



The Effect of Ammoniated *Cymbopogon nardus* Waste as Forage Substitution on Nutrient Digestibility and Performance of Ettawa Crossbreed Dairy Goat

Rusmana Wijaya Setia Ningrat¹, Mardiaty Zain^{1*}, Elihasridas¹, Erpomen¹, Windu Negara², Ezi Masdia Putri, Roni Pazla, Putri Okta Shafura¹ and Umami Amanah¹

¹Department of Animal Nutrition, Faculty of Animal Science, Andalas University, Jl. Unand, Limau Manis Campus, Padang 25163, West Sumatra, Indonesia

²Research Center for Animal Husbandry, National Research and Innovation Agency (BRIN) Indonesia, Jl. Raya Jakarta Bogor Cibinong 16915, Indonesia

*Corresponding author: mardiaty@ansci.unand.ac.id

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ABSTRACT

This study aimed to determine the effect of using ammoniated *Cymbopogon nardus* waste (ACNW) as a substitute for grass on growing male Ettawa Crossbreed dairy goats (ECDG). A total of eighteen male ECDGs aged between 24-30 months with a body weight of 26.4 ± 1.01 kg were used in this study. The study used a Randomized Block Design (RBD) which consisted of three treatments and six replication. Treatments were A=40% native grass+60% concentrate, B=30% native grass+10% ammoniated *C. nardus* waste (ACNW)+60% concentrate, and C=20% native grass+20% ACNW+60% concentrate. Parameters observed were nutrient intake, digestibility of nutrients, and body weight gain of ECDG. The results showed that the treatment did not have a different effect on nutrient intake and digestibility of nutrients, body weight gain, and ration efficiency in male ECDGs that were given ammoniated *C. nardus* as a substitute for grass. Nutrient intake for each treatment were A=1.13kg/h/d, B=1.09kg/h/d, C=1.05kg/h/day. Digestibility of dry matter were A=77.85%, B=76.47%, C=76.46%. Daily weight gain were A=135g/d, B=122g/d, C=118g/d. The conclusion is the use of ammoniated *C. nardus* waste of up to 50 % as a grass substitute can be used for fattening Ettawa Crossbreed dairy goat.

Key words: Ammoniated *Cymbopogon nardus* waste, Daily weight gain, Digestibility, Ettawa crossbreed dairy goat, Nutrient intake.

INTRODUCTION

Feed is a crucial part of livestock management because approximately 70% of farm cost is allocated for feed supply. Nevertheless, Pazla et al. (2023a) stated that fluctuating feed availability and various feed quality still the main problem in Indonesia. It certainly causes low productivity of livestock. From these problems, the utilization of feeds using agriculture waste become the best strategy to enhance feed supply. *Cymbopogon nardus* waste can be utilized as feed for ruminant.

Cymbopogon nardus is essential oils plant that widely known since War World II, and it becomes the superior plantation commodities over the last decade, with an average plantation area 19,370ha and a biomass production of 2,340tons/year (Sulaswaty et al. 2019). The total

agricultural yield of *C. nardus* is approximately 3.51kg/plant/year (Gusmaini and Syakir, 2020). These huge commodities are advantageous for feed source. The primary product from *C. nardus* is essential oil (Citronella oil) about 0.5-1.5%. The waste product from *C. nardus* refining process is *C. nardus* waste and distillation water (Usmiati et al. 2012).

C. nardus waste has better quality compared to rice straw. Protein content of *C. nardus* is 7%, higher than rice straw which is only 3.9%. Crude fiber of *C. nardus* is lower (25.73%) than *Pennisetum purpureum* and rice straw which are 25.73% and 34.15%, respectively (Balai Penelitian Tanaman Obat dan Aromatik, 2010). *C. nardus* waste has 11.97% of protein, 25.14% of crude fiber, 0.87% of extract ether, 71.07% NDF, and 35.02% of ADF (Elihasridas et al. 2020).

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The great potential of *C. nardus* waste and its nutritional content shows that it is very suitable for ruminant feed as an alternative source of fiber. Unfortunately, the obstacle in utilizing *C. nardus* waste as ruminant feed is the content of essential oils in the form of citronella and geraniol which may still remain. The essential oil components in *C. nardus* are not completely safe and may be carcinogenic. To minimize essential oil residues and increase the digestibility of *C. nardus* waste, drying and ammoniation processes were carried out. The drying process will evaporate the volatile components in *C. nardus* waste, while the ammoniation process can break down the fiber fraction and increase the protein content of feed. The *in vitro* study from Elihasridas et al. (2020) confirmed that the addition of 50% ammoniated *C. nardus* waste as a substitute for grass in forage-based ration resulted insignificantly different.

