

Calliandra calothyrsus and *Artocarpus heterophyllus* as anti-parasite for Bligon Goat

W. Setyono, K. Kustantinah*, E. Indarto, N. D. Dono, Z. Zuprizal and I. H. Zulfa
Department of Animal Feed Science, Faculty of Animal Science, Universitas Gadjah Mada,
Jl. Fauna No.03, Yogyakarta – Indonesia

*Corresponding E-mail: kustantinah@ugm.ac.id

Received May 02, 2019; Accepted October 19, 2019

ABSTRAK

Penelitian ini dilakukan untuk mengetahui potensi nutrisi dan efektivitas hijauan pakan ternak yang mengandung tanin sebagai antikoksidia dalam mendukung kinerja ternak kambing Bligon betina. Lima belas ekor kambing Bligon betina dibagi secara acak menjadi 3 kelompok yaitu kelompok I sebagai kontrol (KG), yaitu kambing diberi pakan 100% Bahan Kering (BK) rumput raja (King grass), kelompok II (KGC) merupakan kelompok kambing yang diberi ransum 50% BK rumput raja dan 50% BK daun *Calliandra calothyrsus* dan kelompok III (KGA) merupakan kelompok kambing yang diberi ransum berupa 50% BK rumput raja dan 50% BK daun *Artocarpus heterophyllus* (daun nangka). Hasil penelitian menunjukkan bahwa suplementasi hijauan yang mengandung tanin dapat meningkatkan konsumsi dan pencernaan Bahan Kering (BK), Bahan Organik (BO) dan Protein Kasar (PK). Ternak yang mendapat suplementasi hijauan yang mengandung tanin memiliki bobot badan harian lebih tinggi 22,85 g/hari dan 29,52 g/hari berturut-turut untuk K.II dan K.III apabila dibandingkan dengan kontrol. Efek anti koksidia yang diharapkan dari suplementasi hijauan yang mengandung tanin ditunjukkan dengan adanya penurunan jumlah oosista koksidia dalam feses kambing yaitu 3.166 (KG), 841 (KGC) dan 450 (KGA) butir per gram feses. Suplementasi hijauan yang mengandung tanin dapat meningkatkan konsumsi BK, BO, PK dan nutrisi tercerna BK, BO dan PK. Ternak yang mendapat suplementasi hijauan mengandung tannin memiliki pertambahan bobot badan yang lebih tinggi. Jumlah oosista koksidia pada masing-masing perlakuan pakan mengalami penurunan. Penurunan paling besar terhadap jumlah oosista koksidia dalam feses terjadi pada suplementasi daun nangka (*Artocarpus heterophyllus*).

Kata kunci: antiparasit, hijauan, kambing Bligon, suplementasi

ABSTRACT

This study investigated the nutritional potency and efficacy of tannin-containing forages as anti-parasites sources to support the performance of female Bligon goats. Fifteen female Bligon goats were divided into 3 different groups based on feeding treatments. The first group (KG) served as the control and was fed 100% king grass (dry matter basis). The second group (KGC) was fed 50% king grass and 50% *Calliandra calothyrsus* leaves (dry matter basis). The third group (KGA) was fed 50% king grass and 50% *Artocarpus heterophyllus* leaves (dry matter basis). The study showed that supplementation with tannin-containing forages could improve feed consumption and the digestibility of dry matter (DM), organic matter (OM), and crude protein (CP). The groups that received tannin-containing forages had higher body weight gains at 22.85 g/day and 29.52 g/day for KGC and KGA respectively than the control group. The anti-parasites effects were successfully indicated by the declining number of coccidian oocysts in the feces (number/gram feces), which were 3,166; 841; and 450 for KG, KGC, and

KGA respectively. Tannin-containing forage supplementation could improve the consumption and digestibility of DM, OM and CP. Supplementation improved the daily body weight gain. The number of coccidian oocysts in animals receiving supplementation was also reduced. The greatest effects on fecal coccidian oocyst reduction were attained with Jackfruit leaves (*Artocarpus heterophyllus*) supplementation

Keywords: Anti-parasites, Forages, Bligon Goat, Supplementation

INTRODUCTION

It is known that parasites do not have an effect on livestock death directly, however economic losses can be severe. Parasitic infection is considered a significant problem in animal production, since it causes poor production performance. In some acute cases, it even leads to death. Anti-parasitic supplementation is considered an absolute means to prevent parasitic infection in livestock. Gut-parasite control depends on the frequency of the treatment. The misuse of anti-parasitic agents may cause resistance in the parasite itself (Jackson and Coop, 2000).

