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Blood and Hormone Profile of Kacang Goats with a *Palisada perforata* (Bory) K.W.Nam Supplemented Diet

Nur Hidayah[1,2], Cuk Tri Noviandi[3], Andriyani Astuti[3], Pradita Iustitia Sitaresmi[4] and Kustantinah[3*]

[1]Graduate Program, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta, Indonesia;
[2]Department of Animal Science, Faculty of Agriculture, Universitas Tidar, Magelang, Indonesia;
[3]Department of Animal Nutrition and Feed Science, Faculty of Animal Science,
Universitas Gadjah Mada, Yogyakarta, Indonesia; [4]Research Center for Animal Husbandry,
National Research and Innovation Agency (BRIN), Jakarta, Indonesia

[*]*Corresponding author:* kustantinah@ugm.ac.id

Abstract

Blood and hormone profile analysis can reliably determine the health status of an animal. This study aimed to test the inclusion of two levels of one red seaweed species, *Palisada perforata* (Bory) K.W.Nam (PP), at 2.50 to 5.00% organic matter (OM) in a basal diet (total mixed ration/TMR) on the blood (metabolite and hematology) and hormone (glucagon and ghrelin) profiles of Kacang goats. The study employed a randomized complete block design with three treatments and four replicates, involving 12 female Kacang goats with live weights of 23.84±5.26 and 26.96±4.10 kg. The result revealed that for the blood metabolites, supplementation of PP at 2.50% and 5.00% OM (2.97% and 5.94% dry matter, respectively) on the TMR as a basal diet increased ($p < 0.05$) the glucose and iron concentration, tended to increase ($p < 0.1$) the total protein, decreased ($p < 0.05$) the ureum and blood urea nitrogen concentration, and did not affect the cholesterol concentration in the blood of Kacang goats. TMR supplemented with PP at 5.00% OM had the lowest counts ($p < 0.01$) of white blood cells, lymphocytes, monocytes, and neutrophils. This treatment also increased ($p < 0.01$) the red blood cells and tended to increase ($p < 0.10$) the hemoglobin and hematocrit but did not affect the mean corpuscular volume, mean corpuscular hemoglobin, and mean corpuscular hemoglobin concentration of the blood. The plasma glucagon and ghrelin levels decreased ($p < 0.01$) at 5.00% OM supplementation with this seaweed. Therefore, supplementing a basal diet with PP at 5.00% OM is the optimum treatment to increase the health status of Kacang goats because it exhibits ideal blood and hormone profiles.

Keywords: feed additive; heath status; native goats; seaweed

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INTRODUCTION

Kacang goats (*Capra aegagrus hircus*), one of Indonesia's indigenous goat breeds for meat production, are used as a side business for Indonesian farmers (Khalil et al., 2019; Depison et al., 2020). This goat breed readily adapts to local conditions, has low-maintenance requirements, and reproduces while surviving with basic feeding and rearing methods (Khalil et al., 2019; Beyleto et al., 2022). Nasich et al. (2019) reported that Kacang goats are well-suited to various environmental conditions in Indonesia, including lowland and highland areas. However, like many livestock animals, their nutrition can influence their productivity and health status.

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Thus, ensuring optimal nutrition improves their immune function, reproductive performance, and overall health.

Seaweed, particularly tropical species, has emerged as a valuable feed additive because of its high content of bioactive compounds, such as polysaccharides, vitamins, minerals, and secondary metabolites that have been demonstrated to have antioxidant activity (Michalak et al., 2022). Liu and Sun (2020) revealed that seaweed-derived antioxidants can benefit animal health in various ways, including providing prebiotic, immunomodulatory, antimicrobial, anti-inflammatory, and antioxidant effects. A study by Angulo et al. (2020) reported that supplementation of *Sargassum* sp. at 2.50% and 5.00% in a basal diet increased ($p < 0.05$) the antioxidant enzymes (catalase (CAT) and superoxide dismutase (SOD)) and immune-related activities (lysozyme, anti-protease, and myeloperoxidase/MPO, and immunoglobulin A levels) in the intestinal mucus, several tissues, and goat serum, which indicates a strengthened immune system. This seaweed supplementation increases the amount of protein in the blood serum and other tissues, which is beneficial for general health.

