2026, Scienceline Publication
World's Veterinary Journal
World Vet J, 16(2): 573-579.
ISSN 2322-4568

DOI: https://dx.doi.org/10.54203/scil.2026.wvj45
PII: S232245682600054-16

Effects of Dietary Supplementation of Turmeric Powder on Haematological Profiles and Serum Biochemical Parameters in Local Sheep in Indonesia

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ORIGINAL ARTICLE
Received: March 28, 2026
Revised: April 29, 2026
Accepted: May 26, 2026
Published: June 30, 2026

ABSTRACT

Productivity and livestock health are significantly affected by nutritional strategies, especially natural feed additives with immunomodulatory and antioxidant properties. Turmeric (*Curcuma domestica*) is considered a sustainable, safe alternative to synthetic additives. The present study aimed to evaluate the haematological and serum biochemical parameters in local sheep following the inclusion of turmeric powder in their diet. The experiment involved 12 male local thin-tailed sheep (*Ovis aries*), approximately 1 year old, with an average body weight of 24 kilograms. The present study was carried out at a private farm in Pringsewu, Lampung, Indonesia, using a completely randomized design with three dietary treatments, including a basal diet without turmeric supplementation (P0), a basal diet supplemented with 2.5% dry matter (DM) of turmeric powder (P1), and a basal diet supplemented with 5% DM of turmeric powder (P2). Hemoglobin, packed cell volume (PCV), total plasma protein (TPP), blood glucose, and low-density lipoprotein (LDL) levels were assessed. Dietary supplementation with turmeric powder in Group P2 modulated haematological parameters, as indicated by increased hemoglobin (14.30 ± 0.48 g/dL) and PCV levels (43.43 ± 1.48%) compared to the control group. Serum biochemical parameters were affected in Group P2. Total plasma protein remained within the physiological range in all groups (6.50-6.80 g/dL), while blood glucose levels decreased as turmeric inclusion increased, with a level of 60.00 ± 6.27 mg/dL in Group P0 compared with groups P1 and P2. The LDL concentrations demonstrated a moderate increase across the treatment groups, reaching the highest level in Group P2 at 23.25 ± 5.05 mg/dL. Supplementing local sheep diets with 5% DM of *Curcuma domestica* powder influenced hemoglobin, PCV, glucose, and LDL.

Keywords: *Curcuma domestica*, Haematological parameter, Phytogenic feed additive, Serum biochemical parameter, Sheep

INTRODUCTION

The increasing restriction on the use of antibiotic growth promoters has accelerated the exploration of phytogenic feed additives as natural alternatives in small ruminant production systems. In Asia, plant-based supplements have garnered significant interest due to their potential to enhance rumen function, metabolic efficiency, and physiological resilience under practical farm conditions (Nastoh et al., 2024; Wang et al., 2024). Among these plant-based supplements, turmeric (*Curcuma domestica syn*. *Curcuma longa* L.) is widely recognized for its bioactive compounds, particularly curcuminoids and essential oils, which exhibit antioxidant, anti-inflammatory, and hepatoprotective activities (Amalraj et al., 2016; Sureshbabu et al., 2023). These biological properties indicate that turmeric supplementation could affect overall physiological responses, not just growth performance (Jiang et al., 2019).

Haematological parameters such as hemoglobin (Hb) concentration and packed cell volume (PCV) reflect oxygen-carrying capacity and erythrocyte status, whereas serum biochemical indices, including total plasma protein (TPP), blood glucose, and lipid fractions, serve as metabolic balance indicators, nutritional adequacy, and hepatic function (Khalil et al., 2024; Korelidou et al., 2026). In local sheep production systems, particularly under smallholder management in tropical regions, these physiological traits may differ due to dietary variability, environmental stress, and management constraints. Therefore, nutritional interventions that stabilize or modulate these parameters are essential to sustain productivity and animal health (Sultan, 2022; Okoruwa et al., 2025).