Indonesia has many plants biodiversity that provides abundant natural compounds that are used in various disease treatments, including parasite treatment. In addition to modern approaches, plant bioactive compounds, mainly secondary metabolites, have been identified as promising means to modulate the biological aspects of parasites. Pharmacologically, condensed tannins present ovicidal, larvicidal, and vermifugal properties (Hoste *et al.*, 2006). Numerous tropical plants such as *Carica papaya*, *Manihot esculenta* Crantz, *Coriandrum sativum*, *Gliricidia sepium*, *Calliandra calothyrsus*, and *Artocarpus heterophyllus* have been proven to have anti-parasitic effects (Nawaz *et al.*, 2014; Odhong *et al.*, 2014; Setyono, 2014; Daryatmo *et al.*, 2008; Eguele *et al.*, 2007). The use of natural anti-parasitic compounds is considered an appropriate treatment to control parasites. There is concern that the use of commercial anthelmintic drugs such as *albendazole* and *ivermectin*, which have a wide antiparasitic spectrum will lead to resistant parasites because of the inefficiency of the treatment itself (Taylor *et al.*, 2016; Haryuningtyas, 2008; Gilleard, 2006). Tannins have beneficial effects to reduce cell mucosa and permeability, and act as an anti-parasitic compound in the livestock gut (Paolini *et al.*, 2003). In nature, tannins protect plants from predators. However, tannins have double sided effects, both positive and negative impacts on

animal health. The beneficial effects include anti-parasitic, anti-vermin and methane reduction properties (Kustantinah *et al.*, 2017; Kustantinah *et al.*, 2014).

This study was aimed to support scientific development, further investigation to explore the potency of local plants as natural anti-parasitic agents and their preventive roles in parasite resistance is necessary.

MATERIALS AND METHODS

Materials

This study used 15 female Bligon goats, aged less than 1 year, and weighing 13 kg. The forages provided for the animals included king grass, *Calliandra calothyrsus*, and *Artocarpus heterophyllus* (Jackfruit) leaves. The feed formulation of each treatment is shown in Table 1. The animals were equally divided into 3 groups (KG, KGC, and KGA), each treatment was consisted of 5 goats as replication.

Methods

The study was performed by using a completely randomized design (CRD) consisted of 3 different treatment groups. The first group (KG) was fed a basal diet based of 100%_King grass and served as the control group. The second group (KGC) was fed 50% King grass and 50% *Calliandra calothyrsus* leaves. The third group (KGA) was fed 50% King grass and 50% *Artocarpus heterophyllus* leaves. All of the feeding treatments were based on a dry matter basis.

The adaptation period was lasted for 10 days. Composite samples of forages, feed leftover, and feces collection were collected for 14 days. Fecal observations from feces obtained directly from the animal's rectum were performed weekly during 7 weeks. The oocysts in feces were obtained according to Mc. Master's method (Coles *et al.*, 1992). Two grams of feces were weighed and added to 60 ml of ZnSO₄. Then, it was stirred vigorously to breakdown and homogenize the

fecal sample. The contents were poured through a sieve or a cheesecloth-lined funnel into a second container. The samples were rested for 1-3 minutes to allow eggs to float to the top and debris to fall to the bottom of the chamber. Under 10x power, the eggs that fell within the gridded area on both sides of the chamber were counted. The total numbers of eggs in the 2nd chamber were multiplied by 100 to obtain the eggs per gram of feces.

The body weight of each animal was recorded on the first day of the study and then periodically (every 7 days), over 94 days. Weighing was carried out in the morning, before feeding. Individual body weight gain was also calculated.

Parameters

Parameters observed in this study included the nutrient value (proximate analysis) of the ration in each treatment (AOAC, 2005), feed consumption, feed digestibility, average daily

gain, and number of coccidia oocysts in the feces.

Data Analysis

The data were evaluated by using a one-way analysis of variance for a completely randomized design. Differences among treatments were then subjected to the Duncan's multiple range test (DMRT).

