Original Research

Journal of Advanced Veterinary Research
(2024) Volume 14, Issue 1, 209-213

Moringa oleifera leaf meal to substitute soybean meal increase the performance of Javanese thin-tailed ewes

Rahmawati Rahmawati[1,2], Liesmira Yusiati[3], Sigit Bintara[3*], Ali Agus[4]

[1]*PhD Student of Faculty Animal Science, Universitas Gadjah Mada, Yogyakarta 55281.*
[2]*Animal Husbandry Study Program, Faculty of Agriculture, Universitas Gajah Putih Takengon, Nanggroe Aceh Darussalam, Indonesia 24552.*
[3]*Department Animal Breeding and Reproduction Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta, Indonesia 55281.*
[4]*Department of Animal Nutrition and Feed Science, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta, Indonesia 55281.*

ARTICLE INFO

Recieved: 03 November 2023

Accepted: 25 December 2023

***Correspondence:**

Corresponding author: Sigit Bintara
E-mail address: sigitbintara2@gmail.com

Keywords:

Digestibility
Growth
Hematology profile
Moringa oleifera leaf meal
N balance

ABSTRACT

Moringa oleifera Leaf Meal (MOLM) has the potential as a protein source that might replace soybean meal. In Indonesia, soybean meal is an imported commodity whose price is high. This study aimed to analyze the use of MOLM to substitute soybean meal in complete ration on the consumption of nutrients, digested nutrients, digestibility nutrients, N balance, hematology, and ADG of Javanese Thin-Tailed Ewes (JTTE). Fifteen JTTE 2-3 years old were divided into three different levels of MOLM treatment with 5 replications. The complete ration consists of 60% concentrate and 40% Dried Ipomea Aquatica Straw (DIAS) as a source of fiber. The concentrates used are soybean meal, corn meal, pollard, copra meal, and MOLM. The composition of the treatment rations: (T1) 0% MOLM + 60% concentrate + 40% DIAS, (T2) 10% MOLM + 50% concentrate + 40% DIAS. (T3) 20% MOLM + 40% concentrate + 40% DIAS. Treatment feed was given for 2 months as much as 4% of body weight/day, and drinking water was given ad libitum. The collected data included feed consumption, feed refusal, blood, faeces, urine, and body weight. The results showed that sheep received 10% MOLM levels of increase ($P<0.05$) DM, OM, CF, ETN, and TDN consumption compared to controls. However, the levels of 20% decrease ($P<0.05$) DM, OM, CF, ETN, and TDN consumption compared to controls. Compared to controls, the 10% MOLM increase ($P<0.05$) digested nutrients DM, OM, ETN, and TDN. Compared to controls, the level of 10% MOLM increase ($P<0.05$) ETN, and TDN digestibility coefficient. Sheep that received a 10% MOLM increase ($P>0.05$) balance N and nitrogen retention compared to control. The 10% MOLM level increase ($P<0.05$) ADG compared to the 20% level and control (120 vs. 10^6 vs. 112 g/head/day). Sheep treated with 10% MOLM increased ($P<0.05$) white blood cells (WBC) than controls and those treated with 20% MOLM (10.5 vs. 6.40 vs. 7.20). It could be concluded that the level of 10% MOLM (20% soybean meal substitution) in a complete ration based on Dried Ipomea Aquatica Straw (DIAS) has a better effect on nutrient consumption, digested nutrients, retention N, hematology and ADG of JTTE.

Introduction

As the world's most populous Muslim country, Indonesia needs sheep to support religious worship activities. Every year, up to 2 million sheep are slaughtered, including during the Qurban holiday. In fact, Indonesia import hundreds of thousands of live sheep every year. In Indonesia, one of the main obstacles in the livestock business is the availability of quality feed. Agricultural waste is the main feed, so it is necessary to concentrate protein sources to increase the protein content in complete feed based on agricultural waste.

Moringa oleifera, quite common in Indonesia, has the potential as a protein source to replace soybean meal, an imported feed ingredient. *Moringa oleifera* is easy to develop with lower production costs compared to soybean meal. *Moringa oleifera* can produce biomass reaching 43-115 tons/ha at 40-day cutting intervals with a CP content of 26% (Sultana *et al.*, 2014). The most abundant content in MOLM is protein (Chodur, 2018). *Moringa oleifera* has the potential to be developed as a functional food crop because it is easy to develop, drought-resistant, and can live on marginal land. *Moringa oleifera* leaves can be stored dry as an animal feed supplement. The nutritional content is not much different between fresh and dried.

