p-ISSN: 2406-7489 e-ISSN: 2406-9337

Accredited by
Ministry of Research and Technology/NRIA
Strengthening No: 200/M/KPT/2020; December 23, 2020

JITRO (Jurnal Ilmu dan Teknologi Peternakan Tropis)
May 2022, 9(2):392-399

DOI: 10.33772/jitro.v9i2.22522
http://ojs.uho.ac.id/index.php/peternakan-tropis

Pre-mating Performance of Garut Ewes Fed by Sorghum-Indigofera Based Diet During the Acclimatization Period

Rachmat Somanjaya[1, 2*], Asnath Maria Fuah[3], Sri Rahayu[3], Luki Abdullah[4], Mohamad Agus Setiadi[5]

[1]Study Program of Animal Husbandry, Faculty of Agriculture, University of Majalengka
Jl. K.H. Abdul Halim 103 Majalengka - West Java 45418, Indonesia
[2]Graduate Study Program of Animal Production and Technology, Faculty of Animal Science, IPB University
Jl. Agatis, Kampus IPB University Dramaga Bogor 16680, Indonesia
[3]Department of Animal Production and Technology, Faculty of Animal Science, IPB University
Jl. Agatis, Kampus IPB University Dramaga Bogor 16680, Indonesia
[4]Department of Nutrition and Feed Technology, Faculty of Animal Science, IPB University
Jl. Agatis, Kampus IPB University Dramaga Bogor 16680, Indonesia
[5]Divisions of Reproduction and Obstetrics, Department of Veterinary Clinical, Reproduction, and Pathology, Faculty of Veterinary Medicine, IPB University
Jl. Agatis, Kampus IPB University Dramaga Bogor 16680, Indonesia

*Corresponding author: rachmat.somanjaya@unma.ac.id

(Submitted: December 19, 2021; Accepted: February 25, 2022)

ABSTRACT

This study aimed to evaluate the effect of sorghum-indigofera forage-based feed on the pre-mating performance of Garut ewes. A total of 28 Garut ewes was divided into two groups of treatment so that each treatment consisted of 14 heads. The treatment of field grass (FG) as a control and the feed composition in the formula of 50% sorghum forage silage + 40% indigofera hay + 10% rice bran (SI). The animals were distributed under a completely randomized design, and the data were analyzed using a t-test. The results showed that the dry matter intake (DMI) and nutrient digestibility values of FG were higher ($p<0.05$) than SI. However, the impact on body weight gain, blood urea nitrogen (BUN) and blood cholesterol level did not differ ($p>0.05$). The average pre-mating bodyweight of Garut ewes for all treatments was the same number relatively, were 35 kg/head. BUN and blood cholesterol levels in the FG and SI treatments were 36.18±3.47 vs 35.27±4.23, and 66.13±5.56 vs 69.25±3.95 mg/dl, respectively. It can be concluded that SI feed had higher efficiency values and better readiness for the reproductive phase. Therefore, SI feed can be used as a substitute for field grass for the reproductive stage of Garut ewes.

Keywords: green complete feed, Indonesian local sheep, pre-reproduction perfomance

INTRODUCTION

Garut sheep is an indigenous Indonesian genetic resource with advantages over other local sheep, even sheep globally. The sheep population in Indonesia in 2020 reached 17.77 million heads, and 69.07% of the population was concentrated in West Java Province (BPS, 2021). The motivation of the people of West Java to raise sheep, especially Garut sheep is very high. However, the pattern of breeding is still traditional, the scale of business is small, the use of technology in raising sheep is still low, and the feed provided only relies on field grass. The availability and quality of field grass is not stable every year and is very dependent on the season (Somanjaya et al., 2015).