Moreover, Kannan et al. (2007) reported that supplementing with 2.00% brown seaweed (*Ascophyllum nodosum*) extract decreased ($p < 0.05$) the eosinophil count. Furthermore, the bioactive compounds in seaweed influenced hormone regulation in livestock. Hormones are essential for controlling various physiological processes to ensure that organisms grow, reproduce, and effectively respond to environmental challenges (Bharati et al., 2023; Little and Seebacher, 2024). Hong et al. (2015) reported that adding 2.00 to 4.00% brown seaweed by-product to the basal diet of Holstein cows increased the plasma estrogen, progesterone, triiodothyronine, and thyroxine levels compared with the control treatment after three months of pregnancy.

Research on the effects of seaweed supplementation in ruminants, such as Kacang goats, especially regarding their health status (i.e., blood and hormone profiles), remains somewhat limited. In contrast, Indonesia is one of the top producers of cultivated seaweeds (Michalak et al., 2022), with a high potential as a seaweed source. Erniati et al. (2016) stated that Indonesia has the most extensive seaweed diversity globally and that 555 species of the total 8,000 species grow well in Indonesia (Soetjipto et al., 2019). *Palisada perforata* (Bory) K.W.Nam (PP) is a red seaweed species from Gunungkidul, Yogyakarta, Indonesia. Initial research by Hidayah et al. (2024) reported that PP is abundant with a rich nutrient content, especially proteins and minerals, as well as phenolic compounds; therefore, it has potential as an alternative feed additive for ruminants.

Phenolic compounds, such as phenol, tannin, and flavonoid, can decrease ruminant methane, antioxidant, antimicrobial, and anthelmintic production and reduce rumen protein degradation, thus increasing ruminant productivity (Tedeschi et al., 2021; Fonseca et al., 2023). However, to the best of researchers' knowledge, research on the *in vivo* effect of this seaweed on ruminants' health status has not been conducted. Therefore, this study aimed to test two levels of inclusion (2.50% and 5.00% organic matter (OM)) of one red seaweed species, PP, on a basal diet (total mixed ration/TMR) compared with a control diet on health status. This study assessed the effect of this inclusion on the blood (metabolite and hematology) and hormone (glucagon and ghrelin) profiles of Kacang goats.

MATERIALS AND METHOD

Experimental design and diets

This study used 12 female Kacang goats in a fully randomized complete block design with four replicates and three treatments. Due to a coefficient of variation (CV) of > 10%, the body weight was blocked, which may influence dietary intake. These treatments were the control/without seaweed supplementation (T1), which was used for Kacang goats that weighed 26.96±4.10 kg; supplementation of PP at 2.50% OM or 2.97% dry matter (DM) (T2) for Kacang goats that weighed 25.16±4.15 kg; and supplementation of PP at 5.00% OM or 5.94% DM (T3) for Kacang goats that weighed 23.84±5.26 kg. The goats were housed in separate pens with ad libitum access to water and feed. This *in vivo* experiment was conducted for 60 days, with 14 days for adaptation and 46 days for treatment. This experiment and sample analysis were performed between January and June of 2024, and all procedures were reviewed and approved by the Faculty of Veterinary Medicine Ethics Committee from Universitas Gadjah Mada (UGM), Yogyakarta, Indonesia (number: 143/EC-FKH/Eks./2024).

The daily basal diet used a TMR consisting of 60% Napier grass (*Pennisetum purpureum* cv. Gama Umami) and 40% concentrate based on the DM. The concentrate ingredients were rice brand 20.25%, wheat pollard 45.00%, soybean meal 4.25%, coconut cake meal 14.50%, corn gluten feed 10.00%, molasses 5.00%, and premix 1.00%. The Napier grass was collected from the Livestock Development Center, Faculty of Animal Science, UGM. Meanwhile, the PP was harvested from Gunungkidul Beach, Yogyakarta, Indonesia. Seaweed was spread out on a bamboo shelf for drying after being rinsed with water to remove sand and debris and reduce the salt content. The drying process was performed under a roof at approximately 25 to 30 °C for 4 days and then ground into a fine powder using a Willey mill with a 2 mm screen. Table 1 shows the nutrient content of the TMR.

