IN VIVO GREENHOUSE GASES EMISSIONS, NUTRIENT INTAKE, DIGESTIBILITY AND RUMEN PARAMETERS OF GROWING SHEEP AFFECTED BY DIETARY SILAGE SOURCES

Nguyen Van Thu

College of Agriculture, Can Tho University, Vietnam

Corresponding author: Nguyen Van Thu; Email: nvthu@ctu.edu.vn

ABSTRACT

This experiment was done to evaluate *in vivo* greenhouse gases production, nutrient utilization and rumen parameters affected by silages in diets of sheep from Feb to May, 2018 at Can Tho University farm. Four male sheep with average live weight of 17,3±1,48 kg were arranged in a 4x4 Latin square design with 4 treatments including (1) *Paspalumatratum* (PA), and (2) 40% *Pennisetumpurpureum* silage (PPS40), (3) 40% *Operculinaturpethum* silage (OTS40) and (4) 40% *Psophocarpusscandens*silage (PSS40) replacing *Paspalumatratum* (%DM) in the diets. Methane and carbon dioxide were measured by using the chambers for 2 continuous days and analyzed by a Greenhouse Gas Analyser (USA). The results showed that the CH_4 production (g/kg OM intake) of sheep was significantly different among the treatments (P<0.05). The CH_4 production (g/kg OM intake) of the OTS40 treatment (6.37) was the lowest, following by the PSS40 treatment (6.93), the PPS40 treatment (7.69), and the PA treatment (9.60). The metabolizable energy (ME) intake was improved by the silage diets (P=0.056), while digestible protein intake and nitrogen retention of the OTS40, PSS40 PPS40 treatments tended to be higher than that of the PA treatment (P>0.05). Daily weight gains (g/day) of sheep were likely to be higher (P>0.05) for the OTS40, PPS40 and PSS40 treatments. The conclusion was that replacing *Paspalumatratum* grass by PPS, OTS or PSS at level of 40% (DM) in diets reduced CH_4 output, tented to improve total DM intake, crude protein digestibility, rumen parameters and nitrogen retention and reduced CH_4 output of growing sheep.

Keywords: *methane, nitrogen retention, nutrient digestibility, sheep, silage*.

INTRODUCTION

Greenhouse gas (GHG) emissions is one of the environmental problems for livestock production in recent years. While methane is a main source of GHG emissions from the agricultural sector. Methane has 23 times higher potential to exacerbate global warming than carbon dioxide. Livestock sector contributed about 14.5% of total global GHG emissions from human activities in 2010,while small ruminant production of meat and milk is responsible for 428.8 million tones CO_2. Sheep production produced 254.4 million tones CO_2 while 174.5 tones CO_2 (41 percent) for goat production (Anna, 2014). Although sheep population in Vietnam is small, it has exposed an increasing tendency. Sheep, namely Phan Rang sheep, are mainly raised in the South Central coast of Vietnam. This breed adapts well to the dry and hot climate and low quality diets of this region. The sheep production in Vietnam is variable and has low efficiency due to the dependence on natural feed resources (Khuc Thi Hue, 2012) and there is a lack of staple feeds during the dry seasons. In the Mekong Delta Vietnam, locally natural forages such as Para grass, *Operculumturpethum* and *Psophocarpusscandens* and planted grasses as *Paspalumatratum* and *Pennisetumpurpureum* were widely used for feeding sheep. Silage can be successfully fed to sheep to improve performance, pasture utilization and management by transferring surplus feed to less favorable periods of feed supply (Stanley, 2003). Silages content higher lactic acid compared to grasses which can reduce methane production in rumen (Cao et al., 2010). Martin et al. (2010) also reported that feeding ruminants with silages tends to reduce methane production compared to this with ground dry roughages or pellets. This study was toevaluate *in vivo* greenhouse gases production as well as identify the feed nutrient utilization and rumen parameters affected by different silages in diets of growing sheep.

MATERIALS AND METHODS

Location and experimental design

The trial was carried out at the experimental farm of CanTho University in CanTho City from Feb 2018 to May 2018. Four Phan Rang male sheep (17,3±1,48kg) were arranged in a Latin Square design with 4 treatments and 4 periods. The four treatments were *Paspalumatratum* (PA) and 40% *Pennisetumpurpureum* silage (PPS40), 40% *Operculinaturpethum* silage (OTS40) and 40% *Psophocarpusscandens*silage (PSS40) replacing *Paspalumatratum* in the diets. Each experimental period was 14 days including 7 days for adaptation and then 7 days for sample collection. The level of different silages replacing *Paspalumatratum* grass in the diets of 40% (DM) was followed the method decribed by Yulistiani (2016).