We require to discover the effect of ammoniated *C. nardus* addition in forage-concentrate-based ration. Due to its potential availability and nutritional content, the study on the utilization of *C. nardus* waste as the component of ruminant feed is important. For these reasons, a research was carried out on the effect of ammoniated *Cymbopogon nardus* waste as forage substitution on nutrient digestibility and performance of Ettawa Crossbreed dairy goat.

MATERIALS AND METHODS

Ethical Approval

This experiment has referred to research ethics using livestock based on the Republic of Indonesia government law number 18 of 2009 (Section 66), which addressed animal keeping, raising, killing, and proper treatment and care. This experiment also followed the guide from Guide for the Care and Use of Agricultural Animals in Research and Teaching outlined by Federation of Animal Science Societies (American Dairy Science Association, 2020).

Sample Preparation and Experimental Diets

Experimental Site

This study was conducted at Elfitra Farm, Nanggalo District, Padang, West Sumatra from January to April 2022. The geographical position of this area is 0°58'S and 100°E. The average rainfall is 384.88mm/year.

Experimental Design

Eighteen Ettawa Crossbreed dairy goats (24-40 month of ages) with initial BW of 26.4±1.01kg were randomly allocated to metabolic cage 1.5x0.5m. This study was carried out using Randomized Block Design (RBD) consist of three treatments and six replication. Treatments were A=40% native grass+60% concentrate, B=30% native grass+10% ammoniated *C. nardus* waste (ACNW)+60% concentrate, and C=20% native grass+20% ACNW+60% concentrate. Data obtained in this study was analyzed according to analysis of variance procedure using Statistix8 software. Significant difference ($P<0.05$) is followed by posthoc Duncan Multiple Range Test.

This study was divided into four periods, namely the adaptation period, preliminary period, and collection period. The adaptation period aims to allow Ettawa Crossbreed dairy goat (ECDG) recognizing and adapting

the treatment rations. This period was carried out until ECDG are used to the treatment ration. Then, the preliminary period was carried out for 10 days. In this period, the treatment was given according to the needs of 4% DM. The live weight of the cattles were measured in the beginning and the last day of each periods. During the fifth-day of collection period, ration intake and feces excreted per day were recorded. Dried ration and feces samples were subjected to proximate analysis (AOA 2016) and fiber fraction analysis (Goering and Van Soest 1970).

Treatment rations were consisted of native grass, concentrate (*Zea mays*, tofu waste, and rice bran), and ammoniated *C. nardus* waste. Nutrient composition of experimental treatments in this study was shown in Table 1 and the formula of 100% concentrate was shown in Table 2.

RESULTS

Nutrient Intake

Nutrient intake from this study was shown in Table 3. From Table 3. we can observe that the addition of 25-50% ammoniated *C. nardus* waste in ration as a substitute for forage did not have a significant effect on nutrient intake ($P>0.05$). Dry matter intake was range 1.05-1.13kg/h/d. Organic matter intake was range 0.96-1.04kg/h/d. Crude protein intake was range 0.152-0.161kg/h/d. Extract ether intake was range 0.038-0.039kg/h/d. Crude fiber intake was range 0.181-0.196 kg/h/d. NDF intake was range 0.263-0.287kg/h/d. ADF intake was range 0.169-0.183kg/h/d. Cellulose intake was range from 0.130-0.150kg/h/d and hemicellulose intake was range 0.095-0.104kg/h/d.

Nutrient Digestibility

Nutrient digestibility from this study was shown in Table 4. From this Table we can observe that the addition of 25-50% ammoniated *C. nardus* waste in ration as a substitute for forage did not have significant effect on nutrient digestibility ($P>0.05$). Dry matter digestibility was range 76.46-77.85%. Organic matter digestibility was range 77.79-79.80%. Crude protein digestibility was range 68.16-77.41%. Extract ether digestibility was range 82.56-84.18%. Crude fiber digestibility was range 65.01-69.29%. NDF digestibility was range 50.22-55.16%. ADF digestibility was range 35.07-44.19%. Cellulose digestibility was range from 57.98-64.21% and hemicellulose intake was range 71.12-79.11%.