The introduction of sorghum and indigofera forage is a solution to maintain the availability of feed throughout the year with good nutritional quality. Sorghum plants from the stems and grains can be used as raw material for bioethanol, sugar, and a source of animal feed ingredients in the form of grains, forage, silage and hay (Habyarimana et al., 2004). This plant has been widely cultivated as a feed crop and is quite popular in various world regions (Glamočlija et al., 2011). Atis et al. (2012) investigated four types of sorghum plants harvested at different ages. The best nutrient content and productivity of sorghum is when it is harvested in the dough stage. After being processed into silage, Lima et al. (2011) reported that the nutrient content and digestibility value became better and reduce methane gas production (CH_4) by as much as 60.37%.

The *Indigofera zollingeriana* plant is one of the potential legumes as forage ruminant feed. Its growth is good with high production and nutritional value. *Indigofera zollingeriana* protein content reaches 29.16% (Abdullah 2010), total production of dry materials at the age of 88 days after pruning reached 5.41 tons ha^{-1} $harvest^{-1}$ (Suharlina et al., 2019). Indigofera has also been used as a source of protein in ruminant feed. The use of *Indigofera zollingeriana* can increase feed protein levels, digestibility of dry matter and total VFA rumen in vitro (Suharlina et al., 2016).

Several research results state that the content of antioxidants and arginine compounds in indigofera can improve the reproductive performance of ruminants. Antioxidants can reduce stress levels in Malpura sheep and increase fertility and the prolification of ewes (Sejian et al., 2014). Meanwhile, arginine compounds improve reproductive performance and the uterine environment to maintain pregnancy in sheep (Lassala et al., 2010; Wu et al., 2013). Administration of arginine during pregnancy can improve nutrition for the fetus (Thureen et al., 2002), increase fetal protein accretion, which can ultimately increase lamb birth weight (De Boo et al., 2005), increase the percentage of live fetuses, and prevent fetal growth retardation in malnutrition ewes (Lassala et al., 2010).

Based on the results of in vitro research, Teleng et al. (2017) stated that in-situ rations in the silage with forage ingredients of sorghum and indigofera would improve the production performance of ruminants. Combining sorghum and *Indigofera zollingeriana* forage is expected to be a good for animal feed. It can increase the nutritifonal value of feed and improve the pre-mating performance of Garut ewes. The objective of this study was to evaluate the effect of forage-based feeding sorghum-Indigofera to improve the pre-mating performance of Garut ewes.

MATERIAL AND METHOD

Location, Animals, and Diets

The Animal Ethics Committee had approved this experiment, Faculty of Veterinary Medicine Bogor Agricultural University with Ethical Clearance Number 011/KEH/SKE/V/2021. The experiment has been done for 30 days in April 2021, located in West Java - Indonesia, with the coordinate 6°48'50.0"S 108°13'35.8"E; 141 m asl. The object of this research is 28 heads of Garut ewes with the following requirements: healthy, normal, have given birth, aged 2-3 years, a minimum life weight of 30 kg, and not pregnant. Ultrasonography was used to determine the pregnancy of Garut ewes. The animals were distributed under a completely randomized design so that in each treatment, there were 14 ewes.

The primary treatment in this study was the provision of two types of feed carried out during the acclimatization period before the ewes were mated. The feed treatment is field grass (FG) as control and combined 50% sorghum forage silage + 40% hay forage indigofera + 10% rice bran (SI). FG gives 4%, while SI is 3% of body weight per day (dry matter). More FG gave because it is assumed that not ewes like all FG.

The types of sorghum used are sweet sorghum variety Samurai 1 issued by the National Nuclear Energy Agency (BATAN) in 2014 and *Indigofera zollingeriana*. Both plants were harvested at the age of 70 and 50 days, respectively. The feed is given twice a day in the morning and evening, while drinking water is given *adlibitum*. The experiment nutrient content for animal feed is formulated as recommended by the National Research Council Canada (NRC) (1985) for prolific ewes. Meanwhile, the nutrient content of FG feed is affected by field conditions. The field grasses used in this study are grasses that grow wild, including legumes that grow vines that exist in nature and are commonly used by traditional farmers. The co-dominant species of field grass and legumes include: *Cynodon dactylon* (Kawatan Grass), *Cynodon Plectostachyus* (African Grass), *Brachiaria decumbens* (BD Grass), *Brachiaria ruziziensis* (Ruji Grass), *Panicum repens* (Lampuyang Grass), *Digitaria decumbens* (Pangola Grass), *Paicum maximum* (Benggala Grass), *Leersia hexandra* SW. (Swamp Rice Grass), *Centrosema* (Centro), and *Calopogonium mucunoides* (Asu Beans). All feed nutrient content is analyzed in the Integrated Laboratory of the Faculty of Animal Science IPB University Indonesia.

