

Effect of organic chromium on the selected hematological profile of male Jawarandu goats under transportation stress

Pengaruh kromium organik terhadap profil hematologis kambing Jawarandu jantan yang mengalami stres transportasi

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ABSTRACT

This study aimed to evaluate the effect of organic chromium supplementation on the physiological and hematological responses of male Jawarandu goats subjected to transportation stress. Nine adult male goats aged 1-2 years with an average body weight of 30.84 kg were used consisting of three treatments with three replications: T0 (no supplementation), T1 (0.5 ppm organic chromium), and T2 (1 ppm organic chromium). Transportation was carried out over a distance of 289 km with a travel time of 5 hours using an open-back pickup truck without providing feed or water. The observed parameters included total protein (refractometer), packed cell volume (PCV), basophils, eosinophils, and monocytes, measured before and after transportation. The results showed that organic chromium supplementation had no significant effect on total protein, basophils, eosinophils, and monocytes, but significantly affected PCV values. PCV values across all groups remained within the normal range for ruminants (22-38%), with a decrease in T1 indicating a role in reducing hemoconcentration, and an increase in T2 suggesting a function in maintaining red blood cell levels.

ABSTRAK

Penelitian ini bertujuan untuk mengevaluasi pengaruh suplementasi kromium organik terhadap respon fisiologis dan hematologis kambing Jawarandu jantan yang mengalami stres transportasi. Kambing berumur 1-2 tahun dengan bobot rata-rata 30,84 kg digunakan dalam penelitian dengan rancangan acak lengkap terdiri dari tiga perlakuan dan tiga ulangan: P0 (tanpa suplementasi), P1 (0,5 ppm kromium organik), dan P2 (1 ppm kromium organik). Transportasi dilakukan sejauh 289 km dengan waktu tempuh selama 5 jam menggunakan kendaraan bak terbuka tanpa pemberian pakan maupun minum. Parameter yang diamati meliputi total protein refraktometer, PCV hematokrit, basofil, eosinofil, dan monosit yang diambil sebelum dan setelah transportasi. Hasil penelitian menunjukkan bahwa suplementasi kromium organik tidak berpengaruh nyata terhadap total protein, basofil, eosinofil, dan monosit, namun memberikan pengaruh signifikan terhadap PCV hematokrit. Nilai PCV pada seluruh kelompok masih dalam kisaran normal (22-38%), dengan penurunan pada P1 yang mengindikasikan peran dalam menekan hemokonsentrasi, serta peningkatan pada P2 yang menunjukkan fungsi dalam mempertahankan jumlah sel darah merah.

Kata kunci:
Profil hematologis
Kambing Jawarandu
Kromium organik
Stres transportasi

INTRODUCTION

As small ruminants, goats play a strategic role in supporting global food security (Budisatria et al., 2021). The goat farming sector has

experienced rapid growth, as goats are raised by many communities worldwide, including in Indonesia (Koluman, 2023; Lu, 2023). Compared to large ruminants, goats possess several advantages, such as high adaptability to diverse



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agroecosystem conditions, relatively modest feed requirements, and simple management practices that are suitable for smallholder farmers (Koluman, 2023). These characteristics establish goats as a strategic livestock commodity that contributes significantly to food security, income generation, and the overall welfare of rural households. In addition to their economic importance, goats also serve essential socio-economic functions, frequently acting as family assets, a form of financial savings, and a readily tradable resource to meet urgent needs. Moreover, in certain regions, goats hold cultural and religious significance, particularly as sacrificial animals or as part of traditional community practices (Budisatria et al., 2021).

Indonesia is one of the countries where many people raise goats. Of the various goat breeds that are widely raised by the people, one of them is the Jawarandu goat (also known as the Bligon goat in other areas), which is the result of a cross between a male Kacang goat with a fat body characteristic and a female Etawa crossbred goat with a tall body characteristic (Widiastuti et al., 2022; Ashshaadiq et al., 2024). The Jawarandu goat has the characteristics of having a fat body originating from the male parent and a height originating from the female parent. Increasing the productivity of goat livestock does not only depend on genetic aspects, but also environmental factors, namely management which includes post-harvest livestock handling management and distribution (Ogwu et al., 2024).