RESULTS AND DISCUSSION

The nutrient value of each forage used in this study is shown in Table 2. The tannin-containing forages used were *Calliandra calothyrsus* and *Artocarpus heterophyllus*, which contained 1.60% and 3.21% condensed tannins respectively. The use of these forages was intended to deliver beneficial effects as an anti-parasitic supplement in the gut since tannins have been reported to have direct effects on reducing parasite populations in goats and sheep (Paolini *et al.*, 2004; Athanasiadou *et al.*, 2001). Tannins form a

Table 1. Animal Groups and Feeding Treatment (gram DM/day)

Group	King Grass (<i>P. hybrid</i>)	<i>Calliandra calothyrsus</i>	<i>Artocarpus heterophyllus</i>
King grass (KG)	640.00 (<i>Ad libitum</i>)	-	-
King grass+Calliandra (KGC)	320.00	320.00	-
King grass+Artocarpus (KGA)	320.00	-	320.00

DM: Dry Matter; CP: Crude Protein; TDN: Total Digestible Nutrients

Nutrient value of each treatment:

KG = CP: 7.86%; TDN: 52.32%

KGC = CP: 13.87%; TDN: 62.87%

KGA = CP: 10.00%; TDN: 69.79%

Table 2. Nutrients Value of Each Forage (% of DM)

Forages	DM	100% (Dry Matter Basis)					
		OM	CP	CF	EE	NFE	Tannin
<i>Pennisetum hybrid</i>	18.74	82.87	7.86	27.06	1.50	48.81	0.00
<i>Calliandra calothyrsus</i>	32.24	93.18	19.88	16.27	1.52	55.64	1.60
<i>Artocarpus heterophyllus</i>	40.59	86.24	12.14	15.87	2.04	57.90	3.21

DM: Dry Matter; OM: Organic Matter; CP: Crude Protein; CF: Crude Fiber; EE: Extract Ether; NFE: Nitrogen Free Extract

complex associated with parasite proteins that modifies the parasite's biological processes (Hoste *et al.*, 2006). In vitro studies have confirmed that tannins from tropical plants can act as an inhibitory agents for infectious larvae (Athanasiadou *et al.*, 2007; Ketzis *et al.*, 2006).

Condensed tannins form a protein complex (Adamczyk *et al.*, 2011). Tannins are also able to form a complex with carbohydrates, lipids, and minerals (Smith *et al.*, 2005). Tannins are currently used to decrease protein degradability in the rumen (Theodoridou *et al.*, 2010; Pawelek *et al.*, 2008).

Feed Consumption and Digestibility

Feed consumption was consecutively recorded for 14 days. The nutrient consumption including DM, OM, and CP in the treatment groups (KGC and KGA) were significantly different from those in the control group (KG), (Table 3).

The dry matter consumption values in the treatment groups were greater (KGC and KGA) than that in the control group (KG). The tannin consumption values in KGC and KGA were 3.67 and 6.57 grams DM/day respectively. These tannin consumption results included DM and OM consumption, and the consumption rates in KGC and KGA were higher than that in KG. The practice of tannin supplementation is widely intended to protect high-protein feed from ruminal digestion, increase amino acid availability in the

small intestine, and improve amino acid absorption to enhance animal productivity (Makkar, 2003).

Tannin consumption in KGC and KGA allowed the formation of complexes with feed protein during mastication, shielding it from rumen microbes (Barry and Mc Nabb, 1999). Thus, this enabled animals to utilize proteins more efficiently, improved digestibility (Table 4), enhanced production performance which can be seen in the daily body weight gain (Kahiya *et al.*, 2003), and reduced the number of internal parasites (Figure 1) (Min *et al.*, 2005; Akkari *et al.*, 2008).

The OM consumption in the treatment groups was significantly different from the control group (Table 3). This might be the result of DM consumption (g/kg body weight/day) in the treatment groups (KGC and KGA) which was different from that in the control group. The OM consumption is associated with DM consumption. The increase of DM consumption corresponds to increase OM consumption (Van Soest, 1994).