Table 1. The experimental feed nutrient

Feed composition	Nutrient content								
	DM	Ash	TDN	CP	Fiber	EE	Ca	P	GE
	..... %								(kal/g)
Field grass	30,88	11,89	51,00	12,60	22,90	2,18	0,83	0,45	3.396
Sorghum-Indigofera	26,45	10,34	59,35	19,82	30,57	1,91	1,48	0,56	4.423

Notes: DM = dry matter, TDN = total digestible nutrient, CP = crude protein, EE = ether extract, Ca = calcium, P = phospor, GE = gross energy

Measurement of Garut ewes pre-mating performan

Fresh matters intake, feces excretion, the pattern of feed intake and feces excretion, dry matter intake (DMI), body weight gain, feed digestibility value (dry matter, organic matter, crude protein, and crude fiber digestibility), blood urea nitrogen (BUN) and blood cholesterol concentration were measured as variables of ewes pre-mating performance. Blood sampling was carried out in the last week of the feed acclimatization period using venoject through the jugular vein. Blood urea and cholesterol levels were measured using a spectrophotometer at a wavelength of 365 nm using the Berthelot Reaction method. (Roseler et al., 1993).

Data Analysis

The research data were analyzed using an independent two-sample t-test and presented in the average ± standard error means (SEM). SPSS program version 25.0 (SPSS Inc., Chicago, IL) was used for data processing.

RESULT AND DISCUSSION

Field grass (FG) intake in the fresh matter was 66.35 kg higher ($p<0.05$) than SI feed, or SI feed intake was 52.55% lower than FG. The comparison between the feed given with intake, FG was 86.01%, while SI was 80.16%. It is suspected that FG intake is more likely because sheep are naturally accustomed to consuming FG. In addition, the types of grass in FG are very diverse, so the palatability value is high. Yang et al. (2017) report that forage intake and body weight gain of ewes fed various types of grass simultaneously were higher than those given only one type of forage. The amount of field grass giving can also affect the level of consumption. Field grass is given more than SI due to the fact that Garut ewes can consume not all types of grass. FG is given as much as 4-5% of body weight, while SI is given according to ewes needs, which is 3% of body weight (in dry matter). The consumption of fresh matter for Garut ewes feed is presented in Figure 1

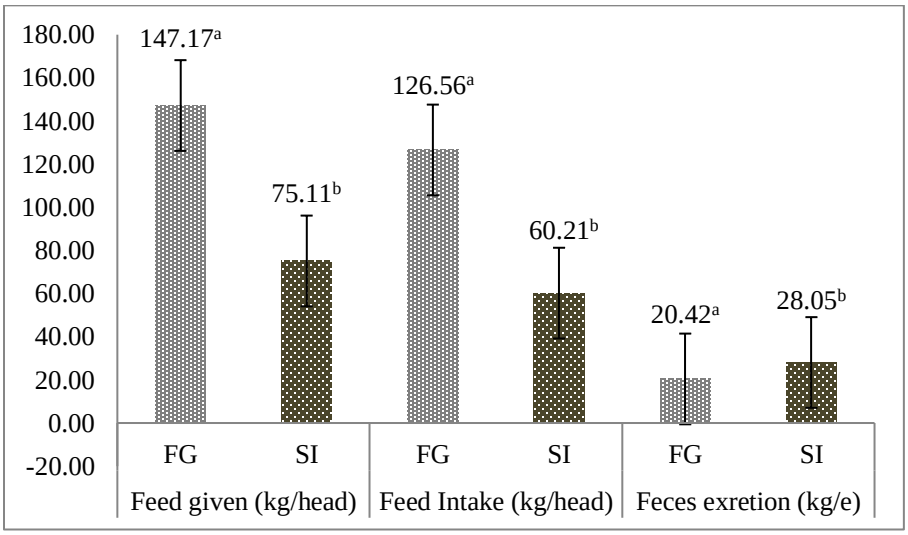

Figure 1. The feed given, feed intake, and feces excretion in the fresh matter in the acclimatization phase (30 days)