Although dietary turmeric supplementation has been investigated in different livestock species, existing studies have primarily concentrated on growth performance, feed efficiency, and immune responses, with inclusion levels typically assessed up to 3% of the diet (Jaguezeski et al., 2018; Odhaib et al., 2021; Okoruwa et al., 2025). Limited evidence

To cite this paper: Dewi ADT, Alfisyahri A, Hanif AS, Andini FC, Sholeh A, Santosa PE, Suharyati S, Qisthon A, Liman L, Widiastuti LK, Muhtarudin M, and Adhianto K (2026). Effects of Dietary Supplementation of Turmeric Powder on Haematological Profiles and Serum Biochemical Parameters in Local Sheep in Indonesia. *World Vet. J.*, 16(2): 573-579. DOI: https://dx.doi.org/10.54203/scil.2026.wvj54

exists regarding the dose-dependent effects of turmeric on haematological and serum biochemical responses in locally adapted sheep. In particular, the common inclusion levels used in field conditions, such as 2.5% and 5% of turmeric powder in the diet, have not been extensively studied for their effects on systemic physiological indicators. Therefore, the present study aimed to evaluate the effects of turmeric (*Curcuma domestica*) powder supplemented to the diet of local sheep at inclusion levels of 2.5% and 5% on haematological and serum biochemical parameters.

MATERIALS AND METHODS

Ethical approval

Ethical approval was obtained from the Ethical Review Committee of the Faculty of Agriculture, University of Lampung, Indonesia (Approval No. 117a/UN26.14/TU/2025). All experimental procedures were rigorously designed and monitored to minimize animal stress and discomfort, ensuring adherence to animal welfare principles throughout the study.

Location and animals

The experiment was conducted at a private sheep farm in Pringsewu, Indonesia, under an intensive management system following standard husbandry and feeding practices. A total of 12 clinically healthy local sheep with relatively uniform age and body weight were used in the present study. The animals were housed individually in pens measuring 0.8 × 1.5 m to facilitate feeding and monitoring throughout the study. Feed and drinking water were provided separately. Feed was offered twice daily, in the morning and afternoon, while clean drinking water was available *ad libitum*.

Study design

The present experiment was conducted from October to December 2024, using 12 male local thin-tailed sheep (*Ovis aries*), aged approximately 1 year, with an average body weight of around 24 kg. Each sheep served as an experimental unit and was randomly assigned to one of three dietary treatments, with four replicates per treatment. The treatment groups were a basal diet without turmeric supplementation as the control group (P0), a basal diet supplemented with 2.5% DM of turmeric powder (P1), and a basal diet supplemented with 5% DM of turmeric powder (P2). The compositions of the basal and experimental diets are provided in Table 1.

Table 1. Chemical composition of sheep experimental diets containing different levels of turmeric powder

Parameters / Treatment	P0	P1	P2
Dry matter (%)	58.0	58.2	58.3
Crude protein (% DM)	12.7	12.9	13.1
Ether extract (% DM)	3.0	3.0	3.1
Crude fiber (% DM)	20.3	20.5	20.7
Ash (% DM)	11.0	11.1	11.3
Total digestible nutrients (% DM)	61.2	60.9	60.6
Metabolizable energy (Mcal kg^{-1} DM)	2.22	2.21	2.19

DM: Dry matter, P0: Basal diet without turmeric supplementation (control), P1: Basal diet + 2.5% of turmeric powder, P2: Basal diet + 5.0% of turmeric powder. The diets were formulated to provide approximately 13% crude protein and 2.2 Mcal kg^{-1} DM of metabolizable energy, meeting the nutrient requirements for growing sheep as recommended by NRC (2007).

Parameters

The hematological and serum biochemical parameters, including Hb (g/dL), PCV (%), TPP (g/dL), blood glucose (mg/dL), and low-density lipoprotein (LDL, mg/dL), were measured. These parameters were analyzed to assess the metabolic and physiological status of the sheep.