Soliva *et al.* (2005) reported that the unextracted *Moringa oleifera* leaves have great potential as a substitute for soybean meal because they are less degraded in the rumen, the digestibility of organic matter, and crude fiber is higher than soybean meal, the gross energy is the same as soybean meal, increasing microbial protein synthesis and gas emission, methane is reduced by 17%. *Moringa oleifera* Leaf Meal (MOLM) is an ideal feed for the reproductive performance of female ruminants because it can create an energy balance in the livestock body (Kekana *et al.*, 2020). The relationship between nutrition and reproduction in female ruminants is how to balance energy and protein in the livestock body (Scaramuzzi *et al.*, 2006). Most dried leaves of *Moringa oleifera* contain 19 different amino acids and various bioactive compounds, primarily antioxidants like vitamin E, vitamin C, selenium, zinc and beta-carotene (Al-Shahat *et al.*, 2022). Feed containing antioxidants will improve health and positively affect reproductive performance. Antioxidants protect the ovum from damage caused by free radicals (Agarwal *et al.*, 2009). Ewes gestation with twins have higher levels of free radicals in their bodies, so feed ingredients containing antioxidants need to be added for the health of the ewes and fetus. *Moringa oleifera* prevents free radical generation and restores antioxidant activity, which reduces the negative effects (Abo-Elmaaty *et al.*, 2023). Therefore, MOLM is good to give to ewes.

This complete ration (Table 1) based on DIAS substituting soybean meal with MOLM is prepared for flushing feed for ewes 1 month before mating, 1 month before and after parturition. The complete ration is prepared with high energy (TDN 70%) and protein (17%). The follicles in ewes fed corn and soybean meal with wheat straw were greater than those fed only straw (Mostafa and Farghal, 2022). Feed consumption of ewe before and after lambing days decreases. It is necessary to flush feed with high amounts of protein and energy before and after lambing. This research focused on the effect of using MOLM on feed consumption, digested nutrients, nutrient digestibility, N balance, hematology profile, and ADG in JTTE.

Materials and methods

Location and animal care

This research was conducted at the Faculty of Animal Science, UGM, Yogyakarta. The Ethics Commission approved this research protocol on using Experimental Animals for Veterinary Research at the Faculty of Veterinary Medicine, Universitas Gadjah Mada, with number 0033/EC-FKH/Ex/ 2020.

Feed and treatments

The study used fifteen JTTE (23.43±1.4 kg of BW) aged 2-3 years that were divided into three treatments at different MOLM levels with five replications. The research used a completely randomized (CRD) design in one direction. All ewes received DIAS and concentrate. The concentrate comprised soybean meal, corn meal, pollard, and copra meal, having TDN 70% and crude protein 17%. Complete feed formulation and chemical composition can be seen in Table 1. The composition of the treatment rations: (T1) 0% MOLM: 60% concentrate + 40% DIAS, (T2) 10% MOLM + 50% concentrate + 40% DIAS. (T3) 20% MOLM + 40% concentrate + 40% DIAS. Treatment feed was given for three months as much as 4% of body weight/day. Drinking water was given ad libitum. Feed adaptation was carried out for three weeks, followed by a preliminary period of 1 month to eliminate the influence of the previous feed, after which a collection period was carried out for one week. The data collected included body weight, feed consumption, feed refusal, and faeces.

Table 1. Complete feed formulation and chemical composition (%).

Feed ingredients	MOLM levels		
	0%	10%	20%
DIAS*	40	40	40
Corn meal	10	10	10
Copra meal	15	15	15
Soybean meal	10	8	6
Pollard	24.7	16.7	8.7
MOLM	0	10	20
Premix mineral*	0.3	0.3	0.3
Total	100	100	100
Chemical Composition			
Dry matter	89.9	88.4	90
TDN	69	70	69
Crude Protein	17.9	17.6	16.6
Ether Extract	5.51	4.19	4.88
Crude Fiber	15.9	14.6	14.5
Nitrogen Free Extract	53.6	54.4	55.9
NDF	46.1	45	40.7
ADF	27.3	25.3	28
Calsium (Ca)	6.66	7.87	5.96
Phosfor (P)	1.87	2.22	2.26
Antioxidant capacity, DPPH (%)	18.9	30.2	27.1

The chemical composition of the complete feed was analyzed in the Animal Nutrition Biochemistry Laboratory, Faculty of Animal Science, Universitas Gadjah Mada.
Production from Agromix Lestari, Yogyakarta, Contain Ca: 243,4 g/kg, P: 3,2 g/kg, Na: 24,3 g/kg, Fe: 12,5 g/kg, Mg: 1,8 g/kg Mn: 1,2 g/kg, Zn: 439 mg/kg, K: 277,9 mg/kg, Cu: 179,4 mg/kg, S: 30,4 mg/kg Co: 5,4 mg/kg. DIAS) Dried Ipomea aquatica straw.