The excreted feces in the SI was higher than the FG treatment with a 7.63 kg/head difference. This variable can use to indicate the digested value of feed in an animal that consumes it. The more significant amount of feces excreted in the SI treatment could be associated with the high fiber content of the feed (Tabel 1). When harvested, the age of sorghum and indigofera plants and many woody stems in indigofera can cause the high content of crude fiber and lignin that the ewes cannot digest. Tillman et al. (1991) stated that the high fiber content in the feed could lead to decreased feed digestibility. According to Van Soest et al. (1991), the digestibility value of crude fiber is related to the particle size of the fiber, which stimulates the process of rumination and ensalivation to filter and prevent the flow of nutrients that are too fast and even lose of nutrients.

The consumption pattern of Garut ewes on FG and SI feed types (Figure 2) shows a considerable distance. The high and low consumption of feed can also be related to the nutritional content of the feed that is by animal needs. Roche et al. (2008) and Jalali et al. (2012) reported that the decreased DM digestibility is due to increased fiber content and decreased fiber digestibility, which increases rumen fill and the retention time of the feed rumen, thereby limiting feed intake in ruminants.

Observation of the chemical feces composition (Table 2) was obtained through feces collection during the acclimatization period based on the treatment. The feces is mixed and taken as a sample to be tested in the laboratory. The feces chemical content and the amount of feces excreted are needed to calculate feed digestibility. The difference between the number of nutrients consumed and nutrients excreted in the feces is the number of nutrients digested.

The dry matter intake of ewes on SI feed was 38.88% more effective than FG, with a similar effect ($p>0.05$) on body weight gain (Table 3). Garut ewes consumption of more FG than SI could be because they used them to being given FG before. Significant differences in DMI were not followed by a significant increase in body weight of Garut ewes. The difference in body weight gain during the acclimatization period was only 0.15 kg. This shows that the SI feed is quite effective and efficient in maintaining the body condition of the Garut ewes before mating.

DMI of feed silage forage is 0.79 Kg/head/day or 2.42% of body weight, following the recommendations in the study of Jonker et al. (2016), i.e. in the range of 2% of body weight. Meanwhile, the consumption of dry matter FG in this study was the same relatively as the results of Heimbach et al. (2020), which measures the DMI of *Texel* x *mixed-breed* sheep grazing in tropical grasslands as much as 1.26 kg/head/day.

Generally, the measurement of feed digestibility is intended to determine the quality of feed and feed effectiveness on livestock growth and development. Tillman et al. (1991) stated a positive relationship between feed consumption and the digestibility of the feed it self. The easier it is to digest a feed, the more feed is consumed.

