli*, *Salmonella spp* and *Lactobacillus spp*). A 10-fold serial dilution method was used in which 1% peptone solution was mixed with caecal samples and poured unto agar plates (Model R4-02X, Punjab, India) and incubated at 37°C for 48 h. Visible colonies were enumerated using colony counter and the results were expressed as $\log_{10}$ CFU/g of caecal digesta.

Phytochemical analysis

Phytochemical analysis of GIGM was carried out using standard methods described by Harborne [15], Odebiyi and Sofowora [16].

Statistical analysis

Data obtained were subjected to one -way analysis of variance (ANOVA) using SPSS (23.0) and significant means were separated using the software of the same package. Significant was declared if $P \leq 0.05$.

RESULTS

Phytochemical composition of ginger (*Zingiber officinale*) and garlic (*Allium sativum*) oil

The phytochemical composition of ginger (*Zingiber officinale*) and garlic (*Allium sativum*) oil (GIGM) is presented in **Table 2**. The sample contains flavonoids, saponins, terpenoids, phenols, oxalates, alkaloids and tannins at 20.78 %, 6.10 %, and 12.71 %, 17.90 %, 2.04 %, 10.31 % and 9.44 % respectively. In order of abundance flavonoids > phenols > terpenoids > alkaloids > tannins > saponins > oxalates.

Table 2. Phytochemical composition of ginger (*Zingiber officinale*) and garlic (*Allium sativum*) oil.

Constituents	Composition (%)
Flavonoids	20.78
Saponins	6.10
Terpenoids	12.71
Phenols	17.90
Oxalates	2.04
Alkaloids	10.31
Tannins	9.44

Growth performance of broiler chickens fed dietary inclusion of ginger (*Zingiber officinale*) and garlic (*Allium sativum*) (GIGM) oil

Growth performance of broiler chickens fed dietary inclusion of ginger (*Zingiber officinale*) and garlic (*Allium sativum*) oil is presented in **Table 3**. Initial body weight (IBW) ranged from 42.80 - 43.10 g, final body weight (1720.4 - 2720.0 g), weight gain (1677.6 - 2677.0 g), average daily weight gain (30.72 - 47.80 g), total feed intake (3880.3 - 4565.8 g), average daily feed intake (69.29 - 81.53 g) and feed conversion ratio (1.50 - 2.72). WG, ADG, TFI and ADFI were highest in T3, T4 and T5 relative to the other treatments (P<0.05). FCR were significantly different among the treatments (P<0.05).

Table 3. Growth performance of broiler chickens fed dietary inclusion of ginger (*Zingiber officinale*) and garlic (*Allium sativum*) (GIGM) oil.

Parameter	T1	T2	T3	T4	T5	SEM
IBW (g)	42.80	42.90	43.10	43.00	43.20	0.22
FBW (g)	1720.4^{c}	2260.1^{b}	2568.3^{a}	2605.1^{a}	2720.0^{a}	10.82
WG (g)	1677.6^{c}	2217.2^{b}	2525.2^{a}	2562.1^{a}	2677.0^{a}	9.44
ADG (g)	30.72^{c}	39.59^{b}	45.09^{a}	45.75^{a}	47.80^{a}	1.05
TFI	4565.8^{a}	4243.8^{b}	4230.9^{b}	4031.4^{b}	3880.3^{c}	12.23
ADFI	81.53^{a}	75.78^{b}	75.55^{b}	72.00^{b}	69.29^{c}	2.44
FCR	2.72^{a}	1.91^{b}	1.70^{b}	1.60^{c}	1.50^{c}	0.12

Means in the same row with different superscripts differ significantly (P<0.05); T1: 0 % GIGM; T2: 0.1 % GIGM; T3: 0.2 % GIGM; T4: 0.3 % GIGM; T5: 0.4 % GIGM; IBW: initial body weight; FBW: final body weight; WG: weight gain; ADG: average daily weight gain; TFI: total feed intake; ADFI: average daily feed intake; FCR: feed conversion ratio.

Caecal microbial population of broiler chicks fed diets with different level of GIGM

Caecal microbial population of broiler chicks fed diets with different level of GIGM is presented in **Table 4**. Microbial population of *E. coli*, *Lactobacillus spp* and *Salmonella spp* ranged from 20.12 - 34.98 (log_{10}CFU/g), 15.40 - 30.44 (log_{10}CFU/g) and 18.20 - 29.09 (log_{10}CFU/g). *E. coli* and *Salmonella spp* values were highest in T1 relative to other treatments (P<0.05) contrary to *Lactobacillus spp* count where T5 was highest, T2, T3, T4 followed similar trend and lowest in T1 (P<0.05).

