HAEMATOLOGY, BIOCHEMICAL RESPONSES, AND LIPID PROFILES IN DOES SUPPLEMENTED WITH TURMERIC RHIZOME (*CURCUMA LONGA*)

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Abstract

The use of natural feed additives in rabbit diets has gained prominence, particularly those that can enhance growth performance, immunity, and health, while mitigating environmental risks. This study was undertaken to examine the haematological characteristics, serum biochemical indices, and lipid profiles of rabbit does following dietary supplementation with turmeric (*Curcuma longa*) rhizome meal. A total of twenty-four rabbit does were randomly distributed into four treatment groups comprising six animals each, with each group further divided into three replicates of two does per unit. The animals were raised under intensive management in wired hutches, with all necessary welfare protocols observed. Four experimental diets were prepared to include turmeric rhizome meal at 0.0%, 1.0%, 2.0%, and 3.0% inclusion levels. At the end of a 16-week feeding period, 3 mL of blood was collected from a randomly selected doe per replicate into EDTA-treated tubes for haematological analysis. Additional samples were collected for serum biochemical assays. Data were analyzed using analysis of variance (ANOVA) under a completely randomized design (CRD) with SPSS version 21. The results indicated that turmeric supplementation significantly ($p<0.05$) affected packed cell volume (PCV), red blood cell (RBC) count, white blood cell (WBC) count, haemoglobin concentration (Hb), mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC). PCV was highest in groups T3 and T1, with values of 39.33% and 38.00%, respectively. Significant ($p<0.05$) effects were also observed on serum urea, enzymes, and creatinine levels. Total protein values ranged from 64.50 to 71.50 g/dL. These findings suggest that incorporating turmeric at a 2.0% dietary level enhances haematological and biochemical profiles, thereby promoting improved health status in rabbit does with positive health benefits on human health.
Keywords: haematology, biochemical responses lipid profile, turmeric, does, *Curcuma longa*, rhizome

Introduction

Commercial rabbit farming has experienced a resurgence owing to the species' high reproductive rate, rapid growth, and lean meat yield (Savietto et al. 2015, Mínguez 2014, Ricke et al. 2012). Rabbits require relatively inexpensive feed inputs and housing, and they exhibit lower competition with humans for cereal grains compared to poultry and pigs (Petrescu et al. 2013). Their meat is nutritionally rich, containing approximately 22% protein, and is low in fat (4%) and cholesterol (5%), rendering it a healthy dietary option (Nistor et al. 2013). Nistor et al. (2013) also reported that rabbit meat has superior calcium (21.4 mg/100 g) and phosphorus

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(347 mg/100 g) content, with relatively reduced levels of fat (9.2 g/100 g) and cholesterol (56.4 mg/100 g) when compared to other meat sources.
The use of natural feed additives in rabbit diets has gained prominence, particularly those that can enhance growth performance, immunity, and health, while mitigating environmental risks (Foldesiova et al. 2015). Turmeric (*Curcuma longa*) has emerged as a promising phytogenic feed additive, renowned for its anti-inflammatory, antioxidant, and antimicrobial properties, attributed largely to curcuminoids and essential oils (Nelson et al. 2017). Turmeric rhizome consists of 60–70% carbohydrates, 6–13% moisture, 6–8% protein, 5–10% fat, and 3–7% each of dietary minerals, essential oils, and fiber (Nelson et al. 2017). It is rich in turmerone, germacrone, atlantone, zingiberene, and micronutrients such as riboflavin, niacin, thiamine, calcium, potassium, phosphorus, and iron (Hong et al. 2014, Hu et al. 2014, Nwankwo 2014).
Haematological assessment serves as a reliable tool for evaluating the physiological and health status of livestock. It plays an integral role in diagnosing anaemia, infection, and immune responses, and in monitoring the influence of dietary supplements (Maxwell 2013, Rasko 2013, Etim et al. 2014). Parameters such as RBC, WBC, Hb, and PCV are pivotal indicators of health and can reflect genetic resilience to environmental stressors and disease (Isaac et al. 2013).Therefore, this study was designed to investigate the effects of dietary inclusion of turmeric rhizome meal on the haematological indices, serum biochemistry, and lipid profile of rabbit does, with a view to assessing its potential as a functional feed additive for enhancing animal health and productivity.