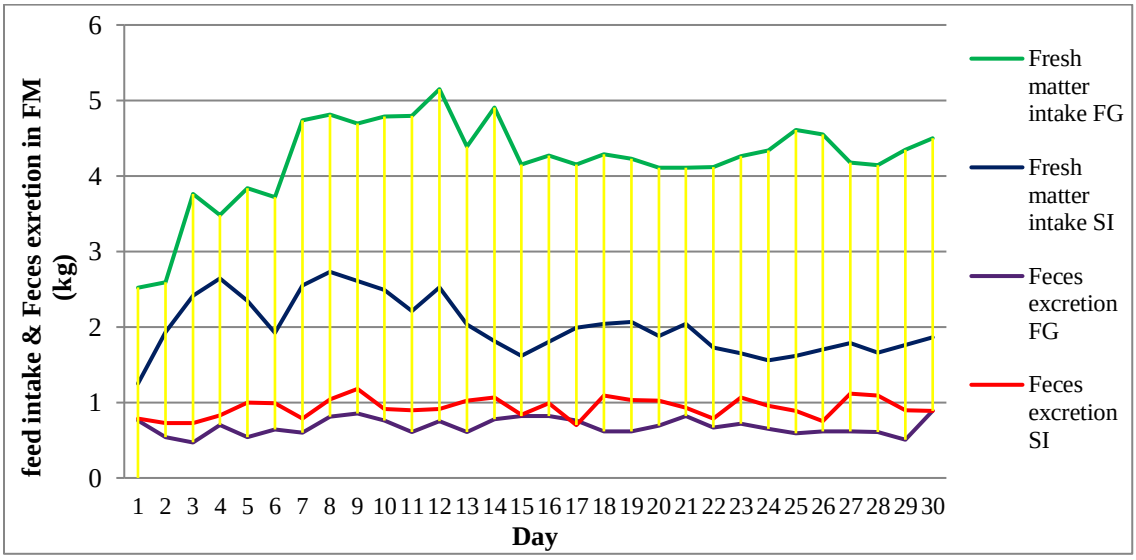

Figure 2. The Patterns of Garut ewes feed intake and feces excretion during the acclimatization period

Table 2. The Garut ewes feces chemical content after fed by experimental feed

Variable	Treatment	
	FG	SI
Dry matter (%)	22.65	22.35
Ash (%)	18.71	12.92
Crude protein (%)	10.35	13.77
Crude fiber (%)	24.23	20.23

Notes: FG = field grass, SI = sorghum-Indigofera, Laboratory tests were carried out at the Ruminant Animal Nutrition and Animal Feed Chemistry Laboratory, Faculty of Animal Science, Padjadjaran University.

Table 3. Garut ewes Pre-mating performance during the acclimatization period

Variables	Treatment	
	FG	SI
Number of Population (N)	14	14
Number of samples (n)	6	6
Initial body weight rate (kg/head)	32.93±2.74	32.67±1.55
Dry matter intake (kg/head)	39.11±3.06^{a}	23.84±1.54^{b}
Daily dry matter intake (kg/head/d)	1.30±0.10^{a}	0.79±0.05^{b}
Weight gain (kg/head)	2.82±1.09	2.67±0.54
Average daily gain (kg/head/d)	0.09±0.04	0.09±0.02
Number of feces excretion (kg)	4.63±0.44^{a}	6.27±0.56^{b}
Dry matter digestibility (%)	88.22±0.28^{a}	73.68±1.46^{b}
Organic matter digestibility (%)	89.14±0.26^{a}	74.94±1.39^{b}
Crude protein digestibility (%)	90.33±0.23^{a}	81.71±1.01^{b}
Crude fiber digestibility (%)	94.68±0.13^{a}	82.58±0.96^{b}
Blood Urea Nitrogen (BUN) (mg/dl)	36.18±3.47	35.27±4.23
Serum Cholesterol (mg/dl)	66.13±5.56	69.25±3.95
Final body weight rate (kg/head)	33.16±5.52	33.92±3.49

Notes: FG = field grass, SI = sorghum-Indigofera, Mean values in the same row with different superscript letters differ significantly ($p<0.05$).

All of the digestibility values of the nutrient content of the field grass were significantly ($p<0.05$) higher than the SI feed (Table 3). Field grass given to Garut ewes during the study was cut and carry. In the field, grasses are selected based on the variety of species preferred by the sheep and are most likely mixed with creeping legumes. In addition, the average field grass given is young and still green. This condition is suspected of causing the high digestibility value of field grass in Garut ewes.

