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EFFECT OF GINGER (*Zingiber officinale*), GARLIC (*Allium sativum*) AND UTAZI (*Gongronema latifolium*) EXTRACT INCLUSION IN WATER ON THE BLOOD PARAMETERS AND LIPID PROFILES OF BROILER CHICKENS

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ABSTRACT
This study investigated the effects of ginger (Zingiber officinale), garlic (Allium sativum) and utazi (Gongronema latifolium) on the blood parameters and lipid profile of broiler chickens. A total of 150 day-old broiler chicks were procured and randomly assigned to four treatment groups (Control, Ginger, Garlic, and Utazi groups). Each group was further divided into three subgroups based on their dosages (high, medium, and low). Aqueous extracts of the plants were prepared using cold maceration method to ensure that the bioactive components were preserved, and subsequently administered in prescribed doses in milliliter of drinking water for eight weeks. Serum biochemical and hematological parameters including lipid profiles were collected to evaluate their impacts. Data were analyzed using one-way Analysis of variance, ANOVA. The result showed positive influence on hematological parameters, with garlic notably increasing hemoglobin levels to 12.26 g/dL and ginger boosting red blood cell counts up to 3.40 × 10^6/µL at low doses. Garlic was very good in reducing serum cholesterol to 158.27 mg/dl while Utazi elevated total cholesterol to 186.00 mg/dL at low doses. Garlic showed the most substantial reduction in total cholesterol, with the low-dose group (GAL, 158.27) being the most effective. Ginger exhibited a dose-dependent reduction in total cholesterol levels, with the lowest levels observed in medium-dose (GIS, 164.47) and high-dose (GIH, 168.47) groups. This study concludes that aqueous extracts of these plants, when administered in appropriate dosages will positively impact on the blood parameters and lipid profile of broiler chickens.

Keywords: Blood Parameters, Broiler Chickens, Garlic Extracts, Ginger Extracts, Lipid Profile, Water

1.0 INTRODUCTION
Poultry production is an essential industry worldwide and has positive impact on food security and income generation. Broiler chicken production is a critical segment of poultry production that plays a significant role in meeting the demand for animal protein. Broiler chickens are known for their rapid growth rate, high feed conversion efficiency and relatively short production cycle, making it a preferred option for meat production worldwide (Williams *et al*., 2023). The rising demand for broiler chicken is attributed to its affordability, nutritional value, and minimal cultural restrictions on their consumption. However, achieving optimal growth performance in broiler chicken production requires a strategic management of nutrition, environment, and health. Antibiotics have served as growth promoters (AGPs) in broiler chicken production by improving feed efficiency, enhancing growth performance and decreasing mortality by preventing disease outbreaks (Akinwunmi *et al.,* 2018). Their prolonged usage has generated apprehensions regarding antibiotic resistance, which presents considerable threats to human and animal health (Dibner *et al.,* 2005). In reaction to these issues, some nations, notably the European Union, have enacted prohibitions on the usage of antibiotics as growth enhancers in animal feed (Castanon, 2007). This has necessitated the quest for natural, safe, and effective substitutes for antibiotics in poultry nutrition. Medicinal plants and indigenous spices have garnered significant interest as natural alternatives due to their abundant phytochemical composition and proven health benefits (Windisch *et al.,* 2008). Spices such as ginger (*Zingiber officinale*), garlic (*Allium sativum*), and *Gongronema latifolium* (often referred to as utazi) are well-documented for their antibacterial, antioxidant, and anti-inflammatory properties (Ghasemi *et al.,* 2010).

Ginger, a rhizome recognized for its pungent fragrance, is medicinal herb containing bioactive components like gingerol, shogaol, and zingerone. Research indicates that ginger might beneficially affect feed consumption, digestion, and nutrient absorption (Onu, 2010). More so, ginger has been shown to reduce lipid peroxidation of chickens and enhance their antioxidant status thereby safeguarding them from oxidative stress (Zhang *et al*., 2009). Ginger is known for its bioactive compounds, such as gingerols and shogaols, which possess antioxidant and antimicrobial properties. Research has explored its impact on broiler performance when administered through drinking water. Herawati and Marjuki (2011) administered ginger extract in the drinking water of broiler chickens which led to a significant improvement in their body weight gain and feed conversion efficiency with feed intake not significantly affected. Garlic, an extensively researched spice, contains sulphur compounds like allicin, which have potent antibacterial and immune-enhancing properties (Elagib *et al.,* 2013). Garlic supplementation in chicken has been linked to enhancements in weight gain, feed conversion ratio, and immunological responses, positioning it as a viable alternative to antibiotic growth promoters (Issa and Omar, 2012). Furthermore, it has been demonstrated that garlic has the ability to lower blood cholesterol levels and improve liver function (Demir *et al.,* 2003). *Gongronema latifolium* (utazi), although less researched than ginger and garlic, is a climber plant extensively utilized in West Africa for its therapeutic properties. Utazi is abundant in flavonoids, saponins, and tannins, and is proven to possess anti-diabetic, anti-inflammatory, and antioxidant properties (Okafor *et al.,* 2011). Recent research indicates its potential involvement in improving broiler health and overall growth performance (Akinmoladun *et al.,* 2018). Ekine *et al.* (2021) investigated the effects of *Gongronema latifolium* (Utazi) on the performance, organ weights, serum enzymes and lipid profile of broiler chickens and recorded positive results on these parameters. Despite the intriguing attributes of these spices, there exists a paucity of scientific data regarding their specific impacts on the blood parameters and lipid profiles of broiler chickens. Hence, the objective of this study is to evaluate the effects of these spices (utazi, ginger, and garlic) on the hematological, serum and lipid profiles of broiler chickens.