Feeds and feeding

The formulation of experimental diets and dietary nutrients and metabolized energy concentration were showed in Table 1.

Table 1. Dietary formula and nutrients and metabolized energy concentration in different diets of the experiment (%DM)

Item	Treatment			
	PA	PPS40	OTS40	PSS40
Paspalum atratum(PA)	81.16	48.94	49.73	50.45
Pennisetumpurpureum silage (PPS)	-	32.62	-	-
Operculinaturpethum silage (OTS)	-	-	33.16	-
Psophocarpusscandens silage (PSS)	-	-	-	33.63
Soybean	17.56	17.19	15.95	14.84
Urea	1.28	1.25	1.16	1.08
CP	19.1	19.19	19.50	19.78
ME, MJ/kg DM	8.59	8.83	9.23	9.15

Note: PA: 100% Paspalumatratum, PPS40, OTS40 and PSS40 were Pennisetumpurpureum silage, Operculinaturpethum silage and Psophocarpusscandens silage replacing 40% DM Paspalumatratum

The silages were made from *Pennisetumpurpureum* silage, *Operculinaturpethum* silage and *Psophocarpusscandens* collected within the campus of Can Tho University. They were used for feeding sheep from 14 to 21 days after incubation with 11.5% molasses (DM basis) following the suggestions of Nguyen Van Thu (2019). Daily feeds were divided 3 parts and offered the experimental sheep 3 times a day at 7:30, 13:30 and 16:30. *Paspalum atratum*was offered for sheep after they completely consumed the silage. Soybean seeds and urea were bought at feed stores around Can Tho City, in one occasion during experiment. The soybean seeds were roasted and ground before using to feed experimental sheep.

Samplings and Chemical analysis

Feeds, refusal and feces were daily collected, measured and analyzed of DM, OM and Ash following procedure of AOAC (1990), NDF by Van Soest et al. (1991) and metabolizable energy (ME) according to Bruinenberg et al. (2002).

Measurements taken

Daily feed intake and weight gain of sheep in the experiment were measured and calculated every two weeks. Apparent DM, OM, CP and NDF digestibility were done according to McDonald et al. (2002). Rumen fluid was collected via an esophagus tube before and 3 hours post feeding. Total VFAs of rumen fluid was determined following method of Barnet and Reid (1957). Greenhouse gas emissions were measured in 2 consecutive days by chambers, which were designed as method described by Dong Hua Li (2010) and the gas samplings were done by every 30 min. Methane and carbon dioxide concentration of samples were analyzed by the Fast Greenhouse Gas Analyzer, USA.

Statistical analysis

The data were analyzed by analysis of variance using the ANOVA of General Linear Model (GLM) of Minitab Reference Manual Release16.0 (Minitab, 2016). While the Tukey test was used for paired comparison between 2 treatments.

RESULTS AND DISCUSSION

Feed chemical composition and nutrient intake

Chemical compositions of feeds used in the experiment are presented in Table 2.

Table 2. Chemical composition (%DM) of feeds used in the experiment

	DM, %	% DM						pH	VFAs (g/kg)	ME (MJ/kg)
		OM	CP	EE	NDF	ADF	Ash			
PA	18.2	87.0	10.4	4.09	60.8	38.5	13.0	-	-	7.50
PPS	29.9	87.1	10.3	6.47	56.9	37.0	12.9	3.85	27.2	8.32
OTS	27.7	84.5	13.7	7.88	39.8	31.8	15.5	3.80	21.1	9.74
PSS	29.1	86.0	16.2	7.16	43.1	31.6	14.0	4.28	29.4	9.66
Soybean meal	96.9	94.2	41.8	17.2	31.8	24.3	5.85	-	-	13.8
Urea	-	-	288	-	-	-	-	-	-	-

The DM of *Paspalum atratum* (18.2%) was lower than that of the silages (29.9%, 27.7% and 29.1% for PPS, OTS, PSS, respectively). For the forage feeds, PSS and OTS contented the higher CP values compared to PA and PPS, while fiber components (NDF and ADF) was opposite. Soybean meal and urea were used in the experimental diets for supplying crude protein for sheep.

Feed and nutrient intakes

Feeds, nutrients and metabolizable energy intakes of experimental sheep are presented in Table 3.

