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Effect of White Ginseng (*Panax ginseng*) root meal as feed additive on growth performance, lipid profiles and serum biochemistry on broiler chickens

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ABSTRACT

Aim: Purpose of the study was to determine the effect of including dietary white ginseng root meal (WGRM) at different levels on the growth performance, fatty acid profiles and serum biochemistry of broiler birds.

Method and materials: Total 180 days-old chicks (Cobb 500), with equal numbers of males and females, were used for the study. The birds were carefully divided into five treatments and assigned to five treatment diets in a Completely Randomized Design (CRD) as follows: T1, T2, T3, T4, and T5. Each dietary treatment consisted of three replicates, each containing twelve birds (six males and six females). The replacement levels were 0% WGRM for T1, Oxytetracycline (15g/20L) for T2, (0.2% WGRM for T3, 0.4% WGRM for T4, and 0.6% WGRM for T5). After eight weeks of rearing, blood samples were collected and analyzed for total cholesterol, HDL, LDL, Triglyceride, ALT and AST.

Results: Results showed significant differences in body weight gain, feed intake, feed conversion ratio and mortality rate of the male birds fed diet T4 and T5 containing 0.4% and 0.6% WGRM respectively. The fatty acid profiles showed that there was a significant ($P<0.05$) difference in HDL of female birds merely with the highest value seen in T2 (53.10 ± 2.408) and the lowest value seen in T1 (38.44 ± 6.496). Serum biochemistry showed no significant ($P>0.05$) difference between ALT and AST in both male and female.

Conclusion: It was concluded that white ginseng inclusion at 0.4% and 0.6% diet enhanced growth performance, reduced mortality and fatty acids profiles and serum biochemistry of broiler birds. White ginseng root meal represents a promising phytogenic additive for sustainable broiler production, potentially contributing to healthier meat products and improved economic returns for farmers.

Keywords: *Panax ginseng*, Growth parameters, Lipid profiles, Serum Biochemistry

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Introduction

The global poultry industry faces increasing pressure to meet growing protein demands while reducing reliance on antibiotic growth promoters, whose use has raised concerns about antimicrobial resistance and drug residues in food products (Peng Zhang *et al*., 2024). In many African countries, including Cameroon, poultry production remains crucial for food security and economic stability, with local chickens constituting approximately 80% of poultry production in Sub-Saharan Africa (Wozerou *et al*., 2024).

According to Ani and Okeke (2011), poultry production is one of the quickest ways to improve the population's nutritional status due to its short lifespan, generation interval, rapid turnover rate, and low capital outlay. This sector is a primary source of animal proteins and provides a valuable repository for bridging the gap between demand and the availability of balanced nutrition. Due to the numerous advantages involved in poultry production, the use of antibiotics has facilitated the efficient production of poultry, allowing consumers to purchase at a reasonable cost, high-quality meat and eggs (Donoghue, 2003).

Donoghue (2003) further explained that antibiotics have been widely used in the livestock industry for growth promotion and to improve feed efficiency over the last few decades. Kelley *et* *al*. (1998) observed that there is growing concern that the use of antibiotics in livestock and poultry feed may increase the number of antibiotic-resistant pathogens and cause antibiotic residues in animal products, particularly meat and eggs. Dipeolu *et al*. (2005) stated that these residues may further pose a threat to human health. According to Ndelekwute *et al*. (2014), the restrictions and drug resistance problems caused by antibiotics, nutritionists have turned inward to alternative sources such as probiotics, yeast, prebiotics, organic acids, and feed-grade enzymes are examples of alternative feed additives. It was also found that bioactive plant materials, otherwise known as phytogenic, are a good alternative when properly applied. Phytogenic compounds such as essential oils and spices have been reported to exhibit growth-promoting properties.

Yildirim *et al*. (2013) state that ginseng is considered an adaptogenic agent that helps to enhance physical performance, promote vitality, and stimulate metabolic function. Several studies have documented that ginseng contains saponins, antioxidants, peptides, polysaccharides, alkaloids, lignin, etc. Among these, saponins (ginsenosides) are considered to be the principal bioactive ingredients (Palazon *et al.,* 2003). Saponins possess anti-inflammatory properties, haemolytic activity, cholesterol-binding properties, and bitterness. The primary bioactive components have been shown to improve nutrient absorption, enhance immune function, modulate lipid metabolism, and reduce oxidative stress in various animal models (Zhang *et al*., 2024). Alkaloids, on the other hand, are known to possess many pharmacological properties, including anti-hypertensive effects, anti-malarial activity, and anti-carcinogenic potentials (Saxena *et al.,* 2013). Kim and In (2010) and Yildirim *et al.* (2013) observed that ginseng has properties that boost the immune system and provide pharmaceutical and antioxidant benefits to humans and animals. These positive properties could be exploited for better broiler productivity.

While most research has focused on processed forms of ginseng (such as red ginseng) or specific extracts (Zhou *et al*., 2022), the use of whole white ginseng root meal as a direct dietary supplement remains relatively unexplored, particularly in the context of Sub-Saharan African poultry production systems. White ginseng, consisting of dried raw ginseng root, contains a diverse profile of bioactive compounds that may positively influence poultry physiology and productivity. Previous studies conducted elsewhere have demonstrated the potential of ginseng in poultry nutrition. Research by Yan et al showed that dietary supplementation with wild-ginseng adventitious root meal improved growth performance and blood profiles in broilers (Yan *et al*., 2011). Another study found that white ginseng to roast chickens improved quality characteristics and reduced lipid oxidation (Zhou *et al.*, 2022). Notably, recent research from the University of Buea has demonstrated that *Panax ginseng* root meal supplementation improved reproductive performance in Cameroon Kabir chicken (Wozerou *et al.*, 2024), suggesting similar benefits might be achievable in broiler production.

