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Impact of dietary taurine supplementation on broiler birds' lipid metabolism, tissue enzyme activities, and antioxidant status

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ABSTRACT

Taurine, a sulphur-containing semi-essential amino acid, has recently gained interest for its potential health benefits in poultry. This study investigated the effects of dietary taurine supplementation on lipid metabolism, tissue enzyme activities, and antioxidant status in broiler chickens. A total of 175 one-day-old-unsexed broiler chicks were randomly assigned to five treatment groups (5 replicates per treatment, 7 birds per pen) and fed diets supplemented with 0.00%, 0.01%, 0.02%, 0.03%, and 0.04% taurine for 49 days. Lipid profiles (total cholesterol, triacylglycerol, HDL, LDL), liver and kidney function markers (ALT, AST, ALP), and antioxidant enzyme activities (SOD, CAT) were evaluated. Birds fed 0.01% taurine showed reduced total cholesterol and increased HDL; 0.03% taurine increased HDL and reduced triacylglycerol ($p < 0.05$). In contrast, 0.02% taurine increased both the serum total cholesterol and LDL concentrations ($p < 0.05$). Liver enzyme responses varied among treatments: 0.03% taurine increased ALT activity, 0.01% taurine elevated AST activity, and 0.04% taurine increased ALP activity ($p < 0.05$). Serum SOD activity was significantly reduced at 0.02% and 0.03% taurine compared with the control ($p < 0.05$), whereas liver SOD activity increased across multiple supplemented groups. Serum CAT activity decreased at 0.02% and 0.04% taurine ($p < 0.05$), while kidney CAT activity increased, and liver CAT activity was higher in birds fed 0.02% to 0.04% taurine ($p < 0.05$). Conclusively, dietary taurine supplementation modulated lipid profiles, liver and kidney enzyme activities, and antioxidant status, with optimal effects observed at 0.01% for lipid parameters and 0.02–0.04% for antioxidant enhancement.

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Introduction

Taurine is a sulfur-containing semi-essential amino acid vital to a wide variety of physiological functions. It acts as an osmoregulator, neuromodulator, and antioxidant (1). The Nigerian poultry industry, one of the largest in sub-Saharan Africa, faces persistent challenges related to oxidative stress, metabolic disorders, and high production costs, making the investigation of cost-effective nutritional supplements such as taurine particularly relevant (1). Recent research suggests that dietary taurine supplementation may benefit poultry health. Studies have shown taurine to improve growth performance in animal models such as rats (2) as well

as enhance the immune response in broiler chickens (3). However, the impact of taurine on broiler chickens' lipid metabolism, tissue enzyme activities, and antioxidant status remains less explored.

A large amount of HDL is synthesised in the liver (with a smaller amount in the intestine), whereas VLDL is converted into LDL by the hydrolysis of lipase at target sites. The major circulatory complex for cholesterol appears to be LDL (4). Understanding these metabolic pathways is critical to interpreting how dietary taurine supplementation may alter lipid homeostasis in broiler chickens.

ALT, AST, and ALP are liver enzymes commonly used to assess liver and kidney function and to detect the onset

of diseases such as chronic kidney disease, hepatic disease, bone disease, bile duct obstruction, or gallbladder disease (5).

Superoxide dismutase (SOD) is a cytosolic enzyme and can be classified into types based on the metal ion it uses (6). Nearly every living organism exposed to oxygen produces catalase (CAT). CAT decomposes hydrogen peroxide into water and oxygen, thereby protecting the cell from oxidative damage induced by reactive oxygen species (ROS) (7).

Taurine has a protective effect against oxidation and shields tissues from toxic oxidant components. Taurine reduces ROS levels by boosting antioxidant enzyme levels, thereby protecting macrophages and adjacent tissues from the harmful effects of ROS. It also enhances cellular antioxidant capacity and mitigates oxidative stress (8).

The 49-day experimental period was selected to cover both the starter (days 1–21) and finisher (days 22–49) phases of broiler production, thereby capturing the full metabolic trajectory of taurine supplementation across the production cycle, which extends beyond the conventional 35–42-day cycle to allow complete biochemical assessment. This study investigated the effects of dietary taurine supplementation on some key aspects of broiler health. It was hypothesised that taurine supplementation would improve lipid profiles, modulate tissue enzyme activities, and enhance antioxidant enzyme activity in broiler chickens.

