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Abstract

This research aimed to study the effects of enriched protein supply from tree legume leaves in a complete ration based on tropical grass and concentrates fed to growing goats. The treatments were: EG: Dwarf Elephant Grass as control; GS: EG + *Gliricidia sepium*; LL: EG + *Leucaena leucocephala*; IZ: EG + *Indigofera zolingeriana*. Concentrates were included in all diets. Twenty male goats with body weight 13 - 15 kg were allocated to two groups: 4 goats for digestibility study, and 16 goats for growth trial.

Apparent digestibility coefficients, feed intake, live weight gain and feed conversion were improved when the diet of elephant grass and concentrates was supplemented with leaves from legume forage trees. *Indigofera zollingeriana* appeared to support better growth performance than *Leucaena leucocephala* or *Gliricidia sepium*.

Keywords: *complete ration, enteric methane, Gliricidia sepium, Indigofera zolingeriana, leaf protein, Leucaena leucocephala, tannin*

Introduction

Indonesia has the 5th biggest human population in the world. Red meat is imported to meet the national demand of this commodity, since the price of the local product is higher than that which is imported. One of the main constraints to increasing livestock productivity in the tropical region is the scarcity of good quality feed through the year, particularly during the long dry season. Poor quality feed based on tropical grasses leads to low daily weight gain of cattle and gooats and poses an environmental impact in terms of emissions of enteric methane.

The problem is that the supply of forages is insufficient due to limitation of space for forage production and lower production in the dry period. As stated by Fujisaka et al (2000), tropical grass as the main source of feed is never sufficient to meet nutrient requirements of high-producing ruminants. Grasses also produce more enteric methane than leaves from leguminous trees (Maselma and Chigwa 2017; Preston et al 2019).

The use of leaves of tropical tree legumes in ruminant nutrition has been widely implemented due to their high content of protein. On the other hand, most tree legume leaves contain condensed tannins which enhance the rumen "escape" of the protein (Preston and Leng 1987; Barry and McNabb 1999). The legume trees *Gliricidia*

sepium, Leucaena leucocephala, and *Indigofera zollingeriana* grow abundantly in Indonesia and are widely available along the year. These tree legumes produce leaves of high crude protein content and could be used to improve the quality of grasses. Among these trees, *Indigofer*a *zollingeria* is a new species being evaluated in Indonesia; it has good agronomic traits such as rapid re-growth with a defoliation interval of 60 days and a production of up to 50 tonnes/ha/year (Abdullah 2010). This species is well adapted to low soil fertility and has high seed production according to Suharlina and Abdullah (2010) with crude protein content in the leaves of 23%. It was reported by Tarigan and Ginting (2011) that fresh leaf of this species increased daily weight gain and efficiency of local goats by up to 45 and 30%, respectively.
This study was carried out to evaluate the contribution of leaves from tree legumes to enrich a complete ration based on *Pennisetum purpureum* (Dwarf Elephant Grass) and concenrates.

Materials and methods

This research was conducted at the Asassement Institute of Agriculture Technology (AIAT) in Pandu village, North Minahasa regency of the province of North Sulawesi, Indonesia., located on the geographical position of Lat. 1^0 30' N, and 124^0 54' E, and at 67 meters above sea level. The study lasted 7 months from January to late August 2019. The plant material used in this study consisted of*Pennisetum purpureum* (Dwarf elephant grass), and leaves of*G. sepium*, *L. leucocephala* and *I. zollingeriana*. All the plants had been trimmed to get homogenous re-growth. The grass was harvested at the age of 45 days re-growth; tree legumes were harvested at the age of 60 days of re-growth.
Dwarf elephant grass was defoliated at first node from the soil surface (approximately 10 cm above ground level). Samples of this grass were taken from five plants in two different places in each plot, so there were 10 plants as samples in each plot. All tree legumes were defoliated at 1m from the soil surface. Fresh samples were then dried at 60 ^{0}C for 48 h to determine the dry weight and proximate composition.
Complete rations used in this research consisted of dried chopped grass, dried ground leaves of one of the three tree legumes and a concentrate which consisted of rice bran, ground yellow maize, tapioca powder, salt, and mineral mixture. The treatments (Table 1) were: EG*:* Dwarf elephant grass GS: grass +leaves of *Gliricidia sepium;* LL: grass + leaves of *Leucaena leucocephala*; and IZ: grass + leaves of *Indigofera zollingeriana*.

Table 1. Formulation of the experimental complete feeds (% DM basis)

Ingredients (%)	**Treatments**			
	EG	**LL**	**GS**	**IZ**
Dwarf elephant grass	80	40	40	40
Leucaena leucocephala	-	40	-	-
Gliricidia sepium	-	-	40	-
Indigofera zollingeriana	-	-	-	40
Concentrate	20	20	20	20

The concentrate consisted (% DM basis) of: rice bran 45, ground yellow maize 35, coconut meal 12.5, tapioca 5.00 and mineral-mixture 2.00. The ingredients in each treatment were mixed to form a block of 10 cm x 20 cm x 5 cm which was dried under sunlight.

Twenty male goats with average body weight of 15 kg were divided into two groups. One group of 4 animals was used for a digestibility study of the four treatments arranged as a 4 x 4 Latin square design with three days for adaptation to confinement in individual pens, then 10 days for adaptation to the diets, and 5 days for determination of intake and digestibility. Feed offered and refused and fecal output were recorded daily during the 5 days collection period. Drinking water was available freely. Feed and feces samples were analyzed for dry matter, crude protein, crude fiber, and ash according to the standard procedure of AOAC (1990). The second group of 16 animals, housed in individual pens, was arranged according to a completely Randomized Design, to measure feed intake, weight gain and feed conversion. The goats were weighed in the morning before feeding every ten days over 60 days of the experiment.