Table 3. Feeds, nutrients and metabolizable energy intakes of experimental sheep

Item	**Treatment**				**SEM**	**P**
	PA	**PPS40**	**OTS40**	**PSS40**		
Feed intake, gDM/head/day						
PA	467[a]	312[b]	344[b]	324[b]	16.6	0.002
PPS	-	203	-	-	-	-
OTS	-	-	227	-	-	-
PSS	-	-	-	216	-	-
% silage/PA	-	39.6	40.0	39.9	-	-
Nutrient intake, gDM/head/day						
DM	597	642	690	652	23.6	0.148
OM	529	568	603	574	20.6	0.192
CP	123	127	135	133	4.55	0.327
EE	44.6	49.0	54.2	50.2	2.15	0.095
NDF	321	342	335	323	11.8	0.596
ME, MJ/day	5.47	6.21	6.93	6.32	0.28	0.056
ME, MJ/kgW^{0,75}	0.574	0.678	0.732	0.678	0.03	0.065

The DM and OM intakes of sheep in the PPS40, OTS40 and PSS40 treatments tended to higher than those of the PA treatment, however, no statistical significance was found ($P>0.05$). The DM intake of experimental sheep ranged 597-690 g/head/day. This finding was similar to the report of Huynh Hoang Thi (2013), being 476-642 g/head/day by using different levels of *Operculinaturpethum* in growing sheep diets. The OM consumption of sheep in this trial (529-603 g/head/day) consisted with the results of Bekele et al. (2013) being 548-733 g/head/day and Dessie et al. (2009) being 508-680 g/head/day. The CP intakes were 123, 127, 135 and 133 g/day for PA, PPS40, OTS40 and PSS40 treatments, respectively, but no significant (P>0.05). The ME consumption of sheep fed the silages (6.21, 6.93 and 6.32 MJ/day corresponding to PPS40, OTS40 and PSS40 treatments) were higher (P=0.056) than that of PA treatment (5.47 MJ/day). These values consisted with findings of Paul et al. (2003) stated that growing sheep at 15-20 kg live weight consumed 4.94-9.61 MJ/day. The results in the Table 3 indicated that sheep fed the forage silages in diets at a level of 40% replacement (DM) moderately improved DM, nutrient and ME intakes.

Digestible nutrients, nitrogen balance, daily weight gain and rumen parameters

Table 4. Digestible nutrients, nitrogen balance and daily weight gain of experimental sheep

Item	Treatment				SEM	P
	PA	PPS40	OTS40	PSS40		
Digestible nutrients, g/head/day						
DM	376	433	489	443	22.4	0.060
OM	343	393	440	398	18.7	0.055
CP	103	106	116	114	3.49	0.098
EE	33.0	38.1	44.1	39.7	2.22	0.062
NDF	204	236	234	222	15.1	0.462
Nitrogen balance, g/head/day						
N intake	19.7	20.3	21.6	21.3	0.72	0.298
N feces	3.27	3.37	3.08	3.06	0.34	0.899
N urine	1.50	1.28	1.32	1.33	0.15	0.753
N excrete	4.76	4.65	4.40	4.39	0.32	0.798
N retention	14.9	15.7	17.2	16.9	0.59	0.096
N retention, g/kgW^{0,75}	1.59^{b}	1.71^{ab}	1.83^{a}	1.82^{a}	0.05	0.034
Initial live weight, kg	18.8	18.5	19.1	18.8	0.44	0.831
Final live weight, kg	20.1	19.8	20.7	20.2	0.26	0.223
Daily weight gain, g/day	91.1	94.6	116	96.4	27.7	0.916

The digestible DM, OM, CP, EE and NDF values tended to be higher for the silage treatments compared to the PA one, particularly these were approached a statistical significance (P≤0.06) for the digestible DM and OM. Thus the use of silages in sheep diets (PPS40, OTS40 and

PSS40 treatments) moderately improved digestible nutrients. The digestible DM and OM values of sheep in this experiment were similar to those reported by Huynh Hoang Thi (2013) with DM and OM digestible being 337-489 and 316-450 g/head/day for the growing sheep, respectively. Nitrogen intake of experimental sheep of PPS40, OTS40 and PSS40 treatments was slightly higher (P>0.05) than that of PA treatment (20.3, 21.6 and 21.3 g/head/day vs 19.7 g/head/day). Nitrogen retention (g/head/day) tended to be higher for the silage treatments (P>0.05), however nitrogen retention (g/kg$W^{0.75}$) of OTS40 and PSS40 diets was significantly higher (P<0.05) than that of PA treatment. The daily weight gain of sheep in this experiment were not significantly different (P>0.05) among treatments although these values were numerically higher for the PPS40, OTS40 and PSS40 treatments.