Materials and Methods

Study Site/ Location

The research was conducted at the Rabbitry Unit of the Teaching and Research Farm, Department of Animal Science, University of Uyo, Akwa Ibom State, Nigeria. The study area is situated at a latitude of 5.0377°N and a longitude of 7.9128°E, with an elevation above sea level. The region experiences an average annual rainfall of approximately 2500 mm and a mean annual temperature ranging from 27 °C to 28 °C (World Weather Online, 2021).

Procurement and Processing of Turmeric Powder Meal

Fresh turmeric rhizomes (*Curcuma longa*) were procured from the Akpan Andem Market, Uyo Local Government Area. The rhizomes were thoroughly washed, sliced into manageable portions, and subsequently sun-dried until fully dried. The dried rhizomes were then milled into fine powder using an electric grinding machine. The turmeric powder was stored in airtight, dry containers to preserve quality and prevent contamination or fungal infestation prior to incorporation into the experimental diets.

Experimental Diets

Four dietary treatments were formulated to meet the nutritional requirements of rabbit does as recommended by the National Research Council (NRC, 1994). These diets were supplemented with turmeric powder at inclusion rates of 0.0%, 1.0%, 2.0%, and 3.0%, and designated as T1, T2, T3, and T4 respectively.

Experimental Design and Protocol

A total of twenty-four (24) mongrel rabbit does were used for the study, structured in a Completely Randomized Design (CRD). The does were randomly allotted into four treatment groups, each containing six animals, further subdivided into three replicates of two does per replicate. The animals were housed in individual wire-mesh cages and provided with consistent care under intensive management conditions.

Table 1. Composition of Experimental Diets to be fed to Experimental Animals

Ingredients (%)	T_1 (0.0%TPM)	T_2 (1.0% TPM)	T_3 (2.0% TPM)	T_4 (3.0% TPM)
Maize	35.00	35.00	35.00	35.00
Soybean	15.00	15.00	15.00	15.00
Wheat offal	46.00	46.00	46.00	46.00
Bone meal	3.00	3.00	3.00	3.00
Common salt	0.25	0.25	0.25	0.25
Premix*	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Nutrient Content (%)				
Metabolized Energy (Kcal/Kg)	2824.10	2833.9	2866.9	2899.8
Crude Protein (%)	17.72	17.72	17.73	17.73
Crude Fibre (%)	5.59	5.53	5.55	5.58
Ether Extract (%)	3.61	4.23	4.88	5.53

*To provide the following per kilogram of diet: Vitamin premix = Vitamin A (12,000,000 IU); Vitamin D_3 (2,500,000IU); Vitamin E (30,000 IU); Vitamin K (2,500mg); Vitamin B1 (2,250mg); Vitamin B2 (6,000mg); Vitamin B6 (4,500mg); Vitamin B12 (15mg); Niacin (40,000mg) ; Pantothenic Acid (15,000mg); Folic Acid (1,500mg); Biotin (50mg); Choline chloride (300,000mg); Manganese (80,000mg); Zinc (50,000mg); Iron (20,000mg); Copper (5,000mg); Iodine (1,000mg); Selenium (200mg); Cobalt (500mg); and Antioxidants (125,500mg).

Data collection

Haematological Profile Examination

At the end of the 14-week feeding period, blood samples (3 mL) were aseptically collected from the ear vein of one randomly selected doe per replicate using a sterile 5 mL disposable syringe with a 22-gauge needle between 7:00 and 8:00 AM. Samples were transferred into EDTA-treated tubes for haematological analysis. Parameters such as packed cell volume (PCV), red blood cells (RBC), white blood cells (WBC), haemoglobin (Hb), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC) were analyzed using an automated haematology analyzer.

