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EFFECT OF DIETARY SUPPLEMENTATION OF CATECHIN ON HAEMATOLOGY, SERUM BIOCHEMISTRY AND OXIDATIVE STRESS BIOMARKERS OF RED SOKOTO GOAT REARED INTENSIVELY

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ABSTRACT

Catechin, a plant-derived polyphenol with antioxidant and anti-inflammatory properties, was evaluated for its effects on haematology, serum biochemistry, and oxidative stress biomarkers in Red Sokoto goats. Eighteen growing goats (7.0 ± 0.55 kg) were randomly assigned to three dietary treatments: control (0 g/kg catechin), 3 g/kg, and 6 g/kg catechin in a completely randomized design. Haematological indices, serum biochemical parameters, and oxidative stress markers were analyzed using one-way ANOVA and Tukey's test. Packed cell volume, haemoglobin, red and white blood cells, eosinophils, monocytes, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration increased significantly ($p < 0.05$), with most improvements observed at 3 g/kg. Serum parameters were largely unaffected except for total bilirubin and aspartate amino transferase, which remained within normal ranges. Superoxide dismutase increased significantly in supplemented groups, while glutathione was higher in the control group. Malondialdehyde and glutathione peroxidase were unchanged. Dietary catechin at 3–6 g/kg improved haematological profile and enhanced antioxidant status in goats.

Keywords: Red Sokoto Goat, Haematology, Serum Biochemistry, Oxidative Stress, Catechin

INTRODUCTION

Small ruminants represent the principal economic output most especially for rural farmers, contributing a large share of the income of farmers (Wodajo *et al*., 2020). Animal numbers have increased over the last two decades, driven by a rising demand for animal products (Thornton, 2010). The changing climatic patterns are increasing desertification, resulting in a decline in rangeland resources, which are often insufficient to meet current demand, coupled with a fall in total feed resources due to overgrazing, ploughing of marginal plant and soil erosion (Ahmed et al., 2024). Consequently, goats and sheep are facing serious nutrient shortages. These animals often depend on low quality crop residues (e.g. straws, stubbles). To mitigate the problem of malnutrition and enhance the health of animals, researchers have proposed the use of feed that are rich in antioxidants, thus, catechin might be a favourable supplement (Sahoo and Karim, 2010). Catechins are important ingredient from tea leaves and have intensive antioxidants and representative physiological activities. They are members of the group of polyphenol compounds found in many medicinal plants (Bae et al., 2020).

The major sources of catechins are *Camellia sinensis* (*C. sinensis*) and *C. assumica* green tea contains 75–80% water and polyphenol compounds (flavanols, flavandiols, flavonoid, and phenolic acid) (Bae *et al*., 2020), and catechins account for more than 75% of the polyphenol compounds in tea leaves. They are condensation-type tannins with a ring and the basic structure of flavan-3-ol. Apart from green tea, catechins are present in many dietary products, plants, fruits (such as apples, blueberries, gooseberries, grape seeds, kiwi, Strawberries), green and black tea, red wine, beer, cacao liquor, chocolate and cocoa. The main catechins present in the green tea include (−)-epigallocatechin gallate, (−)-epicatechin, (−)-epigallocatechin, (−)-epicatechin gallate and (+) - catechin (Jin et al., 2006; Bae et al., 2020). The use of catechin and other flavonoids has reduced the use of antibiotics as supplements in animal diets, reducing its side effect and resistance ability. Natural antioxidants applied as feed additives can not only improve animals' health and overall performance but also increase their resistance to environmental stress such as heat stress, bad housing conditions, diseases, etc. (Wang et al., 2024).

Catechin exhibits significant antimicrobial activity against a wide range of bacteria, fungi, and viruses (Friedman *et al*., 2006; Davidova *et al*., 2024). It can enhance the immune response by stimulating the production of cytokines and other immune mediators, thereby strengthening the body's defence mechanisms against infections and diseases (Davidova *et al*., 2024), By modulating the composition of gut microbiota and promoting the growth of beneficial bacteria, catechin contributes to improved digestive efficiency and nutrient utilization. Catechin, with its potent antioxidant properties, scavenges free radicals and reduces oxidative damage to cells and tissues (Shen et al., 2023). However, improving the health and productivity of Red Sokoto goats is essential for sustainable livestock production and livelihood enhancement in regions where they are prevalent.

