Kinetics of rumen fermentation of dwarf Elephant grass (*Pennisetum purpureum cv. Mott*) with indigenous forage from karst mountain in Gombong, Central Java, Indonesia

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Abstract. The damage to ecosystem due to limestone mining in karst mountain has decreased the productivity rate of indigenous forage. Dwarf elephant grass (*Pennisetum purpureum cv. Mott*) has been introduced to used for limestone mining area of karst mountain in Gombong, Central Java Indonesia. The aim of the research was to evaluate the intake level of dwarf elephant grass as the indigenous forage-based goat feed derived from the karst mountain in Gombong, Central Java Indonesia. The experimental method with in vitro was used to measure the different ration level of dwarf elephant grass i.e. R0: 0%, R1: 25%, R2: 50% and R3: 75%. The result reported that the dry matter digestibility of R0: 60.95% ± 3.82, R1: 63.06% ± 2.77, R2: 61.83% ± 2.00, and R3: 59.62% ± 2.04; organic matter digestibility of R0: 53.79% ± 1.78, R1: 56.82% ± 2.42, R2: 55.95% ± 1.75, and R3: 55.63% ± 1.53; the production of volatile fatty acids of R0: 124 mM ± 7.48, R1: 122 mM ± 5.16, R2: 142 mM ± 12.44 and R3: 126 mM ± 3.65; N-NH3 R0: 3.30 mM ± 0.26, R1: 2.80 mM ± 0.33, R2: 2.75 mM ± 0.44 and R3: 2.45 mM ± 0.33. The result of experiment showed that the supplementation of 25% dwarf elephant grass of the total forage could improve the kinetics of ruminal fermentation.

1. Introduction
Karst Mountain has a strategic function because it contains carbonate rocks such as limestone and dolomite that are extensively used for building materials and the main component of cement. Also, karst mountain is a landscape that has an essential value for the environment including water resources, biodiversity and tourism. Gombong karst mountain in Central Java, Indonesia is one of the karst landscapes with a unique geological component and functions as the natural water management with scientific value. Limestone mining in Gombong karst mountain in 1963 has triggered a change in the ecosystem, leading to the decreasing productivity and diversity of indigenous forage which eventually decreases the productivity of goat farming in the area of Gombong karst mountain.

The land that has not been affected by limestone mining shows a good fertility level in terms of having 2.9 – 4.52% organic matter, 0.239 – 0.427% total Nitrogen, 0.095 – 0.184% total P2O5, 0.069 – 0.237% total K2O and 2.758% total calcium (Ca). The study also showed that the diversity of indigenous forage in Gombong karst mountain is high, indicating 36 species that include 12 species of grass (33.3%), eight legumes (22.2%), 14 bushes (38.9%) and two ferns (5.6%) with a productivity rate 29.75 ton/ha/year. The changing ecosystem due to limestone mining has affected the productivity and diversity of indigenous forage [1]. An open ex-mining area of limestone suffered from a decreased fertility with only 0.049 - 0.141% total Nitrogen, 0.067 - 0.133% total P2O5 and 0.086 - 0.100% total K2O. The reduced land fertility also affected the decline of indigenous forage diversity, resulting in nine species including five grass (55.5%), one legume (11.1%) and three bushes (33.4%) with 8.37 ton/ha/year productivity [2].
One of the efforts to increase the productivity of forage in Gombong karst mountain is the introduction of dwarf elephant grass (*Pennisetum purpureum* cv. Mott) in an open formerly limestone mining area that can produce dwarf elephant grass 4.4 – 8.4 ton/ha/defoliation or around 52.9 ton/ha/year with 15.9% crude protein content. The success in developing dwarf elephant grass in used limestone mining open area is expected to improve the productivity and quality of forage in Gombong karst mountain as the source of feed for goat. The growth of dwarf elephant grass in used mining open area is enhanced by goat compost for fertilization and mixed crop with seasonal legume. Therefore, further investigation is needed on the supplementation intake of dwarf elephant grass as the alternative indigenous forage.

