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Rumen Fermentation Optimization of Kacang Goats Fed Complete Silage-Based Feed Sorghum-Clitoria ternatea with Various Concentrate Levels Contains $ZnSO_4$ and Zn-Cu Isoleucinate

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ABSTRACT

This research was conducted to determine fermentation in the rumen, consumption, and digestibility as well as utilization of protein and energy in Kacang goats that were given Sorghum-Clitoria ternatea [PKSS-Ct] Silage-based Complete Feed. The study used an experimental method with a randomized block design [RBD] with four treatments and four replications, namely T0: Silage of sorghum - Clitoria ternatea without concentrate; T1: T0 + 10% concentrate with 150 mg $ZnSO_4$ / kg DM ration and 2% Zn-Cu isoleucinate/kg DM concentrate; T2 : T0 + 20% concentrate with 150 mg $ZnSO_4$/kg ration feed and 2% Zn-Cu isoleucinate/kg DM concentrate and T3: T0 + 30% concentrate with 150 mg $ZnSO_4$/kg BK diet and 2% Zn-Cu isoleucinate/ kg BK concentrate. Parameters measured were 1]. Chemical composition of feed 2]. Rumen Fermentation of kacang goat. The results showed that the treatment had an effect on increasing the crude protein content and BETN, conversely there was a decrease in crude fiber content and a very significant increase in NH3 concentration and VFA production [P<0.01] and the highest increase was in T2. It can be concluded that complete feeding based on Clitoria ternatea sorghum silage with the addition of concentrate containing 150 mg $ZnSO_4$/kg DM ration and 2% Zn-Cu isoleucinate/kg DM concentrate at a level of 20% can increase the concentration of NH3 and the highest VFA production in kacang goats.

Keywords: Sorghum; Clitoria ternatea; $ZnSO_4$; Zn-Cu isoleucinate, NH_3; VFA

INTRODUCTION

In an effort to increase livestock productivity, it is very important to pay attention to the availability of feed throughout the year, both in quantity and quality. Naturally, ruminants such as goats require forage as a source of fiber and energy for the synthesis and growth of rumen microorganisms. However, until now the need for forage has not been available throughout the year, so the nutritional needs for livestock are not met and this condition will have an impact on weight loss and even cause death [Suryana, 2008]. This condition reflects how important it is to provide forage to be able to meet the nutritional needs of livestock, so it is necessary to develop superior types of forage that are not affected by the season. One alternative crop that can be used as forage for livestock is sorghum and butterfly pea [Clitoria ternatea] [Nullik, 2009].

Sorghum [Sorghum bicolor L] is a cereal crop that has great potential to be developed in Indonesia because it is tolerant to drought, waterlogging, can produce on marginal land and is more resistant to pests or diseases [Sirappa, 2003]. In developed countries, sorghum is grown as an ingredient in animal feed because it contains a relatively high source of nutrients, namely 11.00% crude protein, energy 3.32 Kcal/kg, carbohydrates 73%, fat 3.30%, fiber 2.30% and Ca, P and Fe content 2.8, 2.87 and 4.40 mg from 100 g of material, respectively [Sirappa, 2003].

However, its use as feed is very limited by the relatively high tannin content, reaching 0.40-3.60% [Rooney and Sullines, 1977 in [Sirappa, 2003]. The next researcher reported that the nutritional content of sorghum plants in the vegetative phase contained crude protein 13.76% - 15.66% with a crude fiber content of 26.06%-31.81% [Purnomohadi, 2006].To increase the protein content of forages in planting, it is necessary to combine it with legumes because it can increase the availability of soil nitrogen [Willey, 1990]. So that it can overcome the shortage of fertilizer for farmers to increase forage production.There needs to be a breakthrough using technology including silage technology to reduce sorghum tannin levels, so that the value of its benefits as animal feed increases.

Another common problem faced by farmers today is the difficulty of obtaining fertilizer to add to the soil to increase crop production. One type of plant that can replace fertilizer and one type of plant that can be used is the butterfly pea flower [Clitoria ternatea]. Clitoria ternatea can adapt well to the local environment in semi-arid areas and is quite successful if it is planted in an intercropping system with grasses such as elephant grass, corn and sorghum and so on with quite high production [Nullik, 2009; Jelantik, et al., 2015].

Therefore, this forage is the most prospective crop to be used as a raw material for animal feed due to the high production and quality of forage compared to other legumes [Jelantik et al., 2015]. In terms of plant quality, Clitoria ternatea contains protein ranging from 16-18%, crude energy 18.6 MJ/kg, organic matter digestibility 69.7%, energy digestibility 66.6% and ruminant energy 12.4 MJ/kg [Sutedi , 2013]. The Clitoria ternatea plant has great potential as a feed crop because apart from having a high nutritional value, this plant is also very important for livestock and is very suitable for growing with tall grasses such as elephant grass, king grass, sorghum and so on. In terms of quality, the leaves contain protein ranging from 18-25%, while the mixture of stems and leaves contains 9-15% protein, with a dry matter digestibility value of up to 70%.