Blood is an important and reliable medium for assessing the health status of individual animal. Examining blood for their constituents is used to monitor and evaluate health and nutritional status of animals (Ntagbu *et al*., 2025). Blood acts as a pathological reflector of the status of exposed animals to toxicant and other conditions (Olafedehan *et al*., 2010). However, despite the growing interest in natural additives for animal nutrition and health, there is limited scientific literature exploring the effects of catechin on the haematological parameters of Red Sokoto goats. Therefore, this present study sought to evaluate the effect of catechin

supplementation on the blood and oxidative parameters of Red Sokoto Goats reared intensively.

MATERIALS AND METHODS

Experimental Site

This experiment was conducted at the Small Ruminant Unit of the Directorate of University Farms (DUFARMS), Federal University of Agriculture, Abeokuta, Ogun State. The site is in the rain forest vegetation zone of South–Western Nigeria on latitude 7° 10′ N, longitude 3° 2′ E and altitude 76 mm above the sea level. The climate is humid with a mean annual rainfall of 1037 mm and mean temperature and humidity of 34.7 °C and 83%, respectively.

Experimental Design and Treatment

A total of eighteen matured red sokoto goats were procured from a reliable goat farmer within Abeokuta. The animals were quarantined on arrival on the farm for a period of four (4) weeks, to check out for disease and ectoparasite. The quarantine period also served as a period to acclimatize the animals to the environmental condition and the intensive system. The goats were randomly assigned to three treatment groups consisting of six animals per treatment. The animals were raised intensively in pens made of wood and covered with galvanized iron sheet for protection against sun and rainfall. Goats assigned to Treatment 1 belonged to the control group on basal feed and concentrate fed without catechin, those in Treatment 2 had diet supplemented with 3g of catechin per kg of feed offered and those in Treatment 3 had diet supplemented with 6g of catechin per kg of feed offered. The animals were administered multi-vitamins (Multinor) and Antibiotics (L.A Oxytetracycline) at a dosage of 2ml per 10kg. The animals were raised intensively in pens made of wood and covered with galvanized iron sheet for protection against sun and rainfall. The pens were cleaned every morning. Feed and water were provided for the animals every day. The experimental animals were fed with the basal diet at an ad libitum, while the concentrate diet was fed at 4% body weight. This experiment lasted for 82 days.

Experimental Dietary Composition

The catechin (99% RU58841 powder) was procured from LONGILATBIO, China. The concentrate was formulated at a local feed mill at Eleweran, Abeokuta. Three inclusion levels of catechin were administered (0, 3 and 6) grams for the experimental diets composition of the goats as shown in Table 1. The experimental diet (Table 1) contained a basal diet M. maximus and a supplemented diet of concentrate.

Table 1: Composition (%) Of Experimental Diet

Ingredient Composition	(%)
Maize	5
Palm kernel cake	25
Wheat offal	20
Rice bran	20
Maize offal	25
Bone meal	3.5
Salt	1.5
Total	100
Calculated Analysis	
Crude protein (%)	12.25
Metabolizable Energy (MJ/kg)	41.5

* Catechin was added as a supplement and not additive

Data Collection

Blood Sample Collection

Blood samples were collected twice, first at the onset of the experiment and second at the last week of the experiment. The blood samples from an individual animal were collected via jugular vein puncture into a plain vacuum tube and that containing ethylenediaminetetraacetic acid (EDTA), 16 100 mm (Becton Dickinson, Rutherford, NJ) for serum and haematology analysis, respectively. The serum was separated by centrifugation of the blood samples at 3000 rpm for 15 min and stored in vials at −20 °C.

Haematological parameters of Red Sokoto Goat

Laboratory analysis for haematological parameters was carried out following standard procedures. The packed cell volume (PCV) was determined by the micro-haematocrit method (Schalm et al. 1975; Thrall *et al*. 2012), haemoglobin concentration (Hb) was determined by the cyano-methaemoglobin method (Arnaud *et al*. 2008), red blood cell (RBC) count was carried out by the haemocytometer method (Thrall *et al*. 2012) and white blood cell count and its differentials were determined according to the methods of Tevares-Dias *et al*. (2008).