Materials and methods

Ethical approval

Approval was granted by the Ethical Review Board of Fountain University, Osogbo (FUCRIT), under reference number FUCRIT/BCH/2023/002.

Source of birds and taurine

175 unsexed one-day-old broiler chicks were purchased from Zartech hatchery in Ibadan, and Taurine was sourced from AliExpress.

Diets

The diets formulated and supplemented with taurine are shown in Tables 1 and 2 for the starter and finisher phases, respectively. Diet formulation is in accordance with the AOAC standard (9).

Experimental design and birds management

A total of 175 one-day-old unsexed broiler chicks were used and were randomly assigned to five dietary treatments, including a control diet (0.00% Taurine)

consisting of a basal formulation designed to meet the nutritional needs of broilers. The other four dietary treatments were supplemented with taurine at 0.01%, 0.02%, 0.03%, and 0.04%, each added to the basal diet. In all, each treatment group consisted of 5 replicate pens with 7 birds per pen.

Birds were housed in well-ventilated pens under standard conditions: temperature was maintained at 32–33°C during the first week and reduced by approximately 3°C per week to reach 22–24°C; lighting was provided for 23 hours per day. All birds were given free access to feed and water throughout the 49-day experimental period.

Sample collection and analysis

At the conclusion of the experiment, the birds were weighed and sacrificed. Blood samples were collected and centrifuged to obtain the serum, while liver and kidney tissues were harvested, cleaned, weighed and homogenised for further analysis. Serum lipid profiles were equally assessed using standard enzymatic methods according to Rifai *et al.* (10), Allain *et al.* (11), Friedewald *et al.* (12), and Foster and Dunn (13). Tissue enzyme activities (ALT, AST, ALP) and antioxidant enzyme activities (SOD, CAT) were assessed using spectrophotometric assays following established protocols described by Reitman and Frankel (14), Bessey *et al.* (15), Misra and Fridovich (16), and Beers and Sizer (17).

Assay techniques

Total cholesterol concentrations (serum and liver homogenates) were measured using the method described by Rifai *et al.* (10). Serum and liver homogenate HDL concentrations were measured using the spectrophotometric precipitation method outlined by Allain *et al.* (11). The method described by Friedewald *et al.* (12) was employed to determine LDL concentration in serum and liver homogenates. Triglyceride concentrations in serum and liver homogenates were determined using the method outlined by Foster and Dunn (13). The activities of Alanine Aminotransferase (ALT) and Aspartate Aminotransferase (AST) were assayed using the method described by Reitman and Frankel (14). The Alkaline Phosphatase Activity (ALP) was conducted using the method described by Bessey *et al.* (15). The activity of superoxide dismutase in the serum, liver, and kidney was measured using the method outlined by Misra and Fridovich (16), while catalase activity in the serum, liver, and kidney was assessed using the method described by Beers and Sizer (17).

Statistical analysis

All data analyses were performed using GraphPad Prism 5.0. One-way analysis of variance (ANOVA) was used to compare the means of the data among the treatment groups. The threshold for significance was set at $P < 0.05$. Means were separated using the Tukey post hoc test.

Results

Feed composition

Tables 1 and 2 contain the gross composition of experimental diets, both at starter and finisher phases, in accordance with AOAC (9). The diets were formulated to meet the birds' nutritional needs at different phases. Taurine, the main research sample, was incorporated as an add-on to the standard diets.

Serum and liver lipid profiles

Table 3 shows the serum cholesterol, triacylglycerol, HDL, and LDL levels in broiler birds in the control group and in those fed diets containing varying concentrations of taurine. Birds that received the 0.01% taurine diet had decreased ($P < 0.05$) total cholesterol concentration, increased ($P < 0.05$) HDL concentration, and no significant difference ($P > 0.05$) in triacylglycerol and LDL concentration compared with the control group. Notably, birds that received 0.02% taurine exhibited increased total cholesterol and LDL concentrations ($P < 0.05$), indicating an adverse lipid effect at this dose level. A decreased ($P < 0.05$) triacylglycerol concentration was also observed at 0.02%, with no significant difference ($P > 0.05$) in HDL concentration compared with the control group. Birds that received the 0.03% taurine diet had increased ($P < 0.05$) HDL concentration, decreased ($P < 0.05$) triacylglycerol concentration, and no significant difference ($P > 0.05$) in total cholesterol and LDL concentration compared with the control group. Birds receiving 0.04% taurine had decreased ($P < 0.05$) triacylglycerol concentration and no significant difference ($P > 0.05$) in total cholesterol, HDL, and LDL concentration compared with the control group.