Serum Biochemical Profile Determination

Another 3 mL of blood was drawn from the ear vein of each replicate animal into plain sample bottles without anticoagulant. The blood was allowed to clot and the serum was separated by centrifugation. Biochemical parameters analyzed included total protein (albumin and globulin), urea, glucose, alkaline phosphatase (ALP), alanine aminotransferase (ALT), and aspartate aminotransferase (AST). Additionally, ALT, AST, and ALP levels were evaluated using an Audiocomb Serum Auto-analyzer (Bayer Express Plus, Bayer Germany, Serial No. 15950).

Lipid Profile

For lipid profile analysis, 3 mL of blood was collected from the ear vein into plain tubes. The sera were separated via centrifugation at 4000 rpm for 5 minutes at 20°C. The samples were analyzed at the University of Uyo Teaching Hospital using a biochemical autoanalyzer (Cobas Mira Plus, Roche Diagnostics) to determine concentrations of triglycerides, total cholesterol, high-density lipoprotein (HDL), and low-density lipoprotein (LDL).

Statistical analysis

All data collected were subjected to analysis of variance (ANOVA) using the IBM SPSS Statistics software version 21, following a completely randomized design. Treatment means were separated using Duncan's Multiple Range Test as described by Duncan (1955).

Statistical model used:

$$X_{ij} = \mu + Y_i + \Sigma_{ij}$$

Where: X_{ij} = Individual Observation (haematological indices, lipid profile and serum biochemical)

μ = Overall Mean

Y_i = Effect of Treatment (turmeric powder)

Σ_{ij} = Experimental Error

Results

Haematological profile of rabbit does fed diets supplemented with turmeric rhizome powder

The effects of dietary supplementation of turmeric powder (TP) on haematological parameters in rabbit does are summarized in Table 2. Significant differences ($p<0.05$) were observed across treatments for packed cell volume (PCV), white blood cell (WBC) count, red blood cell (RBC) count, haemoglobin (Hb), mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC). The highest PCV values were recorded in does fed the T3 (2.0% TP) and control (T1) diets, with values of 39.33% and 38.00%, respectively, while the lowest value was observed in T4 (3.0% TP) at 34.00%.White blood cell count was significantly elevated ($p<0.05$) in T2 does (9.45×10^9/dL), compared to those in T1, T3, and T4, which exhibited statistically similar but lower values. Platelet counts ranged from 116.00 to 181.50 $\times10^9$/dL across the treatments and showed no significant differences. RBC values ranged from 5.05 to 5.97×10^{12}/L, with T3 does recording the highest count. Although RBC values in T1, T2, and T3 were statistically similar ($p>0.05$), does in T4 recorded significantly lower values. No significant variation was noted in mean corpuscular volume (MCV) among treatments. However, significant differences ($p<0.05$) were found in MCH and MCHC, with the highest MCHC recorded in T4 (32.50%). Haemoglobin concentration was significantly higher ($p<0.05$) in T3 (12.30 g/dL), followed by T1 (11.90 g/dL), T2 (11.45 g/dL), and T4 (11.25 g/dL). Lymphocyte and neutrophil percentages were unaffected ($p>0.05$) by turmeric inclusion. Lymphocyte counts increased progressively from T1 to T4 (52.00% to 60.00%), while neutrophils decreased (42.50% to 34.00%), but these trends were not statistically significant.

Table 2. Haematological profile of rabbit does fed diets supplemented with turmeric powder

Parameters	T1 (0.0% TP)	T2 (1.0% TP)	T3 (2.0% TP)	T4 (3.0% TP)	SEM
Packed Cell Volume (%)	38.00^{ab}	36.00^{bc}	39.33^{a}	34.50^{c}	0.65
White Blood Cells ($\times10^9$/dL)	7.25^{b}	9.45^{a}	6.37^{b}	5.30^{b}	0.54
Platelet	181.50^{a}	116.00^{c}	151.00^{b}	133.00^{bc}	13.07
Red Blood Cells ($\times10^{12}$/L)	5.70^{ab}	5.75^{ab}	5.97^{a}	5.05^{b}	0.14
MCV (fl)	66.65	63.00	66.33	69.00	1.01
MCH (pg)	21.00^{ab}	20.50^{b}	21.00^{ab}	22.50^{a}	0.32
MCHC (%)	31.50^{bc}	32.00^{ab}	31.00^{c}	32.50^{a}	0.19
Haemoglobin (g/dL)	11.90^{ab}	11.45^{ab}	12.30^{a}	11.25^{b}	0.17