Production Performance

Compared to the control group, the treatment groups (KGC and KGA) had significant differences in daily body weight gain. Although a tendency toward increased daily body weight gain was observed, the difference between the treatment groups was not confirmed. This might have resulted from the increased DM and CP

Table 3. Feed Consumption (g/kg Body Weight/Day)

Nutrient	Group			P
	KG	KGC	KGA	
Dry Matter (DM)	35.63 ^a	47.96 ^b	70.32 ^c	P<0.01
Organic Matter (OM)	29.20 ^a	40.92 ^b	58.66 ^c	P<0.01
Crude Protein (CP)	3.49 ^a	7.40 ^b	8.36 ^c	P<0.05
Crude Fiber (CF)	9.61 ^a	10.11 ^a	13.30 ^b	P<0.05
Extract Ether (EE)	0.69 ^a	0.80 ^a	1.45 ^b	P<0.05
Nitrogen-Free Extract (NFE)	21.38 ^a	24.73 ^{ab}	38.86 ^b	P<0.01
Total Digestible Nutrients (TDN)	18.73 ^a	30.22 ^b	49.11 ^b	P<0.01

Different superscript on the same line show a significantly difference (P<0.05) or highly significant difference (P<0.01)

Table 4. Nutrient Digestibility (%)

Nutrient	Groups			P
	KG	KGC	KGA	
Dry Matter (DM)	57.17 ^a	67.89 ^b	74.00 ^b	P<0.01
Organic Matter (OM)	58.06 ^a	67.06 ^b	74.80 ^b	P<0.01
Crude Protein (CP)	4.38 ^a	8.57 ^b	8.80 ^b	P<0.05
Crude Fiber (CF)	12.18	13.44	15.20	ns
Extract Ether (EE)	0.73 ^a	1.04 ^b	1.30 ^b	P<0.05
Nitrogen-Free Extract (NFE)	34.11 ^a	38.51 ^b	42.84 ^b	P<0.01
Total Digestible Nutrient (TDN)	52.32 ^a	62.87 ^b	69.79 ^c	P<0.01

Different superscript on the same line show a significant difference (P<0.05) or highly significant (P<0.01), ns= non significant (P>0.05)

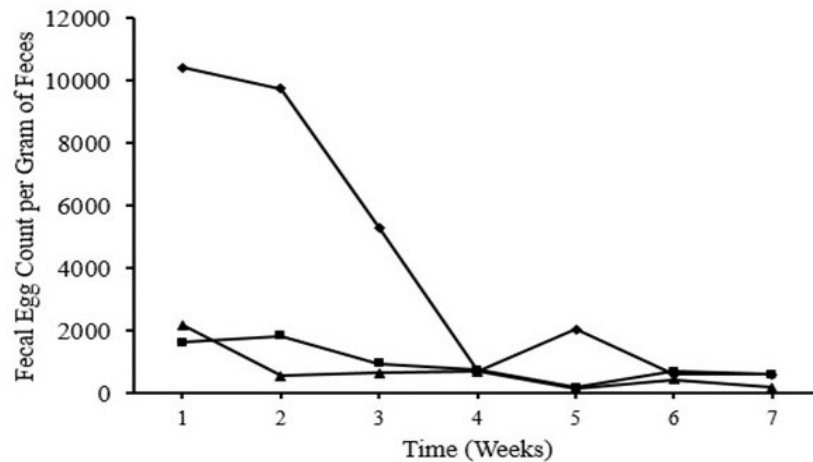


Figure 1. Number of oocysts coccidian on feces. The symbol represent KG served as control – fed with 100% king grass (dry matter basis) (◆); the second group (KGC) were fed with 50% of king grass and 50% of *Calliandra calothyrsus* leaves (dry matter basis) (■); and the third group (KGA) were fed with 50% of king grass of *Artocarpus heterophyllus* leaves (dry matter basis) (▲).

(g/kg body weight/day) in the treatment groups compared to the control group.

The result of this study showed that animals that received *Calliandra* and Jackfruit leaves had an improved ability to utilize nutrients, resulting in body weight gain. Thus, the treatment groups had higher daily body weight gain values than the control group, which received only grass. Cenci *et al.* (2007) stated that even a small number of tannins in forages may provide beneficial effects

in animals. Min *et al.* (2005) confirmed that the growth rate of goats fed tannin-containing forages (Cassava, Jackfruit, and *Leucaena* leaves) was higher than that of goats consumed only grass.

This *in vivo* study confirmed that *Calliandra* and Jackfruit leaf supplementation led to increase daily body weight gain, with an increase of 22.85 and 29.52 grams/day in KGC and KGA compared with the control group. This positive result might be caused by the increase of DM, OM, or CP

consumption in the treatment groups compared to the control group.

