

Growth Rate, Feed Efficiency and Methane Production of Six Different Breeds of Sheep

D Yulistiani^{1*}, Y Widiawati¹, W puastuti¹ and E. Handiwirawani²

¹Indonesian Research Institute for Animal Production, Bogor, Indonesia

² Center for Animal Research and development, Bogor, Indonesia

*Corresponding author. E-mail: dwiyulistiani@yahoo.com

ABSTRACT

Breed selection toward sustainable ruminant production should consider the breed that have high feed efficiency in the same time produce low methane emission. The study was conducted to evaluate the productivity and estimated methane production of six different breed of sheep fed on total mixed ration contained CP 16% and energy metabolism 2.3 Mcal/kg. The evaluation of this study involved breed of sheep developed in Indonesian Research institute for animal production (IRIAP), consisting of 1. Compass Agrinak (CA); 2. Garut Composite (KG); 3. Barbados cross (BC); 4. St Croix (SC); local Sumatera (SMT), and 6. Lokal Garut (GL) sheep. Five heads of post weaning male sheep from each breed were used in the study. Study were conducted in randomized complete block design. Feed consumption was highest ($P<0.05$) in BC sheep (744.62g/day), while average daily gain of KG was the highest ($P<0.01$). The best feed efficiency was KG sheep (0,173) which was similar to SC. Estimated methane production was similar among the sheep breeds with the average was 24.73 mol/100mol. In conclusion the best performance of the sheep breed was KG sheep, even though its methane production was similar among the breeds but it has highest ADG and feed efficiency.

Keywords: Breed, feed efficiency, growth rate, methane, sheep,

1. INTRODUCTION

In Indonesia local breed sheep characterized by high prolificacy and small body size. One of the efforts to increase body size is by cross breeding follow by selection. In Indonesian Research for Animal Production (IRIAP) has been conducted cross breeding between local breed in Indonesia (Garut or Sumatera sheep) with exotic breed (Barbados cross, Multon Charolais or St Croix). The purpose of this cross breeding is to obtained breed with superior characteristic adaptable to Indonesia Agroecosystem. Indonesian thin tail sheep (Garut or Sumatera) breed is characterized by their ability to resistant with intestinal parasites [1]. Various cross bred sheep has been created in IRIAP, consisting of Compass Agrinak (CA);crossing between local Sumatera breed with St Croix and Barbados cross breed), Sumatera cross bred (crossing local sumatera with St Croix breed), and Garut composite Breed (crossing between Garut and multon charolais and St croix). The expected results of the breed crossing that CA sheep had the resistance ability to intestinal parasite infection but high adaptation with tropical circumstance consisting of climate and forage in Indonesia. Garut composite breed is expected

to have high prolificacy and high growth rate. Some of the cross breeds available in IRIAP has been distributed in community particularly in small scale farmers to improve breed quality in the community.

Sustainability of livestock farming should also consider the effect of livestock farming to the environment. Ruminants animal producing methane as by-products from feed fermentation in the rumen and represents lost of 2-12% of the feed energy [2]. Methane is one of green house gas (GHG) substantially contribute to climate change [3]. Reducing methane emission can be conducted through mitigation and adaptation. Adaptation usually conducted through the improving the animal ability to the environmental condition, which did not decrease its production ability with the climate change condition. Crossing and selection programs is the one methods of adapting the animal to the current climatic condition and increasing their productivity. Therefore, the objective of the study was to evaluate different breed of sheep on growth rate, feed efficiency and prediction of methane production.

2. MATERIALS AND METHODS

2.1 Animal and feeding

Study was conducted using six breed of sheep which was used to create cross bred sheep in IRIAP the six sheep breeds used were: 1. CA; 2. Garut Composite (KG); 3. Barbados cross (BC); 4. St Croix (SC); local Sumatera (SMT), and 6. Lokal Garut (GL) sheep. The local breed was used as comparison to cross bred sheep as their ancestor. Five heads of post weaning male lambs of each breeds were used in the study. The sheep were fed on total mixed ration containing elephant grass and concentrate with ratio 40 : 60% DM. The crude protein (CP) content and metabolized energy (ME) content of the ration was 16% and 2.3 Mcal/kg, respectively. During growth trial the sheep was kept on individual pen for 12 weeks. Fee offered and feed residue was measured daily. To obtain growth rate, the sheep was weighed weekly. At the end of growth trial the rumen fluid was collected using stomach tube. The rumen fluid then measured the pH, then one drop of concentrated HCl was added to stop the fermentation process. The rumen fluid was centrifuged the supernatant was analyzed for total volatile fatty acid (VFA) and partial VFA content. The methane production was predicted using calculation from Moss et al [4] using equation CH_4 production = $0.45 \times$ (acetate, C2) – 0.275 (propionate, C3) + $0.4 \times$ (butyrate, C4); where C2, C3 and C4 is molar proportion of VFAs. Feeds, residues and feces were analyzed for DM, GE and CP, VFA was analyses using gas chromatography.

2.2 Design experiment and Statistical analyses

The study was conducted in a randomized complete block design, each treatment had five replications. Data were analyzed using GLM from SAS software 9.0. [5].