Blood collection and analysis

Blood samples were taken on the last day of the total collection period. Sterile tubes filled with ethylenediaminetetraacetic acid (EDTA) as an anticoagulant (3.00 ml, BD Vacutainer, Plymouth, Devon, UK) were used to collect the blood sample from the jugular vein using a venoject needle before morning feeding. The blood sample was placed in an icebox and taken to the laboratory within 30 minutes. The serum samples were collected by centrifugation at 4,000 rpm for 10 minutes and then stored at -20 °C for future analysis.

Metabolite parameter analyses included the measurement of glucose (mg dl^{-1}), total protein (g dl^{-1}), ureum (mg dl^{-1}), blood urea nitrogen (BUN; mg dl^{-1}), cholesterol (mg dl^{-1}), calcium (mg dl^{-1}), and iron (mg ml^{-1}) levels. These parameters were evaluated using a blood hematology analyzer. Metabolite parameters were analyzed using the following methods: glucose and cholesterol (photometry with wavelength 546 nm, Photometer Microlab 300, VitalScientific, USA), total protein (photometry with wavelength 546 nm, Photometer Microlab 300, VitalScientific); ureum and BUN (urease/glutamate dehydrogenase with wavelength 357 nm, Thermo Scientific Multiskan SkyHigh Microplate Reader, Thermo Fisher Scientific Inc., USA); calcium (Photometrics Arsenazo III with wavelength 650 to 670 nm, Thermo Scientific Multiskan SkyHigh Microplate Reader, Thermo Fisher Scientific Inc.), and iron (Atomic Absorption Spectrophotometer, AA-610S, Shimadzu Co., Kyoto, Japan).

The evaluated hematology parameters, including total white blood cell (WBC, 10^9 l^{-1}), lymphocyte (10^9 l^{-1}), monocyte (10^9 l^{-1}), neutrophils (10^9 l^{-1}), and red blood cell count (RBC, 10^{12} l^{-1}), and the hemoglobin (g dl^{-1}), hematocrit (%), mean corpuscular volume (MCV, fl), mean corpuscular hemoglobin (MCH, pg), and mean corpuscular hemoglobin concentration (MCHC, g dl^{-1}) values, were determined automatically using a five-part differential hematology analyzer (VetScan HM5, Zeotis, USA). However, hormone samples were collected at the end of the treatment period. Glucagon and ghrelin analyses were performed to determine their concentration in the blood plasma using the ELISA Kit Glucagon (Bioenzy, Indonesia) and Ghrelin (Bioenzy) (Sitaresmi et al., 2024).

Statistical analysis

Duncan's multiple range test was used to evaluate differences among the treatments, and an analysis of variance (ANOVA) was used for the statistical analysis of all other data. The SPSS program was used for all analyses, and the results are presented as the mean±standard deviation.

Table 1. The nutrient content of TMR based on DM

Nutrient content	Percentage (% DM)		
	0.00% OM	2.50% OM	5.00% OM
OM	87.93	87.90	87.88
Ash	12.07	12.09	12.12
CP	12.59	12.80	13.06
EE	2.06	2.75	2.99
CF	27.13	27.43	27.72
NFE[1]	45.61	44.86	44.11
TDN[2]	60.39	60.29	60.31

Note: DM = Dry matter, OM = Organic matter, CF = Crude fiber, CP = Crude protein, EE = Extract ether, NFE = Nitrogen-free extract, TDN = Total digestible nutrient. NFE[1] = 100 × (%CP + %CF + %EE + %ash), TDN[2] = 70.6 + 0.259 CP + 1.01 EE – 0.76 CF + 0.091 NFE (Sutardi, 1980)