Coccidian Oocysts

One of constraints faced by farmers who are trying to improve goat production is the growth inhibition caused by parasitic infection in the gut (Goodwin, 2007). Parasites can cause both direct and indirect effects such as body weight loss (Hungerford, 2005) or even death in severe infection cases (Siegmond *et al.*, 1983), resulting in economic losses (Maichimo *et al.*, 2004). Kustantinah *et al.* (2008) reported that the number of coccidian oocysts in Bligon goats fed a single type of grass (*ad libitum*), and goats supplemented with 220 and 515 g (DM basis) of dried Cassava leaves were 4,573; 1,442; and 723 respectively. Dried Cassava leaves have also been confirmed to significantly reduce the number of coccidian parasites in the goat's gastrointestinal tract. The tannins and phenolic compounds in the Cassava leaves might correspond to this result (Magdeleine *et al.*, 2010). Min *et al.* (2005) reported that vermin eggs in the feces of goats fed grass (*Guinea* and *Ruzi*) were 4 times higher than those in goats fed leaves (Cassava, Jackfruit, and *Leucaena*).

The study revealed that the number of coccidian oocysts in feces were 3,166; 841; and 450 eggs per gram feces for KG; KGC; and KGA respectively. The number of coccidian oocysts in the KGA was significantly reduced. Jackfruit leaves contained 3.61% tannins and were confirmed to effectively reduce the number of coccidian oocysts in this study. A moderate number of tannins (2 to 4%) can improve the protein availability in the ruminant small intestine. It has indirect effects on host resistance and is active against parasites (Khampa *et al.*, 2009). Numerous previous studies have reported both direct and indirect effects of tannins on reducing coccidian oocyst numbers (Cenci *et al.*, 2007 and Min *et al.*, 2005). Tannins have positive effects to protect intestinal mucosa, thus reducing the development and reproduction of coccidia that live in the intestinal epithelium. Feeding livestock tannin-containing forages can increase the number of mast cells in the intestinal mucosa (Paolini *et al.*, 2003), prompting a local immune response against internal parasites. Hence, a reduction in the number of coccidian oocysts that live in the intestinal mucosa and oocysts in the feces can be achieved.

CONCLUSION

Tannin-containing forage supplementation can improve the consumption and digestibility of DM, OM and CP. The supplementation improved the daily body weight gain. The number of coccidian oocysts in animals receiving supplementation was also reduced. The greatest effects on fecal coccidian oocyst reduction were attained with Jackfruit leaf (*Artocarpus heterophyllus*) supplementation.

ACKNOWLEDGMENTS

Authors would like to thanks of Directorate of Research Universities, Universitas Gadjah Mada (UGM) through "Rekognisi Tugas Akhir (RTA)" 2019. Contract number: 3268/UN1/DITLIT/DIT-LIT/LT/2019.

REFERENCES

- Adamczyk, B., S. Adamczyk, A. Smolander and V. Kitunen. 2011. Tannic acid and Norway spruce condensed tannins can precipitate various organic nitrogen compounds. *Soil Biol. Biochem.* 43(3): 628-637.
- Akkari, H., M.A. Darghout, and H.B. Salem. 2008. Preliminary investigations of the anti-nematode activity of *Accacia cyonophylla Lindl.*: Excretion of gastrointestinal nematode eggs in lambs browsing *A. cyanophylla* with and without PEG or grazing native grass. *J. Small Rum. Res.* 74(1-3): 78-83.
- AOAC. 2005. Official Methods of Analysis of the Assosiation of Official Agricultural Chemist. Published by the Association of Official Analytical Chemists, Maryland, USA.
- Athanasiadou, S., I. Kyriazaki, F. Jackson and R.L. Coop. 2001. Direct anthelmintic effects of condensed tannins towards different gastroin-testinal nematodes of sheep: in vitro and in vivo studies. *Vet. Parasitol.* 99(3): 205-219.
- Athanasiadou, S., J. Githiori and I. Kyriazakis. 2007. Medicinal plants for helminth parasite control: facts and fiction. *Animal* 1(09): 1392-1400.
- Barry, T.N. and W.C. McNabb. 1999. The effect of condensed tannins in temperate forages on animal nutrition and productivity. *Tannins in livestock and human nutrition.*