Table 5. Rumen parameters of pH, N-NH3 and total VFAs of experimental sheep

Item	**Treatment**				**SEM**	**P**
	PA	**PPS40**	**OTS40**	**PSS40**		
pH at 0 h	6.88	6.80	6.92	6.81	0.06	0.463
pH at 3 h after feeding	6.75	6.77	6.67	6.75	0.04	0.370
N-NH_3 at 0 h, mg/100ml	24.3	26.6	24.6	26.3	2.56	0.890
N-NH_3 at 3 h after feeding, mg/100ml	39.9	45.9	42.9	40.8	2.59	0.435
Total VFAs at 0 h, mmol/l	71.8	73.3	69.0	62.8	7.57	0.776
Total VFAs at 3 h after feeding, mmol/l	80.1	82.3	89.1	81.8	6.00	0.737

Note: PA: 100% Paspalumatratum, PPS40, OTS40 and PSS40 were Pennisetumpurpureum silage, Operculinaturpethum silage and Psophocarpusscandens silage replacing 40% DM Paspalumatratum. VFAs: volatile fatty acids

In the Table 5 showed that the pH at 0h and pH at 3h after feeding of rumen fluid of sheep were similar among the treatments (P>0.05). The pH at 0h and pH at 3h after feeding ranged 6.8-6.92 and 6.67-6.77, respectively. It indicated that using forage silages for growing sheep did not affect on pH of rumen fluid. The values of pH in present experiment consisted to those reported by Osakwe et al. (2004) and Nguyen Van Thu and Nguyen Thi Kim Dong (2012) being 6.49-6.75 and 6.59-6.80, respectively. The N-NH3 and VFAs values at 0h and at 3h after feeding of rumen fluid of experimental sheep were not significantly different (P>0.05) among treatments. The N-NH3 and VFAs at 3h after feeding values were higher than compare to these values at 0h. Nguyen Dong Hai (2008) also found that N-NH3 0h and at 3h after feeding values of sheep rumen fluid being 24.2-27.7 mg/100ml and 36.4-47.6 mg/100ml, respectively. Similarly, Kusmartono (2007) stated that N-NH3 at 3h after feeding values of sheep rumen fluid being 37.6-41.3 mg/100ml. The VFAs values at 0h in this experiment were similar to findings of Huynh Hoang Thi (2013) being 62.8-73.3 mmol/l and VFAs at 3h after feeding consisted to thosestated by Osakwe et al. (2004) being 80.6-91.6 mmol/l.

Greenhouse gases emissions

The greenhouse gas production by the sheep was presented in Table 6 and Table 7. The methane and carbon dioxide production (l/day) of sheep in this experiment were similar (P>0.05) among treatment but these values of PPS40, OTS40 and PSS40 treatments were slightly lower than those of PA treatment. The methane production (g/day) of OTS40 (3.87g/day), PSS40 (4.0 g/day) and PPS40 (4.37 g/day) treatment decreased 21.7%, 19.0% and 11.5% compare to PA treatment (4.94 g/day). The methane production values (g/kg DMI, g/kg OMI) of sheep were significantly different among the treatment (P<0.05) with the lowest value for the OTS treatment (Table 6). The methane production (g/kg DMI) of sheep of the PA diets were 20.0%, 28.2% and 34.5% higher compared to PPS40, PSS40 and OTS40 treatments, respectively. Nguyen Van Thu Nguyen Thi Kim Dong (2012) found that using catfish oil at 1-3% levels in growing sheep reduced methane production (g/kg DMI) from 23.3 to 39.5%. The methane production values (g/day, g/kg BW) of experimental sheep were similar to report of Wyatt et al. (2002) being 3.48-5.32 g/day and 0.12-0.60 g/kg BW by using Kikuyu grass for growing sheep.