Body Weight Gain and Feed Efficiency

Body weight gain and feed efficiency from this study are shown in Table 5. From Table 5. we can observed that the addition of 25-50% ammoniated *C. nardus* waste in ration as a substitute for forage did not have significant effect on Body weight gain and feed efficiency ($P>0.05$). Body weight gain in this study was range 118-135gr/h/d. Meanwhile, feed efficiency was range 31.18-31.83%.

DISCUSSION

Nutrient Intake

The recent study showed that the addition of ammoniated *C. nardus* waste in ration did not give significant effect on nutrient intake, although there was a decrease trend of nutrient digestibility with the increase of

Table 1: Nutrient composition of experimental treatments

Diet composition (%)	Experimental Treatments		
	A	B	C
Native grass	40	30	20
<i>Cymbopogon nardus</i> waste	0	10	20
Concentrate	60	60	60
Total	100	100	100
Nutrient composition (% dry matter)			
Crude Protein	12.19	12.93	13.67
Total Digestible Nutrient	72.99	71.46	69.93
Crude Fiber	15.61	17.70	19.79
Neutral Detergent Fiber	26.52	27.34	28.15
Acid Detergent Fiber	16.66	17.17	17.69
Lignin	2.34	2.77	3.20

Table 2: Formula of 100% concentrate

Feed	Formula (%)
Tofu waste	75
<i>Zea mays</i>	17
Rice bran	5
Mineral	3
Total	100

Table 3: Nutrient intake of Ettawa crossbred dairy goat with experimental treatments

Nutrient Intake	Experimental Treatments			
	A	B	C	SE
Dry matter (kg/h/d)	1.13	1.09	1.05	0.03
Dry matter (%BW)	4.45	4.39	4.08	0.05
Dry matter (metabolic BW)	99.67	97.87	91.65	0.09
Organic matter (kg/h/d)	1.04	1.00	0.96	0.03
Crude protein (kg/h/d)	0.161	0.158	0.152	0.04
Extract ether (kg/h/d)	0.039	0.038	0.038	0.06
Crude fiber (kg/h/d)	0.196	0.188	0.181	0.05
NDF (kg/h/d)	0.287	0.269	0.263	0.05
ADF (kg/h/d)	0.183	0.170	0.169	0.06
Cellulose (kg/h/d)	0.150	0.135	0.130	0.04
Hemicellulose (kg/h/d)	0.104	0.097	0.095	0.05

Table 4: Nutrient digestibility of Ettawa crossbred dairy goat with experimental treatments

Nutrient digestibility (%)	Experimental Treatments			
	A	B	C	SE
Dry matter	77.85	76.47	76.46	0.77
Organic matter	79.80	77.99	77.79	0.87
Crude protein	77.41	72.55	68.16	0.61
Extract ether	84.18	82.67	82.56	0.73
Crude fiber	69.29	66.41	65.01	0.42
NDF	55.16	53.06	50.22	0.56
ADF	44.19	37.16	35.07	0.93
Cellulose	64.21	61.43	57.98	0.64
Hemicellulose	79.11	77.83	71.12	0.67

Table 5: Body weight gain and feed efficiency of Ettawa crossbred dairy goat with experimental treatments

Parameter	Experimental Treatments			
	A	B	C	SE
Initial body weight (kg)	25.50	26.60	27.10	0.09
Final body weight (kg)	34.20	34.00	33.80	0/05
Body weight gain (gr/h/d)	135	122	118	0.007
Feed efficiency (%)	31.83	31.18	31.20	0.009

ammoniated *C. nardus* waste level. In line with Nurhayu and Warda (2018) who reported that there was a decrease in dry matter intake in Bali cattle given 20-40% *C. nardus* waste as a substitute for *Pennisetum purpureum*. Otherwise, the present study had higher nutrient intake compared to Al-Kindi et al. (2020) who reported that

nutrient intake of local male sheed fed fermented *C. nardus* as substitute for basal feed was 677.63-860.58g/h/d. The difference in the value of nutrient intake is caused by differences in the type, age, and health condition of the livestock. Factors influenced nutrient intake are feed factors which include digestibility and palatability of feed, livestock factors which include breed, sex, age, and health condition of livestock.