RESULTS AND DISCUSSION

Blood metabolite profile

Supplementation of PP at 2.50% and 5.00% OM on TMR as a basal diet increased ($p < 0.05$) the glucose and iron concentrations, tended to increase ($p < 0.1$) the total protein, decreased ($p < 0.05$) the ureum and BUN concentrations, and did not affect the cholesterol concentration in the blood of the Kacang goats (Table 2). The measured blood metabolites in this study were within the normal healthy range for goats (Stevens et al., 1994; Kaneko et al., 2008; Mohammed et al., 2016). The higher glucose concentration observed in T2 and T3 than in the control treatment was because PP supplementation increased ($p < 0.05$) the propionate proportion (17.41% vs. 19.54% and 21.08%) (Hidayah et al., 2025). The seaweed secondary metabolites can cause a shift in the volatile fatty acid (VFA) pattern with the greater molar percentage of propionate. Larsen and Kristensen (2009) reported that propionate is the most prevalent substrate for gluconeogenesis in ruminants, accounting for 15 to 40% of all ruminally released organic acids. Propionate, amino acids, lactate, and glycerol are the primary substrates of ruminant gluconeogenesis. In ruminants, gluconeogenesis is an ongoing process induced by rumen microbes' metabolism of dietary carbohydrates (Wang et al., 2024). A study by Radojičić et al. (2016) reported that an additional 1 ml kg^{-1} of body weight of 1.84 M Na-propionate in a sterile solution to a basal diet that consisted of roughage and concentrate provided ad libitum significantly increased blood glucose concentrations in 2- and 4-month-old calves.

The total protein concentration tended to increase ($p < 0.1$) because the crude protein intake and digestibility also tended to increase ($p < 0.1$) with PP supplementation. Hidayah et al. (2025) reported crude protein intake at 9.11 vs. 12.21 and 12.87 g kg^{-1} BW$^{0.75}$ and crude protein digestibility at 20.07 vs. 27.36 and 27.45 g kg^{-1} BW$^{0.75}$. A study by Yengkhom et al. (2019) reported that *Turbinaria conoides* (brown seaweed) supplementation at 4.00% DM in a concentrated mixture of straw and brown seaweed increased the concentrations of glucose and total protein in goat blood. Supplementation with PP decreased ($p < 0.05$) the ureum and BUN concentrations. The phenolic compounds in seaweed, particularly the tannin content, may be linked to these effects. PP has a tannin content of 0.76 mg g^{-1} DM (Hidayah et al., 2024). Tannins can protect proteins, thereby reducing their degradation rate.

The study by Hidayah et al. (2025) explained that the crude protein intake tended to increase ($p < 0.1$) without an increase ($p > 0.05$) in the NH_3 concentration (12.10 to 13.57 mg 100 ml^{-1}) with supplementation of PP up to 5.00% OM. Muir (2011) stated that protein and fiber fractions in the rumen can combine with tannins to form complexes that reduce their degradability. The lower ureum and BUN concentrations and NH_3 did not increase compared with the control treatment, indicating that nitrogen was more efficiently used for microbial protein synthesis. They were 277.89 vs. 279.89 and 362.30 mg 100 ml^{-1}. A similar result was reported by Maxiselly et al. (2022), where 100, 200, and 300 g day^{-1} of dried coffee cherry pulp that contained phenolic compounds (condensed tannin, polyphenols, and caffeine) was added to the feed of Thai Native and Anglo Nubian goat crossbreds, which revealed lower BUN concentrations.