2.0 MATERIALS AND METHOD

2.1 Study Area

The study was conducted at the Teaching and Research Farm of Michael Okpara University of Agriculture, Umudike, Abia State. The University is located within the South East agro-ecological zone of Nigeria, with geographical coordinates of 5.4801°N latitude and 7.5437°E longitude which is conducive for poultry and crop production.

2.2 Ethical Considerations

The study adhered to the ethical guidelines for the care and use of animals in research as outlined by the Ethical Committee of Michael Okpara University of Agriculture Umudike. All procedures were designed to minimize animal discomfort, and proper veterinary care was provided throughout the study.

2.3 Experimental Design

A total of 150 day old broiler chicks were acquired from an accredited distributor in Umuahia. Prior to arrival, a brooding pen was carefully washed, disinfected and provided with adjustable heat and light sources. The broilers were randomly assigned to one control and three treatment groups, with each group consisting of 3 replicates of 12 broilers each. The groups were as follows:

- Control group: Broilers fed a standard commercial diet (Hi-pro®) without any spice supplementation and plain water administered.
- Ginger Group: Broilers fed a commercial diet with the ginger extract administered in their drinking water at a dose recommended by Aswanida (2015) across the different subgroups.
- Garlic Group: Broilers fed a commercial diet (Hi-pro®) and the garlic extract administered in their drinking water at a dose recommended by Aswanida (2015) across the different subgroups.
- Utazi Group: Broilers fed a commercial diet (Hi-pro®) with utazi extract administered in their drinking water at a dose recommended by Aswanida (2015) across the different subgroups.

Each treatment group received a specific dosage of the spice extract. The dosage for each spice extract was standardized based on previous studies according to their safety margin for broilers and were administered in their drinking water in mls per liter for a period of 8 weeks. The birds were maintained on deep litter and were given feed and clean water containing the extracts *ad libitum*. They were given appropriate vaccination and preventive medications. The care and management of the birds followed accepted guidelines for broilers as recommended by FASS (1999).

2.4 Sourcing of Herbs and Spices.

The utazi leaves, ginger and garlic bulbs were sourced from Ndolu Market in Ikwuano L.G.A., Abia State. These were acquired under standard conditions and were properly identified in the Department of Plant Science, Michael Okpara University of Agriculture, Umudike, Abia State.

2.5 Preparation of the spices for extraction.

The garlic and ginger were peeled, cut into chips and together with the utazi leaves were allowed to dry at room temperature for a period of four weeks. They were ground into smooth powder and stored separately in an air tight container. The weight of the individual spices was measured using Metler weighing balance. Aqueous extract of these spices was prepared by adding appropriate amount of water as recommended by Aswanida (2015) in separate amber chemical bottles. The mixtures were stored at room temperature for twelve hours with each vigorously shaken at intervals of 2 hours. Consequently, the extract was obtained by filtration using filter paper, and then administered to the chicks in their drinking water following the recommended dose per litre/ day according to Aswanida (2015).

Table 1: Showing the volume of extracts administered

DOSE	GINGER	GARLIC	UTAZI
HIGH	26 ml/l	37.60 ml/l	40.60 ml/l
MEDIUM	13 ml/l	18.80 ml/l	20.30 ml/l
LOW	6.50 ml/l	9.40 ml/l	10.15 ml/l

2.5 Determination of hematological and serum and lipid profiles

At the end of the treatment period, three birds were randomly selected from each group and sacrificed. Blood were collected by cardiac puncture of three birds per treatment into K3 Ethylene-diamine tetra-acetic acid (EDTA) and plain bottles for hematological and serum biochemical analyses, respectively. The erythrocyte was counted using the hemocytometer method as describe by Schalm *et al.* (1975) while the hemoglobin concentration was determined according to the techniques described by Cole (1986). In determining the packed cell volume (PCV), the Winthrop microhematocrit tube was filled with blood by capillary action up to two thirds (2/3). The samples were spun in a centrifuge for 5 minutes at 10,000 rpm and the PCV was read and recorded in percentage using a microhematocrit reader. Other hematological indices namely, MCH, MCV and MCHC were calculated according to the formulae reported by Schalm *et al*. (1975). The Mean Cell Hemoglobin was determined as MCH (pg) = Hb x 100/RBC, the Mean Cell Volume as MCV (fl) = PCV x 100/RBC and Mean Cell Hemoglobin Concentration as MCHC (g/dl) =Hbx100/PCV (Schalm *et al.,* 1975). The leukocyte or white blood cell count was obtained using a hemocytometer after a 1: 20 dilution in Natt and Hendricks diluents to obtain a 1:20 blood dilution (Schalm *et al*., 1975). The white blood cell was differentiated into granulocytes (heterophils), lymphocytes, monocytes, eosinophils and basophils with the aid of automated WBC differential machine (Model: Durga, China). The blood samples contained in plain bottles were centrifuged at 3000 rpm for 10 minutes to obtain clear sera which were transferred into fresh plain bottles and labelled appropriately. Serum biochemical tests were carried out using Randox commercial test kit following manufacturer's instructions. Parameters analyzed included total protein, bilirubin and cholesterol levels, albumin, globulin, urea, and creatinine concentrations, alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP). On blood lipid profile test, blood was delivered into a vacuum container without anticoagulant and centrifuged for 5 minutes to separate the serum. 30 microliters of the serum were pipetted and used in measuring the lipid profiles (total cholesterol, triglycerides, LDL and HDL) using Rosche method following all standard procedures.