Complete feed based on forage sorghum and indigofera (SI) was given in the silage and hay and added rice bran to increase the palatability for ewes. Age and stem parts of these two plants were thought to cause the high content of crude fiber and lignin, so the digestibility value was lower than FG. The digestibility value of feed in this study was almost similar to the results of Tulung et al. (2020), which compared feed based on corn cobs with mixed grass combined with 50% concentrate each. The results showed that the digestibility value of feed made from corn cobs was lower than mixed grass. The comparison of dry matter digestibility (DMD), organic matter digestibility (OMD), and crude protein digestibility (CPD) values between the two types of feed were 77.05% vs. 80.15%; 78.64% vs. 83.44; and 82.13% vs. 85.55%, respectively. The high digestibility value in the study results was presumably because the composition of each experimental ration contained 50% concentrate.

The content of blood urea nitrogen (BUN) and blood cholesterol showed no significantly difference ($p>0.05$), and the difference between the two variables is only about 3.64 mg/dl and 2.63 mg/dl, respectively. The value of the BUN content can be used as a parameter for an energy deficit in the ruminant body. The greater the BUN value can also interpret the more significant the energy deficit in the animal's body (Manalu & Sumaryadi 1997). It can also be interpreted that the body cannot synthesize urea in non-protein nitrogen (NPN) into protein due to a lack of energy in the ruminant body.

The content of BUN in the body of the ewes in this study was still in normal conditions. Mitruka and

Rawnsley (1981) stated that the standard BUN content in the blood ewes is about 15.00 – 36.00 mg/dl. However, the BUN content in the pre-mating phase was higher than the results of Manalu and Sumaryadi's (1997) study, and there is a difference of 11.72 and 8.08 mg/dl for each treatment, respectively. The difference value in FG treatment is more high than SI. This is thought to be due to the lower energy content of FG compared to SI (Table 1). This condition proves that the energy content in the feed has a linear impact on the BUN content.

The blood cholesterol content in the pre-mating phase appears to be higher in the SI treatment than the FG, although statistically, it did not show a significant difference ($p>0.05$). The blood cholesterol content in this study was lower when compared to the results of the research of Khotijah et al. (2015), with a difference of 12.09 and 9.46 mg/dl, respectively. These differences can occur as a result of the type of feed given. The feed given in this study was Brachiaria humidicola grass + concentrate (30:70%), with a higher nutrient content than either FG or SI treatments. Based on these facts, it appears that the quality of feed is very influential on the production of blood cholesterol in the body.

The final result of this study was determined by final body weight, which showed that SI feed was stable enough to maintain body weight and body condition score (BCS) during the feed acclimatization period. SI feed is reliable enough to continue with the reproductive process. Further research hopes that SI feed can provide a better reproductive performance of Garut ewes than field grass.

CONCLUSION

The complete feed based on Sorghum-Indigofera forage has higher efficiency values and better readiness for the reproductive phase. Therefore, SI feed can be used as a substitute for field grass for the reproductive stage of Garut ewes.

CONFLICT OF INTEREST

The authors state no conflicts of interest related to financial, personal, other people, or organizations based on the material discussed in the manuscript.

ACKNOWLEDGMENT

The Ministry of Research, Technology and Higher Education of The Republic of Indonesia funded this study through the IPB University under the Doctoral Research Grant 2020 (contract number: 1/E1/KP.PTNBH/2020), and BPP-DN 2017 (contract number: 2903/D3/PG/2017).

REFERENCES

Abdullah, L. 2010. Herbage production and quality of shrub indigofera treated by diff erent concentration of foliar fertilizer. Media Peternakan 33(3):169-175. DOI: 10.5398/ medpet.2010.33.3.169.

Atis, I., O. Konuskan, M. Duru, H. Gozubenli, & S. Yilmaz. 2012. Effect of harvesting time on yield, composition and forage quality of some forage sorghum cultivars. International Journal of Agriculture and Biology 14:879-886.