Serum Biochemical Parameters of Red Sokoto Goat

The serum analysis was done using Vector (VChem Next) programable biochemistry analyser using Randox kits. Aspartate aminotransferase (AST) was analyzed using Randox kit (AS 1202) according to methods of Tietz (1987). Glucose was analyzed following procedures of Tietz (1990) with Randox kit (GL364). Randox kit (TP 245) was used to analyze total protein according to method of Tietz (1995). Albumin was analyzed using Randox kit (ALB 362) following procedure of Doumas *et al*. (1971). Randox kit (CH 200) was used in analyzing cholesterol according to method of Roeschlau *et al*., (1974). Bilirubin was analyzed using Randox kit (BR411) according to Sherlock (1951).

Oxidative stress biomarkers parameters

Blood samples were collected by vein puncture after 82 days of experiment into plain tubes from all the experimental animals. The blood tubes were placed in ice until arrival in the laboratory for immediate analysis. The samples were centrifuged at 3000 rpm for 15 min to harvest the serum. The serum was analysed for glutathione peroxidase (GPx), glutathione (GSH), superoxide dismutase (SOD) and malondialdehyde (MDA). Glutathione peroxidase (GPx) activity was measured by the method of Paglia and

Valentine (1967) using the RANDOX-Ransel enzyme kit. Superoxide dismutase (SOD) activity was determined by a modified method of iodophenyl nitrophenol phenyltetrazolium chloride using the RANDOX RANDOX kit. Determination of malondialdehyde (MDA) concentration in the serum was performed using the method of thiobarbituric acid which measures MDA reactive products (Placer *et al*., 1966) as described by Todorova *et al*. (2005).

Statistical Analysis

All data collected during experimental period were subjected to one-way analysis of variance (ANOVA) using a completely randomized design in accordance with SPSS (2000) while Tukey's test was employed to reveal significantly differences at ($p < 0.05$) among the treatment means.

Model

$Yij = \mu + Ti + \varepsilon ij$

Where:

Yij – the observed value of jth animal fed ith treatment,

μ – Population mean,

Ti – effect of ith treatment,

Ɛij – random error.

RESULTS AND DISCUSSION

The haematological parameters of Red Sokoto goats at the onset of the experiment is presented in Table 2. All the haematological parameters considered were not significantly ($p> 0.05$) differed except white blood cell, lymphocyte, eosinophils and mean corpuscular haemoglobin concentration. The white blood cell was higher ($8.80a \pm 0.84$) in the control group compared to the other groups. The lymphocyte concentrations in goats on 6g inclusion level of catechin and control given were significantly higher ($p < 0.05$) compared to other treatment on 3g of catechin per kg of feed offered. The eosinophils concentration in goats fed 3g/kg inclusion level of catechin and 0g/kg inclusion level of catechin were significantly higher compared to those given 6g of catechin per kg of feed offered. For MCHC, 3g and 6g of catechin per kg of feed offered were significantly higher ($p< 0.05$) compared to those placed on control.

The health and productivity of livestock, including goats, depend on several factors, including nutrition, management practices, and disease control (Mahgoup *et al*., 2025). Hematological and serum biochemical parameters serve as vital indicators of the physiological status and health of animals (Olafadehan *et al*., 2010). They provide insights into the status of various bodily functions, including oxygen-carrying capacity, immune response, and overall metabolic activity (Ribeiro *et al*., 2018). Any alteration in hematological parameters may reflect underlying health issues, stress, or nutritional deficiencies, ultimately impacting the productivity and well-being of the animals (Rini et al., 2026). According to Animashahun *et al*. (2006) and Ojebiyi *et al*. (2007), the use of haematological studies is very important in considering the health status of animals used in various feed trials. The initial haematological parameters serve to note the initial health status of the experimental goats. Although similar, the PCV values for Red Sokoto goats range from 23.6%-24.3%, which falls within the reference range of 22-38% as documented by Daramola *et al*., (2005) and 25.7+3.1 (%) reported by Tambuwal *et al*. (2002).

The final haematological parameters of Red Sokoto Goat fed diet supplemented with catechin at the end of the experiment are presented in Table 3. The Pack Cell Volume, Haemoglobin, Red Blood Cell, and Mean Corpuscular Haemoglobin Concentration in goat offered supplemented diets were significantly higher ($p < 0.05$) compared with the control. The White Blood Cell was higher ($10.51a \pm 1.56$) in goats offered 6g/kg inclusion level of catechin compared with the one offered 3g/kg body weight and the control. Monocyte and Mean Corpuscular Haemoglobin concentration was significantly higher in the control group compared to the supplemented groups.