Table 3 also shows the liver lipid profile of broiler birds. Birds that received 0.01% taurine had decreased ($P < 0.05$) total cholesterol, triacylglycerol, HDL, and LDL concentrations compared with the control group. Birds receiving 0.02% taurine had decreased total cholesterol and triacylglycerol concentrations ($P < 0.05$), with no significant difference in HDL and LDL concentrations ($P > 0.05$). Birds on 0.03% taurine showed no significant difference ($P > 0.05$) in any liver lipid parameter. Birds on 0.04% taurine had

decreased ($P < 0.05$) HDL concentration and no significant difference ($P > 0.05$) in total cholesterol, triacylglycerol, and LDL concentration.

Tissue enzyme activities

The alanine transaminase (ALT) activities (IU/L) of broiler birds fed diets supplemented with varying concentrations of taurine are presented in Table 4. Serum ALT levels in birds on the 0.01% and 0.02% taurine-supplemented diets were statistically higher ($p < 0.05$) compared to controls. Serum ALT at 0.03% taurine was also higher ($p < 0.05$), while birds on 0.04% taurine did not differ significantly ($p > 0.05$) from controls. Significant elevation ($p < 0.05$) in liver ALT activities was observed in birds on 0.01% to 0.04% taurine compared with the control group. Kidney ALT activities showed no significant differences ($p > 0.05$) in birds on the 0.02% and 0.04% taurine diets, while birds on the 0.01% and 0.03% taurine diets exhibited a significant increase ($p < 0.05$).

The aspartate aminotransferase (AST) activities (IU/L) are shown in Table 4. Serum AST levels were presented in the sequence: serum \rightarrow liver \rightarrow kidney for clarity. Serum AST in birds on 0.01%, 0.02%, and 0.04% taurine diets was significantly higher ($p < 0.05$) compared to the control, while no significant difference was noted at 0.03% taurine. Liver AST was significantly increased at 0.01%, 0.02%, and 0.04% taurine ($p < 0.05$), while birds on 0.03% taurine did not differ from controls ($p > 0.05$). Kidney AST showed no significant differences ($p > 0.05$) at 0.02% and 0.04% taurine, while birds on 0.01% and 0.03% taurine exhibited significantly higher values ($p < 0.05$).

The alkaline phosphatase (ALP) activities (IU/L) are shown in Table 4. Serum ALP at 0.01% and 0.02% taurine was not significantly different ($p > 0.05$) from control, while birds on 0.03% and 0.04% exhibited significant increases ($p < 0.05$). Liver ALP showed no significant differences at 0.01%, 0.02%, and 0.03% taurine, but a significant increase was noted at 0.04% taurine. Kidney ALP showed no significant differences at 0.02%, 0.03%, and 0.04% taurine, but a significant increase ($p < 0.05$) was observed at 0.01% taurine.

Antioxidant enzyme activities

The activities of superoxide dismutase (SOD) (mmol/min/mg protein) in broiler birds are presented in Table 5. Serum SOD activities were significantly lower ($p < 0.05$) in birds on the 0.02% and 0.03% taurine diets compared to control, while birds on 0.01% and 0.04% taurine did not differ significantly ($p > 0.05$) from control. Liver SOD activities in birds on the 0.01%,

Table 1: Gross composition (kg/100 g DM) of experimental diets (starter phase)

Ingredient (%)	TAURINE SUPPLEMENT				
	Diet 1 (0.00%)	Diet 2 (0.01%)	Diet 3 (0.02%)	Diet 4 (0.03%)	Diet 5 (0.04%)
Maize	51.38	51.38	51.38	51.38	51.38
Oil	0.4	0.4	0.4	0.4	0.4
SBO	21.29	21.29	21.29	21.29	21.29
W/O	11	11	11	11	11
GNC	13	13	13	13	13
Lime Stone	1.55	1.55	1.55	1.55	1.55
DCP	0.41	0.41	0.41	0.41	0.41
Common Salt	0.35	0.35	0.35	0.35	0.35
Methionine	0.17	0.17	0.17	0.17	0.17
Lysine	0.2	0.2	0.2	0.2	0.2
Premix	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100

Table 2: Gross composition (kg/100 g DM) of experimental diets (finisher phase)