Transportation plays an important role in the livestock distribution chain as it connects farmers, collectors, markets, and consumers across various destinations. This process is inseparable from the animal-based food supply system, particularly in meeting the demand of local and regional markets (Bhatt et al., 2021). However, transportation is also recognized as one of the main stressors affecting livestock. Several studies have reported that during transportation, animals are frequently exposed to stress-inducing conditions such as loading and unloading, high stocking density, vehicle vibrations, temperature fluctuations, and limited access to feed and water (Meléndez et al., 2020; Meléndez et al., 2021).

The factors that induce stress during livestock transportation are diverse and interact in a complex manner. In general, these stressors can be classified into three main categories:

physical, physiological, and psychological. Physical factors include vehicle-induced vibrations, excessive stocking density, exposure to extreme temperatures, and potential fighting among animals due to restricted movement (Buckham-Sporer et al., 2023). Physiological factors encompass fatigue resulting from long journeys, dehydration caused by limited water availability, and hunger due to the absence of feed during transport (van Dijk et al., 2023). Meanwhile, psychological stressors may arise from fear triggered by handling procedures, exposure to loud noises, and rough human interactions during loading and unloading (Vogel et al., 2024). The combination of these stressors does not act independently but instead reinforces one another, creating mechanisms that define transportation stress as a multidimensional and complex condition. This complexity leads to significant alterations in animal physiology, behavior, and health, with direct implications for animal welfare, product quality, and the overall efficiency of livestock production systems (Buckham-Sporer et al., 2023; van Dijk et al., 2023).

During transportation, energy loss in livestock is compensated by the mobilization of hepatic and muscular glycogen into the systemic circulation as the primary source of glucose (Minka et al., 2007). The utilization of glucose by cells is highly dependent on the role of insulin secreted by the pancreas, since insulin facilitates the translocation of glucose transporters and promotes glucose entry into cells, where it is subsequently oxidized to produce energy (Kahn, 1994; Lutz, 2023). These conditions lead to increased mobilization of body energy reserves through the breakdown of glycogen and fat, thereby contributing to body weight loss and prolonging the post-transport recovery period before animals return to normal physiological conditions (van Dijk et al., 2023). In addition, elevated stress hormones such as cortisol can suppress immune function and disrupt metabolic homeostasis, ultimately reducing production efficiency and animal welfare (Vogel et al., 2024).

Under transportation stress, elevated cortisol levels may interfere with insulin function, leading to insulin resistance and reduced efficiency of glucose utilization (Qiao et al., 2024). Recent studies have demonstrated that organic chromium (Cr^{3+}) supplementation can enhance

insulin sensitivity, improve glucose metabolism, and support energy balance in ruminants subjected to stress (Liu et al., 2017; Zarczynska et al., 2020; Hung et al., 2021).

Organic chromium supplementation has been reported to improve glucose metabolism and enhance hematological stability in livestock under stress conditions. Chromium functions as a cofactor that potentiates insulin action, thereby facilitating glucose uptake and utilization for energy production (Hernández-García et al., 2024). In ruminants, the improvement of insulin sensitivity through chromium supplementation not only contributes to maintaining energy balance but also helps in sustaining hematological homeostasis, which is essential for supporting oxygen transport, immune responses, and overall physiological adaptation during transportation stress (Zarczynska et al., 2020; Hung et al., 2021). The level of transportation-induced stress can be evaluated by measuring physiological parameters (such as body temperature, heart rate, and respiratory rate) and hematological parameters (such as hematocrit, hemoglobin, and leukocyte count), as these indicators reflect the state of body homeostasis and the health status of livestock during and after exposure to stress (Meléndez et al., 2020; van Dijk et al., 2023). Therefore, physiological and hematological analyses serve as important indicators for assessing the impact of transportation stress as well as the effectiveness of chromium supplementation in maintaining sheep productivity.