Lymphocytes (%)	52.00	54.50	56.33	60.00	2.67
Neutrophils (%)	42.50	40.00	38.00	34.00	2.58

MCV - mean corpuscular volume, MCH – mean corpuscular haemoglobin, MCHC – Mean corpuscular haemoglobin concentration, SEM – Standard error of means; Means with different superscripts are significant ($p<0.05$)

Effect of turmeric supplementation on serum biochemical indices in rabbit does

The results on serum biochemistry in rabbit does fed diets supplemented with turmeric meal are presented in Table 3. The result revealed that turmeric significantly influenced ($p<0.05$) blood urea level, serum enzymes and creatinine. The mean total proteins in does fed diets supplemented with turmeric meal were 66.00, 64.50, 71.50 and 69.50 g/dL. Turmeric supplementation significantly affected ($p<0.05$) urea in does with higher mean values in does fed T3 (6.80 mmol/L), which was similar ($p>0.05$) to does in T2 (6.00 mmol/L), but different ($p<0.05$) for does in T1 (5.70 mmol/L) and T4 (5.60 mmol/L) respectively.

Serum enzymes were all influenced ($p<0.05$) by dietary supplementation of turmeric meal in the rabbit does' diets in the current study. Aspartate aminotransferase (AST) was elevated ($p<0.05$) in does fed diets supplemented with turmeric in T4 (39.00 μ/L) and T3 (34.00 μ/L). The mean AST values of does observed in this study were similar ($p>0.05$) in T1 (23.00 μ/L) and T2 (23.00 μ/L) which were significantly lower ($p<0.05$) that those of does in T4 and T3 respectively. Higher values ($p<0.05$) of mean alanine aminotransferase (ALT) was observed in rabbit does fed diets supplemented with turmeric meal in treatment groups 4 and 3 with mean values of 38.00 and 30.00 μ/L respectively while does fed T1 and T2 shared similar ($p>0.05$) lower values of 22.00 and 23.00 μ/L respectively. Turmeric meal supplementation increased ($p<0.05$) alkaline aminotransferase (ALT) in rabbit does in this study, although does in T2 had similar statistical value with those in the control group (T1), without turmeric supplementation. The meal ALT values recorded were 14.00, 16.50, 21.00 and 23.50 μ/L for T1, T2, T3 and T4 respectively. The values were observed to increase with corresponding higher dose of supplement in the does' diets.

Creatinine values were higher in does with turmeric meal in their diets however, these values were statistically similar in rabbit does in T1, T2 and T4 with mean values of 97.00, 114.00 and 123.00 μ/L respectively. Turmeric meal did not have any significant effect ($p>0.05$) on blood glucose level in the does in this study, although higher non-significant ($p>0.05$) values were seen in rabbit does with turmeric meal in their diets when compared with those of the control group without turmeric meal supplementation in their diets. Glucose values were 4.05, 4.85, 4.95 and 5.45 g/dL for T1, T2, T3 and T4 respectively.

Table 3. Effect of turmeric supplementation on serum biochemical indices in rabbit does

Parameters	T1 (0.0% TP)	T2 (1.0% TP)	T3 (2.0% TP)	T4 (3.0% TP)	SEM
Total protein (g/dL)	66.00	64.50	71.50	69.50	1.78
Urea (mmol/L)	5.70^{b}	6.00^{ab}	6.80^{a}	5.60^{b}	0.19
AST (μ/L)	23.00^{b}	23.00^{b}	34.00^{a}	39.00^{a}	2.45
ALP (μ/L)	22.00^{b}	23.00^{b}	30.00^{ab}	38.00^{a}	2.25
ALT (μ/L)	14.00^{c}	16.50^{bc}	21.00^{ab}	23.50^{a}	1.32
Creatinine (mg/dL)	97.00^{b}	114.00^{ab}	142.00^{a}	123.00^{ab}	6.52
Glucose (g/dL)	4.05^{c}	4.85^{b}	4.95^{b}	5.45^{a}	0.22

AST - Aspartate aminotransferase; ALP – Alanine amino phosphatase; ALT - Alanine aminotransferase; SEM – Standard error of means; Means with different super Scripts are significant ($p<0.05$).