Chemical analyses of feed and faeces were performed according to the protocols of the Association of Official Analytical Chemists (AOAC, 2005). Daily nutrient consumption wascalculated as the difference in the amount of nutrients in the complete feed minus the amount of nutrients in the remaining feed. Digestible nutrients were equal to the amount of nutrients consumed minus the nutrients in the faeces. The percentage of nutrient digestibility was estimated as the amount of digested nutrients divided by nutrient consumption multiplied by 100%. Body weight gain was calculated as the difference between the initial body weight minus the final body weight divided by the number of maintenance days. Urinary outputs were collected from each animal daily and weighed; 10% of the daily urine output was preserved with 50% sulphuric acid, and frozen till it was required for nitrogen analysis with by using spectrophotometric methods. Analysis of MOLM tannin and saponin levels were done by using spectrophotometry. The antioxidant capacity of the complete feed was analyzed using the DPPH (2,2-diphenyl-1-picrylhydrazyl) test. Blood samples were taken from the jugular vein using a Venoject needle-connected to vacutainer tube containing Ethylenediaminetetraacetic acid (EDTA) to prevent clotting. Subsequently, the blood was centrifuged at 3000 x g for 10 minutes and was used for hematology analysis. Hematological analysis (PCV, Hb, RBC, WBC, MCHC, MCH, and MCV) was done by using a Sysmex KX-21 Hematology Analyzer.

Statistical analyses

The data obtained was carried out analysis of variance. If there are differences in each treatment, it is continued with the Duncan Multiple Range Test (DMRT). Statistical analysis using IBM SPSS software version 26.

Results

Nutrient Consumption

The results in Table 2 showed the addition of 10% MOLM to ewes feed increase ($P<0.05$) DM consumption. However, an addition of 20% decreased ($P<0.05$) DM consumption compared to controls. The same pattern also occurs in OM, NFE, and TDN consumption. The crude protein and fibre consumption in sheep fed the 10% MOLM level was not different ($P>0.05$) compared to the control group. However, it decreased ($P<0.05$) in the 20% level group.

Table 2. Effect of *Moringa oleifera* leaf meal on nutrient consumption g/head/day).

Variables	Levels MOLM		
	0%	10%	20%
Dry Matter	729^{a}±8.15	869^{b}±6.82	750^{a}±7.51
DM/weight (%)	3.12^{a}±0.18	3.39^{b}±0.13	2.91^{a}±0.14
Organic matter	670^{a}±24.9	792^{b}±19.28	692^{a}±22.9
Crude protein	149^{b}±12.5	170^{b}±14.13	127^{a}±7.03
Crude fiber	119^{b}±5.00	132^{b}±4.30	111^{a}±8.52
Ether extract	42.9^{b}±4.20	39.8^{a}±2.71	37.8^{a}±3.35
NFE	370^{a}±12.0	530^{b}±7.72	419^{a}±1.22
TDN	530^{a}±13.8	617^{b}±14.5	512^{a}±14.5

[abc]Different superscripts in the same line show significantly different ($P<0.05$)

Digested Nutrients

The average digested nutrient value of the complete feed with different MOLM levels can be seen in Table 3. Compared to controls, the 10% MOLM level increased ($P<0.05$) digested nutrient DM, OM, CP, ETN, and TDN. The 20% MOLM level non-significant effect toward digested DM, OM, CF, ETN, and TDN compared to controls.

Digestibility coefficient

The average digestibility coefficient value of the complete feed with different MOLM levels can be seen in Table 4. Compared to controls, the level of 10% MOLM increase (P<0.05) ETN, and TDN digestibility coefficient nutrients. While other nutrient digestibility coefficients were non-significant (P>0.05).

Table 3. Effect of *Moringa oleifera* leaf meal on digested nutrient (g/head/day).

Variables	Levels MOLM		
	0%	10%	20%
Dry Matter	507[a]±11.6	630[b]±7.23	515[a]±6.13
Organic Matters	468[a]±7.87	550[b]±10.3	470[a]±3.85
Crude Protein	115[b]±9.62	137[c]±1.58	97.4[a]±2.00
Crude Fiber	73.2[b]±7.00	88.1[b]±6.76	67.2[a]±1.19
Ether Extract	35.30[b]±2.24	26.7[a]±1.60	25.6[a]±1.40
BETN	231[a]±2.70	445[b]±13.3	302[ab]±6.73
TDN	369[a]±12.0	457[b]±2.92	380[a]±4.76

[abc]Different superscripts in the same line show significantly different (P<0.05)

Table 4. Effect of *Moringa oleifera* leaf meal on digestibility coefficient (%).