Data collection

Approximately 5 mL of blood was collected from the jugular vein of each animal. Of the total volume, 3 mL was transferred into sterile tubes containing ethylenediaminetetraacetic acid (EDTA) for assessing haematological parameters, including Hb and PCV, following standard procedures (Shaikat et al., 2013). The remaining 2 mL was transferred into Vacutainer tubes without anticoagulant for serum preparation. Samples were centrifuged at 3000 rpm for 15 minutes using a laboratory centrifuge to separate the serum, which was subsequently transferred into Eppendorf tubes and stored at −20°C until analysis. Haematological parameters were analyzed using a Haematology Analyzer RD-7021 (China), and serum biochemical parameters, including TPP, blood glucose, and LDL, were determined using an automatic biochemical analyzer in accordance with standard laboratory protocols. All hematological and serum biochemical analyses were conducted at the Lampung Veterinary Center in Indonesia.

Statistical analysis

All data are expressed as mean ± standard deviation (SD). Data management and basic computations were performed using Microsoft Excel (Microsoft Corporation, USA). Data evaluation was limited to descriptive statistical analysis, in which treatment means for each parameter were qualitatively compared with established physiological reference ranges for sheep. This descriptive approach aimed to determine whether dietary turmeric supplementation maintained haematological and serum biochemical parameters within normal physiological limits, rather than evaluating statistically significant differences among the treatment groups

RESULTS AND DISCUSSION

An increase in Hb and PCV was observed in Group P2 compared to groups P1 and P0. The TPP level remained stable in Group P2, while blood glucose levels decreased and LDL levels increased (Table 2).

Table 2. Effects of dietary turmeric on haematological and blood biochemical parameters in sheep

Parameters / Treatment	P0	P1	P2
Hemoglobin (g/dL)	13.13 ± 1.99	14.13 ± 0.49	14.30 ± 0.48
Packed cell volume (%)	38.95 ± 6.77	42.45 ± 0.98	43.43 ± 1.48
Total plasma protein (g/dL)	6.70 ± 0.26	6.50 ± 0.40	6.80 ± 0.48
Blood glucose (mg/dL)	60.00 ± 6.27	57.00 ± 7.61	48.25 ± 16.50
Low-density lipoprotein (mg/dL)	19.00 ± 4.54	21.75 ± 2.36	23.25 ± 5.05

P0: Basal diet without turmeric supplementation (control), P1: Basal diet + 2.5% of turmeric powder, P2: Basal diet + 5.0% of turmeric powder. Data are presented as mean ± SD.

Hemoglobin and packed cell volume

Hemoglobin concentration increased progressively with increasing levels of dietary supplementation (Table 2), rising from 13.13 ± 1.99 g/dL in the control group to 14.30 ± 0.48 g/dL in Group P2. Similarly, PCV level increased from 38.95 ± 6.77% in the control group to 43.43 ± 1.48% in Group P2. In sheep, the physiological reference range for Hb typically ranges from 9 to 15 g/dL, while the PCV generally ranges from 27% to 45%, depending on factors such as breed, age, and physiological condition (Mohamed et al., 2021; Nastoh et al., 2024). All values recorded in the present study remained within these established physiological limits, indicating that turmeric inclusion up to 5% did not induce hematological imbalances and might even suggest an improvement in hematological status (Nastoh et al., 2024). Hemoglobin and PCV are primary indicators of erythrocyte mass and oxygen-carrying capacity in small ruminants and are widely used to evaluate nutritional adequacy and systemic health (Nastoh et al., 2024). Increases in these parameters are commonly associated with enhanced erythropoiesis and improved nutrient availability, particularly protein and iron (Mohamed et al., 2021). Recent studies have indicated that phytogenic turmeric, as a feed additive, can positively influence hematological indices in small ruminants by improving nutrient digestibility and metabolic efficiency (Swelum et al., 2021; Ntsongota et al., 2025). The progressive increase observed in the 2.5% and 5% turmeric groups indicated enhanced erythrocyte production and physiological adaptation.