In an effort to improve the quality of sorghum and overcome the scarcity of fertilizer, a mixed cropping system has been implemented using the intercropping system of Clitoria ternatea. Sumarsono [2008] states that the purpose of the intercropping cropping pattern is to increase soil productivity, due to the increased amount of solar radiation energy that can be captured by the plant canopy. In the tropics, it is necessary to pay attention to the types of plants planted in intercropping patterns because legumes grow slower than non-legume plants. To overcome this problem of mixed cropping, legumes must be planted at appropriate spacing [Sumarsono, 2009]. Intercropping cropping patterns with wide spacing and different root systems as well as sufficient fertilization will not result in competition for both sunlight and nutrients [Effendi et al., 2010]. The research results of Hartati et al., [2018; 2019] show that intercropping planting sorghum with Clitoria ternatea at a spacing of 40x40 cm is an ideal spacing in influencing the production and quality of the forage produced. It was further reported that the silage mixed with sorghum-Clitoria ternatea at a spacing of 40x40 cm was the best silage in influencing rumen fermentation as indicated by the total VFA concentration parameter produced. The use of silage mixed with sorghum-Clitoria ternatea 40x40 cm resulted in a higher digestibility value of crude fiber and organic matter compared to the spacing of 20x20 cm or 60x60 cm. Previous studies evaluating PKSS-Ct in vitro showed that the concentrations of NH_3 and VFA were highest when making PKSS-Ct with a concentrate level of 10% which had an impact on increasing the digestibility of dry matter [KcBK] and organic matter [KcBO] in vitro [Hartati et al. , 2022]. The study was designed to study fermentation in the rumen, consumption and digestibility of nutrients and the benefits of protein and energy in kacang goats fed Complete Feed based on Sorghum-Clitoria ternatea Silage [PKSS-Ct].

MATERIALS AND METHODS

The materials used were sorghum intercropped with Clitoria ternatea with a spacing of 40x40 cm, concentrates based on local feed, $ZnSO_4$ and Zn-Cu isoleucinate, young kacang goats as experimental animals were placed in individual cages. The equipment used is forage cutters, electric scales with a capacity of 50 kg, tarpaulins and silos of plastic drums.

The method used in the research was an experiment conducted at the Undana Dry Land laboratory. The design used was randomized block design [RBD] with 4 treatments and 4 replications. The treatment to be studied is complete feed based on Sorghum-Clitoria ternatea silage which is planted at a spacing of 40x40 cm [the best result from the research of Hartati et al. 2018] with the addition of 4 levels of concentrate containing 150 mg $ZnSO_4$/kg DM ration and 2% Zn-Cu isoleucinate/kg DM concentrate [Hartati et al., 2009].

The treatments were:
T0 : Silage of Sorghum - Clitoria ternatea without concentrate
T1 : T0 + 10% concentrate containing 150 mg $ZnSO_4$/kg DM ration and 2%Zn-Cu isoleucinate/kg DM concentrate
T2 : T0 + 20% concentrate containing 150 mg $ZnSO_4$/kg DM ration and 2%Zn-Cu isoleucinate/kg DM concentrate
T3 : T0 + 30% concentrate containing 150 mg $ZnSO_4$ /kg

DM ration and 2% Zn-Cu isoleucinate/kg DM concentrate
The variables measured in this study were: 1] Feed Chemical Composition using Proximate Analysis using the AOAC method [2005] Fermentation products in the rumen, namely ammonia [NH_3] production using the Conway microdiffusion technique analysis and Total Volatile Fatty Acid [VFA] using steam distillation technique [General Laboratory Procedure, 1996]; 2] Digestibility of nutrients [total collection method]. The research data were analyzed using variance to test the effect of treatment on the observed parameters, then to find out the differences between treatments an LSD test was performed. Data analysis used the SPSS Release 21 program package.

RESULTS AND DISCUSSION

Chemical composition of feed ingredients and research rations

The average chemical composition of complete feed treatment rations based on sorghum-Clitoria ternatea silage [PKSS-Ct] with the addition of various levels of concentrate containing 150 mg $ZnSO_4$/kg DM ration and 2% Zn-Cu isoleucinate/kg DM concentrate is presented in Table 1.

TABLE 1: Chemical Composition of Research Rations.