Variables	Levels MOLM		
	0%	10%	20%
Dry matter[ns]	69.66±3,77	73.0±2.65	68.3±1.96
Organic matters[ns]	69.8±2.46	69.4±1.95	67.9±1.94
Crude protein[ns]	77.2±1.44	80.59±2.02	76.4±2.2
Crude fiber[ns]	60.9[b]±1.61	58.7±2.09	56.0±0.87
Ether extract	82.2[b]±2.60	78.0[ab]±2.52	76.6[a]±2.21
NFE	62.4[a]±3.63	73.0[b]±1.61	74.5[b]±2.8
TDN	69.6[a]±1.63	74.1[b]±2.55	70.10[a]±2.5

[abc]Different superscripts in the same line show significantly different (P<0.05)

Balance Nitrogen

The average nitrogen balance can be seen in Table 5. Substitute soybean meal with 10% MOLM increase (P<0.05) nitrogen balance and retention.

Table 5. Effect of *Moringa oleifera* leaf meal on performance, balance nitrogen, and hematology.

Variables	Levels MOLM		
	0%	10%	20%
Performance			
ADG	112[b]±2.70	120[c]±1.50	108[a]±4.80
FCR[ns]	7.14±0.71	7.15±0.72	7.30±0.86
Balance nitrogen			
N intake (g/day)[ns]	23.49±1.87	24.67±2.03	23.03±1.77
Faecal N (g/day)	5.09±0.25	4.51±0.05	5.33±0.23
N digestion (g/day)[ns]	18.4±1.08	20.16±0.97	17.7±0.78
Urinary N (g/day)[ns]	1.17±0.53	1.03±0.34	1.16±0.35
N output (g/day)	6.26±0.15	5.54±0.25	6.49±0.56
N balance (g/day)	17.23[a]±0.6	19.13[b]±0.7	16.54[a]±0.45
N Retention intake (%)	73.35[a]±1.34	77.54[b]±1.22	71.82[a]±1.07
N Retention digestion[ns] (%)	93.64±3.04	94.89±2.56	93.44±3.24
Hematology			
Hematocrit (%)[ns]	44.94±3.4	41.20±2.5	38.48±3.23
Hemoglobin (g /dl)[ns]	11.64±0.78	10.98±1.10	11.00±0.47
WBC count (x10^3 /mm^3)	6.40[a]±1.06	10.5[b]±1.19	7.20[a]±0.37
RBC count (x10^6/ mm^3)[ns]	10.57±0.88	9.76±1.22	9.32±1.33
MCHC (%)[ns]	25.00±1.34	26.2±2.35	28,68±2.46
MCH (pg)[ns]	10.8±0.45	10.88±0.23	11.80±0.4
MCV (fl)[ns]	42.9±1.23	41.52±1.04	41.18±0.93

[abc]Different superscripts in the same line show significantly different (P<0.05)

Average Daily Gain dan Feed Conversation Rasio

The Average Daily Gain (ADG) and Feed Conversation Ratio (FCR) nutrient value of the complete feed with different MOLM levels can be seen in Table 5. The 10% MOLM level increase (P<0.05) ADG compared to the control; however, the 20% level decrease (P<0.05) ADG. There was no difference (P>0.05) in the FCR between the three treatment sheep groups.

Hematology Profile

The average hematological values for the blood of sheep that received MOLM treatment can be seen in Table 5. Sheep treated with 10% MOLM increase (P<0.05) white blood cells (WBC) than controls and those treated with 20% MOLM (10.5 vs. 6.40 vs. 7.20). The hematocrit, hemoglobin, red blood cell (RBC), mean corpuscular hemoglobin concentration (MCHC), mean corpuscular hemoglobin (MCH) and mean corpuscular volume (MCV) values were not significantly different (P>0.05) between treatments and the value is within normal limits.