Table 4. Caecal microbial population of broiler chicks fed diets with different level of GIGM.

Parameter (log_{10}CFU/g)	T1	T2	T3	T4	T5	SEM
E. coli	34.98^{a}	25.10^{b}	23.98^{b}	23.18^{b}	20.12^{b}	1.30
Lactobacillus spp	15.40^{c}	20.76^{b}	23.48^{b}	28.87^{b}	30.44^{a}	1.65
Salmonella	29.09^{a}	19.32^{b}	19.04^{b}	18.58^{b}	18.20^{b}	0.96

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

DISCUSSION

The pharmacological importance of EOs is primarily due to bioactive chemicals in plant tissues as primary and secondary metabolites [17]. These constituents have several therapeutic properties for instance terpenoids possess anticarcinogenic, antimalarial, anti-ulcer, antimicrobial or diuretic activity [18,19]. Flavonoids in plants possess medicinal benefits which includes antioxidant and anti-inflammatory activities [20,21]. They have the ability to scavenge hydroxyl radicals, super oxide anions and lipid peroxy radicals [22]. Alkaloids perform antimalarial, antimicrobial, antioxidant and protection of plants from pathogens [23]. Phenolic compounds show a wide range of pharmacological activities including anticancer, anti-inflammatory and prevention of cardiovascular diseases [24].

The superior growth performance observed among birds in T3, T4 and T5 (P<0.05) could be attributed to the essentials oils combination which exerted synergistic effects to prevent the consequence of intestinal inflammation. Activities of phytochemicals in GIGM have also proven to stimulate functions of the intestinal tract to improve digestive secretions, nutrient absorption and metabolism [25]. The dietary inclusion of GIGM in broilers also exerted a significant difference in feed intake (P<0.05).

The activities of pathogenic bacteria in the caecum of the birds decreased as the dietary inclusion of GIGM increases (P<0.05) across the treatments. This result agrees with the findings of Singh [1] and Adewale [2] who reported that phytochemicals such as flavonoids, phenols and alkaloids are capable of reducing the activities of pathogenic bacteria through competitive exclusion and promoting the proliferation of beneficial bacteria like *Lactobacillus spp*, thus playing a role of a probiotic. GIGM can act at different sites of the gastrointestinal tract (GIT) and relay on different targets such as modifying the intestinal microbial balance in favor of beneficial bacterial strains, colonization of the mucosa by adhering non-pathogens and occupation of specific receptors on mucosal surface (prebiotics) [26,27].

CONCLUSION

It was concluded from this experiment that the use of essential oils (GIGM) is effective and effective and it represents one of the promising alternatives to antibiotics because it contains several secondary metabolites which performs several medicinal properties. Dietary inclusion of GIGM at 0.4 % had a significant impact on growth as well as reducing the population of pathogenic bacteria without causing any deleterious effect on the performance and health of the animal.

REFERENCES

1. Singh AS, Alagbe JO, Sharma S, Oluwafemi RA, Agubosi OCP (2021) Effect of dietary supplementation of melon (*Citrallus linatus*) seed oil on the growth performance and antioxidant status of growing rabbits. J Multidimension Res Rev 2(1): 78-95.
2. Adewale AO, Alagbe JO, Adekemi AO (2021) Dietary Supplementation of *Rauvolfia Vomitoria* Root Extract as A Phytogenic Feed Additive in Growing Rabbit Diets: Hematology and serum biochemical indices. Int J Orange Technol 3(3): 1-12.
3. Musa B, Alagbe JO, Betty AM, Omokore EA (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 J Res Technol 2(2): 13-21.