Table 6. Methane production (g/kgDMI, OMI, DDM, DOM, BW and DWG) of sheep in the experiment

Item	Treatment				SEM	P
	PA	PPS40	OTS40	PSS40		
CH_4, L/day	6.89	6.09	5.40	5.57	0.48	0.219
CH_4, g/day	4.94	4.37	3.87	4.00	0.34	0.220
CH_4, g/kg DMI	8.50[a]	6.80[ab]	5.57[b]	6.10[ab]	0.57	0.044
CH_4, g/kg OMI	9.60[a]	7.69[ab]	6.37[b]	6.93[ab]	0.65	0.050
CH_4, g/kg DDM	15.0	10.6	7.87	9.39	1.68	0.097
CH_4, g/kg DOM	16.4	11.6	8.74	10.4	1.85	0.104
CH_4, g/kg BW	0.250	0.230	0.190	0.200	0.01	0.080
CH_4, g/kg DWG	102	51.9	54.5	80.9	41.7	0.813

Note: PA: 100% Paspalumatratum, PPS40, OTS40 and PSS40 were Pennisetumpurpureum silage, Operculinaturpethum silage and Psophocarpusscandens silage replacing 40% DM Paspalumatratum. DMI: Dry matter intake, OMI: Organic matter intake, DDM: Digestible dry matter, DOM: Digestible organic matter, BW: Body weight, DWG: Daily weight gain. The numbers with different superscript letters in the same row were significantly different (P<0.05).

In general, CO_2 production values of sheep in present experiment were similar (P>0.05) among treatments but those values tended to lower for the PPS40, OTS40 and PSS40 treatments compared to the PA treatment (Table 7). In summary,the results of GHG emissions indicated that there was a reduction of *in vivo* CH_4 and CO_2 for the silage diets. These findings in the present study were consisted with those found by Cao et al. (2010) and Martin et al. (2010) when feeding silages containing higher lactic acid compared to grasses, which can reduce methane production in rumen.

Table 7. Carbon dioxide production (g/kgDMI, OMI, DDM, DOM, BW and DWG) of sheep in the experiment

Item	Treatment				SEM	P
	PA	PPS40	OTS40	PSS40		
CO_2, L/day	121	113	105	113	8.22	0.604
CO_2, g/day	239	222	205	222	16.1	0.605
CO_2, g/kg DMI	414	347	299	345	28.1	0.127
CO_2, g/kg OMI	468	392	341	392	32.0	0.144
CO_2, g/kg DDM	742	536	422	528	88.5	0.179
CO_2, g/kg DOM	810	587	468	584	96.7	0.189
CO_2, g/kg BW	12.3	11.6	10.3	11.3	0.69	0.334
CO_2, g/kg DWG	5140	2593	3163	4528	2199	0.833

Note: PA: 100% Paspalumatratum, PPS40, OTS40 and PSS40 were Pennisetumpurpureum silage, Operculinaturpethum silage and Psophocarpusscandens silage replacing 40% DM Paspalumatratum. DMI: Dry matter intake, OMI: Organic matter intake, DDM: Digestible dry matter, DOM: Digestible organic matter, BW: Body weight, DWG: Daily weight gain.

CONCLUSION

It could be concluded that feed and nutrient intakes and digestible nutrients of the growing sheep moderately improved by using silages of *Pennisetumpurpureum*, *Operculinaturpethum* and *Psophocarpusscandens* to replace 40% of *Paspalumatratum* (DM basis) in the diets. The use of forage silages at a level of 40% in growing sheep diets reduced methane and carbon dioxide production. Performance studies of feeding silages in growing sheep diets should be implemented to confirm these findings for production recommendations.

REFERENCES

Anna, K. J. 2014. The mitigation of greenhouse gas emission in sheep farming systems.A thesis for the degree of doctor of Philosophy to Bangor University. School of Environment, Natural Resources and Geography Bangor University, May 2014.

AOAC. 1990. Official methods of analysis (15th edition).Association of Official Analytical Chemists. Washington, DC. Volume 1, pp. 69-90.

Barnet, A. J. G. and Reid, R. L. 1957. Studies on the production of volatile fatty acids from grass by rumen liquor in an artificial rumen. The volatile fatty acid production from Chen, X. B. and M. J. Gome, 1995.Estimation of microbial protein supply to sheep and cattle based on urinary excretion of purine derivatives-An over of the technical details. International Feed Resources Unit.RowettReseach Institute. Bucksburn Aberdeen AB2 9SB. UK.

Bekele, W., Melaku, S. and Mekasha, Y. 2013. Effect of substitution of concentrate mix with Sesbaniasesban on feed intake, digestibility, body weight change and carcass parameters of Arsi-Bale sheep fed a basal diet of native grass hay. Trop Anim. Health Prod., DOI 10.1007/s11250-013-0413-4.