3.0 RESULTS AND DISCUSSION

3.1 Effect on Serum Biochemical Indices

3.1.1 Effect on glucose

The garlic groups have the highest glucose level ($P < 0.05$) of 221.67, 214.33 and 209.67 mg/dL for GAL, GAS and GAH respectively than the ginger groups: GIH (203 mg/dL), GIL (201 mg/dL) and GIS (196.67 mg/dL) while the utazi groups are significantly lower ($p > 0.05$) than all the treatment groups including the controls. Utazi reduced glucose significantly even at low and high doses (153.33–160.33 mg/dL) which is in consonance with findings of Igene and Iwegbu (2022), reflecting its hypoglycemic and anti-diabetic properties. Ginger increases glucose levels (GIL, GIS and GIH) comparable to control (196.67–203.00 mg/dL) which is contrast with the report of Al-Moramadhi (2010). The research suggested that ginger supplementation in broiler chickens can decrease glucose levels in treated groups compared to controls, as seen in studies of Shanmugam *et al.* (2009), where ginger reduced serum glucose in diabetic rats, and which confirms ginger's efficacy via drinking water in broilers. Values of 103.95 mg/dL (ginger group) versus 173.89 mg/dL (control) align with this trend, suggesting that ginger may enhance insulin sensitivity in broilers. On the other hand, Garlic has shown significant increase ($P < 0.05$) in glucose levels possibly indicating hyperglycemia.

3.1.2 Creatinine and Uric acid levels

It can be observed from Table 2 that there exists significant difference ($P < 0.05$) between the control groups and the treatment groups with Utazi groups having the highest increment. Control groups have creatinine (0.57, 0.53 and 0.57 mg/dL) and uric acid (18.37, 17.90 and 18.10) for C1, C2 and C3 respectively. Utazi had elevated creatinine (1.28, 1.26 and 1.28 mg/dL) and uric acid with (30.80, 31.53 and 29.37 mg/dL) UTL, UTS and UTH respectively indicating renal stress especially in higher dose which is in accordance with the study of Igene and Iwegbu (2022) who recorded 1.30mg/dL in 50ml/l of water. Ginger had a moderate increment in creatinine ranging from (0.87–0.96 mg/dL) while garlic was slightly higher than control but was within safe limits (0.69–0.89 mg/dL) indicating its renal protective effects in lower uric acid levels.

3.1.3 Effects on Total Protein, Albumin, and Globulin

Garlic has a significantly (P < 0.05) highest protein and albumin, especially in GAS and GAL (up to 5.79 g/dL total protein, 3.40 g/dL albumin) indicating that it enhanced protein metabolism. (Issa *et al*., 2015). Control groups has stable protein (3.98g/dL, 4.18 g/dL and 4.10g/dL), albumin (1.87g/dL, 2.09 g/dL and 2.06 g/dL), and globulin (2.12 g/dL, 2.20 g/dL and 2.07 g/dL) for C1, C2 and C3 groups respectively. There exists no significant difference (P > 0.05) within utazi groups regarding total protein levels while there is an increase from UTH to UTL on both albumin and globulin levels as shown in the Table 2. Ginger showed moderate protein and albumin increments, with stable globulin thus offering balanced protein synthesis. This is in contrast with report from Oleforuh-Okoleh *et al*. (2015) where it is significantly increased (P < 0.05) in total proteins (5.85g/dL) and Albumin (3.44 g/dL).

3.1.4 Effects on Alanine Transaminase (ALT) and Aspartate aminotransferase (AST)

Observed values for control groups are ALT (34.88–36.31 U/L) and AST (75.67–77.70 U/L). Utazi is significantly reduced in both ALT (22.18–23.02 U/L) and AST (36.73–37.97 U/L), indicating liver protection (Omodamiro and Nwankwo, 2015). Ginger shows moderate ALT increase, especially GIS (26.16 U/L), with a slight AST reduction. Garlic has the highest ALT values (28.28–28.82 U/L) and a moderate AST decrease (48.73–51.73 U/L). Utazi groups is significantly reduced (P > 0.05) than other treatment groups especially in GAH which corresponds with Ekine *et al.* (2021) that worked with 0.8% inclusion. The ALT and AST values of utazi as seen in this study is in contrast with the study of Igene and Iwegbu (2022) where it was significantly increased (P < 0.05) to (141.00 iu/l) but reduced in ALT (10.00 iu/l) at 50ml/l.