[BPS] Badan Pusat Statistik. 2021. Populasi domba menurut provinsi di Indonesia. Badan Pusat Statistik. Jakarta. https://www.bps.go.id/ indicator/24/473/1/populasi-domba-menurut-provinsi.html. [Indonesia]

De Boo, H.A., P.L. Van Zijl, D.E.C. Smith, W. Kulik, H.N. Lafeber, & J.E. Harding. 2005. Arginine and mixed amino acids increase protein accretion in the growth-restricted and normal ovine fetus by different mechanisms. Pediatric Research 58(2):270-277. DOI: 10.1203/01. PDR.0000169977.48609.55.

Glamočlija, D., S. Janković, S. Rakić, R. Maletić, J. Ikanović, & Ž. Lakić. 2011. Effects of nitrogen and harvesting time on chemical composition of biomass of Sudan grass, fodder sorghum, and their hybrid. Turkish Journal of Agriculture and Forestry 35(2). DOI: 10.3906/ tar-0911-58.

Habyarimana, E., D. Laureti, M. De Ninno, & C. Lorenzoni. 2004. Performances of biomass sorghum [*Sorghum bicolor* (L.) Moench] under different water regimes in Mediterranean region. Industrial Crops and Products 20:23-28. DOI: 10.1016/j.indcrop. 2003.12.019.

Heimbach, N. da S., C.C.B.F. Ítavo, L.C.V. Ítavo, G. dos S. Difante, A.M. Dias, R.C. Brumatti, M.

de N.B. Gomes, C.D. Baur, G.J. de Moraes, M.C.M. da Costa, N. D. Kozerski, E.S. Leal, & A.L.C. Gurgel. 2020. Different grass availabilities of tropical pasture on performances and carcasses of lambs. Tropical Animal Science Journal 43(3):211-218. DOI: 10.5398/tasj.2020.43.3.211.

Jalali, A.R., P. Nørgaard, M.R. Weisbjerg, & E. Nadeau. 2012. Effect of stage of maturity of grass at harvest on intake, chewing activity and distribution of particle size in faeces from pregnant ewes. Animal 6(11):1774-1783. DOI: 10.1017/S1751731112000493.

Jonker, A., K. Lowe, S. Kittelmann, P.H. Janssen, S. Ledgard, & D. Pacheco. 2016. Methane emissions changed nonlinearly with graded substitution of alfalfa silage with corn silage and corn grain in the diet of sheep and relation with rumen fermentation characteristics in vivo and in vitro. Journal of Animal Science 94(8):3464-3475. DOI: 10.2527/jas.2015-9912.

Khotijah, L., K.G. Wiryawan, M.A. Setiadi, & D.A. Astuti. 2015. Reproductive performance, cholesterol and progesterone status of garut ewes fed ration containing different levels of sun flower oil. Pakistan Journal of Nutrition 14(7):388-391. DOI: 10.3923/pjn.2015.388.391.

Lassala, A., F.W. Bazer, T.A. Cudd, S. Datta, D.H. Keisler, M.C. Satterfield, T.E. Spencer, & G. Wu. 2010. Parenteral administration of L-arginine prevents fetal growth restriction in undernourished ewes. Journal of Nutrition 140(7):1242-1248. DOI: 10.3945/jn.110. 125658.

Lima, R., R.F. Díaz, A. Castro, & V. Fievez. 2011. Digestibility, methane production and nitrogen balance in sheep fed ensiled or fresh mixtures of sorghum-soybean forage. Livestock Science 141:36-46. DOI: 10.1016/ j.livsci.2011.04.014.

Manalu, W. & M.Y. Sumaryadi. 1997. Perubahan Status kecukupan energi induk domba ekor tipis dengan berbagai jumlah anak sejak kebuntingan sapai laktasi. Buletin Peternakan 21(3):126-132. [Indonesia]

Mitruka, B.M. & H.M. Rawnsley. 1981. Clinical, biochemical and hematological reference values in normal experimental animals and normal humans. Masson Publishing. New York.

[NRC] National Research Council. 1985. Nutrient Requirements of Sheep. Washington, D.C.

Roche, J.R., D. Blache, J.K. Kay, D.R. Miller, A.J. Sheahan, & D.W. Miller. 2008. Neuroendocrine and physiological regulation of intake with particular reference to domesticated ruminant animals. Nutrition Research Reviews 21(2): 207-234. DOI: 10.1017/S0954422408138744.