Ammoniated *C. nardus* waste is quite palatable to livestock causes the substitution of native grass with ammoniated *C. nardus* waste did not affect ration consumption. Feed palatability is generally associated with high digestibility of feed. Zimpel et al. (2018) and Pazla et al. (2023b) stated that palatability is the main factor explaining the difference in dry matter intake between feed and low-producing livestock. Positive nutrient intake in the present study reflected that the ammonia treatment is able to improve the physical quality of *C. nardus* waste and potentially reduce the limiting factor utilizing *C. nardus* waste as livestock feed. In agreement with Li et al. (2021) and Zeidali-Nejad et al. (2018) who stated that nutrient intake is influenced by the shape and physical quality of the feed, the chemical composition of the ration, the frequency of administration and anti-nutrients in the ration.

Nutrient intake is basically intended to meet the energy requirement of livestock. The compact and dust-free form of ration is highly preferred by livestock, while the high fiber content especially lignin will reduce nutrient intake. Likewise, bulky feed characteristics and low digestibility feed will reduce nutrient intake. Livestock will stop eating when their energy needs are met. Fiber-rich feed and rumen capacity are the main limiting factor for nutrient intake. Besides, nutrient intake is also influenced by nutrient digestibility and rumen fermentation process. Another factor that causes insignificant nutrient intake is because the age of ECDG in the present study is almost the same so that the ability of ECDG in consuming rations is also almost the same.

Nutrient Digestibility

Digestibility is defined as that part of a feed nutrient which is able to be absorbed by the animal's body and is not excreted in the form of feces. Digestibility of dry matter is one of the determinants of ration quality. The higher the digestibility of dry matter, the higher the opportunity for nutrients that can be utilized by livestock. The digestibility of dry matter in this study was in line with dry matter intake. The increasing substitution of naive grass with ammoniated *C. nardus* waste, the lower the consumption and digestibility of dry matter. However, this was not statistically significant, so that ammoniated *C. nardus* waste was stated to have the same digestibility value as native grass in ECDG. The average dry matter digestibility in this study was higher than the study of Zain (2009) which gave local sheep ammoniated cocoa pod husks as a substitute for field grass, which was 61.88-65.86%.

Nutrient digestibility is influenced by the composition and nutrient content of the feed ingredients in feed formulation. Agricultural waste including *C. nardus* is characterized by high lignin content. Lignin is known to be a limiting factor for the digestibility of a feed ingredient in ruminants. Increasing the substitution of native grass with ammoniated *C. nardus* waste further increases the lignin

content of the ration so that the nutrient digestibility also decreases. Lignin is a digestibility limiting factor because it binds directly to the fiber fraction so that the lignin content will be negatively correlated with the nutrient digestibility of the ration. In line with Oluokun (2005) and Pazla et al. (2021a) who stated that high lignin and silica content in feed can cause low digestibility, because lignin cannot be digested by rumen microbes and can even interfere with digestion. Lignin content in ration A is 2.34%, ration B is 2.77%, and ration C is 3.20%. The percentage of lignin content in rations A to ration C increased which resulted in decreased nutrient digestibility.

The content of the fiber fraction in the composition of the ration greatly affects its digestibility. The fiber fraction is part of the plant cell wall which generally binds to lignin which is difficult for rumen microbes to digest, so that when the content of the fiber fraction in the ration is high, the contents of the cells are also easily digested. This is due to the fact that the higher fiber fraction can act as an inhibitor in rumen biodegradation. In this study, from rations A to rations C, there was an increase in the content of the fiber fraction which caused a decrease in the digestibility of dry matter, organic matter, crude protein, fat, crude fiber, NDF, ADF, cellulose and hemicellulose.

Concentrate in this research also helps improve nutrient digestibility. It has been reported by Rodrigues et al. (2021) and Zain et al. (2023) that giving concentrate in feed formulation can increase overall feed digestibility. The more concentrate that can be digested, it means that the flow of feed in the digestive tract becomes faster, causing increased rumen emptying and causing a sensation of hunger in livestock. consequently enabling livestock to increase feed consumption.