Bruinenberg, M. H., Valk, H., Korevaar, H. and Struik, P.C. 2002. Factors effecting digestibility of temperate forages from semi-natural grasslands. Grass and Forage Science, 57(3), pp. 292-301

Cao, Y., Takahashi, T., Horiguchi, K., Yoshida, N. and Cai, Y. 2010. Methane emissions from sheep fed fermented or non-fermented total mixed ration containing whole-crop rice and rice bran. Anim. Feed Sci. and Technol., Vol. 157, No. 1, pp. 72–78.

Dessie, J., Melaku, S., Tegegne, F. and Peters, K.J. 2009. Effect of supplementation of Simada sheep with graded levels of concentrate meal on feed intake, digestibility and body-weight parameters. Trop Anim. Health Prod., 42, pp. 841–848.

Dong Hua Li. 2010. A respiration-metabolism chamber system for measuring gas emission and nutrient digestibility in small ruminant animals. Department of Animal Science and Environment, Konkuk University, Seoul 143-701, Republic of Korea, pp. 444-450.

Huynh Hoang Thi. 2013. Effects of different replacement levels of Para grass by Operculinaturpethum and Psophocarpusscandens in diets on *in vitro* CH4 and CO2 production, nutrient digestibility, rumen fluid parameters and nitrogen retention of growing sheep. Master thesis in Animal Science, Can Tho University.

Khuc Thi Hue. 2012. Feeding cassava foliage to sheep. Doctoral thesis Swedish University of Agricultural Science Uppsala 2012, ISSN: 1652-6880.

Kusmartono. 2007. Effects of supplementing Jackfruit (Artocarpusheterophyllus L) wastes with urea or Gliricidia/cassava leaves on growth, rumen digestion and feed degradability of sheep fed on rice straw basal diet. Livestock Research rural Development, 19(2), pp. 1–13.

Martin, C., Morgavi, D. P. and Doreau, M. 2010. Methane mitigation in ruminants: From microbe to the farm scale. Animal, 4, pp. 351-365.

McDonald, P., Edwards, R. A., Greenhagh, J. F. D. and Morgan, C. A. (6th edition). 2002. Animal Nutrition, Longman Scientific and Technical, N, Y, USA

Minitab. 2016. Minitab reference manual release 16.1.0 Minitab Inc.

Nguyen Dong Hai. 2008. Effects of protein different levels in the diets on fee utilization, nitrogen retention and rumen fluid parameters of goat and sheep. Master thesis in Animal Science, Can Tho University

Nguyen Van Thu and Nguyen Thi Kim Dong. 2012. A response of in vitro and in vivo methane production, nutrient digestibility and rumen parameters of sheep by Cat fish oil (CFO) supplementation. JIRCAS-CTU proceedings.

Nguyen Van Thu. 2019. An evaluation on quality of water hyacinth silage effected by adding molasses and ground maize. J. Anim. Sci. and Technol. Vol 96, pp. 69-77

Osakwe, I. I., Steingass, H. and Drochner, W. 2004. Effect of dried Elaeisguineense supplementation on nitrogen and energy partitioning of WAD sheep fed a basal hay diet. Animal Feed Science and Technology, 117, pp. 75–83.

Paul, S. S., Mandal, A. B., Mandal, G. P., Kannan, A. and Patthak, N. N. 2003. Deriving nutrient requirements of growing Indian sheep under tropical conditions using performance and intake data emanated from feeding trials conducted in different research institute. Small Ruminants Research 50, pp. 97-107.

Stanley, D., 2003. The role of silage in lamb-finishing systems.Proceeding of the Joint Conference of GVS and GSNSW 2003, pp. 57-61.

Van Soest, P. J., Robertson, J. B. and Lewis, B. A. 1991. "Symposium: Carbohydrate methodology. metabolism and nutritional implications in dairy cattle: methods for dietary fiber and nonstarch polysaccharides in relation to animal nutrition". Journal Dairy Science 74. pp. 3585–3597.

Wyatt, M. J., Lassey, K. R., Shelton, I. D. and Walker, C. F. 2002. Methane emission from dairy cows and wether sheep fed subtropical grass-dominant pastures in midsummer in New Zealand. New Zealand Journal of Agricultural Research 45, pp. 227-234

Yulistiani, D. 2016. Response of sheep fed on corn cob silage or elephant grass basal diet with or without Calliandra Leaf Meal Supplementation. JITV 21(3), pp. 165-173. DOI: http://dx.doi.org/10.14334/jitv.v21i3. 1574.

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