Chemical Composition*]	Treatments			
	T_0	T_1	T_2	T_3
Dry Matter [%]	28,571	27,576	36,502	38.281
Organic Material [%]	86.075	92,204	92,490	89.455
Crude protein [%]	8,464	11,721	13,161	14,241
Crude Fiber [%]	30,398	27,295	18,158	17,856
Crude Fat [%]	5,173	5,808	6,506	6,697
CHO [%]	72,438	74,675	72,823	68,517
BETN [%]	42,039	47,380	54,666	50,661
GE [kcal/kg]	3.892,39	4.892,07	4.278,56	4.188,06
EM [kcal/kg]	2.574,19	2.975,47	3.394,39	3.284,39

*] Result of feed chemistry laboratory analysis, Fapet, Undana.

Table 1 shows that the crude protein content has increased along with the increase in the percentage of carbohydrates added in the preparation of complete feed silage based on a sorghum-*Clitoria ternatea* mixture planted at a spacing of 40x40 cm [Hartati et al., 2019]. The highest increase in crude protein content in complete feed rations based on sorghum silage *Clitoria ternatea* with the addition of concentrate containing 150 mg $ZnSO_4$/kg DM ration and 2% Zn-Cu isoleucinate/kg DM concentrate is at a level of 30% by 68.25% compared to that without concentrate [Table 2].

The chemical composition of each of the above treatments is in accordance with the research results reported by Hartati et al. [2021], namely the treatment had a very significant effect [P<0.01] on the crude protein content of Complete Feed based on Sorghum-Clitoria ternate Silage [PKSS-Ct] which contained $ZnSO_4$/kg DM ration and 2% Zn-Cu isoleucinate/kg DM concentrate . This was due to the difference in the administration of concentrates containing 150 mg $ZnSO_4$/kg DM ration and 2% Zn-Cu isoleucinate/kg DM concentrate in the manufacture of complete feed silage sorghum-*Clitoria ternatea* besides the crude protein content of *Clitoria ternatea* being higher than forage sorghum according to Gomez's statement and Kalamani [2003] which is 18-24% in fresh form, *Clitoria ternatea* has a protein content of 21.4% and 22.6% in hay form. Meanwhile, the crude protein content of sorghum-*Clitoria ternatea* silage with a spacing of 40 x 40 cm was 19.22% [Hartati et al., 2019].

The crude fiber content is the part that is difficult to digest which consists of cellulose and hemicellulose and the older the plant contains lignin which is a limiting factor for the growth and activity of microorganisms in the rumen. Cellulose is the fundamental structure of the cell wall, while hemicellulose is a fraction of the cell wall that dissolves in alkalis as polysaccharides [McDonald et al., 2005]. The older the age of the plant causes the plant parts to contain cellulose or hemicellulose with quite high lignin depending on the age of the plant. Meanwhile, lignin is a fiber fraction that is not a carbohydrate and is highly resistant to chemical degradation. The fiber fraction can be utilized by ruminants with the activity of microorganisms in the rumen. Microorganisms produce enzymes that can degrade crude fiber to produce volatile fatty acids [VFA] as an energy source and carbon [C] framework for microbial protein synthesis. Hartati et al's research results. [2019] showed that mixed planting with a distance of 40 cm x 40 cm can increase the crude fiber content of forage. This is due to the wide spacing and different root systems as well as sufficient fertilization, and there will be no competition for sunlight or nutrients. Plant populations that are close together do not cause competition if the available water, soil, nutrient and solar radiation content is at a sufficient level for each plant. According to Keraf et al. [2015] that increasing plant age causes the plant to enter a renesance phase where the plant is already in an aging period, causing plant parts to contain high cellulose and lignin.

In the research Hartati et al. [2021] reported that the crude fiber content of complete feed based on sorghum-*Clitoria ternatea* silage with the addition of 20% concentrate containing 150 mg $ZnSO_4$/kg DM ration and 2% Zn-Cu/kg DM concentrate increased the crude fiber content in the form of hemicellulose.

The content of BETN in the three treatments of adding concentrate in the manufacture of PKSSCt has increased at the level of 20 and 30% concentrate addition. The results of the statistical analysis showed that the treatment had a very significant [P<0.01] effect on the BETN content. This is because the content of BETN which consists of monosaccharides, disaccharides and trisaccharides with the addition of 20% and 30% concentrate has increased the content of BETN as the addition of concentrate increases, but the two are not significantly different. According to Tilman et al [1990] BETN consists of monosaccharides, disaccharides, trisaccharides and polysaccharides, especially those that dissolve easily in acid and alkaline solutions in the analysis of crude fiber which has high digestibility. The extract material without nitrogen in this case serves as a source of C framework together with nitrogen [N] derived from PK feed for rumen microorganism protein synthesis. The results showed that the complete sorghum-*Clitoria ternatea* silage feed with the addition of concentrate containing 150 mg $ZnSO_4$/kg DM ration and 2% Zn-Cu isoleucinate/kg DM concentrate had an increase in BETN content between the four treatments T1, T2, T3 and T4 and it was illustrated from the difference in VFA production in the four treatments.