The Department of Animal Science at the University of Buea has developed substantial research capacity in alternative feed resources and animal nutrition, with several researchers focusing on phytogenic additives for livestock. Dr. Ewane Divine, Acting Head of the Department and Principal Investigator of the Support Programme for the University of Buea Livestock Production and Agripreneurship Students Business Incubator (SP UB LPA SBI), has expertise in innovative animal production systems (First Intra-African Seminar, 2025). The department's research on ostrich production and poultry nutrition demonstrates its commitment to developing sustainable animal production systems suitable for the African context.

This comprehensive study aimed to evaluate the effects of dietary supplementation with white ginseng root meal on growth performance, lipid metabolism, and serum biochemical parameters in broiler chickens. The investigation was designed to identify optimal inclusion levels and provide scientific evidence for the use of this phytogenic additive in poultry production systems in Cameroon and similar regions. The study was aimed to contribute to the growing body of knowledge on natural alternatives to antibiotics in animal production and offer practical insights for poultry farmers in the region.

Materials and Methods

Fresh Fresh Panax ginseng roots were harvested from the Northwest region of Cameroon, specifically from Ndop (Ngoketunjia division), with coordinates N 60 00′0.00″ to E 100 24′ 59.99′′. The roots were transported to Buea, where the experiment was conducted. The study took place in

Molyko-Buea, Fako Division, Southwest Region of Cameroon, at the Faculty of Agriculture and Veterinary Medicine Teaching and Research Farm (FAVM-TRF), University of Buea, situated at an altitude of 870 m above sea level. The farm's coordinates are N 40 9′0.3888″ to E 90 16′ 59.6496′′ (Global Positioning System). Buea is located at a longitude of 4.15ºN and a latitude of 9.24ºE, with temperatures ranging from 20ºC to 28ºC and a mean annual relative humidity between 80% and 95%. It lies within agroecological zone IV (monomodal humid forest) and has a subtropical highland climate due to its position at the foot of Mount Cameroon. Buea experiences an equatorial climate with two main seasons: the rainy season from March to October and the dry season from November to May (Buea Communal Development Plan, 2012). Extended periods of rainfall, characterized by incessant drizzle lasting several weeks, are common during the bimodal rainy season, which peaks in April and September. The topography consists mainly of undulating highlands and lowlands with abundant rocks and gravel. The soils are black and well-drained, reflecting the hilly terrain (BCDP, 2012).

Ethical and Administrative Issues Related to Experimental Animals

Kabir chickens were produced and used for this experiment to assess the impacts of *P. ginseng* root meal on the reproductive performance of the chickens. The animals were housed in standard cages at 25°C on an 18 h light-dark cycle for reproduction. They were supplied with food and water *to* meet their optimum reproductive potential. The experiments were carried out by the National Ethical Committee Guidelines (N° FWA-IRB00001954) and the International (European Committee Council Directive of November 24, 1986 (86/69/EEC); Guide for the Care and Use of Laboratory Animals, U.S. National Research Council, 1996) for the care and use of laboratory animals. All efforts were made to minimize both the suffering and stress of any type to the chickens used.

Preparation of Panax ginseng root before inclusion into the feed as an additive

The roots were washed with clean water to remove dirt and then chopped with the aid of a knife to reduce the size of the roots, thereby increasing the surface area for drying. Subsequently, the weight of the fresh *P. Ginseng* was recorded. The chopped roots were spread to dry in an air-circulated oven drier at 40 °C. The roots were then weighed at intervals until the weight became fairly constant after 72 hours. The dried ginseng roots were then bagged and carried to the mill. It was ground to powder using a pulveriser machine at the FAVM-TRF feed mill and stored in airtight plastic bags to avoid moisture that could lead to fungal growth. All experimental ingredients (excluding maize), such as wheat bran, soybean meal, fish meal, concentrate, bone meal, and oyster shell, were purchased from BELGOCAM, Buea branch. The maize (yellow maize) used for the research was purchased from Bangem, the Southwest Region of Cameroon. It was recorded the root and root powder after preparation before inclusion (Fig. 1).

Fig 1. Panax ginseng root and powder L-R

Birds and Management

Total 180-day-old chickens were bought from SOCAVB (Societe de commercialisation des aliment de la Volaille et du bétail) and the prophylactic calendar (Table 1). 180 healthy and sexed three-week-old (Cobb 500) broiler chickens were used for this research and the chicks were obtained. Feed and water were also put in place before the arrival of the birds.

Table 1: Locally adapted prophylactic calendar for the birds from day one to day 62

Age/day	Types of drug/vaccine
1	Avinew, Bioral, and Galivac
1-5	Anti-stress
6-7	Antibiotics (oxy-furan)
8	Vaccine A, B, G
8-10	Vitamins (Amin-total)
11-13	Antibiotics (Oxy-tetracycline 50%)
14-16	Vitamins
17-19	Vaccine
20-22	Vitamins
21 (Experimental age)	Vaccine (A, B, G)
23-25	Anti-coccidiosis
26-29	Vitamins
30	De-wormer (Anthelmintic)
35-37	Liver protectors
	Vitamin
42-62	

The birds were fed ad libitum with a constant water supply from experimental day till end. Proper management was done to avoid physical damage and environmental stress, and a disease prevention program for broilers was strictly followed.

Experimental Diet of the Broiler Chickens from Day-old

The inclusion levels of *Panax ginseng* were: 0% in T1, 0% in T2, 0.2 in T3, 0.4% in T4, and 0.6% in T5. The two dietary types, one for the starter phase and the other for the finisher phase, were compounded as shown in the proximate analysis (Table 2,3 and 4).