4. Michiels J, Missotten J, Dierick N, De Smet S (2005) *In vitro* effect of botanicals on gut flora of pigs. 30ste Studiedag van de Nederlandstalige Voedingsonderzoekers Merelbeke. pp: 67-68.
5. Charles R, Garg SN, Kumar S (2000) New gingerdione from the rhizomes of *Zingiber officinale.* Fitolerapia 71: 716-718.
6. Chang KJ, Cheong SH (2008) Volatile organosulphur and nutrient compounds from garlic by cultivating areas and processing methods. Fed Am Soc Exp Bio J 22: 1108-1112.
7. Alagbe JO, Oluwafemi RA (2019) Performance and hematological parameters of broiler chicks gives different levels of dried lemon grass (*Cymbopogon citratus*) and garlic (*Allium sativum*) extract. Res Agric Vet Sci 3(2): 102-111.
8. Cheng S, Liu JY, Cheng EH, Cheng ST (2008) Antifungal activity of cinnamaldehyde and eugenol congeners against wood rots fungi. Bioresour Technol 99: 5145-5149.
9. Demir E, Sarica S, Ozcan MA, Suicmez M (2003) The use of natural feed additives as alternatives for an antibiotic growth Promoter in broiler diets. Braz J Poult Sci 44: 44-45.
10. Olafadehan OA, Oluwafemi RA, Alagbe JO (2020) Carcass quality, nutrient retention and caeca microbial population of broiler chicks administered Rolfe (*Daniellia oliveri*) leaf extract as an antibiotic alternative. J Drug Discov 14(33): 146-154.
11. Dormans HJ, Deans SG (2000) Antimicrobial agents from plants: Antibacterial activity of plant volatile oils. J Appl Microbiol 88: 308-316.
12. Burt S (2004) Essential oils: Their antibacterial properties and potential applications in food- A review. Int J Food Microbiol 94: 943-947.
13. Oluwafemi RA, Uankhoba IP, Alagbe JO (2021) Effects of turmeric oil as a dietary supplement on the growth performance and carcass characteristics of broiler chicken. Int J Orange Technol 3(4): 1-9.
14. Balogun O (2001) The Federal Capital Territory of Nigeria: Geography of Its Development. University of Ibadan Press Limited.
15. Harborne JD (1973) Phytochemical methods: A guide to modern techniques of plant analysis. Chapman and Hall, London. pp: 279.
16. Odebiyi A, Sofowora AE (1978) Phytochemical Screening of Nigerian Medicinal Plant. Part III, Lloydia, 41: 234-246.
17. Shittu MD, Alagbe JO (2020) Phyto-nutritional profiles of broom weed (Sida acuta) leaf extract. Int J Integr Educ 3(11): 119-124.
18. Dudareva N, Pichersky E, Gershenzon J (2004) Biochemistry of plant volatiles. Plant Physiol 135: 1893-1902.
19. Krishnaiah D, Sarbatly R, Bono A (2007) Phytochemical antioxidants for health and medicine: A move towards nature. J Biomed Sci 1(3): 97-104.
20. Saxena M, Saxena J, Nema R, Singh D, Gupta A (2013) Phytochemistry of Medicinal Plants. J Pharmacogn Phytochem 8192(1): 168-182.
21. Ojewuyi OB, Ajiboye TO, Adebanjo EO, Balogun A, Mohammed AO (2014) Proximate composition, phytochemical and mineral contents of young and mature *Polyalthia longifolia* Sonn. leaves. Fountain J Nat Appl Sci 3(1): 10-19.
22. Okwu DE (2004) Phytochemical and vitamin content of indigenous spices of South Eastern Nigeria. J Sustain Agric Environ 6: 30-37.
23. Cushnie TPT, Cushnie B, Lamb AJ (2014) Alkaloids: An overview of their antibacterial antibiotic enhancing and anti-virulence activities. Int J Phytochem 44(5): 377-386.
24. Li S, Li RY, Gan FL, Li HB (2013) Antioxidant capacities and total phenolic contents of infusions from 233 medicinal plants. Ind Crop Prod 51: 289-298.
25. Alagbe J, Oluwafemi RA (2019) Growth performance of weaner rabbits fed noni (*Morinda citrifolia*) and *Moringa olifera* leaf mixture as partial replacement for soya bean meal. Int J Adv Biol Biomed Res 7(2): 185-195.
26. Michiels J, Missotten J, Dierick N, De Smet S (2005) *In vivo* degradation and in vivo passage kinetics of carvacol, thymol, eugenol and trans-cinnamaldehyde along the gastrointestinal tracts of piglets. J Food Agric 88: 2371-2381.
27. Dierick N, Michiels J, Van NC (2004) Effect of medium chain fatty acids and benzoic acid as alternative for antibiotics on growth and some gut parameters in piglets. Commun Agric Appl Biol Sci 69(2): 187-190.