The effects of turmeric supplementation on lipid profile are displayed in Table 4. Triglyceride levels showed a significant increase in T3 (4.10 mmol/L), while T1, T2, and T4 exhibited similar and lower values (1.80–2.00 mmol/L). Total cholesterol levels were highest in T3 (4.24 mmol/L) and significantly lower in T1 (2.09 mmol/L). High-density lipoprotein (HDL) levels were significantly elevated in T3 (1.10 mmol/L) and T4 (1.23 mmol/L) compared to T1 and T2 (both at 0.60 mmol/L). Very-low-density lipoprotein (VLDL) concentrations ranged from 0.19 mmol/L in T1 to 0.41 mmol/L in T3, showing significant differences ($p<0.05$). Low-density lipoprotein (LDL) value was highest in T3 (2.60 mmol/L), with the lowest observed in T4 (0.70 mmol/L).

Table 4. Lipid profile of rabbit does fed dietary supplementation of turmeric meal

Parameters	T1 (0.0% TP)	T2 (1.0% TP)	T3 (2.0% TP)	T4 (3.0% TP)	SEM
Triglyceride	2.00^b	1.80^b	4.10^a	1.90^b	0.32
Total cholesterol	2.09^b	1.77^c	4.24^a	2.12^b	0.14
HDL	0.60^b	0.60^b	1.10^a	1.23^a	0.14
VLDL	0.19^d	0.37^b	0.41^a	0.32^c	0.03
LDL	1.30^b	0.80^c	2.60^a	0.70^c	0.23

Discussions

Haematolocal profile of rabbit does fed diets supplemented with turmeric rhizome powder

According to Tobou et al. (2020), blood parameters are considered as the main pathological, nutritional and physiological indices for assessing the state of an organism. Therefore, any change in the constituent elements of blood relative to the normal values is considered an important index for the interpretation of the physiological or metabolic state of the animal, especially the quality of feed.

Turmeric powder supplementation significantly affected the PCV, WBC, RBC, Hb, MCH and MCHC respectively in rabbit does in this study. This result is consistent with the report of Ayodele et al. (2021) who observed a significantly ($p<0.05$) higher Hb and RBC in pullet chicks fed diets containing turmeric powder when compared with those of the other diet groups. In their study, pullet chicks fed diet supplemented with 1%. Turmeric diet had a significantly higher PCV value than those of the other treatment groups. The highest value of PCV was observed in does fed T3 (1.0% TP). This result however, differs from the report of Daramola et al. (2020) who documented no significant effect of turmeric powder supplementation in PCV, Hb, MCH and MCHC in broiler chicken at up to 1.0% supplementation in their diets. The results on PCV, RBC and Hb agree with those of Adegoke et al. (2018) who also observed significant effect on turmeric in broiler chicken but disagrees with the report of Tobou et al. (2020). The increase in PCV, RBC and Hb at 1.0% supplementation in this study showed that the does did not suffer anemia in the course of the study, since RBCs and PCV are significant in the diagnosis of anaemia (Adegoke et al. 2018), neither was the oxygen - carrying capacity in the does' blood compromised. Okpuzor et al. (2009) in their study noted that an increase in the count of RBC, Hb and PCV is suggestive of polycythemia and positive erythropoiesis. El-Rawi et al. (2020) also had variable influence on blood parameters of guinea pigs with the inclusion of *C. longa* powder in their diets. This suggests that turmeric at 1% inclusion will improve oxygen - carrying capacity of the cells as reported by Isaac et al. (2013) which signifies sufficient iron in the blood.