Despite growing evidence regarding the benefits of organic chromium in stress mitigation, studies specifically focusing on its effects on the hematological profile of male Jawarandu goats during transportation remain limited. Given that Jawarandu goats are widely farmed in Indonesia for their dual-purpose traits, understanding how chromium supplementation influences their physiological resilience under stressful conditions is of both scientific and practical importance. This study, therefore, aims to evaluate the effect of organic chromium supplementation on the hematological parameters of male Jawarandu goats subjected to transportation stress, thereby providing novel insights into nutritional strategies to improve animal welfare and productivity under challenging environmental conditions.

MATERIALS AND METHODS

The experimental animals consisted of nine adults male Jawarandu goats, 1-2 years of age, with an average body weight of 30.84 kg. All goats had undergone an acclimatization period in their pen, during which they were provided with green fodder, concentrate, and ad libitum water prior to transportation. During transportation, livestock are generally not provided with drinking water to prevent the risk of aspiration due to vehicle movement and to reduce additional stress caused by handling in confined spaces, and this practice is physiologically tolerable for short journeys as long as the animals are promptly given water upon arrival at the destination.

Experimental Design

A completely randomized design was employed in this study, consisting of three treatments with three replications, as follows:

T0: no organic chromium supplementation (control)

T1: 0.5 ppm organic chromium supplementation

T2: 1 ppm organic chromium supplementation

The organic chromium utilized in this study was provided in powdered form and encapsulated under the trade name Swanson GTF Chromium, with each capsule containing 100 mg of organic chromium. The product was manufactured by Swanson in the United States and was distributed internationally through Swanson Health Products. To ensure homogeneity and complete consumption by the experimental animals (male Jawarandu goats), the organic chromium was mixed thoroughly with grade A rice bran and administered prior to the provision of forage and concentrate. The rice bran premixed with organic chromium was provided in the morning (07:00-08:00 Western Indonesian Time) and was ensured to be fully consumed before the goats were offered their primary feed.

Transportation Procedure

The goats were transported from Tegineneng Sub-district, Pesawaran Regency, Lampung Province, to Sukarami Sub-district, Palembang City, South Sumatra Province (Figure 1) in the morning using an open-back pickup truck. The journey covered a distance of 289 kilometers and lasted approximately 5 hours, with an average vehicle speed of 60-80 km/hour.