Curcuma longa contains curcuminoids and essential oils with strong antioxidant and anti-inflammatory properties, which may contribute to improved hematological profiles. *Curcumin* has been reported to enhance antioxidant defense mechanisms, decrease oxidative damage to erythrocyte membranes, and promote systemic physiological stability (Islam et al., 2018). In ruminants, oxidative stress can shorten erythrocyte lifespan and impair hematological parameters; therefore, dietary antioxidants derived from phytogenic sources may help preserve erythrocyte integrity and support optimal PCV levels (Piao et al., 2023; Wang et al., 2024). Recent feeding trials in sheep supplemented with herbal additives, including turmeric-based formulations, demonstrated improvements in Hb and PCV levels within physiological ranges, consistent with the findings of the present study (Valenzuela-Grijalva et al., 2017).

From a nutritional perspective, Hb synthesis in ruminants is closely linked to protein metabolism. Microbial protein produced in the rumen is the primary source of absorbable amino acids for the animals and is crucial for supporting erythropoiesis (Priyashantha et al., 2026). Phytogenic additives such as turmeric may modulate rumen fermentation patterns, enhance microbial efficiency, and improve nitrogen utilization (Mapiye et al., 2026). Improved rumen microbial protein synthesis increases the availability of essential amino acids required for globin formation, thereby facilitating Hb synthesis and erythrocyte maturation (Tian et al., 2023). The sustained increase in Hb and PCV in sheep fed 5% turmeric indicated improved protein utilization and an enhanced metabolic state. Importantly, erythrocytes in sheep are relatively small but occur in large numbers, making the PCV particularly sensitive to minor alterations in erythropoietic activity and plasma volume dynamics (Tüfekci and Sejian, 2023). The observed increases remained within normal physiological limits (Jiang et al., 2019), indicating improved hematological homeostasis rather than pathological polycythemia. Collectively, the current findings indicated that dietary turmeric at 2.5% and 5% may enhance erythropoietic activity and systemic physiological resilience, potentially through antioxidant mechanisms, and improve rumen microbial protein synthesis.

Total plasma protein

Total plasma protein values in Table 2 ranged from 6.50 to 6.80 g/dL across dietary turmeric supplementation groups, remaining within the established physiological reference range for sheep (6.0-7.9 g/dL; Sultan, 2023). The current findings indicated that turmeric supplementation up to 5% did not adversely affect hepatic synthetic function or systemic hydration status. In small ruminants, the concentration of TPP is frequently utilized as a reliable indicator of liver function, nutritional status, immune competence, and fluid balance (Newcomer et al., 2021; Očenáš et al., 2025).

Plasma proteins in sheep consist primarily of albumin and globulins. Albumin plays a vital role in maintaining colloid osmotic pressure and transporting endogenous and exogenous compounds, whereas globulins are largely associated with immune function and inflammatory responses (Newcomer et al., 2021). Notable deviations in TPP levels are frequently associated with inflammatory disorders, parasitic infestations, dehydration, or hepatic dysfunction (Očenáš et al., 2025). The lack of notable changes observed in the current study indicated that the inclusion of dietary turmeric did not induce systemic inflammatory stress or liver dysfunction.

Phytogenic feed additives, such as turmeric, are recognized for their hepatoprotective and antioxidant properties, which are attributed to bioactive compounds, including curcuminoids and essential oils (Hashemzadeh, 2022). Curcumin has been reported to enhance hepatic antioxidant defense systems, reduce oxidative stress, and stabilize cellular membranes (Ntsongota et al., 2025). In ruminants, oxidative stress and subclinical inflammation can negatively affect protein metabolism and plasma protein synthesis (Amalraj et al., 2016). Thus, the consistent TPP levels in sheep given 2.5% and 5% turmeric likely indicated preserved liver synthetic function and stable protein metabolism. Furthermore, in ruminants, plasma protein levels are strongly linked to dietary protein intake and to rumen microbial protein production, which provides most of the animal's absorbable amino acids (Wang et al., 2024). Phytogenic additives have demonstrated the ability to modulate rumen fermentation and enhance nitrogen utilization efficiency (Mapiye et al., 2026). The maintenance of TPP within the normal physiological range in the present study suggested that turmeric supplementation did not compromise rumen protein metabolism but instead supported stable systemic protein homeostasis. Therefore, the consistent plasma protein profile across treatment groups suggested that incorporating up to 5% dietary turmeric preserved protein levels, further supporting the safety and physiological compatibility of turmeric as a phytogenic feed additive in ovine nutrition.