Table 2. Ingredients and nutritive value of broiler starter diets

Ingredients	T1	T2	T3	T4	T5
Maize	51	51	51	51	51
Soya bean meal	7	5.25	3.5	5.25	3.5
Panax ginseng root meal	0	0	0.2	0.4	0.6
Fish meal	0.5	0.5	0.5	0.5	0.5
Wheat offal	10	10	10	10	10
Palm kernel ca	10	10	10	10	10
Groundnut cake	22.75	22.75	22.75	22.75	22.752
Bone meal	2	2	2	2	2
Oyster shell	1	1	1	1	1
Vitamin/mineral premix	0.5	0.5	0.5	0.5	0.5
Common salt	0.25	0.25	0.25	0.25	0.25
Total	105	105	105	105	105
Calculated CP%	22.10	21.72	21.33	21.72	21.32
Calculated ME Kcal/kg DM	2.960	3.005	3.051	3.004	3.048

Table 3: Ingredients and nutritive value of broiler finisher diets (with P.ginseng additive)

Ingredients	T1	T2	T3	T4	T5
Maize	52.25	52.25	52.25	52.25	52.25
Soya beans meal	5	3.75	2.5	3.75	2.5
Fish meal	3	3	3	3	3
Wheat offal	20	20	20	20	20
Groundnut cake	18	22.75	22.75	22.75	22.75
Bone meal	2	2	2	2	2
Oyster shell	1	1	1	1	1
Vitamin/mineral premix	0.5	0.5	0.5	0.5	0.5
Common salt	0.25	0.25	0.25	0.25	0.25
Total	102	102	102	102	102
Calculated CP%	20.80	20.99	20.71	20.99	20.71
Calculated ME Kcal/kg DM	2.936	2.938	2.971	2.937	2.904

Table 4: Proximate analysis of ginseng

Chemical composition (%)	Quantities
Moisture	8.19
Dry matter	91.81
Crude protein	8.61
Crude fibre	1.56
Fat	0.90
Ash	12.5
Non-fibre carbohydrate	68.26
Total digestible nutrient	69.77

Research Design

The experimental house was partitioned into 15 square-sized pens (1 m x1.6 m) separated by wire mesh and ceiling board structure, such that a space of about 0.15 m² per bird was allocated. The birds were allotted randomly into five experimental groups (T1, T2, T3, T4, and T5) of 36 birds each, with each group divided into three replicates of 12 birds each in a completely randomized design pattern. Feed and water were given *ad libitum.* The feed intake and body weights were measured every week. 180 sexed three-week-old (COBB 500) broilers were divided into five treatments (T1, T2, T3, T4, and T5). The negative control (T1) received only the diet, while the positive control (T2) received the diet and oxy-tetracycline as an antibiotic growth promoter (15 g in 20 L of water). T3, T4, and T5 received *Panax ginseng* in their diets in respective proportions of 0.2%, 0.4%, and 0.6%. Feed and water were measured and served daily, and the leftover was quantified using an SF-400 electronic weighing scale (0.01 g precision) to evaluate feed and water intake, respectively. At the beginning of the experiment, the weight of the birds was taken and subsequently measured every week using a weighing scale (0.01 precision). The growth characteristics, such as feed intake, weight gain, and feed conversion ratio, were measured at the end of the experiment (Fig. 2).

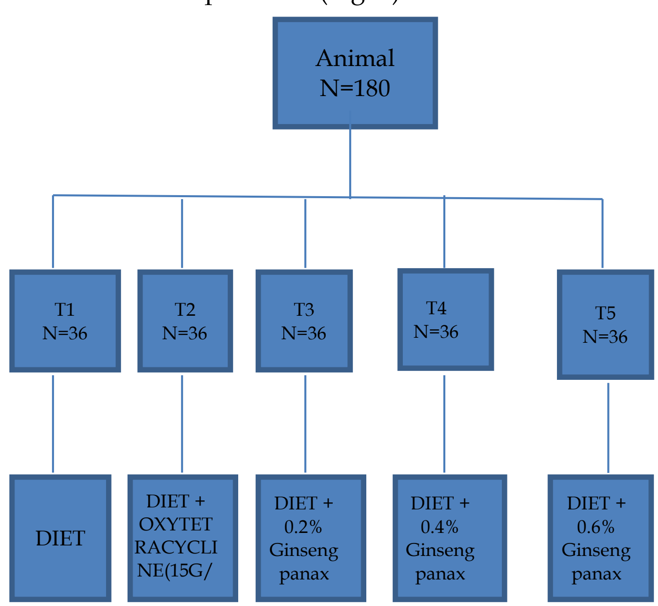

Fig 2. Experimental design setup where (N=number of birds)

Data collection

The following data were collected during this experiment: initial and final body weights, weekly feed intake, weekly water intake, and collection of blood samples for data on the lipid profiles and serum biochemistry of the birds. At the beginning of the experiment, the weights of the birds were taken on day 1 and subsequently taken weekly using an electronic scale with (0.001 g precision) to evaluate the growth characteristics, and the birds were monitored weekly for fifty-six days. For growth performance, birds were weighed at day 1 of the experiment, and subsequently every week till the end. Feed intake was also recorded at each feed change interval during the experimental period

At the end of the experiment, twelve birds were randomly selected from each treatment, and 5 mL of blood was collected into a dry tube from the jugular vein for some serum biochemistry tests. The samples were taken to the Maflekumen Clinic, where the sera obtained were used to run the biochemistry test for the chicken.

Growth measurement of the bird's Feed intake and water intake

Feed intake was recorded daily using the electronic balance, and the total was calculated at the end of the week. Weekly body weights were carried out by randomly selecting six birds per replicate and measuring their weights using an electronic balance. The weight for each treatment is recorded as the mean of the three replicates per treatment. Feed intake (g) = feed offered overfeed.