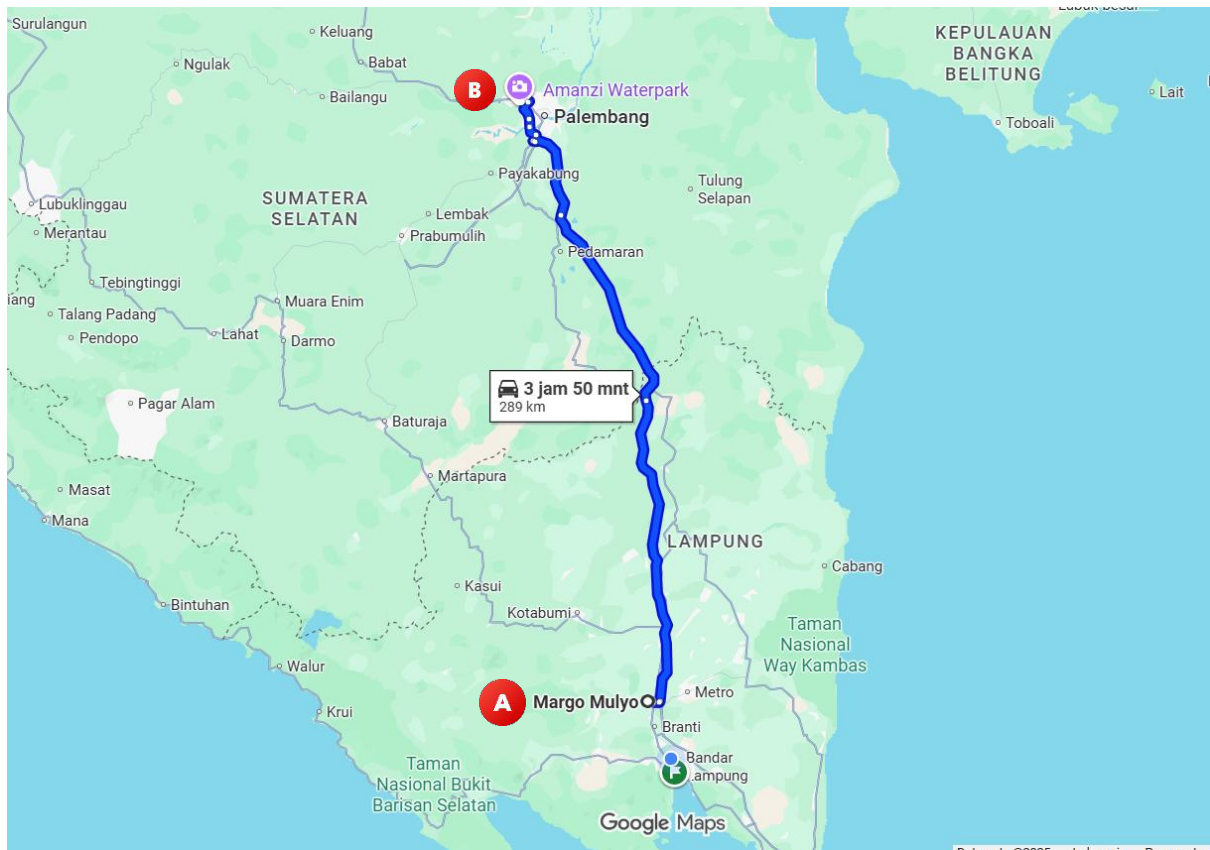


Figure 1. Distance traveled from the point of departure (A) to the destination point (B) (Captured from Google Maps)

During transportation, the animals were not provided with either feed or drinking water.

Hematological Parameter Measurement

Hematological parameters were measured in each goat before and after transportation. Prior to transportation, total protein was determined using a refractometer (g/dL), packed cell volume (PCV) was assessed using a hematocrit centrifuge (%), and the proportions of basophils (%), eosinophils (%), and monocytes (%) were recorded. After transportation, the same parameters consisting of total protein (g/dL), PCV (%), basophils (%), eosinophils (%), and monocytes (%) were remeasured. Delta (Δ) values were subsequently calculated to represent the effects of transportation on the hematological status of the goats, both without supplementation and with organic chromium supplementation.

Total protein refractometer

Total blood protein was measured using a handheld refractometer. Blood samples were collected from the jugular vein and centrifuged at 3,000 rpm for 10-15 minutes to obtain serum or plasma. The refractometer was calibrated with

distilled water to obtain a zero reading. One to two drops of serum/plasma were placed on the refractometer prism, and the total protein value was read directly in g/dL. The refractometric method is based on measuring the refractive index of the solution, which correlates with protein concentration and has been shown to have good agreement with the Biuret method in ruminants (Mesa et al., 2024).

Packed cell volume

Packed cell volume (PCV) was determined using the microhematocrit method. Blood samples were collected from the jugular vein into tubes containing EDTA as an anticoagulant. Capillary tubes were filled to approximately three-quarters of their length with well-mixed blood and sealed at one end with clay. The tubes were centrifuged in a microhematocrit centrifuge at 10,000-12,000 rpm for 5 minutes. After centrifugation, the length of the packed red blood cell column and the total length of the blood column were measured using a microhematocrit reader, and PCV was expressed as a percentage (Meléndez et al., 2020; van Dijk et al., 2023).

$$\text{PCV (\%)} = \frac{\text{Height of packed red blood cells}}{\text{Total height of blood column}} \times 100$$

Basophils

Basophil count was determined using the blood smear and differential leukocyte count method. Blood samples were collected from the jugular vein into EDTA tubes. A thin blood smear was prepared on a clean glass slide, air-dried, and stained with Giemsa or Wright stain. The smear was examined under a light microscope using oil immersion (1,000× magnification). A total of 100 leukocytes were counted, and the number of basophils was recorded and expressed as a percentage of total leukocytes (Rao et al., 2016).