Blood glucose

Blood glucose concentration decreased progressively across dietary turmeric treatment groups, from 60.00 ± 6.27 mg/dL in the control group to 48.25 ± 16.50 mg/dL in Group P2 (Table 2). In ovine species, physiological blood glucose concentrations are generally lower than those observed in monogastric species, typically ranging from 40 to 70 mg/dL (Newcomer et al., 2021). All values recorded in the present study remained within the normal physiological range, indicating that the inclusion of turmeric up to 5% did not induce hypoglycemia or metabolic imbalance (Mapiye et al., 2026).

The relatively low glucose levels in ruminants reflect their metabolic adaptation, in which dietary carbohydrates are fermented by rumen microbes rather than digested directly by enzymes (Wang et al., 2024). This fermentation produces volatile fatty acids, mainly acetate, propionate, and butyrate, which function as the primary energy sources (Wang et al., 2024). Propionate serves as the primary glucogenic precursor, supporting hepatic gluconeogenesis and thereby maintaining systemic glucose homeostasis. Therefore, in sheep, blood glucose levels primarily depend on rumen fermentation and hepatic gluconeogenesis, rather than on direct glucose absorption (Chen et al., 2025). The moderate reduction in glucose concentration observed in the turmeric-supplemented groups may reflect improved metabolic efficiency or enhanced peripheral glucose utilization, rather than indicating a pathological effect. Phytogenic additives such as turmeric can modify rumen fermentation and improve nutrient utilization (Mapiye et al., 2026). In addition, curcumin (the main bioactive compound in turmeric) has been associated with improved insulin sensitivity and carbohydrate metabolism through antioxidant and anti-inflammatory mechanisms (Ntsongota et al., 2025).

The high SD observed in Group P2 indicated considerable individual differences in glucose response. In sheep, such variability may result from differences in feed intake, social hierarchy, stress responses, and rumen microbial composition, all of which can affect propionate production and hepatic gluconeogenesis (Mapiye et al., 2026). Therefore, differences in glucose levels likely reflect normal biological fluctuations rather than metabolic instability due to the treatment. Overall, the reduction in blood glucose levels with increasing turmeric inclusion (0-5%) stayed within normal physiological ranges (Jiang et al., 2019), possibly indicating an adaptive metabolic response linked to rumen fermentation efficiency and peripheral energy utilization. The current findings suggested that dietary turmeric supplementation may influence carbohydrate metabolism without compromising metabolic homeostasis in sheep.

Low-density lipoprotein and lipid metabolism

Low-density lipoprotein concentration in Table 2 increased from 19.00 ± 4.54 mg/dL in the control group to 23.25 ± 5.05 mg/dL in Group P2. In ruminants, including sheep, lipid metabolism differs substantially from that of monogastric species due to the extensive ruminal biohydrogenation of dietary unsaturated fatty acids. Consequently, the circulating levels of total cholesterol and lipoprotein fractions in sheep are typically lower and are metabolically regulated in a distinct manner compared to humans and other monogastric species (Cheng et al., 2025; Mapiye et al., 2026). In ruminants, lipoproteins primarily function to transport endogenously synthesized lipids rather than directly absorbed dietary lipids. Low-density lipoprotein plays a key role in delivering cholesterol from the liver to peripheral tissues, where it supports membrane formation, steroid hormone production, and cellular metabolism. Studies conducted in Asia indicated that moderate increases in LDL concentration in sheep and goats can reflect adaptive lipid mobilization associated with changes in dietary composition and energy balance rather than pathological dyslipidemia (Xue et al., 2021; Cheng et al., 2025).