Table 2: Serum Biochemical Indices of Broilers

	GLUCOSE	CREATININE	UREA	TOTAL PROTEIN	ALBUMIN	GLOBULIN
C1	195.33 ± 0.33^{fg}	0.57 ± 0.01^{h}	18.37 ± 0.09^{g}	3.98 ± 0.02^{f}	1.87 ± 0.01^{g}	2.12 ± 0.01^{cd}
C2	194.00 ± 0.58^{g}	0.53 ± 0.01^{i}	17.90 ± 0.06^{h}	4.18 ± 0.04^{e}	2.09 ± 0.05^{f}	2.20 ± 0.02^{bc}
C3	194.33 ± 0.67^{g}	0.48 ± 0.01^{j}	18.10 ± 0.15^{gh}	4.10 ± 0.15^{ef}	2.06 ± 0.10^{f}	2.07 ± 0.06^{d}
UTL	153.33 ± 0.88^{i}	1.28 ± 0.01^{a}	30.80 ± 0.06^{b}	4.97 ± 0.01^{c}	3.11 ± 0.02^{cd}	1.88 ± 0.02^{e}
UTS	160.00 ± 0.58^{h}	1.25 ± 0.01^{b}	31.53 ± 0.09^{a}	4.98 ± 0.01^{c}	3.35 ± 0.03^{ab}	1.55 ± 0.03^{g}
UTH	160.33 ± 0.33^{h}	1.26 ± 0.01^{ab}	29.37 ± 0.19^{c}	4.85 ± 0.02^{c}	3.06 ± 0.03^{d}	1.74 ± 0.02^{f}
GIL	201.00 ± 0.58^{e}	0.87 ± 0.01^{de}	20.27 ± 0.09^{f}	4.63 ± 0.05^{d}	2.74 ± 0.06^{e}	1.73 ± 0.06^{f}
GIS	196.67 ± 0.33^{f}	0.96 ± 0.00^{c}	22.17 ± 0.12^{d}	4.87 ± 0.01^{c}	3.05 ± 0.02^{d}	1.87 ± 0.02^{e}
GIH	203.00 ± 1.00^{d}	0.87 ± 0.01^{e}	21.57 ± 0.03^{e}	4.57 ± 0.02^{d}	2.85 ± 0.02^{e}	1.69 ± 0.01^{f}
GAL	221.67 ± 0.88^{a}	0.89 ± 0.01^{d}	15.97 ± 0.09^{k}	5.79 ± 0.04^{a}	3.38 ± 0.04^{a}	2.48 ± 0.03^{a}
GAS	214.33 ± 0.33^{b}	0.76 ± 0.00^{f}	17.43 ± 0.03^{i}	5.68 ± 0.01^{a}	3.40 ± 0.01^{a}	2.29 ± 0.02^{b}
GAH	209.67 ± 0.33^{c}	0.69 ± 0.01^{g}	16.63 ± 0.09^{j}	5.42 ± 0.03^{b}	3.23 ± 0.03^{bc}	2.11 ± 0.05^{cd}
p-values	0.000	0.000	0.000	0.007	0.006	0.000

(a-k): Means on the same rows with different superscript are significantly different (p≤0.05) (Mean ± SEM) Control groups: C1 (Non-Infected, Non-treated), C2 (Infected, Non-treated) & C3 (Infected & treated with a commercial antibiotics), UTL: Utazi low dose, UTS: Utazi medium dose, UTH: Utazi high dose; GIL: Ginger low dose, GIS: Ginger high dose, GIH: Ginger high dose; GAL: Garlic low dose, GAS: Garlic medium dose and GAH: Garlic high dose.

3.1.5 Effect on Alkaline Phosphatase (ALP) and Total Bilirubin.

Control Groups (C1, C2 and C3) have high ALP ranging from 172.43–174.73 U/L**,** which may suggest normal bone and liver metabolic activity (Shao *et al.,* 2019). Utazi (UTL, UTS and UTH)**:** Significant reduction (p < 0.05) in ALP levels **(**146.52–149.37 U/L**),** indicating lower bone or liver turnover (Meluzzi, *et al*., 1992). Ginger (GIL, GIS and GIH) had moderate ALP levels ranging from 156.43–157.37 U/L which is slightly lower than controls. Garlic (GAL, GAS and GAH) values of ALP remains closer to control values (159.77–162.30 U/L) and shows consistent activity maintaining normal physiological activity without stressing metabolic systems (Meluzzi *et al*., 1992). Control groups have bilirubin levels range from 0.53–0.60 mg/dL, reflecting normal liver function. Utazi (UTL, UTS and UTH) recorded reduced bilirubin (0.32–0.36 mg/dL), suggesting enhanced liver detoxification or reduced hemolysis. Ginger had (GIL, GIS and GIH) and maintains lower bilirubin levels from 0.34–0.40 mg/dL compared to controls. Garlic supplementation in broilers as seen in (GAL, GAS and GAH) may lead to slightly elevated bilirubin levels (0.40–0.51 mg/dL), possibly reflecting higher metabolic turnover, as seen in mice where garlic increased red blood cell turnover and bilirubin production via heme oxygenase-1 (Akgül *et al.,* 2010). Utazi reduces liver enzyme activity as shown in the Table below, suggesting the beneficial nature of Utazi leaf to the broilers. Tables 2- 3 present the result of serum biochemical indices.