Discussion

The high consumption of feed at the level of 10% MOLM is thought to be due to the highest antioxidant capacity in this feed (Table 2). Antioxidants improve the integrity of cell membranes and optimize the performance of body cells so that the metabolic rate is faster, resulting in a faster rate of emptying the digestive tract so that consumption increases. Wankhede *et al*., (2022), reported that adding moringa leaves to kid goat rations increase body metabolism and feed consumption. The use of MOLM in feed for dairy goats and buffaloes can increase feed consumption (Kholif *et al*., 2015; Leitanthem *et al*., 2023). A natural feed ingredient for MOLM, it can change the rumen fermentation pathway efficiently inhibit methanogens and increase ruminant production (Soliva *et al*., 2005). *Moringa oleifera* leaf meal active compounds with antimicrobial and anthelmintic properties have been proven to increase ruminant feed utilization and animal performance (Kholif *et al*., 2016). MOLM increases the amount of animal protein in ruminant growth and fattening. Makkar and Becker (1997) reported greater rumen-degraded protein in Moringa leaves, causing an increase in N supply to rumen microorganisms and available carbohydrates. Moringa leaves also result in an increase in microbial population and feed utilization efficiency, consequently increasing the rate of digesta breakdown, which causes increased feed consumption. In line with the research results of Kholif *et al*. (2015 ; 2018); Raheem and Hassan (2021) and Leitanthem *et al*. (2023) that the use of MOLM in dairy goat and buffalo feed can increase feed consumption.

The decrease in feed consumption at the level of 20% MOLM is thought to be due to the form of flour increasing the bitter taste of complete feed, reducing palatability and sheep do not like feed in the form of flour. The bitter taste of the secondary metabolites contained in MOLM reduces the palatability of the feed. MOLM contains secondary metabolites: flavonoids, glucosinolates, alkaloids, saponins, and phenolic compounds (Abd Rani *et al*., 2018). In this study, the results of MOLM laboratory analysis showed that it contained 9.54% tannin and 0.2% saponin. The higher content of other secondary metabolites such as flavonoids: 53.3 g quercetin/kg (Kekana *et al*., 2021). The maximum use of MOLM in goat's and buffaloes' lactating feed is 15% in the ration, giving 20% MOLM decreased feed intake (Kholif *et al*., 2015; Raheem and Hassan 2021). Feed consumption is influenced by many factors such as chemical and physical characteristics of feed, feed components and nutrient balance (Kustantinah, 2021).

The increased value of digested nutrients at 10% treatment was due to the consumption value, which also increased at 10% MOLM, but feed with a level of 20% MOLM, DM consumption decreases, causing a lower digested DM value. *Moringa oleifera* Leave Meal has high levels of secondary bioactive, antimicrobial, and antioxidant compounds that can improve livestock health and increase feed utilization (Kekana *et al*., 2020). Giving tannins in small amounts to ruminants can increase digestibility. It will reduce digestibility if given in large amounts. Raheem dan Hasan (2021), reported that using 15% MOLM in buffalo feed significantly increased digestibility, while 20% decreased digestibility compared to control. It was further explained that the decrease in digestibility with the use of 20% MOLM was caused by the activity of the enzymes cellulose, amylase, urease, and protease, which significantly decreased in the feed with the use of 20% MOLM.

The addition of 10% MOLM to sheep feed increases (P>0.05) N balance and N retention in sheep. The increase in N retention occurred because N consumption in the 10% MOLM treatment was the highest compared to the control and 20% MOLM treatments. Makkar and Becker (1997) reported greater rumen-degraded protein in Moringa leaves, causing an increase in N supply to rumen microorganisms and increasing N retention for sheep as hosts. *Moringa oleifera* Leaf Meal (MOLM) is an ideal feed for the reproductive performance of female ruminants because it can create an energy balance in the livestock body (Kekana *et al*., 2020).