Eosinophils

Eosinophil levels were determined using the blood smear and differential leukocyte count method. Blood samples were collected from the jugular vein into EDTA tubes, and thin blood smears were prepared on clean glass slides. The smears were air-dried, fixed, and stained with Giemsa or Wright stain. Differential leukocyte counts were performed under a light microscope at 1,000× magnification using oil immersion by counting 100 leukocytes, and the proportion of eosinophils was expressed as a percentage of total leukocytes (Arsenopoulos et al., 2025; Pizetti et al., 2021).

$$\text{Eosinophils (\%)} = \frac{\text{Number of eosinophils counted}}{\text{Total leukocytes counted}} \times 100$$

Monocytes

Monocyte levels in goat blood were determined using the differential leukocyte count method. Blood samples were collected into EDTA tubes and thin smears were prepared on glass slides, air-dried, stained with Wright or Giemsa stain, and examined under oil immersion (1,000× magnification). A total of 100 leukocytes were counted, and monocytes were expressed as a percentage of the total leukocytes, which reflects the immune and inflammatory status of the animal. Differential leukocyte profiling, including monocyte proportion, is routinely used in caprine hematological assessments to monitor physiological and pathological changes, with typical values falling within reference intervals reported for healthy goats (Arsenopoulos et al., 2025).

Data Analysis

Statistical analysis was performed using the General Linear Model (GLM) Repeated Measures procedure at a significant level of 5% (0.05) with IBM SPSS Statistics version 26 (IBM Corp., Armonk, NY, USA). This approach was applied to evaluate whether significant differences occurred among the treatment groups. When significant effects were detected, post hoc comparisons were conducted using the Least Significant Difference (LSD) method to further identify specific group differences.

RESULTS AND DISCUSSION

The results of this study demonstrated that organic chromium supplementation in Jawarandu goats (Figure 1) subjected to transportation stress exerted varying effects on the observed physiological and hematological parameters. Data analysis using the General Linear Model (GLM) Repeated Measures indicated that significant differences were detected in several parameters among the treatment groups. These findings support the hypothesis that organic chromium plays a role in enhancing the physiological resilience of Jawarandu goats under stress conditions induced by transportation.

Total Protein Refractometer

The results of the study indicated an increase in total protein (TP) concentrations after transportation across all treatment groups, although the increase was not statistically significant ($P > 0.05$) (Table 1). This elevation in TP was most likely associated with a hemoconcentration effect caused by relative dehydration (Stull et al., 2000), as the goats were not provided with drinking water during transportation. This condition is consistent with previous research that transportation stress can alter plasma volume and subsequently affect protein concentrations in the blood (Knowles et al., 2007; Goetz et al., 2023).

In this study, organic chromium supplementation did not result in significant differences in TP levels among treatment groups. This finding is consistent with several meta-analyses reporting that chromium supplementation, whether in organic or inorganic forms, does not consistently influence serum total protein concentrations in ruminants

Table 1. Hematological profile of Jawarandu goats supplemented with organic chromium before and after transportation stress

Variables	Treatment (Mean ± Standard Deviation)			Standard Error	p-value
	T0	T1	T2		
Total protein refractometer (g/dL)					
Before transportation	7.20±0.35	7.27±0.23	7.07±0.50		
After transportation	7.80±0.40	7.60±0.53	8.20±0.35	0.307	0.810
Delta (Δ) ^{ns}	+0.60	+0.33	+1.13		
PCV hematocrit centrifuge (%)					
Before transportation	27.67±4.73	27.67±1.53	25.33±4.51		
After transportation	28.33±4.51	26.67±2.08	28.33±6.11	3.400	0.029
Delta (Δ)	+0.67 ^a	-1.00 ^a	+3.00 ^b		
Basophils (%)					
Before transportation	0.00±0.00	0.00±0.00	0.33±0.58		
After transportation	0.00±0.00	0.00±0.00	0.00±0.00	0.136	0.422
Delta (Δ) ^{ns}	0.00	0.00	-0.33		
Eosinophils (%)					
Before transportation	10.33±10.07	7.33±8.74	8.67±8.62		
After transportation	0.33±0.58	0.00±0.00	0.67±1.15	3.820	0.932
Delta (Δ) ^{ns}	-10.00	-7.33	-8.00		

Note: Different superscripts (a, b) within the same row indicate significant differences (P<0.05). ns: non-significant (P > 0.05). (+) indicates an increase; (-) indicates a decrease.