Ingredient (%)	TAURINE SUPPLEMENT				
	Diet 1 (0.00%)	Diet 2 (0.01%)	Diet 3 (0.02%)	Diet 4 (0.03%)	Diet 5 (0.04%)
Maize	56.0	56.0	56.0	56.0	56.0
Oil	2.0	2.0	2.0	2.0	2.0
Soybeans meal	18	18	18	18	18
W/O	9	9	9	9	9
Groundnut	11.22	11.22	11.22	11.22	11.22
Lime Stone	2	2	2	2	2
Dicalcium phosphate	0.4	0.4	0.4	0.4	0.4
Common Salt	0.37	0.37	0.37	0.37	0.37
Methionine	0.62	0.62	0.62	0.62	0.62
Lysine	0.14	0.14	0.14	0.14	0.14
Total	100	100	100	100	100

Table 3: Effect of varying taurine concentrations on the serum and liver lipid biochemical index of broilers birds

Taurine concentration in %	SERUM				LIVER			
	Total cholesterol in mmol/L	Triacylglycerol in mmol/L	HDL in mmol/L	LDL in mmol/L	Total cholesterol in mmol/L	Triacylglycerol in mmol/L	HDL in mmol/L	LDL in mmol/L
0	27.89±0.58 ^b	4.47±0.48 ^b	14.83±0.28 ^a	12.66±0.42 ^a	47.75±1.25 ^c	23.59±0.41 ^c	45.72±0.1 ^b	12.85±0.45 ^a
0.01%	23.99±0.84 ^a	4.30±0.32 ^b	16.22±0.40 ^b	12.27±0.23 ^a	37.24±0.96 ^a	14.31±0.80 ^a	43.21±0.0 ^a	11.86±0.23 ^b
0.02%	29.57±0.61 ^c	3.52±0.17 ^a	15.02±0.36 ^a	13.16±0.26 ^b	42.98±2.14 ^b	16.56±0.94 ^b	46.23±0.1 ^b	12.08±0.99 ^a
0.03%	26.86±0.44 ^b	3.71±0.35 ^a	15.97±0.29 ^b	12.81±0.12 ^a	46.31±1.19 ^c	22.00±0.47 ^c	45.78±0.1 ^b	12.72±0.25 ^a
0.04%	26.67±0.43 ^b	3.89±0.22 ^a	14.11±0.29 ^a	11.86±0.16 ^a	46.11±0.66 ^c	21.72±0.68 ^c	44.65±0.1 ^a	12.74±0.53 ^a

Values are means ± SEM (n=5 replicates per treatment). Means in the same column with different superscripts (a, b, c) are significantly different (P<0.05). Means with the same superscript or no superscript are not significantly different (P>0.05).

Table 4: Alanine transaminase (IU/L), Aspartate aminotransferase (IU/L), and Alkaline phosphatase (IU/L) activities of broiler birds fed varying concentrations of taurine supplementation.

Taurine Supplementat ion (%)	ALT			AST			ALP		
	Serum	Liver	Kidney	Serum	Liver	Kidney	Serum	Liver	Kidney
0.00	3.68±0.11 ^a	8.67±0.30 ^a	9.76±0.32 ^a	9.97±0.19 ^b	8.07±0.41 ^a	8.60±0.23 ^a	81.35±0.36 ^b	71.16±0.14 ^b	76.02±0.67 ^b
0.01	2.85±0.23 ^c	9.64±0.19 ^b	10.74±0.42 ^b	12.46±0.33 ^d	9.04±0.38 ^b	9.72±0.29 ^b	80.37±1.20 ^b	71.34±0.67 ^b	64.45±0.66 ^a
0.02	3.34±0.27 ^b	10.00±0.36 ^b	9.75±0.27 ^a	10.88±0.47 ^c	8.80±0.29 ^{ab}	8.83±0.36 ^a	84.06±0.76 ^b	68.39±0.49 ^b	74.48±1.27 ^b
0.03	3.87±0.78 ^c	10.43±0.34 ^b	10.69±0.51 ^b	10.41±0.47 ^b	8.43±0.51 ^a	9.54±0.38 ^b	72.90±0.13 ^a	70.12±0.23 ^b	75.15±0.28 ^b
0.04	2.92±0.10 ^a	9.52±0.21 ^b	9.27±0.61 ^a	8.95±0.19 ^a	8.91±0.26 ^{ab}	8.92±0.36 ^a	74.78±0.62 ^a	63.54±0.49 ^a	73.07±0.94 ^b

Values are means ± SEM (n=5 replicates per treatment). Means in the same column with different superscripts (a, b, c, d) are significantly different (P<0.05). Means with the same superscript are not significantly different (P>0.05).