In this result, the PCV was elevated with an increased level of catechin because of the antioxidant properties in the flavonoids, which protect erythrocytes from oxidative stress, leading to enhance erythropoiesis and thus, indicating the absence of anaemia. Previous studies suggest that lower PCV can lead to anaemia, reduced oxygen carrying-capacity of blood, increased pulse rate, and consequently heart failure (Naparlo et al., 2020). Hence, it can be added that the experimental animals were able to maintain normal body function, indicating that catechin supplementation can aid in maintaining the packed cell volume of experimental goats. Hemoglobin concentration observed in this study range fell within the reference range 8-12 g/dL (Aikhuomobhogbe and Orheruata, 2006). The flavonoids also have a positive impact on haemoglobin levels. Haemoglobin is the protein in red blood cells responsible for transporting oxygen. Flavonoids, particularly catechin, have been found to enhance haemoglobin concentration in the blood. A study by Li *et al.* (2018) on rabbits showed that flavonoids supplementation resulted in significant increase in haemoglobin level. The RBC count for these goats' ranges from 10.2-11.2 x 10^12/L, aligns with the reference range of 8 to 18 x 10^12/L recorded by Belewu *et al*. (2007). This indicated that flavonoids in catechin favoured increased Red Blood Cells concentration through increase oxygen Saturation which enhanced oxygen transport in RBCs and higher haemoglobin levels. Thus, the body's capacity to transport oxygen from the lungs to the tissues improves through catechin supplementation. The WBC count varies from 6.7-8.8 x 10^9/L, fitting within the normal reference range of 4-13 x 10^9/L Aini and Hamid, (1999). The increased White Blood Cells and its differentials by the flavonoids in the catechin may be in response to dietary changes, to fight infection, defend the body by phagocytosis against invasion by foreign organisms and to produce or at least transport and distribute antibodies in immune response. Animals with low WBC are exposed to high risk of disease infection. While those with high count can generate antibodies in the process of phagocytosis and high degree of resistance to diseases. The animals ordinarily reacted to increase in the level of catechin which increase the immune response of the animals. Neutrophils (NEUT) the range of 34.7 - 36.6% is within the reference range of 30-48% (Ezenwenyi, 2020). Lymphocytes values (60.0-63.5%), however, were within the reference range of 50-70% (Egbe-Nwiyi *et al*., 2014). Eosinophils (EOS) value (0.2-1.0%) also falls within the normal 1-8% reported for Red Sokoto goats (Ige *et al*., 2004). The significantly higher differential count Lymphocytes and EOS were within the normal physiological range for normal fixing of the animals. Indicating that there is no interference with the immune function, no allergic responses. Thus, showing no form of infections. The MCHC values of 33.2-35.2% are within the 30-36% reference range by Kaneko *et al*. (1997). The Mean Corpuscular Haemoglobin concentration was related to this study because it's valuable in monitoring feed toxicity especially with feed constitutes that affect the blood as well as the health status of farm animals. This indicated therefore that the animals were

physically and physiologically fit for the experiment. The nutritional quality of feed/diets is often reflected in the serum biochemical constituents of livestock. In this study, the total protein, albumin and globulin parameters were not within the reference range as documented by Merck's Veterinary Manual (2002) and Daramola *et al*. (2003) which could be as a result of breed or environmental factors, but there was a gradual increase in values with an increase in inclusion level of catechin on total protein.

Table 2: Initial Haematological Parameters of Red Sokoto Goat Fed with Different Levels of Catechin