(Hernández-García et al., 2024; Lalhriatpui et al., 2024; Shoshina, 2024). The effects of chromium have been more frequently observed on energy metabolism, glucose regulation, and endocrine responses rather than on blood protein parameters.

Nevertheless, other studies have reported that organic chromium may exert positive effects on the physiological and immune responses of animals, particularly under stressful conditions (Glombowsky et al., 2024). The absence of significant changes in TP observed in the present study may be attributed to the relatively short duration of supplementation or the use of suboptimal doses. Therefore, further investigations with varying dosages and extended supplementation periods are required to evaluate the potential effects of organic chromium on the blood protein status of goats (Uyanik et al., 2002).

An increase in blood total protein levels after transportation reflects a physiological response of livestock to transport-related stress associated with alterations in fluid balance and metabolic processes (Bhatt et al., 2021). During transportation, animals are often subjected

to restricted water intake, elevated ambient temperatures, and increased physical activity, which may lead to mild dehydration. This condition reduces plasma volume and results in hemoconcentration, thereby relatively increasing total protein concentration without an actual rise in absolute protein content (Nielsen et al., 2011). Several studies have reported that changes in blood biochemical parameters, including total protein and albumin, serve as important indicators of disrupted homeostasis due to transportation stress in ruminants.

In addition to hydration status, elevated total protein levels following transportation may also be associated with immune activation and inflammatory responses. Transportation stress can stimulate the synthesis of acute-phase proteins such as haptoglobin and serum amyloid A, which belong to the globulin fraction and contribute to the increase in total blood protein (El-deeb et al., 2014). This response indicates that the animals are undergoing physiological adaptation to stress experienced during transit. However, total protein should not be used as a single indicator of transportation stress and

must be interpreted in conjunction with other physiological and hematological parameters, including hematocrit, leukocyte count, and stress-related hormones such as cortisol, to obtain a more comprehensive assessment of the animals' stress status (Adhikari et al., 2022). Consequently, an increase in total protein after transportation may indicate the presence of transport-induced stress when supported by concurrent changes in other health-related parameters (Cacciatore et al., 2024).

Packed Cell Volume

The study observed changes in PCV and total protein (TP) levels in Jawarandu goats before and after transportation. The control group (T0) exhibited an increase in PCV from $27.67 \pm 4.73\%$ to $28.33 \pm 4.51\%$ ($\Delta + 0.67$), while the 0.5 ppm organic chromium group (T1) showed a decrease from $27.67 \pm 1.53\%$ to $26.67 \pm 2.08\%$ ($\Delta - 1.00$), and the 1 ppm organic chromium group (T2) had an increase from $25.33 \pm 4.51\%$ to $28.33 \pm 6.11\%$ ($\Delta + 3.00$) (Table 1). In contrast, TP levels did not show significant changes across all groups ($\Delta + 0.33$ to $+1.13$ g/dL). These findings suggest that PCV is more sensitive to short-term physiological changes, such as dehydration during transportation, compared to TP, which remained stable despite the variations in PCV.

Hematocrit reflects the proportion of red blood cells in the blood and can rapidly change in response to fluid shifts, such as dehydration or stress (Bonnin et al., 2016; Johnstone et al., 2017). Total protein, primarily composed of albumin and globulins, is less susceptible to immediate fluctuations and typically requires longer periods to exhibit significant changes (Belinskaia et al., 2021). The observed increase in PCV in the control and T2 groups likely indicates hemoconcentration due to dehydration, whereas the lack of significant change in TP suggests that the protein synthesis mechanisms were not acutely affected during the study period.

The T2 group, receiving 1 ppm organic chromium supplementation, demonstrated the highest increase in PCV, suggesting that organic chromium may enhance the goats' ability to maintain red blood cell concentration during stress (Ghanima et al., 2020). Chromium supplementation has been reported to influence glucose metabolism and insulin sensitivity, which can affect overall energy metabolism and fluid

balance in ruminants (Lashkari et al., 2018; Malik et al., 2024). These metabolic adjustments could contribute to the observed changes in hematocrit levels.