- ACIAR Proceedings 92: 30-35.
- Cenci, F.B., H. Louvandini, C.M. McManus, A. Dell'Porto, D.M. Costa, S.C. Araujo, A.P. Minho and A.L. Abdalla. 2007. Effects of condensed tannin from *Acacia mearnsii* on sheep infected naturally with gastrointestinal helminthes. *J. Vet. Parasitol.* 144(1-2): 132-137.
- Coles, G.C., C. Bauer, F.H.M. Borgsteede, S. Geerts, T.R. Klei, M.A. Taylor and P.J. Waller. 1992. World Association for the Advancement of Veterinary Parasitology (W. A. A. V. P.) methods for the detection of anthelmintic resistance in nematodes of veterinary importance. *Vet. Parasitol.* 44 (1-2): 35-44.
- Daryatmo, J., Kustantinah, E.R. Ørskov, H. Hartadi and W. Nurcahyo. 2008. Nutrition potential of various forages that contain active compound and their effectiveness as anti parasite. Proceedings. The 13th Animal Science Congress of the Asian-Australian Association of Animal Production Societies (AAAP). Sept 22-26. Hanoi, Vietnam.
- Eguale, T., G. Tilahun, A. Debella, A. Feleke, and E. Makonnen. 2007. In vitro and in vivo anthelmintic activity of crude extract of *Coriandrum sativum* against *Haemonchus contortus*. *J. Ethnophar.* 110(3):428-433.
- Gilleard, J.S. 2006. Understanding anthelmintic resistance: the need for genomics and genetics. *Int. J. Parasitol.* 36(12):1227-1239.
- Goodwin, D.H. 2007. Beef management and production. Hutchinson. Australia Pty Ltd. New South Wales, Page: 183-185.
- Haryuningtyas, D dan W.T. Artama. 2008. Analisis Sekuen Gen Tubulin- β Isotipe 1 Cacing *Haemonchus contortus* Isolat Resisten terhadap Benzimidazole pada Domba di Indonesia. *J. AgroBiogen.* 4(2): 45-50.
- Hoste, H., F. Jackson, S. Athanasiadou, S.M. Thamsborg and S.O. Hoskin. 2006. The effects of tannin-rich plants on parasitic nematodes in ruminants. *Trends Parasitol.* 22(6): 253-261.
- Hungerford, T.G. 2005. Disease of livestock. McGraw-Hill Book Company, Sidney.
- Jackson, F. and R.L. Coop. 2000. The development of anthelmintic resistance in sheep nematodes. *Parasitology* 120(7):95-107.
- Kahiya, C., S. Mukaratirwa and S.M. Thamsborg. 2003. Effect of *Acacia nilotica* and *Acacia karoo* diets on *Haemonchus contortus* infection in goats. *J. Vet. Parasitol.* 115(3): 265-274.
- Ketzis, J.K., J. Vercruyse, B.E. Stromberg, M. Larsen, S. Athanasiadou and J.G.M. Houdijk. 2006. Evaluation of efficacy expectations for novel and non-chemical helminth control strategies in ruminants. *Vet. Parasitol.* 139(4):321-335.
- Khampa, S., P. Chaowarat, R. Singhaler and M. Wanapat. 2009. Supplementation of Cassava hay as anthelmintics on fecal egg in heifer grazing on Ruzi grass pasture. *Park. J. Nutr.* 8(5):518-520.
- Kustantinah, Y.D. Artikarini, H. Hartadi dan W. Nurcahyo. 2008. Penggunaan daun ketela pohon di dalam ransum untuk mengatasi endoparasit pada kambing yang dipelihara peternak. *Bulletin Peternakan* 32(1):1-11.
- Kustantinah, W. Setyono, N.D. Dono and E.R. Orskov. 2014. Anthelmintic efficacy of *Gliricidia sepium*, *Calliandra calothyrsus* and *Artocarpus heterophyllus* by in vitro measurement against *Haemonchus contortus* Worm. Proceedings of 16th AAAP Congress November 10-14, 2014. Yogyakarta, Indonesia. 672-675.
- Kustantinah, A., E. Indarto, Zuprizal, C.T. Noviandi, N.D. Dono and F.A. Mukti. 2017. Feed evaluation based on grass production of twelve tropical feedstuffs. Proceeding of the 7th International Seminar on Tropical Animal Production September 12-14, 2017. Yogyakarta, Indonesia. 178-184.
- Magdeleine, C.M., M. Mahieu, L. Philibert, P. Despois and H. Archimede. 2010. Effect of Cassava (*Manihot esculenta*) foliage on nutrition, parasites infection and growth of lambs. *J. Small Rum. Res.* 93(1): 10-18.
- Maichimo, M.W., J.M. Kagira, and T. Walker. 2004. The point prevalence of gastrointestinal parasites in calves, sheep and goats in Magadi division, South-western Kenya. *The Onderstepoort. J. Vet. Res.* 71(4):257-261.
- Makkar, H.P.S. 2003. Effect and fate of tannins in ruminant animals, adaptation to tannins, and strategies to overcome detrimental effects of feeding tannin-rich feeds. *Small Ruminant Research.* 49(3):241-256.
- Min, B.R., S.P. Hart, D. Miller, G.M. Tomita, E. Loetz and T. Sahl. 2005. The effect of