Parameters	0g/kg Feed	3g/kg Feed	6g/kg Feed	Reference range
Packed Cell Volume (%)	23.60 ± 0.89	21.60 ± 3.36	24.28 ± 3.77	22-38*
Haemoglobin (g/dl)	8.00 ± 3.31	7.80 ± 1.10	8.23 ± 1.01	8-12+
Red Blood Cell (X1012/l)	10.800 ± 0.45	10.200 ± 1.48	11.21 ± 1.92	8-18-
White Blood Cell (X109/l)	8.80^{a} ± 0.84	7.00^{b} ± 0.71	6.71^{b} ± 0.83	4-13#
Neutrophils (%)	35.00 ± 2.55	36.60 ± 1.41	34.75 ± 1.48	30-48?
Lymphocyte (%)	63.20^{ab} ± 2.59	60.00^{b} ± 2.12	63.50^{a} ± 0.87	50-70!
Eosonophils (%)	1.00^{ab} ± 0.00	1.20^{a} ± 2.12	0.27^{b} ± 0.44	1-8“
Basophils (%)	0.00 ± 0.00	0.20 ± 0.45	0.00 ± 0.00	0-1#
Monocyte (%)	0.80 ± 0.84	2.00 ± 0.71	1.48 ± 0.50	0-4“
MCV (fl)	22.20 ± 0.45	21.20 ± 0.84	22.01 ± 0.18	16-25*
MCH (Pg)	7.20 ± 0.45	7.40 ± 0.55	7.08 ± 0.17	5.2-8-
MCHC (g/dl)	33.20^{b} ± 0.45	35.20^{a} ± 1.92	33.61^{ab} ± 0.45	30-36Δ

ab: Means in same column with different superscript are significantly (p<0.05) different
* = Aikhuomobhogbe and Orheruata, 2006,
+ = Naparlo et al, 2020,
- = Belewu et al, 2007
= Aini and Hamid J. A., 1999,
? = Ezenweyi, 2020,
! = Egbe-Nwiyi et al, 2014,
“= Ige et al, 2004
Δ = Kaneko et al, 1997

Table 3: Hematological Parameters of Red Sokoto Goat Fed with Different Levels of Catechin at the End of the Experiment

Parameters	0g/kg Feed	3g/kg Feed	6g/kg Feed	Reference range
Packed Cell Volume (%)	25.13^{b} ± 4.80	31.00^{a} ± 3.54	28.50^{ab} ±1.66	22-38*
Haemoglobin (g/dl)	8.59^{b} ± 1.51	10.25^{a} ± 0.10	9.54^{ab} ± 0.63	8-12+
Red Blood Cell (X1012/l)	11.10^{b} ± 1.75	13.84^{a} ±1.43	12.60^{ab} ±0.62	8-18-
White Blood Cell (X109/l)	6.60^{b} ± 0.37	7.08^{b} ± 0.50	10.51^{a} ± 1.56	4-13#
Neutrophils (%)	36.00 ± 4.58	32.88 ± 3.43	35.13 ± 2.56	30-48?
Lymphocyte (%)	62.25 ± 4.45	65.88 ± 3.32	63.63 ± 3.19	50-70!
Eosonophils (%)	0.00^{b} ± 0.00	0.63^{a} ± 0.41	0.00^{b} ± 0.00	1-8“
Basophils (%)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0-1#
Monocyte (%)	1.75^{a} ± 0.43	0.63^{b} ± 0.41	1.25^{ab} ± 0.83	0-4“
MCV (fl)	22.46 ± 0.85	22.32 ± 0.90	22.53 ± 0.95	16-25*
MCH (Pg)	7.70^{a} ± 0.21	7.14^{b} ± 0.15	7.54^{a} ± 0.44	5.2-8-
MCHC (g/dl)	37.96^{b} ± 5.42	45.79^{a} ± 2.90	42.30^{ab} ±1.91	30-36Δ

ab Means in same column with different superscript are significantly (p<0.05) different
* = Aikhuomobhogbe and Orheruata, 2006,
+ = Naparlo *et al*, 2020,
- = Belewu *et al*, 2007
= Aini and Hamid J. A., 1999,
? = Ezenweyi, 2020,
! = Egbe-Nwiyi *et al*, 2014,
“= Ige *et al*, 2004
Δ = Kaneko *et al*, 1997

The serum biochemical parameters of Red Sokoto Goats at the onset of the experiment are presented in Table 4. All the serum biochemical parameters considered were not significantly differed (p>0.05) except Total protein, Albumin, Globulin and Bilirubin. The Total protein concentration in goats on 6 g/kg and 3 g/kg of feed offered was significantly higher than those in the control group. The albumin concentration in goats on 6 g/kg of feed offered and those in the control treatment group were comparably higher than those on 3 g/kg of feed offered. The globulin concentration in goats on 6 g/kg and 3 g/kg of feed offered were significantly higher than those in the control treatment group. The concentration of bilirubin in goats on 6 g/kg and 0 g/kg of feed offered had higher values than those on 3g/kg of feed offered

The effect of supplemental levels of catechin on the Serum Biochemical parameters of Red Sokoto goats at the final state is revealed in Table 5. All the serum biochemical

parameters considered were not affected (p>0.05) by inclusion of catechin across treatment groups except Total bilirubin, and aspartate aminotransferase (AST) The Total bilirubin concentration was higher in goats offered 3g of catechin per kg of feed than those offered 0g and 6g of catechin per kg of feed. The concentration of aspartate aminotransferase was significantly higher in goats offered 6g of catechin per kg of feed than those offered 0g and 3g of catechin per kg of feed.