Increased ADG in sheep receiving feed with a level of 10% MOLM due to increased feed consumption. Increased consumption of food substances will increase ADG. MOLM contains high protein and energy so it can increase ADG. The results of MOLM proximate analysis were DM 90.7%, CP 26%, CF 8.21%, EE 5.89%, and TDN 74%. Wankhede *et al*., (2022), reported that adding *Moringa oleifera* leaves to goat feed significantly increased Growth Hormone (GH) and ADG levels compared to controls. The use of MOLM in ruminant animal feed can increase the efficiency of feed use because it reduces the activity of methanogenic bacteria, decreases feed degradation in the rumen, methane gas production can be suppressed, and energy efficiency increases (Leitanthem *et al*., 2023). Giving MOLM can increase ADG in line with the results of a study (Babiker *et al*., 2017) that showed the substitution of alfalfa hay with *Moringa oleifera* ADG improve 9 % in sows. Allam *et al*. (2015) also reported that the use of 15% whole moringa leaves in male sheep feed increase ADG by 125 g/head/day, had no effect for ADG at the level of 7.5%, reduced ADG to 105 g /head/day at the level of 30%. *Moringa oleifera* Leave Meal has high levels of secondary bioactive, antimicrobial, anti-inflammatory, and antioxidant compounds, which can improve the health status of livestock and increase feed utilization (Kekana *et al*., 2020). This condition may be why adding 10% moringa can increase ADG. The range of consumption data for feed DM, CP, and TDN in this study (Table 2) is to what was reported by Jayanegara *et al*. (2017) that the nutrient requirements for local types of sheep with a body weight of 25 kg with an ADG of 100 g/day are DM: 864, CP 120 and TDN 577 g/head/day. In this study, it was found that ADG was higher. This was thought to be caused by higher protein and TDN consumption values. The formation of muscle/body protein in ruminants requires a carbon framework from easily available carbohydrate sources and nitrogen from the protein content of the feed. Body weight gain is closely related to nitrogen retention. If N retention increases ADG will increase. In this study, nitrogen retention was higher in sheep that received feed with a level of 10% MOLM as well as the ADG value.

The average hematological values for the blood of sheep that received MOLM can be seen in Table 5. Sheep treated with 10% MOLM increased (P<0.05) white blood cells (WBC) than controls and those treated with 20% MOLM (10.5 vs. 6.40 vs. 7.20). In line with the results obtained by Kekana *et al*., (2020), the addition of MOLM to dairy cattle feed increases the number of WBC. Rahayu, *et al*. (2017) stated that the number of leukocytes in ordinary sheep ranges from 4-12 thousand/mm^{-3}. Increasing the number of WBC in livestock that receive MOLM feed is thought to increase the body's resistance to disease. There is evidence in this study that for ewes treated with MOLM feed, the death rate for ewe and child was 0%, which was different from the control diet, with a mortality rate of 20%. Observations were carried out for 14 months with a high risk of infection because the cage was in the same location as cattle, goat, horse, and rabbit cages. Njidda *et al*. (2014) stated that leukocytes are the body's immune system active when non-specific disorders occur. The main function of white blood cells is to defend the body from foreign objects. White blood cells will go to the tissue when a foreign object attacks them by using peripheral blood to deliver them from the bone marrow to the needed tissue.

The hematocrit, hemoglobin, RBC, MCHC, MCH, and MCV values were not significantly different (P>0.05) between treatments and were within normal limits. The sheep's hematocrit was normal at 29%-45% (Panousis *et al*., 2012). In this study, hematocrit values (PCV) were obtained in the high range, namely 38-44%. Fadiyimu *et al*., (2010) obtained a 25-32% PCV value. The PCV value in this study is thought to be higher because the feed contains high concentrate levels. Meanwhile, in Fadiyimu *et al*., 2010, the treatment feed consisted of a mixture of Panicum maximum and *Moringa oleifera*. A hematocrit value below standard indicates that the sheep lacks blood and is malnutrient. Factors influencing hematocrit values include breed and type of livestock, age and production phase, sex, feed, dehydration, local climate, and disease (Kandemir *et al*., 2013). High temperature and humidity in the cage can also affect the value of sheep hematocrit. Astuti *et al*. (2011) stated that the hematocrit value of livestock will decrease at high ambient temperatures. This can happen because of hematocrit related to blood viscosity. At high environmental temperatures, sheep tend to increase drinking water consumption, causing the water content in the body to increase, resulting in a decrease in hematocrit values (Rahayu *et al*., 2016). In this study, dry complete feed was used. This condition is thought to cause a difference in hematocrit values, which are higher compared to a feed using Panicum maximum and fresh *Moringa oleifera* with much higher water content in the feed.

The number of erythrocytes (RBC) in sheep in this study was normal. The normal number of erythrocytes in ewe was 9.0-11.1 x10^6 mm^{-3}. Red blood cell values in this study range from 9.32-10.57 x10^6 mm^{-3}. An Ewe with enough feed will have a normal MCV value of 35.1 - 40.6 μm^{-3}. The average MCV value in this study is higher (41.18 – 42.9 μm^{-3}), so it can be concluded that the feed given in this study has met the nutritional needs of sheep. Meanwhile, the average MCV value of sheep obtained by Fadiyimu *et al*. (2010) was lower than in this study, namely 26.85 - 36.77 μm^{-3}. This difference is thought to be caused by different feed nutrients. This study used high concentrate with a PK content of 17% and TDN of 70%. Meanwhile, Fadiyimu *et al*. (2010) only used forage in the form of Panicum maximum and *Moringa oleifera*.