The PP supplementation up to 5.00% OM on TMR as a basal diet also increased ($p < 0.05$) the blood iron concentration, which is expected as the iron content of PP is 724.38 ppm. Wysocka et al. (2020) explained that iron is an essential micronutrient and necessary component for all animal species. It is involved in several biochemical processes, such as the production of blood, oxygen transport, energy metabolism, and immunological functions. Iron plays a role in the inflammatory response and oxidative stress

Table 2. Blood metabolites of Kacang goats supplemented with PP

Variable	Control	2.50% OM	5.00% OM	*P*-value	Normal range*
Glucose (mg dl^{-1})	38.58^{a}±3.02	40.80^{ab}±1.97	45.33^{b}±3.61	0.05	39.50-81.00
Total protein (g dl^{-1})	6.51±0.30	6.55±0.25	6.97±0.07	0.08	6.00-7.00
Ureum (mg dl^{-1})	52.83^{b}±1.12	45.23^{a}±1.18	46.63^{a}±1.27	0.00	26.60-56.70
BUN (mg dl^{-1})	26.55^{b}±1.91	21.13^{a}±4.03	22.95^{a}±2.69	0.05	8.50-28.50
Cholesterol (mg dl^{-1})	87.38±11.17	89.08±5.35	98.40±9.68	0.34	77.00-130.00
Calcium (mg dl^{-1})	10.64±0.95	10.86±0.95	11.28±0.62	0.52	8.70-10.80
Iron (mg ml^{-1})	0.28^{a}±0.03	0.32^{b}±0.02	0.33^{b}±0.02	0.01	0.21-0.67

Note: *Stevens et al. (1994); Kaneko et al. (2008); Mohammed et al. (2016)

in ruminants. Shawaf et al. (2021) reported that Emaciated Omani goats had lower iron levels compared to healthy ones, 8.70 vs. 15.12 mg l^{-1}. Oral supplementation with 150 mg day^{-1} of iron (ferrous sulfate) in neonatal dairy calves increased ($p < 0.05$) their serum iron levels and total iron binding capacity (TIBC) saturation at day 14, 21, and 28 compared to the control treatment (Mohri et al., 2004).

Blood hematology profile

Blood hematological analysis can reliably determine the health status of an animal. In this study, all hematology parameters were within the normal healthy range for goats, except the white blood cells in the control treatment. The lowest ($p < 0.01$) white blood cell, lymphocyte, monocyte, and neutrophil counts were obtained when the TMR was supplemented with PP at 5.00% OM. Meanwhile, supplementation of this seaweed at 2.50 to 5.00% OM in the basal diet increased ($p < 0.01$) the red blood cells and tended to increase ($p < 0.10$) the hemoglobin and hematocrit but did not affect the MCV, MCH, and MCHC in the Kacang goats' blood (Table 3).

A higher-than-normal white blood cell count 15.01×10^9 l^{-1} in the control treatment might be due to the goats being under stress conditions, particularly heat stress. The temperature in this study was approximately 26 to 30 °C, which may have induced heat stress in the goats. This condition results in labored breathing, open-mouth breathing, and excessive panting in goats. Hammadi et al. (2012) stated that goats' thermoneutral zone is between 12 and 24 °C. Furthermore, a study by Syafiqa et al. (2023) reported that after 8 hours of heat treatment, goats' white blood cell counts were significantly higher than at baseline (0 hour) and during the 16-hour recovery period.

Tharwat (2021) also reported that the white blood cell and neutrophil counts were significantly higher in contagious caprine pleuropneumonia than in healthy goats. In contrast, the red blood cell count was significantly lower. Research on poultry (Scanes, 2016) and ruminants (O'Loughlin, 2011) showed that glucocorticoid treatment and stress increase neutrophil or heterophil counts. Shawaf et al. (2021) reported that emaciated Omani goats had a higher percentage of neutrophils, monocytes, and eosinophils than their healthy counterparts, 61.30% vs. 58.48%; 5.40% vs. 1.21%; and 9.80% vs. 3.88%, respectively. Goats exposed to heat stress often exhibited higher levels of white blood cells, indicating an immune reaction to cope with the physiological strain. This increase is part of the animal's effort to maintain homeostasis during stressful conditions. Pathipati et al. (2020) stated that leukocytosis may occur when stress triggers the hypothalamic–pituitary–adrenal axis.