Effect of Treatment on Acidity Level [pH], Fermentation Products in Kacang Goat Rumen

The level of acidity [pH] in the rumen of goats consuming complete feed based on sorghum-*Clitoria ternatea* silage [PKSS-Ct] with the addition of various levels of concentrate containing 150 mg $ZnSO_4$/kg DM ration and 2% Zn-Cu isoleucinate/kg DM concentrate is presented in Table 4. The table shows that the acidity level [pH] of the rumen fluid in each treatment did not change significantly. However, the pH value is still within normal limits, so it does not interfere with the fermentation process in the rumen or in other words, the rumen fluid pH is still suitable for the growth of microorganisms which will affect bio-fermentation in the rumen as seen from the fermented products produced. This statement is in accordance with the opinion of Hoover and Miller [1992] and Hartati [1998], which ranges from 6.0 to 7.3

Fermentation products in the form of NH3 and VFA in the rumen are used respectively as a source of N and C framework and energy for rumen microorganism protein synthesis whose production is strongly influenced by the level of acidity or pH of the rumen fluid. Fermentation products in kacang goats consuming complete feed based on sorghum-*Clitoria ternatea* silage [PKSS-Ct] with the addition of various levels of concentrate containing 150 mg $ZnSO_4$/kg DM ration and 2% Zn-Cu isoleucinate/kg DM concentrate are presented in Table 2.

TABLE 3: Average pH Value, Rumen Fermentation Products [NH3 and VFA] of Kacang Goats in each Treatment.

Parameters*]	Treatments**]				P-value
	T_0	T_1	T_2	T_3	
VFA [mM]	114,92±4,11^a	121±4,23^a	139,37±6,31^b	124,70±4,88^b	0,000
NH3 [mM]	10,22±1,07^a	10,52±1,43^{ac}	15,50±1,08^b	11,07±1,43^{cd}	0,000
pH	6,56±0,05	6,58±0,38	6,57±0,03	6,55±0,09	0,931

*] Result of feed chemistry laboratory analysis, Fapet, Undana
**] Different subscripts on the same row indicate a difference [P < 0.05]

Volatile Fatty Acid [VFA] is a source of energy for ruminants which is produced when the ration undergoes fermentation in the rumen, so that VFA production in the rumen can be used as a benchmark for the fermentability of feed in the rumen and is closely related to the activity of microorganisms in the rumen.

VFA production in Table 2 shows an increase with the increase in the percentage of added concentrate in the manufacture of complete feed based on *Clitoria ternatea* sorghum silage. The highest increase in VFA production was at the level of adding concentrate containing 150 mg/kg DM ration and 2% Zn-Cu isoleucinate by 20% and 30%. The results of the statistical analysis showed that the addition of concentrate treatment to the sorghum-*Clitoria ternatea* silage had a very significant effect [P<0.01] on the total VFA production of rumen fluid. Means that in this treatment sufficient substrate is available for the normal fermentation process compared to treatment without the addition of concentrate. This was because the content of BETN in the ration consisting of sorghum-*Clitoria ternatea* silage with the addition of concentrate at different levels had an increasing BETN content and was the highest in the T2 treatment. This has implications for higher nutrient content, especially soluble carbohydrates or BETN, resulting in different VFA concentrations [P<0.01] during degradation in the rumen. Further test results showed that between treatment pairs in the four treatments were different and the highest was in the treatment with the addition of complete feed based on *Clitoria ternatea* sorghum silage at 20% treatment.

In Table 1 it can be seen that there was an increase in the content of protein and BETN in the ration in the treatment which had an impact on increasing the supply of NH3 and carbon [C] framework and energy for the growth and activity of rumen microbes. It is this increase in the number and activity of rumen microbes that causes the resulting fermentation product in the form of VFA to also increase. The increase in VFA production is expected to meet the energy needs of livestock and even increase blood glucose levels as a source of energy for livestock and in turn can increase livestock weight gain.

CONCLUSION

It can be concluded that there has been an increase in the content of crude protein and BETN, on the other hand the crude fiber content has decreased which has an impact on increasing NH3 concentrations and VFA production in kacang goats fed a complete diet based on sorghum silage *Clitoria ternatea* with the addition of concentrate containing 150 mg $ZnSO_4$/kg DM ration and 2% Zn-Cu isoleucinate/kg DM concentrate at 20% level.

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