Table 5: Superoxide dismutase (mmol/min/mg protein) and Catalase (mmol/min/mg protein) activities of broiler birds fed with varying concentrations of taurine-supplemented diets

Taurine Supplementation (%)	SOD			CAT		
	Serum	Liver	Kidney	Serum	Liver	Kidney
0.00%	31.56±1.09 ^a	54.04±0.50 ^a	74.42±0.78 ^b	3.83±0.08 ^b	2.75±0.24 ^a	4.15±0.13 ^a
0.01%	31.25±0.33 ^a	73.83±0.75 ^c	74.50±0.38 ^b	3.85±0.06 ^b	2.93±0.17 ^a	4.11±0.11 ^a
0.02%	24.36±0.75 ^b	76.52±0.48 ^c	70.05±0.54 ^a	3.45±0.09 ^a	3.84±0.17 ^c	4.53±0.06 ^b
0.03%	5.96±0.34 ^b	70.33±0.86 ^b	72.82±0.64 ^a	3.75±0.11 ^b	3.17±0.14 ^c	4.29±0.08 ^a
0.04%	30.34±0.33 ^a	75.51±0.45 ^c	72.06±0.41 ^a	3.21±0.07 ^a	3.48±0.08 ^b	4.43±0.08 ^b

Values are means ± SEM (n=5 replicates per treatment). Means in the same column with different superscripts (a, b, c) are significantly different (P<0.05). Means with the same superscript are not significantly different (P>0.05).

0.02% and 0.04% taurine diets were significantly higher than those of the control. No significant differences (p>0.05) were found in kidney SOD activities among birds on the 0.02%, 0.03%, and 0.04% taurine diets, whereas birds on 0.00% and 0.01% taurine exhibited significantly higher (p<0.05) kidney SOD activity. The activities of catalase (CAT) (mmol/min/mg protein) are also shown in Table 5. No significant differences (p>0.05) in serum CAT activities were observed among birds on 0.01% and 0.03% taurine compared to the control. However, birds on the 0.02% and 0.04% taurine diets exhibited significantly lower (p<0.05) serum CAT levels. Liver CAT activities in birds on 0.02% to 0.04% taurine were significantly higher (p<0.05) than control, while no significant difference (p>0.05) was found at 0.01% taurine. Kidney CAT activities were not significantly different (p>0.05) at 0.01% and 0.03% taurine, while birds on 0.02% and 0.04% taurine had significantly higher (p<0.05) kidney enzyme activities compared to the control.

Discussion

Taurine, a non-protein, semi-essential amino acid abundantly found in animal tissues, has been recognised for its diverse physiological roles beyond its traditional osmoregulatory functions. Recent studies have shown promising effects of taurine on lipid metabolism and antioxidant defences in various animal models, including broiler chickens. Poultry production faces challenges related to efficient lipid utilisation and oxidative stress management, making taurine supplementation a compelling area of research. Total cholesterol analysis measures the total cholesterol in the blood, including both HDL and LDL. HDL (High-Density Lipoprotein) is known as "good cholesterol" because it helps remove LDL cholesterol from the arteries. Conversely, LDL (Low-Density Lipoprotein), often referred to as "bad cholesterol," can accumulate in the arteries and

contribute to heart disease. Triglycerides, another type of fat present in the blood, can also heighten the risk of heart disease when levels are elevated. ALT (Alanine Aminotransferase) is an enzyme primarily located in the liver; elevated levels may indicate liver damage or disease. Similarly, AST (Aspartate Aminotransferase) is an enzyme found in the liver and other organs, and elevated levels can also suggest liver damage or disease. ALP (Alkaline Phosphatase) is another enzyme present in the liver, bones, and intestines, and elevated levels may indicate liver or bone disease(18,19). SOD (superoxide dismutase) and catalase are two essential antioxidant enzymes that collaborate to defend cells against oxidative damage caused by reactive oxygen species (ROS). SOD catalyses the conversion of superoxide radicals into hydrogen peroxide, and catalase then decomposes the hydrogen peroxide into water and oxygen. This stepwise process efficiently neutralises ROS, helping to protect cells from oxidative stress and prevent cellular damage(20,21).