Conclusion

Substituting soybean meal with 10% MOLM increase consumption of nutrients, digested nutrients, digestibility coefficient (BETN dan TDN), retention N, hematology profile, and ADG. Complete feed with 10% MOLM has a better value than other rations. Moringa Leaf Meal (MOLM) can substitute soybean meal as much as 20% in complete feed formulations.

Acknowledgments

This research was funded by the Domestic Postgraduate Education Scholarship Program (BPP-DN) 2019

Conflict of interest

The authors declare that they have no conflicts of interest.

References

Abo-Elmaaty, A.M., Al-shahat, D.S., Mohamed, S.A., Kamel, M.A., 2023. Prevention of hepato-renal toxicity with *Moringa oleifera* in gentamicin-treated Rats. Journal of Advanced Veterinary Research 13, 1338-1346.

Allam, S., Fotouh, A., El-Garhy, G., Gamal O., 2015. Use of Moringa leaves (*Moringa oleifera*) in fattening lambs rations. Egyptian Journal of Nutrition and Feeds 18, 1–17. https://doi.org/10.21608/ejnf.2015.104349.

Al-Shahat, D.S., Abo-Elmaaty, A.M., Kamel, M.A., 2022. *Moringa oleifera*: A review of pharmacological benefits. Journal of Advanced Veterinary Research 12, 791-797.

AOAC, 2005. Official methods of analysis, 16th ed. Association of Official Analytical Chemists, Washington, DC, USA

Agarwal, Ashok., Sajal, G., Rakesh, K.S., 2005. Role of oxidative stress in female reproduction. Reproductive Biology and Endocrinology 3, 1-21. https://doi.org/10.1186/1477-7827-3-28

Astuti, D.A., Baba, A.S and Wibawan, I.W. T., 2011. Rumen fermentation, blood metabolites, and performance of sheep fed tropical browse plant. Media Peternakan 34, 201-206

Babiker, E., Fahad, A.L., Juhaimi., Ghafoor, K., Abdoun, K.A., 2017. Comparative study on feeding value of Moringa Leaves as a partial replacement for alfalfa hay in ewes and goats. Livestock Science 195, 21–26. https://doi.org/10.1016/j.livsci.2016.11.010.

Chodur, G.M., Olson, M.E., Wade., K.L, Stephenson, K.K., Nouman W., Garima, Fahey, J.W., 2018. Wild and domesticated *Moringa oleifera* differ in taste, glucosinolate composition, and antioxidant potential, but not myrosinase activity or protein content. Sci. Rep. 8, 7995. https://doi.org/10.1038/s41598-018-26059-3

Fadiyimu, A.A., Alokan, J,A., Fajemisin., A.N., 2010. Digestibility, nitrogen balance, hematological profile of West African Dwarf Sheep fed dietary levels of *Moringa oleifera* as a supplement to Panicum maximum. Journal of American Science 6, 634-643

Jayanegara, A., Ridla, M., Astuti, D.A., Wiryawan, K.G., Laconi, E.B., Nahrowi, N., 2017. Determination of energy and protein requirements of sheep in Indonesia using a meta-analytical approach. Media Peternakan 40, 118–27. https://doi.org/10.5398/medpet.2017.40.2.118.

Kandemir, C., Kosum N., Taskin T., 2013. Effects of heat stress on physiological traits in sheep. Macedonian J. Anim. Sci. 3, 25- 29.

Kekana, T.W., Marume, U., Muya, M.C. Nherera-Chokuda, F.V., 2020. Periparturient antioxidant enzymes, hematological profile and milk production of dairy cows supplemented with *Moringa oleifera* leaf meal, Animal Feed Science and Technology 268, 114606. https://doi.org/10.1016/j.anifeedsci.

Kekana, T.W., Marume, U., Muya, C.M., 2021. *Moringa oleifera* leaf meal as a feed supplement for dairy calves. South African Journal of Animal Science 51, 550-559. http://dx.doi.org/10.4314/sajas.v49i4.12

Kholif, A.E., Gouda,G.A., Morsy, T.A., Salem,A.Z.M., Lopez, S., 2015. *Moringa oleifera* leaf meal as a protein source in lactating goat's diets: Feed intake, digestibility, ruminal fermentation, milk yield and composition, and fatty acids profile. Small Ruminant Research Journal 129, 129-137. https://doi.org/10.1016/j.smallrumres.2015.05.007

Kholif, A.E., Morsy, T.A., Gouda, G.A., Anele,U.Y, Galyean, M.L., 2016. Effect of feeding diets with processed *Moringa oleifera* meal as a protein source in lactating Anglo-Nubian goats, Animal Feed Science and Technology 217, 245-255, https://doi.org/10.1016/j.anifeedsci.2016.04.012.