Feed conversion ratio

FCR (g) = = $\frac{feed\ given}{total\ weight\ gain}(for\ a\ period\ of\ time)$

Water intake (L) =$\frac{\text{water offered}}{\text{left over}}$

Survivability

This is the total number of birds survived at the end of the study.

$$\text{Survivability (\%)} = \frac{number\ of\ survived\ birds}{Total\ number\ of\ birds} x100$$

Collection of blood

Blood collection was carried out at the end of the experiment through the left jugular vein using a sterilised syringe whereby 5 mL of blood was collected. Twelve birds per treatment (four from each replicate) were randomly selected respecting sex as a sample for each treatment. Blood samples for lipid studies were collected into dry tubes (without anti-coagulant) for serum separation. The blood samples for lipid and serological studies were done in Maflekumen clinic in Tiko.

Lipid Analysis

The blood samples collected were spun in dry test tubes to obtain sera which were carefully transferred to 3 ml Eppendorf tubes and taken to Maflekumen clinic to be used for fatty acids analysis. Fatty acid concentrations were expressed as a percentage of each fatty acid relative to total fatty acids.

Serum Biochemical Studies

Serum was extracted from different treatments 8 hours after blood collection, then placed in 3 ml sterilized Eppendorf tubes and refrigerated (-20°C) till further analysis. The serum profiles were obtained by spectrometric method (dual beam UV-Spectrometer) using commercial kits (Chronolab).

Statistical Data Analysis

The data obtained for growth performance, fatty acid profiles, and serum biochemistry were submitted to a one-way analysis of variance to compare the means. The level of significance was established at 0.05, and the software used was a statistical package for social sciences (SPSS) version 21.0.

Daily feed intake and weekly weight gain were measured and recorded per group. Data on feed intake, water intake, Body weight gain, feed conversion ratio, and mortality were recorded as they occurred. The study lasted for eight weeks.

Data Analysis

Data collected was subjected to a one-way analysis of variance (ANOVA). Significantly different means were separated using Duncan's New Multiple Range Test (Duncan, 1955) at a 5% significance level.

Proximate Analysis of the experimental diets

The starter diets' crude protein ranges from 20.3% to 21.6% while total digestible energy ranges from 3297.3 to 2492.5 (kcal/kg DM) (Table 5 and 6).

Table 5: Proximate analysis of the experimental diets

Samples	DM (%)	Ash (%DM)	Organic matter (%DM)	Crude Protein (%DM)	Lipids (%DM)	Crude fiber %(DM)	Metabolisable energy (kcal/kg DM)	Nitrogen-free extract (DM)
T1	89.3	7.4	92.6	21.6	5.3	5.0	3492.5	49.9
T2	89.4	7.1	92.9	20.5	6.1	6.2	3436.3	49.5
T3	88.9	8.5	91.5	20.3	5.7	6.9	3297.3	47.5
T4	88.8	6.5	93.5	20.1	5.6	6.7	3396.2	49.9
T5	89.2	9.4	90.6	20.9	6.4	6.6	3329.4	45.9

Table 6. Proximate analysis of finisher diets for broilers

Samples	DM(%)	Ash(%)	Organic matter (%DM)	Crude Protein (%DM)	Lipids (%DM)	Crude fiber% (DM)	Metabolisable energy (kcal/kg DM)	Nitrogen-free extract (DM)
Control	89.1	11.1	88.3	19.54	5.78	4.45	3593.40	46.98
T2	88.0	11.4	88.46	18.04	6.46	5.32	3359.00	46.65
T3	86.2	8.1	91.93	18.41	6.23	4.73	3540.19	48.74
T4	88.9	9.9	90.12	19.45	5.59	5.77	3384.13	48.71
T5	89.8	11.3	88.73	17.33	7.76	4.65	3500.41	48.77

Table 7. Growth performance of broiler birds fed diets containing varying levels of white ginseng as a feed additive

Week	T1	T2	T3	T4	T5
1	414.62 ± 16.61	416.81 ± 5.23	395.47 ± 15.12	426.83 ±2.65	408.03 ±14.60
2	622.12±53.20^{a}	771.93 ± 52.91^{ab}	785.15 ± 61.07^{ab}	770.33 ± 18.43^{ab}	833.64 ± 61.89^{ab}
3	991.57±90.79	1075.01 ± 20.80	971.80 ± 9.68	976.80 ± 55.58	1015.52 ± 18.42
4	1034.66 ± 67.27	1121.30 ± 30.39	1008.04 ± 26.21	1000.55 ± 49.15	1045.15 ± 31.11
5	1099.17 ± 93.74	1096.79 ± 64.03	1048.86 ± 34.62	1092.33 ± 68.04	1140.26 ± 58.34

Mean ± SEM on the same rows with the same superscript letter(s) is not significantly different at $p = 0.05$ level according to Tukey.

Table 8. Effect of ginseng root meal as a fed additive on feed conversion ratio

	T1	T2	T3	T4	T5
FCR	3.56±0.39^{b}	3.03±0.13^{ab}	2.80±0.08^{a}	3.09±0.22^{ab}	3.03±0.09^{ab}

Table 9. Effect of ginseng root meal as feed additive on feed conversion ratio for Female broilers.

Sex	Week	T1	T2	T3	T4	T5
Female	1	7.38±0.44^{a}	8.09±0.37^{b}	7.59±0.46^{a}	8.48±0.33^{b}	7.15±0.19^{a}
	2	9.06±0.62^{b}	8.67±0.47^{b}	8.95±0.36^{a}	10.47±0.63^{a}	11.95±3.44^{b}
	3	9.38±0.31^{a}	9.08±0.49^{a}	8.84±0.23^{a}	9.61±0.14^{b}	8.09±0.39^{a}
	4	7.23±0.28^{a}	6.92±0.54^{b}	7.56±0.21^{a}	8.94±0.49^{b}	7.97±0.82^{a}
	5	5.93±0.14	6.14±0.16	6.73±0.35	6.87±0.24	6.52±0.49

Results and Discussion

Growth performance of broiler birds fed diets containing varying levels of white ginseng as a feed additive

The growth rate in week 5 showed that the highest growth rate in g was seen in T4 receiving 0.4% ginseng, and the lowest values were recorded in T1 receiving no ginseng (the control diet, respectively) (Table 7).