The glucose level fell within reference range (70- 102 mg/dl) as cited by Jane *et al*. (2018). This indicates that catechin flavonoid could enhance the goat metabolic function and an effective insulin sensitivity causing a reduction in blood glucose level (Wen *et al*., 2022). The cholesterol level of the experimental animals was slightly above reference range (80-130 mg/dl) as documented by Merck's Veterinary Manual (2002). The values also reduced with an increase in the inclusion level of catechin. These variations could be because of breed differences and environmental conditions. The result indicated that catechin could reduce LDL (low-density lipoprotein) cholesterol and increase HDL (High-density lipoprotein) cholesterol contributing to a lower risk of cardiovascular disease (Babu and Liu, 2008). The Total bilirubin values observed in this study were within normal reference range (0.1-1.2mg/dl) obtainable for goats. Bilirubin is a waste product formed from the breakdown of hemoglobin, a component of hemoglobin in red blood cells. Thus, this indicated that catechin flavonoids were able to improve the liver function and enhance detoxification process which probably led to a normalized bilirubin level. The Aspartate aminotransferase value was within the normal reference range (40-150 IU/L) as reported by Zhong *et al.* (2011). The result shows that catechin could significantly improve liver enzyme functions (Kim and Heo, 2022), causing a balance in Aspartate aminotransferase levels.

Table 4: Serum Biochemical Parameters of Red Sokoto Goats at the Onset of the Experiment

Parameters	0g/kg Feed	3g/kg Feed	6g/kg Feed	Reference range
Total protein(g/dl)	4.48^{b}±1.15	6.22^{ab}±0.93	9.88^{a}±0.85	6.4-7.0[#]
Albumin (g/dl)	2.21^{ab}±0.14	2.13^{b}±0.12	2.34^{a}±0.60	2.8-4.3[*]
Globulin(g/dl)	2.27^{b}±1.01	4.09^{ab}±0.81	7.54^{a}±0.25	2.7-4.1[#]
Cholesterol (mg/dl)	111.29±23.38	87.46±2.84	85.79±22.14	80-130[#]
Bilirubin (mg/dl)	0.41^{ab}±0.38	0.22^{b}±0.27	0.85^{a}±0.24	0.1-1.2[*]
Glucose (mg/dl)	56.61±9.02	95.67±78.77	48.96±4.85	50-75[#]
Aspartate aminotransferase (IU/L)	2.03±2.30	0.84±0.32	1.71±1.54	12-38[*]

[a b] Means in the same row having different superscripts differ significantly (p<0.05)
*Daramola *et al.,* 2003
- Merck's veterinary manual (2002)

Table 5: Influence of Supplemental Levels of Catechin on Serum Biochemical Parameters of Red Sokoto Goats at the Final Stage of Experiment

Parameters	0g/kg Feed	3g/kg Feed	6g/kg Feed	Reference range
Total protein (g/dl)	4.24±0.74	4.25±0.56	4.40±0.07	6.4-7.0[#]
Albumin (g/dl)	2.36±0.72	2.09±0.37	2.54±0.26	2.8-4.3[*]
Globulin (g/dl)	1.88±0.36	2.16±0.25	1.76±0.22	2.7-4.1[#]
Glucose (mg/dl)	101.24±15.15	95.32±6.55	108.16±16.61	70-102[@]
Cholesterol (mg/dl)	142.83±17.60	142.03±18.59	124.50±18.61	80-130[#]
Total bilirubin (mg/dl)	0.64^{b}±0.09	0.86^{a}±0.15	0.59^{b}±0.04	0.1-1.2[#]
Aspartate aminotransferase (IU/L)	99.13^{b}±12.02	97.13^{b}±1.88	122.50^{a}±10.06	40-150[$]