Table 3: Effect on Serum Biochemical indices continued

	ALP	T. BILIRUBIN	ALT	AST
C1	172.43 ± 0.29^{c}	0.53 ± 0.01^{c}	36.18 ± 0.03^{a}	75.67 ± 0.15^{c}
C2	174.73 ± 0.15^{a}	0.60 ± 0.01^{a}	34.88 ± 0.05^{b}	77.70 ± 0.06^{a}
C3	173.80 ± 0.23^{b}	0.57 ± 0.01^{b}	36.31 ± 0.16^{a}	76.67 ± 0.19^{b}
UTL	149.37 ± 0.43^{h}	0.35 ± 0.01^{fg}	22.22 ± 0.06^{i}	37.97 ± 0.07^{i}
UTS	146.52 ± 0.20^{i}	0.32 ± 0.01^{h}	22.18 ± 0.09^{i}	37.90 ± 0.12^{i}
UTH	148.67 ± 0.18^{h}	0.36 ± 0.00^{f}	23.02 ± 0.04^{h}	36.73 ± 0.03^{j}
GIL	156.90 ± 0.15^{fg}	0.37 ± 0.00^{f}	24.21 ± 0.30^{g}	40.83 ± 0.09^{f}
GIS	157.37 ± 0.23^{f}	0.40 ± 0.00^{e}	26.16 ± 0.03^{e}	39.67 ± 0.03^{h}
GIH	156.43 ± 0.29^{g}	0.34 ± 0.01^{g}	24.94 ± 0.03^{f}	40.20 ± 0.06^{g}
GAL	162.30 ± 0.26^{d}	0.51 ± 0.00^{c}	28.35 ± 0.03^{d}	51.70 ± 0.15^{d}
GAS	159.77 ± 0.15^{e}	0.40 ± 0.01^{e}	28.82 ± 0.03^{c}	48.73 ± 0.09^{e}
GAH	160.40 ± 0.21^{e}	0.46 ± 0.00^{d}	28.28 ± 0.09^{d}	51.73 ± 0.12^{d}
p-values	0.000	0.000	0.000	0.000

(a-k): Means on the same rows with different superscript are significantly different ($p \leq 0.05$); control groups: C1 (Non-Infected, Non-treated), C2 (Infected, Non-treated) & C3 (Infected & treated with a commercial antibiotics), UTL: Utazi low dose, UTS: Utazi medium dose, UTH: Utazi high dose; GIL: Ginger low dose, GIS: Ginger high dose, GIH: Ginger high dose; GAL: Garlic low dose, GAS: Garlic medium dose and GAH: Garlic high dose.

3.2 Effect on Hematological Parameters

3.2.1 Effects on pack cell volume (PCV)

GIH, GIL and UTH significantly increased PCV ($P < 0.05$) with values 27.37%, 27.00% and 27.00% respectively while GAL, C2 and GAH were reduced significantly with values 23.67%, 23.33% and 22.33% respectively. The study of Igene and Iwegbu (2022) on utazi significantly reduced ($P < 0.05$) PCV (26.00%) at 50ml/l which is contrast to the broilers used in this present study with UTH having 27.00% at 40.60ml/l. This may be as a result of temperature or seasonal effect on the broilers (Zhou *et al*., 1999).

Ginger improved PCV the most, which may indicate enhanced erythropoiesis. Hemoglobin aids in the transport of oxygen to the tissues of the animal for oxidation of ingested food so as to release energy. Garlic (GAL, GAS and GAH) exhibited moderate PCV values, with lower readings but at high doses of inclusion (GAH, 22.33%), it showed mild anemia. The report from Oleforuh-Okoleh *et al*. (2015) on ginger and garlic at 50ml/l were 28.22% and 29.14% respectively which is contrary to finding of this study. The increase in PCV of birds given the test ingredients especially ginger is an indication of better availability of nutrients to the birds which consequently will affect their well-being.

3.2.2 Effects on White Blood cells

Control groups ranged from 9.24–10.94 × $10^3/\mu L$. Utazi at lower doses (6.52–7.19 × $10^3/\mu L$), but UTH shows significant increase (12.66 × $10^3/\mu L$). Ginger: High WBC counts across all doses, peaking in GIS and GIH (12.41–13.80 × $10^3/\mu L$). Garlic: GAS has the WBC count significantly higher ($P < 0.05$) than all the treatment groups with 16.24 × $10^3/\mu L$ and then closely followed by GAL and GIS with WBC of 13.58 × $10^3/\mu L$ and 13.80 × $10^3/\mu L$ respectively. Garlic at medium doses (GAS) and ginger enhanced immune response, as reflected by increased WBC counts. WBC plays a key role in the production of antibodies, thus strengthening the immune system of animals. Therefore, high WBC values in T4 and T5 is an indication that the birds may experience high resistance to diseases.