Effect of ginseng root meal as a feed additive on feed conversion ratio

At the end of the study, FCR was calculated, and it was found that there was no significant difference (Table 8).

Effect of ginseng root meal as a feed additive on feed conversion ratio for Female broilers

At the end of study, FCR was calculated, and it was found that there was a significant difference with the highest from T4 (8.94±0.49) while the lowest was from T1 (5.93±0.14) as recorded (Table 9).

Effect of Panax ginseng on the growth rate of male and broilers

At the end of experiment, it was found that highest weight gain was observed in T4 (1562.13 g), while lowest was in the control group T1 (1365.84 g). The difference was significant at a P-value less than 0.05 as recorded (Table 10.).

Effect of Panax ginseng on the growth rate of female broiler chicken

The highest weight gain was observed in T5 (1434.97 g) and the lowest value was seen in T3 (1330.2), with a P-value less than 0.05 (Table 11).

Effect of Panax ginseng on the Lipid Profile of broiler chicken

The results show no significant difference (p>0.05) among treatments. Cholesterol for males and females falls below the normal value (<60) in all treatments.

Effect of Panax ginseng on cholesterol in both male and female birds

Male chickens' total cholesterol ranges from 142.6±16.27 to 174.4±6.213 for all the treatments, which in-lined with the levels of the normal standard cholesterol (<200). Cholesterol levels in male animals are highest in T1 (control), 174.4±6.213, and lowest in T2, 142.6±16.27, receiving 0.2% of ginseng. On the other hand, Female chickens' total cholesterol ranges from 148.9±13.28 to 172.5±12.67 and is also in line with the levels of the normal standard cholesterol (<200).

Table 10. Effect of *Panax ginseng* on the growth rate of male broiler chicken

	Week	Weight (g) of Treatment				
		T1	**T2**	**T3**	**T4**	**T5**
	I	473.67±19.00	500.67±30.92	505.11±18.14	465.11±30.72	497.78±45.86
	1	724.73±28.98^{a}	799.36±68.93^{a}	710.67±8.67^{a}	729.61±50.31^{a}	735.06±57.44^{a}
	2	1065.36±74.62^{b}	779.11±336.81^{a}	1004.82±45.99^{b}	1577.89±522.9^{c}	1081.94±67.13^{b}
	3	977.83±419.22^{a}	1392.24±30.88^{b}	1334.835±62.22^{b}	1385.83±77.67^{b}	1435.92±86.81^{bc}
	4	1532.23±71.47^{a}	1850.19±121.91^{b}	1610.22±51.95^{a}	1638.94±61.22^{a}	1655.39±102.61^{a}
	5	1839.51±145.85^{a}	2001.53±14.71^{b}	1987.46±64.15^{a}	2027.24±50.02^{b}	1966.69±111.35^{a}
	Wt Gain	**1365.84**	**1500.86**	**1482.35**	**1562.13**	**1468.91**

Table 11. Effect of Panax ginseng on the growth rate of female broiler chicken

Week		**T1**	**T2**	**T3**	**T4**	**T5**
		Weight (g) of Treatment				
Initial		430.95±7.11	418.33±28.08	443.44±12.78	404.33±28.58	443.94±31.11
	1	581.71±13.06^{a}	604.73±36.44^{a}	626.99±15.33^{a}	606.17±24.08^{a}	665.33±20.67^{a}
	2	869.43±45.37^{a}	1010.27±79.22^{b}	1020.95±51.31^{b}	836.11±26.39^{a}	897.97±897.97^{a}
	3	1151.19± 10.90^{a}	1297.54±86.36^{a}	1283.00±16.00^{a}	1148.2±33.40^{a}	1389.33±30.25^{b}
	4	1568.61±67.06^{b}	1759.57±175.36^{c}	1558.22±73.78^{b}	1552.5±79.50^{b}	1313.99±102.16^{a}
	5	1839.51±145.85^{b}	1839.51±145.85^{b}	1773.64±105.61^{a}	1742.31±64.90^{a}	1878.91±163.62^{b}
Wt Gain		**1408.56**	**1421.18**	**1330.2**	**1337.98**	**1434.97**

Female, cholesterol was highest in T4=174.4±6.213 receiving 0.4% ginseng and lowest in T1=142.6±16.27, negative control (Fig 3).

Effect of Panax ginseng on Triglycerides of male and female birds

Triglyceride levels were highest in T5 and lowest in T2 for males but the differences were not statistically significant. In females, all male and female treatment groups but the differences were not statistically significant (Fig 4).

Effect of ginseng root meal on the serum biochemistry of broiler chicken

Effect of Panax ginseng on High-density lipoprotein in male and female Broilers: The results obtained show that there is no significant difference among treatments ($p > 0.05$). However, chickens in T3 registered the highest value, while those in the positive control (T2) recorded the lowest value compared to the other groups.

Effect of Panax ginseng on High-density lipoprotein in male and female chickens: The results obtained show that significant differences were registered amongst treatments (p=0.0453). The chickens in T5 (51.99±2.281) registered the highest value for both sexes, while the chickens in the control (T1, 38.44±6.496) recorded the lowest value compared to the other groups (Fig 5).

Effect of Panax ginseng on Low-Density Lipoprotein in Male and Female Chickens

The results obtained show that there is no significant difference registered amongst treatments ($p>0.05$). The male chickens in T5= 6009±42.1 registered the highest value of LDL, while chickens in the T4=5570±287.6 recorded the lowest value of LDL compared to the other groups. Nonetheless, the female results obtained show that the were no significant differences registered amongst treatments ($p>0.05$). The female chickens in T4= 6239±332.9 registered the highest value, while the female chickens in T1= 5306±485.3 recorded the lowest value compared to the other groups (Fig 6).