There was a significant increase in WBC of the does at 0.5% supplemental level compared to those with 0.0, 1.0, and 1.5% supplementations, respectively. This observation is in tandem with previous studies (Adegoke et al. 2018, Tobou et al. 2020), but varies with the results of Ayodele et al. (2021) and Daramola et al. (2020) who did not observe any significant difference with turmeric powder supplementation on WBC of pullet chicks and broiler chicken, respectively. According to Odesanmi et al. (2010), a decrease in the count of WBC indicates suppression of leucocytes and their production from bone marrow which suggests presence of infection or a regenerative anaemia. Tobou et al. (2020) reported that the incorporation of 0.25% of *C. longa* powder significantly increased white blood cell, hematocrit, lymphocyte, monocyte, granulocyte and platelet concentration in their study. Syed et al. (2018) earlier stated that phytobiotics are also used as blood and immunity purifiers because they stimulate white blood cells and eventually increased interferon levels. Hence, turmeric powder supplementation significantly improved the immunity of the does, thereby increasing their ability to resist or withstand infections in the blood. The supplementation of turmeric powder reduced the platelet values in the does when compared to their counterparts in the control group without turmeric powder supplementation in their diet.

The observed differences in MCH and MCHC are similar to the report of Daramola et al. (2020). They opined that the increase in these parameters is an indication of improving oxygen - carrying capacity of the cells. Haemoglobin, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration are important blood parameters whose values are used to determine the presence and severity of anaemia (Aikpitanyi and Egweh 2020). Tobou et al. (2020) reported a significant difference in guinea pigs with turmeric powder supplementation. This study did not show any significant variation in the lymphocytes and neutrophils of does with supplemental levels of turmeric powder in their diets. When neutrophil number in the blood reaches a critically low level, animals are highly susceptible to bacterial infection (Weiss et al. 2010). Adeyemi (2014) reported that increased numbers of lymphocytes are seen in most viral infections, some bacterial infections, and some cancers while decreased numbers of lymphocytes are seen in steroid exposure, some cancers, immunodeficiency and renal failure. Again, he noted that neutrophils are the most common of the WBCs and serve as the primary defense against infection. According to Adeyemi (2014), the typical response to infection or serious injury is an increased production of neutrophil, and further added that immature forms of neutrophils are seen early in the response to infection. The non-significant effect of turmeric powder supplementation on these parameters suggests the absence of infection in the does in the course of the study.

Serum biochemical indices in rabbit does fed diets supplemented with turmeric powder.

Although turmeric powder supplementation did not show a statistically important effect on total protein and blood glucose in this study, urea, creatinine, AST, ALP and ALT on the other hand, were significantly affected. The non-significant effect of turmeric powder supplementation on serum total protein suggest that the supplement did not have a negative effective on protein digestibility, since Ahamefule et al. (2008) attributed high protein in serum to an indication of protein adequacy. The result on total protein in this study is similar to the findings of Tobou et al. (2020), El-Rawi et al. (2020) and Ayodele et al. (2021) who reported non-significant effect of turmeric powder supplementation in their respective studies. Adegoke et al. (2020) however, observed significant variation in their study. Turmeric powder supplementation increased blood urea at 1.0% (T3), which was similar to values of does in T2 but differ from those of does in T1 and T4, which were also similar. The result disagrees with the report of Ayodele et al. (2021) when they studied the effect of turmeric powder supplementation at 0.0, 1.0 and 2% in broiler chicken. This observed difference may be due to specie difference, though both animals are monogastric. This significant increase in serum urea concentration could be attributed to ammonia production dies in the caecum that is similar to that of the rumen in ruminants as noted by Abdel El-Latif et al. (2019). Serum urea concentration is an index that reflects the state of protein metabolism, renal function and body nutrition as noted by Kryshtafovych et al. (2014). Uric-acid in the blood, as described by Chernecky and Berger (2008), is produced as a result of protein metabolism. Hence, increased protein metabolism as well as stress and dehydration can affect the concentration of Uric acid in the blood.