Roseler, D.K., J.D. Ferguson, C.J. Sniffen, & J. Herrema. 1993. Dietary protein degradability effects on plasma and milk urea nitrogen and milk nonprotein nitrogen in holstein cows. Journal of Dairy Science 76(2):525-534. DOI: 10.3168/jds.s0022-0302(93)77372-5.

Sejian, V., A.K. Singh, A. Sahoo, & S.M.K. Naqvi. 2014. Effect of mineral mixture and antioxidant supplementation on growth, reproductive performance and adaptive capability of Malpura ewes subjected to heat stress. Journal of Animal Physiology and Animal Nutrition 98(1):72-83. DOI: 10.1111/ jpn.12037.

van Soest, P.J., J.B. Robertson, & B.A. Lewis. 1991. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. Journal of Dairy Science 74(10):3583-3597. DOI: 10.3168/jds. S0022-0302(91)78551-2.

Somanjaya, R., D. Heriyadi, & I. Hernaman. 2015. Performa domba lokal betina dewasa pada berbagai variasi lamanya penggembalaan di Daerah Irigasi Rentang Kabupaten Majalengka. Jurnal Ilmu Ternak 15(1):41-49. DOI:10.24198/ijas.v7i3.7029.g7743. [Indonesia]

Suharlina, S., L. Abdullah, & A.D. Lubis. 2019. Kualitas nutrisi hijauan (*Indigofera zollingerina*) yang diberi pupuk organik cair asal limbah industri penyedap masakan. Jurnal Pertanian Terpadu 7(1):28-37. DOI: 10.36084/ jpt..v7i1.179. [Indonesia]

Suharlina, S., D.A. Astuti, N. Nahrowi, A. Jayanegara, & L. Abdullah. 2016. In vitro evaluation of concentrate feed containing indigofera zollingeriana in goat. Journal of the Indonesian Tropical Animal Agriculture 41(4): 196-203. DOI: 10.14710/jitaa.41.4.196-203.

Telleng, M., K.G. Wiryawan, P.D.M.H. Karti, I.G. Permana, & L. Abdullah. 2017. Silage quality of rations based on in situ sorghum-indigofera. Pakistan Journal of Nutrition 16(3):168-174. DOI: 10.3923/pjn.2017.168.174.

Thureen, P.J., K.A. Baron, P.V. Fennessey, & W.W. Hay. 2002. Ovine placental and fetal arginine metabolism at normal and increased maternal plasma arginine concentrations. Pediatric Research 51 4 I:464-471. doi: 10.1203/00006450-200204000-00011.

Tillman, A.D., H. Hartadi, S. Reksohadiprodjo, S. Prawirokusumo, & S. Lebdosoekojo. 1991. Ilmu Makanan Ternak Dasar. Ed ke-5. Tillman AD, editor. Gadjah Mada University Press. Yogyakarta. [Indonesia]

Tulung, Y.L.R., A.F. Pendong, & B. Tulung. 2020. Evaluasi nilai biologis pakan lengkap berbasis tebon jagung dan rumput campuran terhadap kinerja produksi sapi peranakan ongole (PO). Zootec 40(1):2612-8698. DOI: 10.35792/zot.40.1.2020.28254. [Indonesia]

Wu, G., F.W. Bazer, M.C. Satterfield, X. Li, X. Wang, G.A. Johnson, R.C. Burghardt, Z. Dai, J. Wang, & Z. Wu. 2013. Impacts of arginine nutrition on embryonic and fetal development in mammals. Amino Acids 45(2):241-256. DOI: 10.1007/s00726-013-1515-z.

Yang, Z., Y. Wang, X. Yuan, L. Wang, & D. Wang. 2017. Forage intake and weight gain of ewes is affected by roughage mixes during winter in northeastern China. Animal Science Journal 88(8):1058-1065. DOI: 10.1111/asj.12747.