In the present study, digestibility of nutrients tended to decrease with increasing of ammoniated *C. nardus* waste level in ration. This is due to the increase in the lignin content of the rations. Increasing the digestibility of low quality fiber feed can be done by adding a good source of protein for livestock and also adding feed additives. One source of protein that is quite promising in increasing the digestibility and body weight gain of livestock is through the addition of legumes. The addition of *Gliricidia sepium* and *Leucaena leucocephala* can increase the digestibility and production of VFA in high-fiber feeds (Ningrat et al. 2019; Zain et al. 2019, 2020). The addition of additives in the form of *Sacharomyces cerevisiae* from several studies can also increase the digestibility of fiber feeds as reported by Pazla et al. (2018a) and Zain et al. (2011; 2016). For this reason, the use of ammoniated *C. nardus* waste as feed with the addition of legumes and feed additives needs to be studied further.

Nutrient digestibility is related to nutrient intake, so the results of this research on nutrient digestibility obtained the same results as nutrient intake, which was not significantly different ($P > 0.05$). This showed that the ammonia treatment of *C. nardus* waste is able to loosen lignin bonds with cellulose and hemicellulose so that *C. nardus* waste can be digested almost the same as native grass. Ammonia treatment by adding urea also adds a large amount of nitrogen (crude protein) for microbial protein synthesis in the rumen where this substance is naturally limited to agricultural wastes (Pazla et al. 2018b; Putri et al. 2021; Sari et al. 2022).

Urea treatment is done by dissolving urea with water. Although ammonia is a weaker alkali compared to NaOH which is less efficient in degrading fiber, it provides nitrogen which can be converted into microbial protein and contributes to protein supply for ruminant productivity. The ammonia treatment of *C. nardus* waste was able to increase its digestibility, so that the substitution of native grass with 50% ammoniated *C. nardus* waste could match the digestibility of 100% of native grass.

Body Weight Gain and Feed Efficiency

Body weight gain is a reflection of the feed consumption, metabolism, fermentation and absorption of nutrients from feed. Besides, it also reflects the quality of feed consumed by livestock. Body weight gain is strongly influenced by the quality and quantity of feed. This means that the assessment of livestock body weight gain is proportional to the ration consumed. Statistically, the substitution of native grass with ammoniated *C. nardus* waste had no significant ($P > 0.05$) effect on body weight gain. This insignificant body weight gain due to consumption of different rations was also not significant. As seen in Table 5, body weight gain is in line with the consumption and digestibility of ration nutrients.

The present study confirmed that feeding ammoniated *C. nardus* waste up to 20% as a substitute for native grass had no significant effect ($P > 0.05$) on body weight gain of ECDG, in fact it tended to decrease compared to the control treatment. The decrease in body weight gain from the control ration is in line with the results of Al-Kindi et al. (2020) which gave fermented *C. nardus* up to 30% to male local sheep as a substitute for basal feed. The average of body weight gain in this study was higher than Kholif et al. (2021) who observed the body weight gain on lactating Damascus \times Baladi goats fed with coriander oil on diet. Body weight gain in this study was high, because the goats were reared intensively in individual cages.

One of the factors that affect body weight gain is nutrient intake. The higher the body weight gain, the dry matter intake by livestock will also increase. The quantity and quality of feed ingredients will affect body weight gain. Besides, genetics, age and environment will also affect body weight gain. Body weight gain in ration A was higher because the consumption and digestibility of dry matter and organic matter were highest in ration A so that there were more nutrients to produce, especially body weight gain. In accordance with the opinion of Pazla et al. (2022) and Salem and Smith (2008) that the digestibility of feed reflects the amount of nutrients available and can be utilized by livestock for basic life, growth, production and reproduction. However, ration A had an effect that was not significantly different from ration B and C.

Feed efficiency is the value obtained from the body weight gain produced per unit of ration dry matter intake. The greater this value, the better and more efficient the feed. The efficiency of the feed for this study also provided no significant differences between treatments as shown in Table 5. The amount of ration efficiency depends on the amount of dry matter intake that is able to provide body weight gain (Pazla et al. 2021b). Ration will be more efficiently used if the ration is consumed in small quantities and is able to provide a large body weight gain.

Conclusion

Cymbopogon nardus is an alternative fiber source for ruminant. The great chemical ingredients and availability of *C. nardus* are potential as substitution in livestock diet. From this study, it can be concluded that ammonia *C. nardus* waste can be used up to 20% as a substitute for 60% of concentrate and 20% of native grass in Ettawa Crossbreed dairy goat without deleterious effect.

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Authors' Contribution

MZ designed the concept of the study, RWSN, E, and E designed the methodology, WN, EMP, and RP analyzed the data and drafted the manuscript, POS and UA did the analysis in the laboratorium.

Conflict of Interests Declaration

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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