There was significant difference in AST of rabbit does at 1.0% (T3) and 1.5% (T4), turmeric meal supplementation in this study. These values were higher than those of does in 0.0% (T1) and 0.5 % (T2) respectively. Similar observation was made for ALP. The ALT values in the does were also elevated with turmeric powder supplementation although the value for does in T2 (0.5%), was similar to those of does in the control group. The liver as stated by Aikpitanyi and Egweh (2020) is the center of several digestive, metabolic and productive activities, and as such, is susceptible to a varying degree of chemical and biological damages. These damages, they said, are made obvious by the serum levels of specific enzymes originating from the liver, which depending on their levels may cause some disruptions to bodily functions, thereby resulting in poor health and production performance (Aikpitanyi and Egweh 2020). Aikpitanyi and Egweh (2020) described the activities of AST, ALP and ALT in the blood as bioindicators of liver function and damage. Lumeij (2008) also noted that increased levels of these enzymes are associated with liver or muscle damage, resulting from the body's response to stress. This therefore, suggests that the does with 1.0 and 1.5% supplementation may have suffered some levels of liver damage in the course of the study. According to Lumeij (2008), higher serum levels of ALP are observed when there is increased osteoblastic activity, involving the formation and mineralization of bone associated with increased skeletal growth. Tobou et al. 2020) also observed increased serum urea, AST and ALT levels with the inclusion of turmeric powder in the rations.

Creatinine is used to determine the status of the kidney (Ayodele et al. 2021). The primary function of the kidney is to excrete waste products resulting from protein metabolism and muscle contraction as stated by Ileke et al. (2014). Creatinine values increased with turmeric powder supplementation, although does without turmeric powder supplementation and does with 0.5% and 1.5% respectively, had similar creatinine values. Esuboteng in Ayodele et al. (2021) opined that creatinine is excreted by the kidney as a by-product of creatinine phosphate metabolism which is produced as a result of energy production by the skeletal muscles. The elevated value in does fed diets containing 1.0% turmeric powder as a supplement suggests that they may have been exposed to kidney damage; hence, the elevated value in the blood. Turmeric powder supplementation did not influence glucose values in this study.

Lipid profile of rabbit does fed dietary supplementation of turmeric meal

The result on triglycerides showed significant differences, with higher value been observed in does fed the T3 diet. This result differs from the report of El-Rawi et al. (2020) who observed significant reduction in triglyderides in rabbits fed turmeric in their diets. The rabbit does in T3 exhibited a higher total cholesterol value than those of does in T1, T2, and T4 respectively. Nwoko et al. (2022) reported that TC, TG, LDL and VLDL levels were significantly lower for rabbits in T4 compared to treatments 1, 2 and 3 and added that these parameters decreased as Turmeric increased in the diet which contradicts the current study. Dehzada et al. (2023) in their abstract concluded that turmeric/curcumin supplementation seems to be effective in improving blood levels of TC, TG, LDL and HDL. The significant increase in TC and V-LDL in this study disagrees with the findings of Nwoko et al. (2022) who found decrease in TC, LDL, VLDL and suggested that turmeric rhizome powder is a hypocholesterolemic additive. El-Rawi et al. (2020) attributed the decrease in total lipid and cholesterol in their work to the effect of essential oil compounds present in the turmeric on lipid metabolism or due to curcumin that enhances bile production and hence, lipid digestion. The authors also reported that liver triacylglycerol and cholesterol concentrations were considerably less in rats fed curcumin than in control animals. Results on LDL showed significantly higher value at T3 but were significantly lower in rabbit does fed T2 and T4 diets respectively. LDL is known as bad cholesterol because it carries fat from the liver to the blood vessels and encourages arterial cholesterol deposition (Nwoko et al. 2022). Earlier reports (Benzie and Galor 2011, Woode et al. 2011) suggested serum lipids lowering properties of turmeric rhizome powder.

Conclusions

From the findings of this study, it can be concluded that supplementing rabbit does' diets with 2.0% turmeric rhizome meal can improve blood parameters and enhance the overall health of the animals.

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