The PP supplementation at 2.50 to 5.00% OM increased the red blood cells, which can be attributed to the antioxidant effect of seaweed that prevents oxidative damage. Van Dyke and Saltman (1996) stated that red blood cells are especially vulnerable to oxidative stress because of their high membrane content of polyunsaturated fatty acids and internal hemoglobin auto-oxidation. This antioxidant effect is associated with this seaweed's phenolic

Table 3. Blood hematological analysis of Kacang goats supplemented with PP

Variable	Control	2.50% OM	5.00% OM	*P*-value	Normal range*
White blood cells (10^9 l^{-1})	15.01^b±1.39	12.91^b±1.54	8.22^a±0.98	0.001	4.00-13.00
Lymphocytes (10^9 l^{-1})	5.55^b±0.45	5.25^b±0.58	3.30^a±0.54	0.003	2.00-9.00
Monocytes (10^9 l^{-1})	0.23^b±0.02	0.18^b±0.02	0.11^a±0.04	0.004	0.00-0.50
Neutrophils (10^9 l^{-1})	8.98^b±1.29	8.20^b±0.62	4.47^a±0.87	0.000	1.20-8.00
Red blood cells (10^{12} l^{-1})	11.85^a±1.78	14.35^b±1.47	16.20^b±0.84	0.008	8.00-18.00
Hemoglobin (g dl^{-1})	8.28±0.28	8.78±0.50	9.40±0.85	0.091	8.00-12.00
Hematocrit (%)	25.08±3.81	29.29±1.45	30.87±3.91	0.066	25.00-38.00
Mean corpuscular volume (fl)	19.00±1.41	19.75±1.71	19.67±1.70	0.628	16.00-30.00
Mean corpuscular hemoglobin (pg)	5.39±0.57	5.95±0.33	5.50±0.59	0.276	5.20-8.00
Mean corpuscular hemoglobin concentration (g dl^{-1})	31.23±0.79	30.05±1.05	30.47±0.09	0.263	30.00-36.00

Note: *Reece (2015)

compounds (tannin and flavonoid) and minerals. Michalak et al. (2022) explained that seaweed contains three primary types of antioxidants: phenolic compounds, polysaccharides, and pigments. PP used in this study contains tannin and flavonoid at 0.42 and 3.70 mg g^{-1} DM, respectively (Hidayah et al., 2024).

Platzer et al. (2022) explained that the primary way that phenolic compounds work as antioxidants is by scavenging free radicals and preventing oxidation. The structural characteristics of phenolic compounds, such as the quantity and location of their hydroxyl groups, enable them to donate hydrogen atoms more effectively, thereby significantly increasing their antioxidant activity. Meanwhile, the minerals in seaweed contribute to their antioxidant enzymatic activity. Rahman (2007) stated that copper and zinc are co-factors of SOD activity, and PP contains 5.75 ppm copper and 93.76 ppm zinc. A study by Angulo et al. (2020) reported that goat kids supplemented with brown seaweed, *Sargassum* spp., at 2.50% and 5.00% in a basal diet had higher antioxidant (SOD and CAT) and immune-related (lysozyme, MPO, and anti-protease) activities than that of the control treatment.

The PP supplementation up to 5.00% OM on TMR as a basal diet tended to increase ($p < 0.1$) the hemoglobin and hematocrit concentration. This may be due to the seaweed's iron content. Hemoglobin is an iron-porphyrin-protein complex, and iron is an essential component of this structure (Olver, 2022). Silvestri and Nai (2021) reported that iron is needed every day to produce hemoglobin and grow erythroid cells. In a study reported by Crilly and Plate (2022), a 300 mg injection of iron dextran in neonatal lambs resulted in increased hemoglobin levels at one month of age and a notable increase in the daily live weight gain of twins and triplets. After receiving 150 mg of iron, the hemoglobin levels of goat kids at one month of age were notably higher than those of the controls, and their daily live weight gain was quantified. Oral supplementation of 150 mg day^{-1} iron (ferrous sulfate) in neonatal dairy calves increased ($p < 0.05$) the serum iron levels and TIBC saturation, hemoglobin (Hb), and hematocrit—or packed cell volume—at day 14, 21, and 28. Also, it increased the red blood cells on day 28 compared with the control treatment (Mohri et al., 2004).