Effects of Panax ginseng on Alanine Aminotransferase in Male and Female Broilers

The results obtained show that there are no significant differences registered amongst treatment groups in males ($p>0.05$). The male chickens in T2 registered the highest value (94.60±56.90). The chickens in T5 recorded the lowest value (10.05±2.29) compared to the other groups. The results obtained show that there are significant differences registered amongst treatment groups in females ($p>0.05$). The female chickens in T3 registered the highest value (85.77±71.52) while the chickens in T5 recorded the lowest value (11.61±2.72) compared to the other groups (Fig 7).

Effect of Panax ginseng on Aspartate Aminotransferases in male chickens

The results obtained show that there are no significant differences registered amongst treatments ($p>0.05$). The male chickens in T4 registered the highest value (2008±215.5), whereas the chickens in T3) recorded the lowest value (1491±218.3) compared to the other groups.

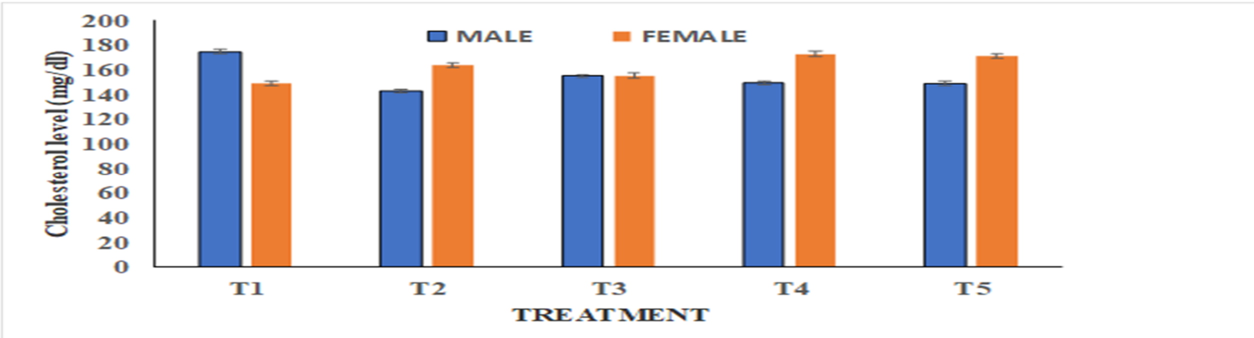

Fig 3. Effect of *Panax ginseng* on cholesterol for both male and female birds. T1=0%ginseng, T2=Oxytetracycline, T3= 0.2% ginseng, T4=0.4%ginseng, T5=0.6% ginseng.

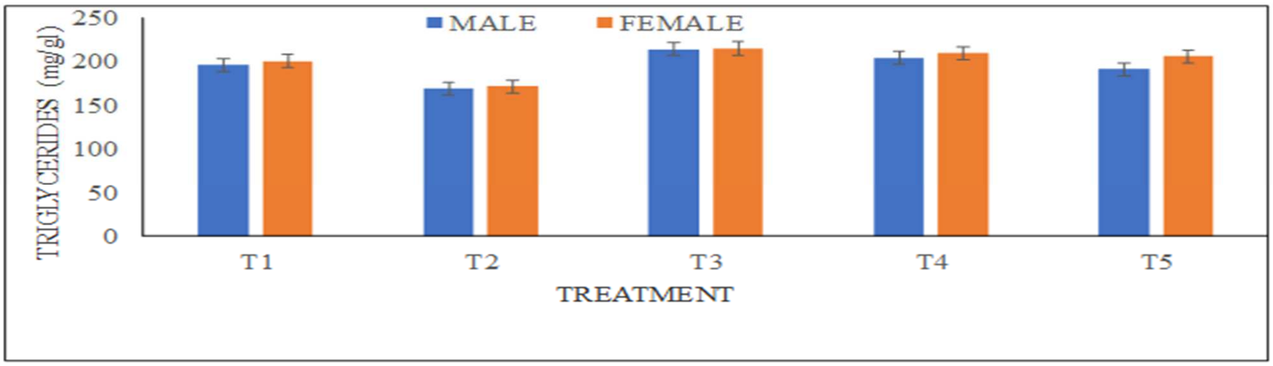

Fig 4. Effects of *P. ginseng* on triglyceride level of broilers, Male and Female. T1=0%ginseng, T2=Oxytetracycline, T3= 0.2% ginseng, T4=0.4%ginseng, T5=0.6% ginseng.

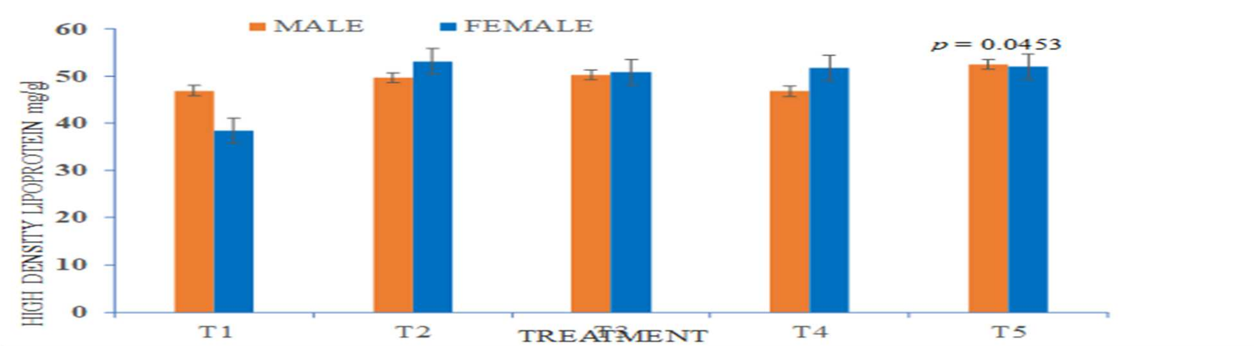

Fig 5. Effect of ginseng root meal on high-density lipoprotein for both male and Female broiler birds