Research on taurine has demonstrated its involvement in lipid metabolism by influencing lipid absorption, transport, and utilisation in different animal species. Taurine has been reported to reduce serum cholesterol levels and improve lipid profiles in rodents and humans(2). In poultry, studies have shown that taurine supplementation can modify lipid metabolic pathways, potentially reducing adiposity and improving meat quality (21). Moreover, taurine acts as a robust antioxidant by neutralising reactive oxygen species (ROS) and boosting the activity of enzymatic antioxidants such as superoxide dismutase (SOD) and catalase (CAT) (22). Also, the study by Ogunbode *et al.* (23) reported that taurine supplementation had no adverse effects on LDH activities, growth performance, immunity, and organ histology (specifically the liver and kidney).

As shown in Table 3, in the serum, the observed decrease in total cholesterol at 0.01% taurine

concentration is in line with the result of Chen *et al.* (24), who reported a decrease in serum cholesterol levels of alcohol-fed rats supplemented with 1g/kg of taurine as compared with those of the control group. However, the increased serum cholesterol and LDL at 0.02% taurine are noteworthy and contrast with Zeng *et al.* (25) who reported that dietary taurine supplementation at 0.05–0.20% decreased total cholesterol in both the serum and liver of broiler birds. This dose-specific adverse lipid effect at 0.02% taurine suggests a non-linear dose–response relationship that warrants further mechanistic investigation. Intermediate doses may transiently upregulate hepatic cholesterol synthesis pathways before higher concentrations activate compensatory bile salt conjugation. Decreases in liver total cholesterol concentrations at 0.01 and 0.02% are in accordance with the established knowledge that formation of bile salts represents the major pathway for cholesterol degradation in the liver, and the rate-limiting enzyme 7 α -Hydroxylase activity is dependent on the presence of taurine for conjugation (4). The observed increased concentration of serum HDL at taurine concentration rates of between 0.01 to 0.03% is in accordance with the report of Han *et al.* (3), which reported an elevated HDL concentration in the serum of broiler birds when their diets were supplemented with taurine at a rate of 2.50, 5.00, and 7.50 g per kg of the diet.

In table 4, the observed increase in liver ALT activity ($p < 0.05$) at 0.01% to 0.04% taurine supplementation, as well as the increased kidney ALT activity ($p < 0.05$) at 0.01% and 0.03%, aligns with the findings of Liu *et al.* (2). Taurine's role in reducing reactive oxygen species (ROS) production, preventing mitochondrial swelling, and mitigating loss of mitochondrial membrane potential, as described by Liu *et al.* (2), provides a mechanistic basis for the observed modulation of liver and kidney enzyme activities. It should be noted, however, that the observed enzyme elevations were within normal physiological ranges for broiler chickens as documented in the literature (reference values: serum ALT 1–10 IU/L; AST 7–17 IU/L; ALP 70–120 IU/L; as benchmarked in Han *et al.* (3). Rather than indicating hepatocellular damage, these increases likely reflect taurine's upregulation of hepatic gene expression involved in cholesterol and lipid metabolism (26). The increased liver AST at 0.01%, 0.02%, and 0.04% taurine, and kidney AST at 0.01% and 0.03%, are consistent with Liu *et al.* (28), who reported that

taurine pretreatment reduces the AST surge in the lipopolysaccharide-challenged liver. Birds on 0.03% and 0.04% with lower serum ALP were consistent with Ogunbode *et al.* (27), who reported that dietary taurine may reduce the burden of osteoporosis.

Table 5 showed SOD and CAT activities, and the elevated SOD activities observed in birds supplemented with 0.01%, 0.02%, 0.03%, and 0.04% taurine may be associated with Shivananjappa and Muralidhara's findings (28), which reported increased antioxidant enzyme activities (SOD and catalase) following oral taurine supplementation in pregnant diabetes mellitus-induced rats. Similarly, Anand *et al.* (29) observed enhanced antioxidant enzyme activities (catalase and glutathione peroxidase) in rats administered taurine at a dose of 100 mg/kg body weight. The beneficial impact of taurine on antioxidant enzyme activity in rats was further reinforced by various studies, including those by Wang *et al.* (30), Maleki *et al.* (31), and Liu *et al.* (2). Maleki *et al.* (31) specifically reported a significant increase in SOD and catalase activities, along with a marked reduction in reactive oxygen species (ROS) production in diabetic rats treated with taurine. This dichotomy suggests compartment-specific antioxidant regulation and should not be interpreted as a uniformly beneficial antioxidant effect. One plausible mechanistic explanation involves taurine's activation of the Nrf2/ARE signalling pathway, which has been shown to upregulate antioxidant enzyme expression in hepatic tissue, with differential effects in peripheral blood compartments (3, 30).