3.2.3 Effects on Red Blood Cells (RBC)

GIL, GAS and UTL with values 3.40× $10^6/\mu L$, 3.38× $10^6/\mu L$ and 3.22× $10^6/\mu L$ respectively are significantly higher ($P < 0.05$) than GAH, GAL and GIH with reduced values of 2.27× $10^6/\mu L$, 2.32× $10^6/\mu L$ and 2.32× $10^6/\mu L$ respectively. Elevated RBC at low doses of ginger (GIL, 3.40 × $10^6/\mu L$), but reduced at high doses (GIH, 2.32 × $10^6/\mu L$), affirmed by the report of Al-Moramadhi (2010) who stated that *Zingiber officinale* aqueous extract increased significantly ($P < 0.05$) the levels of red blood cells and hemoglobin concentration in broilers. Utazi improved RBC count at low doses, while ginger and garlic show dose-dependent effects. Ginger improves erythrocyte indices significantly at medium doses, while Utazi shows diminished erythrocyte indices at high doses. From Table 4 below, MCHC, MCH and MCV are significantly higher in ginger groups (GIL, GIS and GIH) as well as UTH than other groups (GAL, GAS, GAH, UTL and UTS) which is in contrast to Okolo *et al.* (2023) who revealed from their study that there is no significant difference ($P < 0.05$) in these blood parameters.

3.2.4 Effects on Immune Cells (heterocytes, monocytes, eosinophils and Lymphoctes)

Utazi at low doses may suppress immune response, while high doses (UTH) restored lymphocyte activity with heterocytes which peaked at UTS (42.33%), suggesting an inflammatory response. Ginger especially at 87% inclusion enhanced immune modulation in broilers. Garlic showed mixed effects on immune cells (Fadlalla *et al*., 2010).

Table 4: Hematological Indices

	MCHC	HETEROCYTES	MONOCYTES	EOSINOPHIL	LYMPHOCYTES
C1	35.67 ± 1.20^{ab}	20.67 ± 0.88^{e}	1.67 ± 0.67^{b}	0.33 ± 0.33^{ab}	71.00 ± 1.53^{de}
C2	36.67 ± 1.20^{a}	27.33 ± 0.88^{cd}	1.33 ± 0.88^{ab}	1.00 ± 0.58^{ab}	73.33 ± 0.88^{cde}
C3	35.00 ± 0.58^{ab}	26.00 ± 0.58^{cd}	0.00 ± 0.00^{ab}	1.33 ± 0.33^{b}	67.33 ± 1.45^{e}
UTL	31.00 ± 0.58^{d}	33.67 ± 2.19^{b}	0.33 ± 0.33^{ab}	1.67 ± 0.33^{ab}	45.33 ± 2.60^{g}
UTS	30.33 ± 0.88^{d}	42.33 ± 3.18^{a}	1.00 ± 0.58^{a}	2.33 ± 0.33^{ab}	43.33 ± 2.96^{g}
UTH	32.00 ± 0.58^{cd}	14.00 ± 0.58^{fg}	1.33 ± 0.88^{ab}	1.00 ± 0.00^{ab}	78.00 ± 1.53^{bc}
GIL	32.00 ± 0.58^{cd}	10.00 ± 0.58^{gh}	1.00 ± 0.58^{b}	0.33 ± 0.33^{b}	81.67 ± 2.03^{ab}
GIS	34.50 ± 0.29^{ab}	7.67 ± 0.88^{h}	3.67 ± 1.45^{ab}	0.67 ± 0.33^{a}	87.00 ± 0.58^{a}
GIH	31.83 ± 0.44^{cd}	14.67 ± 0.88^{f}	2.33 ± 1.20^{ab}	0.67 ± 0.67^{ab}	75.33 ± 1.76^{bcd}
GAL	36.00 ± 0.58^{a}	29.33 ± 2.03^{bc}	1.67 ± 0.33^{ab}	1.67 ± 0.88^{ab}	59.33 ± 2.60^{f}
GAS	33.67 ± 0.33^{bc}	39.33 ± 1.45^{a}	1.33 ± 0.88^{ab}	2.00 ± 0.58^{ab}	59.33 ± 1.76^{f}
GAH	35.67 ± 0.33^{ab}	24.33 ± 1.45^{de}	3.67 ± 1.20^{ab}	1.67 ± 0.88^{a}	57.67 ± 3.28^{f}

(a-k): Means on the same rows with different superscript are significantly different ($p \leq 0.05$); (Mean ± SEM) control groups: C1 (Non Infected, Non-treated), C2 (Infected, Non-treated) & C3(Infected & treated with a commercial antibiotics), UTL: Utazi low dose, UTS: Utazi medium dose, UTH: Utazi high dose; GIL: Ginger low dose, GIS: Ginger high dose, GIH: Ginger high dose; GAL: Garlic low dose, GAS: Garlic medium dose and GAH: Garlic high dose.