Kholif AE., Gouda, GA., Olafadehan, O.A, Abdo, MM., 2018. Effects of replacement of *Moringa oleifera* for Berseem clover in the diets of Nubian goats on feed utilisation, and milk yield, composition and fatty acid profile. Animal 12, 964-972. https://doi.org/10.1017/S1751731117002336

Kustantinah, I.R.A. 2021. Ruminant nutrition: The importance of energy and protein. Gadjah Mada University Press. Yogyakarta. Indonesia.

Leitanthem., V.K, Chaudhary., P, Maiti. S., Mohini M., Mondal., G., 2023. Impact of *Moringa oleifera* leaves on nutrient utilization, enteric methane emissions, and performance of goat kids. Animals 13, 97. https://doi.org/10.3390/ani13010097

Makkar, H.P.S., Becker, K., 1997. Nutrients and anti-quality factors in different morphological parts of the *Moringa oleifera* tree. The Journal of Agricultural Science 128, 311-322. doi:10.1017/S0021859697004292

Mostafa, A.S., Farghal, M.M., 2022. Effect of flushing with energy or protein sources on the reproductive performance in Ossimi Ewes. Journal Veterinary Medical Research 29, 38-42. http://doi.org/10.21608/jvmr.2022.133773.1053.

Njidda, A., Shuai'Bu, A.A, Isisdahomen, C.E., 2014. Hematological and serum biochemical indices of sheep in the semi-arid environment of northern Nigeria. J. Sci. Front. Res. 14, 49-56.
Panousis N, Brozos Ch, Karagiannis I, Giadinis ND, Lafi S, Kritsepi-Konstantinou, M., 2012. Evaluation of precision exceed meter for on-site monitoring of blood b-hydroxybutyric acid and glucose concentrations in dairy sheep. Research in Veterinary Science 9, 435–439.
Raheem, S.M.A., Hassan, E.H., 2021. Effects of dietary inclusion of *Moringa oleifera* leaf meal on nutrient digestibility, rumen fermentation, ruminal enzyme activities and growth performance of buffalo calves, Saudi Journal of Biological Sciences 28, 4430-4436. https://doi.org/10.1016/j.sjbs.2021.04.037.
Rahayu S., Yamin M., Sumantri, C., Astuti D.A., 2016. Growth performance and physiological responses of Garut Lambs fed diets mung bean sprout waste at different times. J Nutr 15 , 80-84.
Rahayu, S., Yamin, M., Sumantri, C., Astuti, D.A., 2017. Blood hematological profile and metabolite status of garut lamb fed diets mung bean sprout waste in the morning Or evening. Jurnal Veteriner. 18, 38-45.
Abd Rani, N.Z., Husain, K., Kumolosasi, E., 2018. Moringa Genus: A Review of phytochemistry and pharmacology. Frontiers in Pharmacology 9, 108. https://www.frontiersin.org/articles/10.3389/fphar.2018.00108
Scaramuzzi, R.J., Campbell, B.K., Downing, J.F., Kendall, N.R., Khalid, M., Gutiérrez., M.M., Somchit, A., 2006. A review of the effects of supplementary nutrition in the ewe on the concentrations of reproductive and metabolic hormones and the mechanisms that regulate folliculogenesis and ovulation rate. Reproduction Nutrition Development 46, 339–354. https://doi.org/10.1051/rnd:2006016.
Soliva, C.R., Kreuzer, M., Foidl, N., Machmüller, A., Hess, H.D., 2005. Feeding value of whole and extracted *Moringa oleifera* leaves for ruminants and their effects on ruminal fermentation in vitro, Animal Feed Science and Technology118, 47-62.
https://doi: 10.1016/j.anifeedsci.2004.10.005
Sultana, N., Alimon, A.R., Haque, K.S., Sazili, A.Q., Yaakub, H., Hossain, S.M.J., 2014. The effect of cutting interval on yield and nutrient composition of different *Moringa oleifera* tree plant fractions. J. Food Agri. Environ. 12, 599-604.
Wankhede, S.D., Narayan, D., Tambe, M.B., Navneet K, S.E., Jadhav, A.K., Pattanaik., 2022. Effect of dietary inclusion of *Moringa oleifera* foliage on nutrient metabolism, metabolic profile, immunity and growth performance of goat kids. Emerging Animal Species 3, 100005.