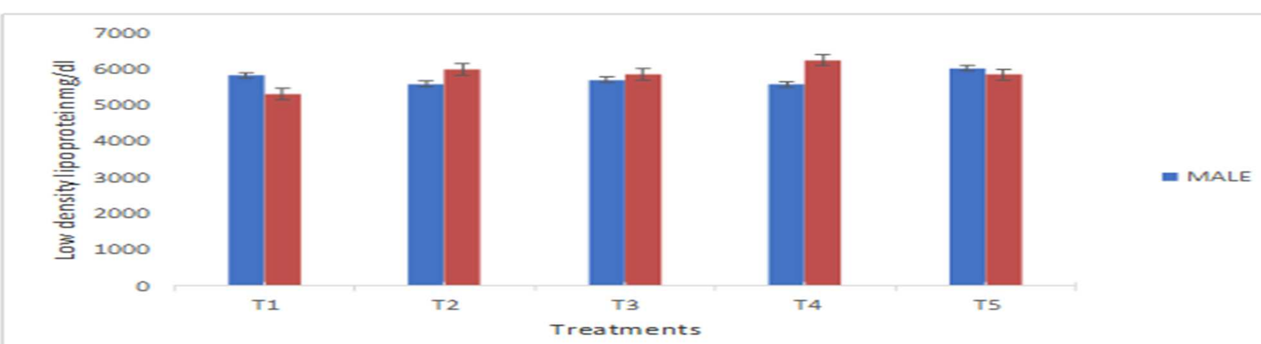

Fig 6. Effect of ginseng root meal on low-density lipoprotein for both male and Female broiler birds

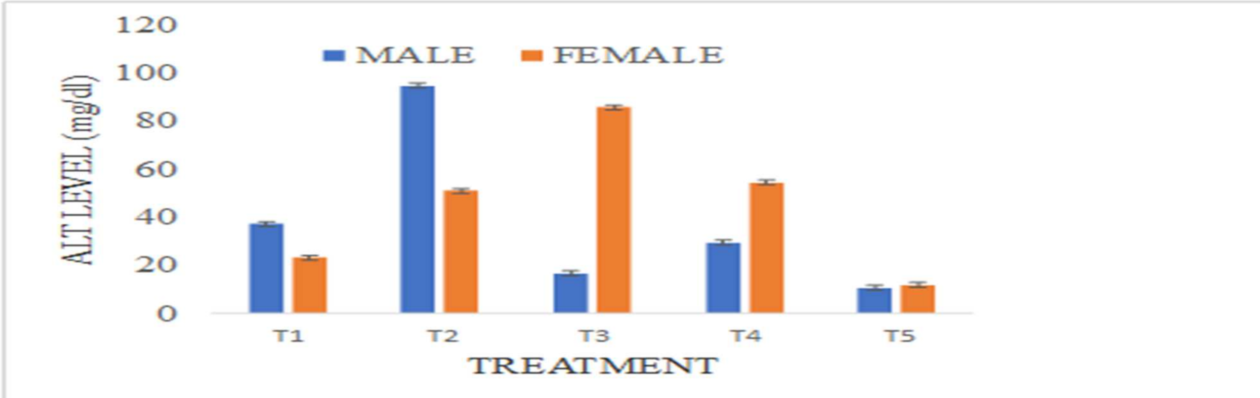

Fig 7. Level of ALT in broiler chickens fed P. ginseng root. ALT=Alanine aminotransferase

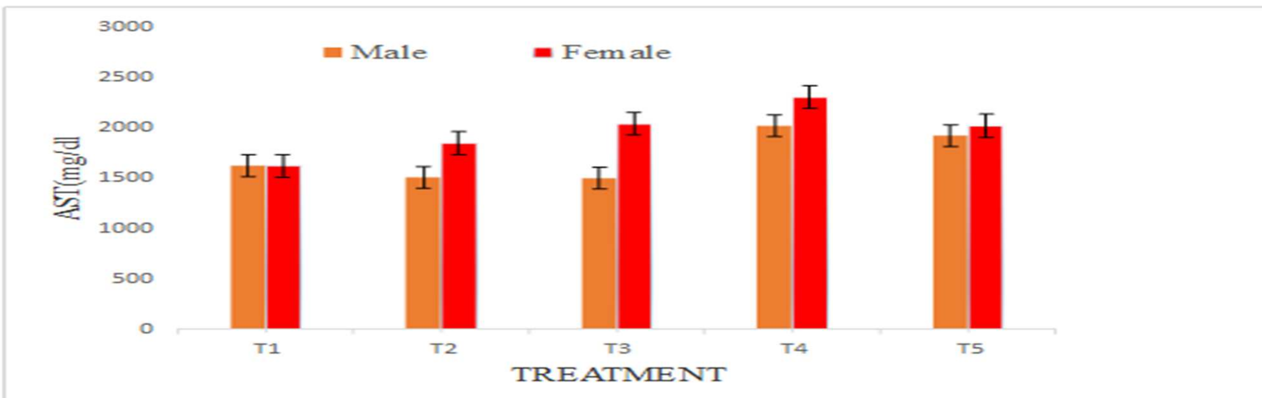

Fig 8. Level of AST in broiler chickens fed *P. ginseng* root

The results obtained show that, the is no significant differences registered amongst treatments (p>0.05). The female chickens in T4 registered the highest value, 2294±470.5, whereas the chickens in T1 recorded the lowest value (1641±229.0) compared to the other groups (Fig 8).

The study evaluated effect of *Panax ginseng* on growth characteristics, lipid profiles and serum biochemistry showed that value of weight gain, feed intake and feed conversion ratio were higher in animals receiving 0.4% *Panax ginseng (P. ginseng)*. The results were similar to those obtained by Amaefule *et al.* (2019) on growth performance of broilers fed varying proportions of *P. ginseng*.