- grazing forage containing condensed tannins on gastro-intestinal parasite infection and milk composition in Angora does. *J. vet. Parasitol.* 130(1-2):105-113.
- Nawaz, M., S.M. Sajid, M. Zubair, J. Hussain, Z. Abbasi, A. Mohi-Ud-Din, and M. Waqas. 2014. In vitro and in vivo anthelmintic activity of leaves of *Azadirachta indica*, *Dalbergia sisso* and *Morus alba* against *Haemonchus contortus*. *Global Veterinaria.* 13(6):4667-4672.
- Odhong, C., R.G. Wahome, M. Vaarst, S. Nalubwama, M. Kiggundu, N. Halberg, and S. Githia. 2014. In vitro anthelmintic effects of crude aqueous extracts of *Tephrosia vogelii*, *Tephrosia villosa* and *Carica papaya* leaves and seeds. *Afr. J. Biotechnol.* 13(52): 4667-4672.
- Paolini, V., J.P. Bergeaud, C. Grizes, F. Prevot, P.H. Dorchie and H. Hoste. 2003. Effects of condensed tannins on goats experimentally infected with *Haemonchus contortus*. *J. Vet. Parasitol.* 113(3-4):253-261.
- Paolini, V., I. Fouraste and H. Hoste. 2004. In vitro effects of three woody plant and sainfoin on third-stage larvae and adult worms of three gastrointestinal nematodes. *Parasitol.* 129(1): 69-77.
- Pawelek, D.L, J.P. Muir, B.D. Lambert and R.D. Wittie. 2008. In sacco rumen disappearance of condensed tannins, fiber and nitrogen from herbaceous native Texas legumes in goats. *Anim. Feed Sci. Technol.* 142(1-2): 1-16.
- Setyono, W. 2014. Kontrol Parasit Menggunakan Hijauan Sebagai Agen Anthelmintika Pada Kambing Bligon Betina. Tesis. Fakultas Peternakan. Universitas Gadjah Mada. Yogyakarta, Indonesia.
- Siegmund, O.H., J. Arcibald, C.B. Douglas, A.H. James, M.N. Paul, H.S. Glenn and L.W. William. 1983. Merck Veterinary Manual. Fifth Edition. Merck and Co., Inc. Rahway, N.J., USA.
- Smith, A.H., E. Zoetendal, and R.I. Mackie. 2005. Bacterial mechanisms to overcome inhibitory effects of dietary tannins. *Microb. Ecol.* 50(2):197-205.
- Taylor, M.A, R.L. Coop and R.L. Wall. 2016. Parasites of sheep and goats, in: *Veterinary Parasitology*, Fourth Edition. pp. 436–523.
- Theodoridou, K., J. Aufrere, D. Andueza, J. Pourrat, A.L. Morvan, E. Stringano, I. Muller-Harvey and R. Baumont. 2010. Effect of condensed tannins in fresh sainfoin (*Onobrychis viciifolia*) on in vivo and in situ digestion in sheep. *Anim. Feed Sci. Technol.* 6(02):245-253.
- Van Soest, P.J. 1994. *Nutritional Ecology of The Ruminant*. 2nd edition. Cornell University Press. Ithaca. USA