Data were statistically analyzed using the ANOVA program in the MINITAB (Version 16) software.

Results

There were major differences in composition of the diets with higher values for crude protein , NFE and ether extract, and lower values for crude fiber in all diets with the legume tree leaves (Table 2).

Table 2. Composition of experimental diets (% of DM)

	CP	CF	NFE	EE	Ash
EG	7.56	33.9	41.1	1.71	14.8
GS	16.50	11.7	52.9	8.88	11.6
LL	15.9	10.5	50.7	7.95	10.9
IZ	18.50	10.10	49.30	8.99	12.7

Coefficients of digestibility were higher for diets that contained leaves of tree legumes with no differences among them (Table 3). These improvements in digestibility were reflected in feed intake, live weight gain and f eed conversion which were all improved when the tree legume leaves were a part of the diet (Table 4; Figures 1-3). For all criteria, the goats fed the tree legume *Indigofera zollingeriana* recorded the best performance.

Table 3. Mean values for apparent digestibility of the complete diets

	Treatments				SEM	*p*
	EG	LL	GS	IZ		
DM	63.26[b]	69.91[a]	69.80[a]	72.49[a]	0.927	<0.001
CP	62.83[b]	69.18[a]	70.65[a]	72.17[a]	0.980	<0.001
CF	58.21[b]	67.36[a]	68.13[a]	69.03[a]	1.237	<0.001

[ab] *Means within rows, without common superscript differ at* $p < 0.05$

Table 4. The effects of complete rations on feed intake, live weight gain and feed conversion

	Treatments				SEM	*p*
	EG	LL	GS	IZ		
DM intake, g/d	523^{d}	565^{b}	562^{c}	571^{a}	0.605	<0.001
Live weight gain, g/d	101^{c}	130^{b}	130^{b}	147^{a}	0.902	<0.001
Feed conversion#	5.16^{a}	4.33^{b}	4.33^{b}	3.87^{c}	0.028	<0.001

^{abcd} *Means within rows, without common superscript differ at* $p < 0.05$

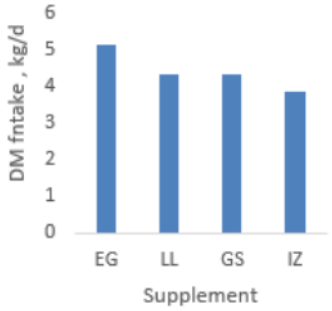

Figure 1. Effect of tree legume leaves on the dry matter intake of the goat

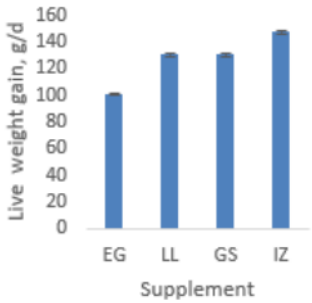

Figure 2. Effect of tree legume leaves on live weight gain

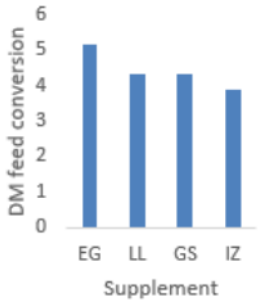

Figure 3. Effect of tree legume leaves on feed conversion

Discussion

The positive effects of the tree legume leaves can be ascribed to their high levels of protein and the presence of condensed tannins that are known to form complexes with dietary protein facilitating their escape from the rumen for more efficient digestion in the intestines (Preston and Leng 1987; Barry and McNabb 1999). Reduced production of enteric methane leads to improved efficiency of energy utilization by ruminants as shown by Johnson and Johnson (1995).

Our finding is in agreement with the report by Preston et al (2019) that gas production and methane content of the gas were lower when the substrates in an *in vitro* rumen fermentation were legume leaves especially *L. leucocephala*, compared with grasses such as *Pennisetum* spp.

Recent esults from *in vivo* trials reported by Pineiro-Varquez et al (2018) showed that methane production decreased linearly with maximum reduction of 61% when 80% of the diet was in the form of *Leucaena leucocephala*. Reduction of rumen methane in turn results in more rumen propionate and hence improved glucogenic status of the diet and better animal performance. The efficient utilization of *Indigofera zollingeriana* in complete rations has also been reported by Suharlina and Abdullah (2010).

Suharlina et al (2016) emphasized the role of dietary elements such as tannins, resulting in a lower proportion of the dietary metabolizable energy in the form of

methane and more in the rumen VFA, especially propionate as reported by Preston et al (2019). It was proposed by Patra and Saxena et al (2009) that condensed tannins in the diet reduce the rumen acetic acid : propionic acid ratio, which in turn reduces the amount of available hydrogen for methanogenesis. Previously, Harrison et al (2015) reported that cattle fed tree legume leaves have higher levels of productivity, as well as lower release of enteric methane to the atmosphere. All treatments containing tree legume leaves had positive effects to improve the quality of complete rations; however, *Indigofera .zollingeriana* leaf has better potential to be developed since *L. leucocephala* is susceptible to attack by the psyllid *Heteropsylla cubana* and *Gliricidia sepium* contains coumarin which often leads to some animals refusing this forage.

Conclusions

- Feed intake, live weight gain and feed conversion of goats were improved when a diet of elephant grass and concentrates was supplemented with leaves from legume forage trees.
- *Indigofera zollingeriana* appeared to support better growth performance than *Leucaena leucocephala* or *Gliricidia sepium*.

Acknowledgments

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