The highest feed intake and feed conversion ratio was observed in T4 with a 0.4% inclusion level. This also led to higher weight gain by broilers with 0.4% ginseng additive in the diet. These results could be justified by the fact that *P. ginseng* contains phytochemicals that enhance the flavour and palatability of feed which improves feed intake and productive performance (Dalon *et al.,* 2016).

Triglyceride levels were generally above normal of ≤150mg/dl according to Regar *et al.* (2019) and the highest was in T3, receiving 0.2% ginseng and the lowest in T2 receiving oxytetracycline. The significantly higher values of triglycerides in the treated diet groups in comparison to the negative control diet was important for good health and was consistent with the result of a previous study by Ciftci *et al.* (2010) which reported that the hypertriglyceridemia effects were not seen in chickens fed with herbs, may be due to active ingredients in these products that lead to a decrease in the activity of lipogenic enzymes in the liver (decrease in the conversion of fatty acids and glycerol into fats).

The results obtained for cholesterol were higher in T4 animals receiving 0.4% of ginseng. This may probably be due to the possible depression of the hepatic activities of lipogenic and cholesterolemia enzymes such as a malic enzyme, fatty acid synthesis, dehydrogenase and 3-hydroxyl-glutaryl-CoA (HMG-CoA) reduced by the active ingredients in ginseng. The values obtained were similar to the results of Mehala (2008) but were contrary to those obtained by Emaldi *et al.* (2007).

The values registered for high-density

lipoprotein (HDL) and low-density lipoproteins (LDL) were higher in chickens that received 0.6% ginseng T5 for both sexes while the animal receiving Oxytetracycline recorded the lowest value compared to the negative control group low-density cholesterol and very -low --low-density lipoprotein is considered as bad cholesterol because a high low-density cholesterol level leads to a build-up of cholesterol in arteries. The reduction in the values of low-density and high-density cholesterol in the treatment receiving 0.6% ginseng root meal adds credence to the fact that the use of *P. ginseng* additive in broiler production can be adjusted as an effective measure of reducing cardiovascular diseases. High-density lipoprotein is good cholesterol due to the fact that it carries cholesterol to the liver which can be removed from the bloodstream before accumulating in the arteries where the excess in the blood is carried to the liver to produce bile salt and steroid hormones (Regar *et al*., 2019).

The values registered for ALT were higher in the male chicken receiving T1 (Oxytetracycline) while the chicken that received 0.6% (T5) registered the lowest value. In females, the values of ALT were higher in chickens receiving 0.2% *P. ginseng* and lowest in (T5) chickens receiving 0.6% *P. ginseng*.
The increase in concentration of ALT in the male chicken receiving oxytetracycline and the female chicken receiving 0.2% ginseng can be attributed to the obstruction of the bile flow. Increased ALT suggests that some abnormality was induced in the liver that might have led to higher levels of ALT in the serum.

The results obtained from AST for male chickens were higher in (T4) chickens receiving 0.4% *P. ginseng* and lower in (T3) chickens receiving 0.2% *P. ginseng*. Whereas for female chickens the higher values occur in chickens receiving 0.4% ginseng while the negative control group registered the lowest value. These results were in line with those of Amafule *et al*. (2006) who reported that liver enzyme activities are sensitive to toxic substances in the feed. The ALT and AST activity were collectively used to assess the homeostatic response of the liver to metabolites that pass through the portal blood and as indicators of liver damage.

The optimal response from ALT and AST, response suggested that broilers could tolerate up to 0.6% DM of Panax ginseng root meal beyond which liver function gets compromised. The response of ALT and AST of broilers fed on ginseng root meal-based diet indicates acceptable physiological status and diet. Elevation of serum ALT and AST can occur as a result of exposure to toxins leading to toxaemia, inflammation, and alteration in the permeability of the hepatocellular membrane.

Conclusion

The best growth performance on separate male and female occurred in T5, which received 0.6% WGR meal, and the least growth performance was seen in the control group T1. But when both male and female growth rates were combined, the best growth performance was seen in T2, which received Oxytetracycline, and the least growth performance occurred in T1, the control group. The growth performance is affected by the inclusion of *P. ginseng* in the diet. Thus, the feed intake, water intake, lower feed conversion ratio, and weight gain were significantly higher in animals receiving 0.4% and 0.6% inclusion of *P. ginseng* than in other groups. The fatty acid profiles are also affected by the inclusion of *P. ginseng* in the diet. Serum biochemical characteristics are influenced by inclusion of *P. ginseng*. The results show that values of ALT and AST were lower at 0.4% and 0.6% inclusion of Panax ginseng in the diet, respectively.

The research demonstrates that dietary supplementation with white ginseng (Panax ginseng) root meal at levels 0.6% and 0.4% effectively enhances the growth performance and feed efficiency of broiler chickens. Furthermore, it significantly improves the serum lipid profile by reducing harmful cholesterol and triglycerides while elevating beneficial HDL cholesterol, and enhances protein metabolism without evidence of hepatic toxicity. The findings suggest that white ginseng root meal is a potent phytogenic feed additive for producing healthier broiler chickens and could serve as a viable natural alternative to antibiotic growth promoters. Its implementation in poultry production systems could contribute to more sustainable and safe practices while potentially improving economic returns for farmers.
Based on the above conclusion, the following recommendations were forwarded:

- Panax ginseng root meal can be added to the diet of broilers up to 0.6% inclusion levels
- Since ginseng root powder is rich in non-fiber protein and total digestible nutrients and low in lipid, it can thus be used as a feed additive for broiler production since it is also readily available and cheap.

- A study could also be carried out on the effect of the length of storage on the chemical composition of Panax ginseng root meal.

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