Taurine supplementation significantly affected the lipid profile of birds. Incorporating 0.01% taurine into the diet reduced total cholesterol and increased HDL levels, suggesting a potential positive effect on cardiovascular health. This finding is consistent with research by Zeng *et al.* (25), which demonstrated that taurine supplementation improved lipid profiles by reducing total cholesterol and increasing HDL cholesterol in broilers. However, higher concentrations of taurine (0.02% and 0.04%) did not consistently improve lipid profiles, suggesting that the optimal dosage for lipid-lowering effects may be species-specific and influenced by individual factors.

Taurine supplementation also influenced liver and kidney function. Elevations in liver enzymes (ALT and AST) were observed in birds fed taurine-supplemented diets, suggesting a potential stimulatory effect on liver function. However, the observed increases were within normal physiological

ranges and did not indicate liver damage. In most cases, these increases in enzyme activity do not signal liver damage but rather enhanced liver metabolism, such as taurine's role in upregulating hepatic gene expression involved in cholesterol and lipid metabolism Surai *et al.*, (22). Similarly, taurine influences alkaline phosphatase (ALP) levels, which are also tied to liver and kidney function. Surai *et al.* (22) reported taurine's protective effects on kidney tissues, particularly by reducing oxidative damage and inflammation. In this study, taurine supplementation increased the activities of SOD and catalase in the livers and kidneys of birds, suggesting that taurine may enhance the body's antioxidant defence mechanisms and protect against oxidative stress-related diseases. These findings align with those of Park *et al.* (32), who reported that taurine supplementation improves antioxidant status and reduces oxidative stress in broiler chickens under heat stress. Additionally, they are consistent with the results of Xiao *et al.* (33), which showed that taurine alleviates oxidative stress and inflammation by modulating antioxidant and inflammatory markers in animal models.

Data analysis revealed significant differences in lipid metabolism parameters among the treatment groups. Broilers supplemented with taurine had lower serum triglyceride and cholesterol levels than the control group, indicating improved lipid profiles. These findings are consistent with Sun *et al.* (34), who reported that taurine supplementation enhances lipid metabolism and decreases serum triglyceride and cholesterol levels in broiler chickens. Similarly, San *et al.* (35) found that taurine regulates lipid metabolism and reduces hepatic steatosis in broiler chickens.

The results of this study support the hypothesis that dietary taurine supplementation benefits lipid metabolism, tissue enzyme activities, and antioxidant status in broilers. The observed reductions in serum lipid levels and enhancements in enzyme activities suggest improved lipid utilisation and digestion efficiency in taurine-treated broiler chickens. Moreover, the increased antioxidant enzyme activities indicate a strengthened antioxidant defence system, potentially reducing oxidative damage in broiler tissues. However, the adverse lipid effects at 0.02% taurine and the reduction in serum SOD at 0.02% and 0.03% taurine indicate that the relationship between taurine dosage and health outcomes is not uniformly positive. These findings are corroborated by Han *et al.* (3) and Łukasiewicz-Mierzejewska *et al.* (36). Ogunbode *et al.* (37) studied taurine at concentrations

of 0.002–0.008%, which are ten-fold lower than the range used in the present study; direct comparisons between these studies should therefore account for this substantial difference in dose range.

Conclusion

Dietary taurine supplementation in broiler chickens exerts dose-specific effects on lipid metabolism, tissue enzyme activities, and antioxidant status. Based on the present results, 0.01% taurine appears optimal for improving serum lipid profiles (reduced total cholesterol and increased HDL), while 0.02–0.04% taurine is associated with enhanced antioxidant enzyme activities in the liver and kidneys. The adverse lipid effects observed at 0.02% taurine highlight the importance of careful dose optimisation. Further studies are needed to determine the optimal taurine inclusion levels and assess their long-term impact on poultry health and production outcomes. Limitations of this study include the lack of sex separation of birds, the extended production cycle beyond the standard 35–42 days, and the lack of direct meat-quality analyses. These should be addressed in future investigations.

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Conflict of interests

The researchers declare none.

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