[ab] Means in the same row having different superscripts differ significantly (p<0.05)
*Daramola *et al.,* 2003
- Merck's veterinary manual (2002)
[@] Babu and Liu, 2008
[$] Zhong *et al*., 2011

Table 6 presents the effect of dietary supplementation of catechin on the oxidative stress biomarkers of Red Sokoto Goats. The superoxide dismutase (SOD) and Glutathione (GSH) were significantly influenced by vary level of catechin. However, Malondialdehyde (MDA) and Glutathione Peroxidase (GPx) were not significantly affected (p>0.05). The SOD concentration in goats offered diets supplemented with 3g/kg of catechin per kg of feed, and 6g/kg per kg of feed were significantly (p< 0.05) higher compared to the control group. The GSH concentration in the control group is (p<0.05) significantly (p>0.05) higher compared to that of goats offered 3g/kg and 6g/kg per kg of feed of inclusion level.

Oxidative stress is a pervasive challenge in livestock farming, impacting animal health and productivity. The increase in superoxide dismutase (SOD) levels observed at 6g/kg inclusion level (1.94) compared to 0g/kg (0.21) and 3g/kg (0.88) inclusion levels suggest that higher catechin levels enhances the body's enzymatic antioxidant defence. Studies have indicated that catechins can upregulate the expression of antioxidant enzymes like SOD (Zhong *et al*., 2013). Superoxide dismutase (SOD) is a critical antioxidant enzyme that places a vital role in protecting cells from oxidative stress by catalysing the dismutation of superoxide radicals into oxygen and hydrogen peroxide. High Superoxide dismutase (SOD) levels indicate a well-balanced diet rich in antioxidants while low Superoxide dismutase levels suggest nutritional deficiencies and poor antioxidant status, thus, indicating the rich level of antioxidant as the level of catechin increases. Glutathione (GSH) levels significantly decreased in goat supplemented catechin (3g/kg of catechin per kg of feed and 6g/kg of catechin per kg of feed) compared to the control (0g/kg of catechin per kg of feed). This result could indicate that catechin at these doses

depletes GSH or increases its utilization in response to oxidative stress. This aligns with study suggesting that certain antioxidants can paradoxically lower GSH levels in specific contexts (Ponnampalam *et al*., 2022). Glutathione is a critical antioxidant that plays a pivotal role in maintaining cellular role in maintaining cellular balance and protecting cell from oxidative damage. High Glutathione (GSH) levels indicate a well-balanced diet rich in antioxidants, while low Glutathione (GSH) levels suggest nutritional deficiencies and potential dietary imbalances. The Glutathione (GSH) content is mainly controlled by GSH-Px, GR and GST (Lushchak, 2012). Tea polyphenols are known to induce phase 2 antioxidant enzymes and therefore to increase the biosynthesis of antioxidant and detoxification enzymes and major cellular antioxidants, especially GSH (Hye-Kyung and Young-Joon, 2008). This justifies the nutritive quality of catechin in terms of antioxidant content, which indicates that the body has a higher antioxidant defence.

Table 6: Influence of Varying Levels of Catechin on Oxidative Stress Parameters of Red Sokoto Goat Raised Intensively

Parameters	0g/kg Feed	3g/kg Feed	6g/kg Feed
Malondialdehyde (MDA)	3.86±1.45	4.83±0.16	4.99±0.35
Superoxide dismutase (SOD)	0.21^{b}±0.79	0.88^{ab}±0.81	1.94^{a}±1.77
Glutathione (GSH)	50.18^{a}±17.43	17.9^{b}±01.83	27.74^{b}±18.69
Glutathione peroxidase (GPx)	25.14±8.83	26.18±15.24	28.05±10.81

[a b] Means in the same row having different superscripts differ significantly (p<0.05)

CONCLUSION

This study therefore concluded that diet supplementation of catechin is capable of maintaining the oxygen-carrying capacity of the blood with reference to normal range of the packed cell volume, haemoglobin and red blood cell in the supplemented group with attendant increased Superoxide dismutase (SOD) activity and balanced Glutathione peroxidase (GPx) stability, which may offer protective benefits against excess reactive oxygen (ROS) and nitrogen (RNS) in red Sokoto goats. Thus, this indicated that dietary supplementation of catechin at 3g and 6g per kg of feed offered can be recommended for health maintenance and oxidative stability to enhance rich antioxidant pool in the blood of red Sokoto goat.

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