Hormone profile

PP supplementation at 2.50% and 5.00% of OM in the TMR significantly decreased ($p < 0.01$) the plasma glucagon and ghrelin levels in the Kacang goats (Figure 1). This study highlights a novel finding: the precise reference ranges for glucagon and ghrelin in small ruminants are generally undocumented. The data indicated that PP supplementation specifically reduced the glucagon and ghrelin levels ($p < 0.01$), with a concurrent increase in glucose and a decrease in BUN levels, which suggests that the treated goats did not experience an energy deficit. Glucagon plays a crucial role in blood glucose regulation, particularly during negative energy balance, such as lactation, by prompting

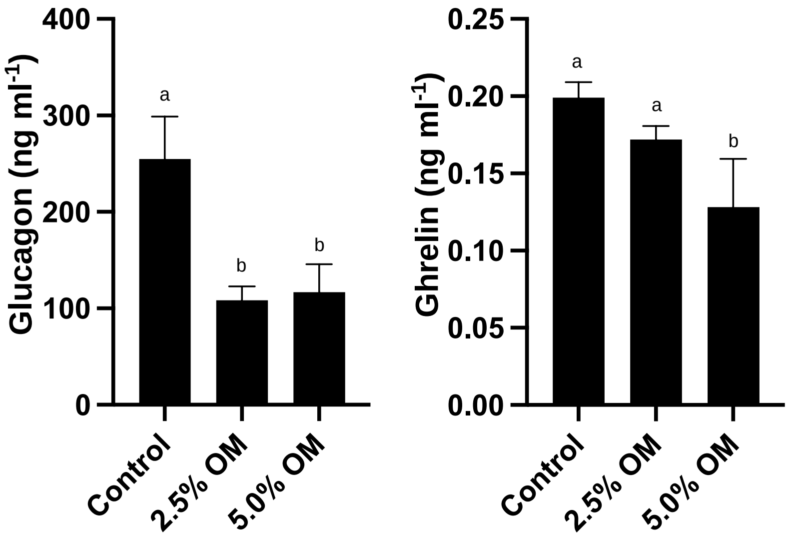

Figure 1. Hormone profile of glucagon and ghrelin in Kacang goats with PP supplementation

glycogenolysis and gluconeogenesis to prevent ketosis (Barbato et al., 2021). The control group that had higher glucagon levels (245.90±43.96 ng ml^{-1}) likely experienced greater glucose variability, with glucagon prompting glucose release via glycogenolysis and the use of noncarbohydrate substrates, which is vital for ruminants with fiber-based diets (Williams et al., 2006).

Increased BUN levels in such cases reflect that protein was broken down for energy (Sitaresmi et al., 2023). Ghrelin is produced in the stomach, regulates hunger and energy balance, and is essential for releasing growth hormones, thereby influencing growth and metabolism (Sovetkina et al., 2020). This study revealed that supplementation with 5% PP significantly lowered ghrelin levels (0.13±0.03 ng ml^{-1}; $p < 0.01$), which may be beneficial for reproductive health by stabilizing the energy balance, as ghrelin is also associated with luteinizing hormone and follicle-stimulating hormone secretion, both essential for fertility (D’occhio et al., 2019). Thus, further research is required to investigate the importance of this comprehensively.

CONCLUSIONS

Supplementing PP at 5.00% OM on TMR as a basal diet is the optimal treatment to increase the health status of Kacang goats. This treatment increased the concentration of glucose and iron, increased the red blood cell count, tended to increase the total protein levels and the hemoglobin and hematocrit concentrations, and decreased the ureum and BUN concentrations and monocyte and neutrophil counts. Future research is needed to examine the effect of seaweed supplementation on the different basal diets and metagenomics to determine the molecular effects and evaluate the influence of seaweed supplementation on other ruminants, such as dairy cattle, beef cattle, and sheep.

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