Organic chromium supplementation at a dose of 0.5 ppm affects PCV values due to its role in regulating energy metabolism and maintaining fluid balance as well as hematological stability under stress conditions. Chromium is a component of the glucose tolerance factor (GTF) that enhances insulin sensitivity and improves cellular glucose utilization (Lashkari et al., 2018; Hung et al., 2021). Under transportation stress, elevated cortisol levels may impair insulin action and disrupt energy metabolism. Supplementation with chromium at a moderate dose (0.5 ppm) helps stabilize this metabolic response, thereby meeting energy requirements without excessive mobilization of body reserves, including blood components.

In addition, chromium at a dose of 0.5 ppm is suggested to play a role in maintaining fluid balance and preventing excessive hemoconcentration due to dehydration during transportation. PCV is highly sensitive to changes in plasma volume; fluid loss leads to an apparent increase in PCV as a result of red blood cell concentration. Chromium supplementation at this level may promote a more stable physiological adaptation to stress, allowing fluctuations in PCV to be minimized and maintained within the normal range. This finding is consistent with reports by Zarczynska et al. (2020; Malik et al. (2024), which indicate that low to moderate levels of organic chromium supplementation can help preserve hematological homeostasis and support metabolic function in stressed ruminants. Thus, the effect of 0.5 ppm organic chromium on PCV reflects its role as a nutritional agent that contributes to maintaining blood physiological stability during transportation stress without inducing excessive increases in hematocrit.

The PCV values in all groups of goats remained within the normal range for ruminants (22-38%), indicating that no signs of anemia or severe dehydration were detected. In the control group (T0), PCV slightly increased after transportation, a condition considered normal since transportation may lead to fluid loss. In the group supplemented with 0.5 ppm chromium (T1), PCV showed a slight decrease, suggesting that supplementation at this level may have

helped to suppress hemoconcentration effects associated with dehydration. In contrast, in the group supplemented with 1 ppm chromium (T2), a more pronounced increase in PCV was observed, although still within the normal range. This finding may be interpreted as evidence that chromium supplementation at 1 ppm contributed to maintaining red blood cell levels during transportation-induced stress.

Despite the variations in PCV, TP levels did not exhibit significant differences across the treatment groups. This lack of change in TP may be attributed to the relatively short duration of the supplementation period and the specific metabolic pathways influenced by chromium (Edmonds et al., 2024). While chromium has been shown to affect protein metabolism, its impact on plasma protein concentrations may require longer supplementation periods or higher dosages to become evident (He et al., 2023; Falcón-Martínez et al., 2025).

Chromium supplementation can influence hematocrit levels in male Jawarandu goats under transportation stress, likely through mechanisms related to energy metabolism and fluid balance. However, the lack of significant changes in total protein suggests that the effects of chromium on protein metabolism may be more subtle or require longer periods to manifest. Future research should focus on varying the dosage and duration of chromium supplementation and include additional biomarkers to comprehensively assess its impact on protein metabolism and overall health in ruminants (Kumar, 2008; Lalhriatpuii et al., 2024; Lashkari et al., 2018).

Basophils

Basophils are classified as one of the granulocyte leukocytes that play an important role in immune mechanisms, particularly those related to allergic and inflammatory responses (Miyake et al., 2017; Zhang et al., 2021). An increase in basophil counts in certain groups can be interpreted as an indication of immune system activation in response to external stressors, as transportation is recognized as one of the major triggers of physiological stress in ruminants (Earley et al., 2017; Singh et al., 2025). The results of this study indicated that the basophil count in Jawarandu goats did not significantly among treatment groups (Table 1), despite supplementation with organic chromium at

levels of 0.5 ppm and 1 ppm. This finding may be interpreted as evidence that the doses of organic chromium applied in this study were insufficient to exert a direct effect on basophil dynamics. This is consistent with the report by Wang et al. (2007; Shofaroh et al., 2024) and which demonstrated that chromium supplementation more consistently affects energy metabolism and endocrine responses rather than specific immune parameters such as granulocytic leukocytes.