Differences among means were compared using Duncan's multiple range test.

3. RESULTS AND DISCUSSIONS

Feed consumption, average daily gain (ADG) and feed conversion ratio are presented in Table 1. Results from the study shows that dry matter intake (DMI) of GL and BC sheep were similar and the highest among other breed of sheep, while the lowest DMI was in SC sheep. However, when the DMI was calculated into g/kg of body weight (BW) and percent of BW, the values of them were not significantly different. The average of DMI in the percent of BW was 3.61%. In contrast to the current study, previous study reported that DMI in percent of BW was affected by breed of sheep [6]. Crude protein (CP) intake in g/day of GL sheep was the highest ($P < 0.01$) and the lowest in SC sheep. The CP intake was similar among breed of sheep with the average was 5.26 g/kg BW. Digestible Energy (DE) intake of SC breed was the lowest, DE intake of CA, KG, BC, and GL was similar. The ADG was affected by breed of sheep, the average daily gain of SM was significantly lower compare to KG and BC but not significantly different to CA, GL and SC. Similar to ADG, the feed conversion ratio of KG and BC was significantly better than SM. Previous study [6] also reported that ADG of the sheep was affected by breed of the in spite of different undegradable protein content in the diet.

The ruminal fermentation of different breed of sheep is presented in Table 2. The ruminal pH was similar among breed of the sheep with the average 6.42. This rumen pH was in optimum condition for cellulolytic activity in the rumen, while ruminal pH greater than 5.7 optimum for ruminal microbial protein synthesis [7]. The

Table 1. DMI, CP, DE intake, ADG and feed conversion of different breed of sheep fed similar diet

Styles	CA	KG	BC	GL	SC	SMT	Significant levels
DMI (g/day)	655.4 ^{bc}	670.3 ^{bc}	704.0 ^{ab}	744.6 ^a	575.6 ^d	632.18 ^{cd}	**
DMI (g/kg BW)	37.67	35.07	35.01	34.39	37.97	35.67	NS
DMI (% BW)	3.77	3.61	3.5	3.44	3.8	3.57	NS
CP intake (g/day)	96.0 ^c	98.8 ^c	105.2 ^b	110.3 ^a	85.7 ^d	95.6 ^c	**
CP intake (g/kg BW)	5.40	5.20	5.14	5.02	5.54	5.30	NS
DE intake (kcal/day)	1801 ^{abc}	1791 ^{abc}	1914 ^{ab}	1922 ^a	1520 ^d	1731 ^c	**
DE intake (kcal/kg BW)	101.6 ^b	94.6 ^{ab}	93.6 ^{ab}	87.5 ^c	98.2 ^{ab}	96.5 ^{ab}	**
ADG (g/day)	100.0 ^{ab}	115.2 ^a	111.4 ^a	104.0 ^{ab}	99.1 ^{ab}	82.4 ^b	*
Feed conversion	6.6 ^{abc}	5.81 ^a	6.35 ^a	7.24 ^{ab}	5.86 ^{ab}	8.13 ^b	*
CP conversion	0.97 ^b	0.86 ^b	0.95 ^b	1.08 ^{ab}	0.87 ^b	1.24 ^a	*
DE intake conversion	18.19 ^{ab}	15.52 ^b	17.26 ^b	18.74 ^{ab}	15.47 ^b	22.41 ^a	*

Different superscripts in the same row indicates significantly (*) $P < 0.05$ or highly significantly different (*) $P < 0.01$. CA, Compass Agrinak; KG, Garut composite; BC, Barbados Cross; GL, Local Garut; SC, St Croix; SMT, Sumatera local

Table 2. Rumen fermentation characteristics and estimated Methane production

Styles	CA	KG	BC	GL	SC	SMT	Significant levels
pH	6.31	6.54	6.36	6.43	6.45	6.45	NS
NH ₃ (mg/dL)	19.36 ^{abc}	14.71 ^c	22.79 ^a	17.62 ^{bc}	19.2 ^{abc}	20.77 ^{ab}	*
VFA total (mM)	133.7	136.4	136.6	126.2	155.7	108.0	NS
Proportion of VFA (%)							
Asetic	66.07 ^a	64.75 ^{ab}	61.14 ^{bc}	59.48 ^c	62.80 ^{abc}	62.31 ^{abc}	*
propionic	25.01	24.42	26.48	28.06	25.90	24.65	NS
Butyric	6.79 ^b	8.378 ^{ab}	9.614 ^a	10.058 ^a	9.077 ^{ab}	10.736 ^a	*
isobutyric	0.752	0.847	0.987	0.869	0.811	0.72	NS
Valeric	0.641	0.744	0.836	0.754	0.685	0.837	NS
iso valeric	0.736	0.856	0.9335	0.777	0.725	0.746	NS
CH ₄	25.57	25.77	24.08	23.07	24.77	25.55	NS

Different letter in the same row indicates significantly (*) $P < 0.05$ or highly significantly different (*) $P < 0.01$. CA, Compass Agrinak; KG, Garut composite; BC, Barbados Cross; GL, Local Garut; SC, St Croix; SMT, Sumatera local

ruminal ammonia was in the range of 14.71-22.79 mg/dL, which was ideal condition for rumen microbial growth. The optimum condition in the rumen resulted in similar ability of all breed sheep to ferment the feed in the rumen as indicated by similar VFA concentration from all breed sheep with the average of total VFA production was 132.7 mM. The VFA is the final product from feed fermentation which is used as source energy for ruminant animals for production. One of the products from the energy utilization is for growth. In this study, VFA production was not significantly different among all breeds, but ADG of SMT breed sheep was lower than KG and BC breed sheep. The differences of the ADG of these breeds could be caused by genetic factors. The KG is created by crossing between Local Garut x Multon Charolais and St Croix, which have faster growth rate and earlier mature weight compare to local Garut sheep [8].