	PACKED CELL VOL.	WHITE BLOOD CELL	HEMOGLOBIN	RED BLOOD CELL	MCV	MCH
C1	21.46 ± 0.36^{f}	9.24 ± 0.43^{f}	7.13 ±0.47^{f}	2.47 ± 0.09b^{c}	88.67 ± 0.33^{c}	29.67 ± 0.33^{cd}
C2	23.33 ± 0.33^{de}	10.76 ± 0.17^{e}	8.52 ± 0.37^{cde}	2.83 ± 0.15^{abc}	82.00 ± 0.58^{e}	31.33 ± 0.88^{bc}
C3	24.33 ± 0.33^{cd}	10.94 ± 0.27^{e}	8.45 ± 0.46^{cde}	2.82 ± 0.17^{abc}	86.67 ± 0.88^{cd}	30.00 ± 0.58^{cd}
UTL	24.50 ± 0.29^{cd}	6.52 ± 0.18^{g}	7.89 ± 0.08^{ef}	3.22 ± 0.25^{a}	65.00 ± 0.58^{f}	25.67 ± 0.88^{f}
UTS	25.00 ± 0.00^{bcd}	7.19 ± 0.42^{g}	7.98 ± 0.19^{def}	3.01 ± 0.10^{ab}	79.67 ± 0.88^{e}	25.00 ± 0.58^{f}
UTH	27.00 ± 0.58^{a}	12.66 ± 0.80^{bcd}	8.78 ± 0.07^{bcde}	2.47 ± 0.19^{bc}	102.33 ± 0.88^{a}	33.33 ± 0.88^{ab}
GIL	27.00 ± 1.00^{a}	12.56 ± 0.38^{bcd}	9.17 ± 0.20^{bc}	3.40 ± 0.17^{a}	101.00 ± 2.08^{a}	26.67 ± 0.88^{ef}
GIS	26.00 ± 1.00^{abc}	13.80 ± 0.30^{b}	9.06 ± 0.23^{bcd}	2.55 ± 0.08^{bc}	102.67 ± 1.20^{a}	35.00 ± 0.58^{a}
GIH	27.37 ± 0.45^{a}	12.41 ± 0.27^{cd}	8.80 ± 0.43^{bcde}	2.32 ± 0.06^{c}	100.50 ± 0.29^{a}	35.00 ± 0.58^{a}
GAL	23.67 ± 0.33^{de}	13.58 ± 0.41^{bc}	12.26 ± 0.58^{a}	2.32 ± 0.27^{c}	88.33 ± 0.33^{c}	32.33 ± 0.33^{b}
GAS	26.33 ± 0.88^{ab}	16.24 ± 0.25^{a}	9.86 ± 0.29^{b}	3.38 ± 0.39^{a}	85.33 ± 0.33^{d}	28.00 ± 0.58^{de}
GAH	22.33 ± 0.33^{ef}	11.38 ± 0.62^{de}	8.01 ± 0.26^{def}	2.27 ± 0.24^{c}	92.00 ± 0.58^{b}	33.33 ± 0.33^{ab}

Table 5: Effect on Hematological parameters continued

(a-k): Means on the same rows with different superscript are significantly different (p≤0.05); control groups: C1 (Non Infected, Non treated), C2 (Infected, Non treated) & C3(Infected & treated with a commercial antibiotics), UTL: Utazi low dose, UTS: Utazi medium dose, UTH: Utazi high dose; GIL: Ginger low dose, GIS: Ginger high dose, GIH: Ginger high dose; GAL: Garlic low dose, GAS: Garlic medium dose and GAH: Garlic high dose.

3.3 Effect on Serum and Lipid Profile

3.3.1 Effect on Total Cholesterol

Utazi significantly increased (P < 0.05) total cholesterol, particularly at low-dose level inclusion (UTL, 186.00), compared to the control groups (C1 – C3). The effect decreased slightly with higher doses (UTH, 183.37). This suggests that Utazi may stimulate cholesterol synthesis or reduce its clearance. However, its therapeutic implications might be dose-dependent. Utazi increased HDL levels. It also raised LDL, total cholesterol, and triglycerides (TG) which is significantly higher (P < 0.05) than other groups which suggest that utazi may not be suitable for individuals at risk of cardiovascular disease, especially at higher doses. This is corroborated by the report of Crouse *et al.* (1984) and Igene *et al.* (2022). Ginger exhibited a dose-dependent reduction in total cholesterol levels, with the lowest levels observed in medium-dose (GIS, 164.47) and high-dose (GIH, 168.47) groups. This points to Ginger's potential as a natural cholesterol-lowering agent, especially at higher doses. Garlic showed the most substantial reduction in total cholesterol, with the low-dose group (GAL, 158.27) being the most effective. This aligns with existing literature that highlights garlic's role in reducing cholesterol synthesis and enhancing its excretion (Fadl *et al*., 2017). Garlic is the most effective natural remedy for improving lipid parameters and reducing cardiovascular risk.

3.3.2 Effects on LDL (Low-Density Lipoproteins)

Garlic markedly reduced LDL, with the low-dose group (GAL: 34.47 ± 0.23 mg/dL) showing a 31% decrease from the control (C1: 45.00 ± 0.21 mg/dL). This supports Qureshi *et al.* (1983), who demonstrated garlic's ability to lower LDL in chickens by suppressing hepatic cholesterol synthesis (Qureshi *et al.,* 1983). Ginger showed minor LDL changes (GIH: 47.97 ± 0.09 mg/dL), while Utazi increased LDL (UTL: 50.30 ± 0.42 mg/dL), posing potential cardiovascular risks as LDL is a key atherosclerosis driver.