Phytogenic feed additives, including turmeric, contain bioactive compounds such as curcuminoids that may influence lipid metabolism by modulating hepatic lipid synthesis and antioxidant status. Studies from Asian livestock management systems have demonstrated that plant-based feed additives can modify serum lipid profiles in small ruminants without inducing adverse metabolic effects, particularly when values remain within physiological ranges (Mapiye et al., 2026; Zhao et al., 2023). Additionally, curcumin has been reported to regulate lipid metabolism by modulating hepatic enzymes involved in cholesterol synthesis and lipoprotein transport, thereby promoting metabolic adaptation rather than pathological lipid accumulation (Cheng et al., 2025). In ruminants, it is crucial to interpret LDL concentrations considering the species-specific physiological limits (Jiang et al., 2019). When there are no elevated inflammatory markers or signs of hepatic dysfunction, moderate increases in LDL are generally regarded as a normal metabolic response to dietary interventions (Očenáš et al., 2025). In the present study, LDL values remained within the normal range for sheep (Jiang et al., 2019), indicating that including turmeric up to 5% might affect lipid transport without causing metabolic disorder. Collectively, the observed increase in LDL concentration in Group P2 likely represented an adaptive response in hepatic lipid transport and peripheral cholesterol utilization associated with dietary turmeric supplementation, rather than a pathological alteration in lipid metabolism.

CONCLUSION

Dietary supplementation with turmeric (*Curcuma domestica*) at 2.5% and 5% in sheep feed modulated hematological and metabolic parameters without exceeding physiological reference ranges. The increases in Hb, PCV, and LDL concentrations, along with stable TPP and reduced blood glucose levels within normal limits, indicated adaptive improvements in erythropoiesis, protein utilization, lipid transport, and energy metabolism rather than pathological alterations. However, the present study was limited by a relatively small sample size and a short experimental duration, which may restrict the generalizability of the findings regarding long-term physiological responses to turmeric supplementation. Therefore, further studies involving larger animal populations, extended feeding periods, and additional biomarkers related to antioxidant status, immune response, and rumen fermentation are recommended to elucidate the underlying mechanisms and optimize the dietary inclusion level of turmeric in small ruminant production systems.

DECLARATIONS

Acknowledgments

The authors gratefully acknowledged the valuable contributions and assistance of all parties who supported the successful completion of this study, particularly the Institute for Research and Community Service (LPPM) of the University of Lampung, Indonesia, for its facilitation and support throughout the study's implementation.

Authors’ contributions

Aini Alfisyahri, Anhar Sukron Hanif, Fathma Choir Andini, and Abdurrochman Sholeh contributed to data curation, formal analysis, investigation, and writing the original draft of the study. Purnama Edy Santosa and Sri Suharyati contributed resources, supervision, and validation, and participated in the drafting, review, and editing processes. Arif Qisthon, Liman Liman, Lusia Komala Widiastuti, and Anggi Derma Tungga Dewi contributed to visualization, data curation, and writing the original draft of the study. Kusuma Adhianto and Muhtarudin Muhtarudin were responsible for conceptualization, methodology, project administration, and writing, reviewing, and editing the manuscript. All authors have read and approved the final edition of the manuscript.

Availability of data and materials

All data generated or analyzed during the present study are included in this published article. Additional data supporting the findings of the present study are available from the corresponding author upon reasonable request.

Competing interests

The authors declared no conflict of interest regarding the publication of this study.

Ethical considerations

All authors have carefully reviewed and confirmed that the manuscript complies with ethical standards in scientific publication. Issues related to plagiarism, consent to publish, research misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been thoroughly examined and are not present in the current manuscript. The authors declared that the manuscript is original, has not been published previously, and is not under consideration for publication elsewhere. The authors confirmed that no AI tools were used to conduct and prepare the present study.

Funding

This study was financially supported by Universitas Lampung, Indonesia, through the BLU Professor Research Scheme under Contract No. 2045/UN26.21/PN/2025

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