Methane production from enteric fermentation is affected by feed intake, feed composition and quantity energy consumed [9]. In the current study, DMI and energy intake of GL sheep was the highest, respectively. On the other side, DMI and energy intake of SC was the lowest, respectively. However, the methane production was not different among dietary treatment. Similar results also reported that breed of cattle did not affect on methane emission [10]. Methane production is also affected by type of VFA production which strongly determines the excess of hydrogen (H) produced as sink for methane production [4]. Acetic acid and butyric acid will increase methane production, while propionic acid reduce it. Acetic acid production was significantly lowest in GL and was significantly different to CA sheep, which have highest proportion of acetic acid production. In contrast, butyric acids production was highest in BC, GL and SM, while the lowest was in CA. Propionic acid proportion on the other hand was not affected by breed of sheep. In the present study, differences in the proportion

of acetic and butyric acid did not affect on methane production. Methane production was affected by rumen microbial population and activity such as the action protozoa, but did not affected by proportion of VFA partial when the sheep was supplemented by tea saponin or fat [11]. Methane emission per unit animal products will be more rational in considering sustainable livestock farming because increasing production of animal in using feed resource will also lower methane emission. The purpose of cross breeding of meat sheep breed is to increase the sheep ability in utilizing feed resource more efficiently and able to reach body weight of market demand [8]. Therefore in this study in shows that BC and KG sheep can be considered as more sustainable sheep breed in sheep farming in lowering methane emission. Composite cross bred between local Garut, Multon Charolais and St croix was reported had faster growth rate and reaching mature body weight earlier and was more efficient biologically and economically [8].

4. CONCLUSION

This study concluded that the growth of the sheep and feed efficiency were affected by breed of sheep. The KG and BC were the most efficient in using feed consumed to be converted in to body weight gain. In addition, methane production was not affected by breed of sheep.

REFERENCES

- [1] Raadsma HW *et al.* 2002. Towards molecular genetic characterization of high resistance to internal parasites in Indonesian thin tail sheep. In: *Proceeding of the Seventh World Congress on Genetics Applied to Livestock Production*; vol 33. Montpellier France 19-23 August 2002.
- [2] Goel G. and Makkar H.P.S (2012). Methane mitigation from ruminants using tannins and

- saponins. *Tropical Animal Health and Production*. 44: 729-739. Doi 10.1007/s11250-011-9966-2.
- [3] Johnson, K.A and Johnson, D.E. (1995). Methane emissions from cattle. *J. Anim. Sci.* 73: 2483-2493.
- [4] Moss, A.R, Jouany J., and Newbold. 2000. Methane production by ruminants: its contribution to global warming. *Ann. Zootech.* 49: 231-253.
- [5] SAS, 2002. *Guide for Personal computers*. SAS Institute Cary, NC USA
- [6] Yulistiani D, Naufaliah N, Kardaya D, Subandriyo 2015. Nutrient digestibility and growth of five breeds of sheep under different levels of undegradable protein. *JITV* 20: 23-30. DOI: <http://dx.doi.org/10.14334/jitv.v20i1.1112>
- [7] Durand, M. and R. Kawashima. 1980. Influence of minerals in rumen microbial digestion. In: *Digestive Physiology and Metabolism in Ruminants* (Eds. Y. Ruckebusch and P. Thivend). MTP Press, Lancaster, UK. pp. 375-408.
- [8] Inounu I., Mauluddin D. dan Subandriyo. 2008. Karakteristik pertumbuhan domba garut dan persilangannya. *JITV*. 13(1): 13-22.
- [9] Monteny G-J, Bannink A, Chadwick, D. 2006. Greenhouse gas abatement strategies for animal husbandry. *Agric. Ecosystems and Environ.* 112: 163–170.
- [10] Maciel I C dF, Barbosa F A, Tomich T R, Ribeiro L G P, Alvarenga R C, Lopes L S, Malacco VMR, Rowntree JE, Thomson LR and Lana AMQ 2019 Could the breed composition improve performance and change the enteric methane emissions from beef cattle in a tropical intensive production system? *PLoS ONE* 14: e0220247. <https://doi.org/10.1371/journal.pone.0220247>
- [11] Mao H. L., Wang J.K., Zhou Y.Y., and Liu J. X., 2010. Effect of addition of tea saponin and soybean oil on methane production, fermentation and microbial population in the rumen of growing lambs. *Livest. Sci.* 129: 56-62