3.3.3 Effects on VLDL (Very Low-Density Lipoproteins)

Garlic achieved the lowest VLDL levels (GAS: 9.28 ± 0.12 mg/dL), mirroring its triglyceride reduction, as VLDL transports triglycerides. Ginger also lowered VLDL dose-dependently (GIH: 9.55 ± 0.05 mg/dL), while Utazi increased it (UTL: 12.03 ± 0.15 mg/dL), reinforcing its unfavorable lipid profile. Garlic's superior efficacy in reducing total cholesterol, LDL, triglycerides, and VLDL aligns with its established role in lipid metabolism. Fadl *et al.* (2017) demonstrated that garlic extract in drinking water enhances broiler performance, likely through bioactive compounds like allicin, which inhibit cholesterol synthesis and promote excretion via bile acids (Fadl *et al.,* 2017). The low-dose group (GAL) being most effective for total cholesterol and LDL suggests an optimal concentration, avoiding potential saturation or adverse effects at higher doses, as noted in Rahmatnejad *et al.* (2021)'s meta-analysis of garlic in poultry (Rahmatnejad *et al.,* 2021). Ginger's benefits, particularly in triglycerides and VLDL, support its use as a complementary agent (Ademola *et al.,* 2009).

Table 6: Lipid Profile

	TOTAL CHOLESTOROL	HIGH DENSITY LIPOPROTIENS	TG	LOW DENSITY LIPOPROTIENS	VERY LOW DENSITY LIPOPROTIENS
C1	173.33 ± 0.22^{d}	116.63 ± 0.18^{d}	56.23 ± 0.35^{d}	45.00 ± 0.21^{c}	11.40 ± 0.17^{b}
C2	174.07 ± 0.30^{c}	118.07 ± 0.23^{b}	56.90 ± 0.15^{c}	45.00 ± 0.06^{c}	11.33 ± 0.12^{b}
C3	173.40 ± 0.12^{d}	117.43 ± 0.09^{c}	53.77 ± 0.15^{e}	45.00 ± 0.12^{c}	10.50 ± 0.17^{c}
UTL	186.00 ± 0.15^{a}	123.34 ± 0.13^{a}	60.00 ± 0.15^{a}	50.30 ± 0.42^{a}	12.03 ± 0.15^{a}
UTS	185.50 ± 0.23^{a}	123.67 ± 0.19^{a}	58.63 ± 0.18^{b}	49.90 ± 0.21^{a}	11.50 ± 0.17^{b}
UTH	183.37 ± 0.15^{b}	123.40 ± 0.17^{a}	57.40 ± 0.17^{c}	48.20 ± 0.25^{b}	11.27 ± 0.19^{b}
GIL	166.57 ± 0.20^{f}	110.60 ± 0.15^{g}	51.57 ± 0.30^{f}	45.53 ± 0.15^{c}	10.21 ± 0.14^{cd}
GIS	164.47 ± 0.15^{g}	109.27 ± 0.12^{h}	50.20 ± 0.06^{g}	45.00 ± 0.26^{c}	9.97 ± 0.09^{de}
GIH	168.47 ± 0.20^{e}	111.07 ± 0.20^{g}	48.00 ± 0.06^{h}	47.97 ± 0.09^{b}	9.55 ± 0.05^{ef}
GAL	158.27 ± 0.12^{j}	114.10 ± 0.06^{f}	47.37 ± 0.09^{f}	34.47 ± 0.23^{e}	9.29 ± 0.11^{f}
GAS	162.13 ± 0.15^{h}	116.23 ± 0.15^{d}	47.37 ± 0.15^{j}	36.37 ± 0.18^{d}	9.28 ± 0.12^{f}
GAH	160.50 ± 0.06^{i}	115.10 ± 0.21^{e}	47.40 ± 0.26^{i}	36.10 ± 0.38^{d}	9.55 ± 0.14^{ef}

(a-k): Means on the same rows with different superscript are significantly different (p≤0.05); (Mean ± SEM) control groups: C1 (Non-Infected, Non-treated), C2 (Infected, Non-treated) & C3(Infected & treated with a commercial antibiotics), UTL: Utazi low dose, UTS: Utazi medium dose, UTH: Utazi high dose; GIL: Ginger low dose, GIS: Ginger high dose, GIH: Ginger high dose; GAL: Garlic low dose, GAS: Garlic medium dose and GAH: Garlic high dose.

4.0 CONCLUSION AND RECOMMENDATION

4.1 CONCLUSION

The study showed increased red blood cell count, packed cell volume, and hemoglobin concentration in treated groups. Serum biochemical indices, including total protein, albumin and glucose levels showed dose-dependent reductions with exception to Utazi group. Notably, the Garlic group exhibited significant reductions in cholesterol and triglyceride levels due to its hypolipidaemic effects. Liver enzyme profiles (AST and ALT) remained within normal ranges across all treated groups, indicating the safety of the plant extracts and their non-hepatotoxic effects.

4.2 RECOMMENDATION

These spices ginger (*Zingiber officinale*), garlic (*Allium sativum*), and utazi (*Gongronema latifolium*) are hereby recommended for inclusion in drinking water for broiler at the prescribed dosage due to their positive and non-detrimental effects on blood parameters and lipid profiles. Generally, they don't have withdrawal period as is the case with antibiotics which is a key driver of antimicrobial resistance when used in sub-therapeutic concentrations.

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