Furthermore, the mechanism of action of organic chromium has been shown to be more closely associated with enhancing insulin sensitivity, modulating glucose metabolism, and reducing oxidative stress (He et al., 2023). Therefore, its impact on basophil populations is likely indirect and may require higher doses or longer supplementation periods to become significant. This observation is consistent with previous reports stating that chromium supplementation predominantly influences energy metabolism, enhances insulin sensitivity, and regulates oxidative stress rather than directly affecting specific leukocyte populations, including basophils (Haldar et al., 2009; Lashkari et al., 2018; He et al., 2023). Therefore, although a tendency for changes in basophil counts was observed, these differences were not statistically significant.

Physiologically, an increase in basophil count is typically associated with the release of histamine Levani (2023) and other inflammatory mediators that may be triggered by transportation-induced stress. However, in the present study, basophil values remained relatively stable across all groups, suggesting that the transportation stress experienced by the goats was not sufficiently severe to elicit an excessive allergic or inflammatory response. This finding is consistent with the view reported by Pratama et al. (2021; Shofaroh et al., 2024) who noted that granulocytic leukocytes, particularly basophils, rarely exhibit sharp fluctuations except under conditions of infection or specific hypersensitivity reactions.

Eosinophils

The results of this study demonstrated a decrease in the percentage of eosinophils across all treatment groups following transportation. This reduction was indicative of a stress response induced by transportation, as eosinophils are

known to be highly sensitive to physiological and environmental stress conditions. Transportation stress is associated with the release of glucocorticoid hormones, particularly cortisol, which suppresses eosinophil activity through a redistribution mechanism from the bloodstream to peripheral tissues (Adenkola et al., 2010; Kumar et al., 2023). Consequently, the reduced eosinophil levels observed after transportation may be interpreted as evidence that the goats experienced physiological stress during the transportation (Batchu et al., 2021).

Organic chromium supplementation at levels of 0.5 ppm and 1 ppm did not result in significant differences in eosinophil counts compared with the control group (Table 1). This lack of effect can be explained by the primary mechanisms of organic chromium, which are more closely related to enhancing energy metabolism, regulating insulin sensitivity, and reducing oxidative stress (Hua et al., 2012; Kooshki et al., 2021; He et al., 2023), rather than directly influencing eosinophil populations. In other words, the doses of organic chromium administered in this study were insufficient to induce measurable modifications in eosinophil levels in Jawarandu goats subjected to transportation stress.

The relatively uniform decrease in eosinophil percentages across all treatment groups suggested that the cellular immune response to transportation stress was more strongly influenced by hormonal factors than by short-term nutrient supplementation (Miller et al., 2021). Previous studies have similarly reported that chromium supplementation, whether in organic or inorganic form, does not consistently affect leukocyte profiles, including eosinophils (Malik et al., 2024). Thus, the role of chromium in stabilizing eosinophil levels may require higher dosages or extended supplementation periods (Tarun, 2018; Sheikhhossein et al., 2020).

CONCLUSIONS

This study demonstrated that organic chromium supplementation at levels of 0.5 ppm and 1 ppm did not significantly affect total protein, basophils, or eosinophils but significantly influenced packed cell volume (PCV). All PCV values remained within the normal physiological range for ruminants (22-38%), indicating no anemia or severe dehydration. However,

supplementation at 0.5 ppm reduced PCV, suggesting suppression of hemoconcentration due to fluid loss.

RECOMMENDATION

Further studies should investigate higher doses and longer supplementation periods of organic chromium to better assess its potential in modulating hematological and immunological responses in goats under transportation stress. Evaluating these factors will also help establish safe and effective dosage limits.

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ETHICAL APPROVAL

All experimental procedures involving animals were conducted in accordance with the guidelines for the care and use of laboratory/experimental animals established by the Government Regulation of the Republic of Indonesia. The experimental protocol was reviewed and approved by the Animal Ethics Committee of the Faculty of Agriculture, Universitas Lampung, Indonesia (Approval No.: [006/UNILA/KEH/EC/2025]).

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