2. Research methods
The material used were the dwarf elephant grass that had been introduced to the formerly limestone mining site; indigenous forage and ruminal fluid of native goat of Gombong karst mountain. Research method was experimental in vitro using a completely randomized design (CRD). Treatments consisted of four types of feed combination formulas consisted of dwarf elephant grass and indigenous forage with four replicates. The treatments were R0: 100% indigenous forage; R1: 25% dwarf elephant grass + 75% indigenous forage; R2: 50%dwarf elephant grass + 50% indigenous forage and R3: 75% dwarf elephant grass + 25% indigenous forage. The measured variables was the kinetic response of rumen fermentation that included dry matter digestibility (DMD), organic matter digestibility (OMD), total VFA (volatile fatty acid) and the level of N-NH3 in vitro [3].

3. Result and discussions

3.1 Dry matter digestibility
The in vitro dry matter digestibility of goat (IVDMD) across the formulations of dwarf elephant grass and indigenous forage in Gombong Karst Mountain was 59.62 – 63.06% as shown in figure 1. The dry matter digestibility was not significantly different from that of other forage. Susanti (2007) showed The in vitro dry matter digestibility of elephant grass (*Pennisetum purpureum*) was 60 – 63% [4], while the feed formulation of *Brachiaria ruziziensis* and Indigofera sp had 60.1 % ± 2.4 IVDMD and increased by 17% linear to the supplementation of Indigofera sp [5].

![Figure 1. Dry matter digestibility of feed formulation with the supplementation level of dwarf elephant grass (*Pennisetum purpureum* cv. Mott).](image-url)
Figure 1 showed that supplementation of 25% dwarf elephant grass and 75% indigenous forage showed the highest dry matter digestibility which would decrease if the supplementation of dwarf elephant grass increased. On the contrary, the dwarf elephant grass (*Pennisetum purpureum* cv. Mott) is the prominent type of grass with ideal blade and stem texture and high quality and production of dry matter. The higher the supplementation of dwarf elephant grass, the lower the dry matter digestibility due to the high dry matter digestibility in the indigenous forage. The composition of indigenous forage in Gombong Karst mountain as goat feed was dominated by 45.5% browse followed by 27.2% grass, 18.3% legume and 10% tree plants. The dry matter digestibility of browse could reach 70.66 – 72% [6].

The result of experiment showed that the supplementation of 75% dwarf elephant grass of the total forage did not significantly affect (P>0.01) the in vitro dry matter digestibility of goat feed. It indicated that the supplementation of dwarf elephant grass as the alternative to indigenous forage of Gombong karst mountain was up to 75% and therefore appropriate to be developed in Gombong karst mountain as the solution to the declining productivity of indigenous forage due to the on going limestone mining.

3.2 Organic matter digestibility

In vitro organic matter digestibility (IVOMD) across the different formulations of dwarf elephant grass and indigenous forage of Gombong karst mountain was 53.79 – 56.82%. The result was similar to the dry matter digestibility which at 25% supplementation resulted in 56.82% ± 2.42. Organic matter digestibility in the present study was lower than that of other forage. The organic matter digestibility of *Brachiaria ruziensis* combined with Indigofera sp. R was 62.5% ± 2.1 [4], while organic dry matter digestibility of Callyandra legume was 62.91 – 64.65% [7]. Nevertheless, the organic matter digestibility of dwarf elephant grass and indigenous forage was better than that of various browse in Pakistan, i.e. 30.64 – 55.44% [6]. The result of organic matter digestibility across the formulations of dwarf elephant grass is presented in figure 2.

![Figure 2. Organic matter digestibility of feed supplemented with dwarf elephant grass (*Pennisetum purpureum* cv. Mott).](image)

The experiment showed that the supplementation of dwarf elephant grass up to 75% of the total forage did not significantly affect (P>0.01) the in vitro organic matter digestibility of goat feed (IVOMD). It indicated that supplementing 75% dwarf elephant grass resulted in a relatively high
organic matter digestibility, and therefore suitable for goat feed in Gombong karst mountain. However, the optimal level was up to 25% because the grass contains a higher neutral detergent fiber (NDF) compared to legume and browse [8].

3.3 Total Volatile Fatty Acids

The result of this study showed that the increased level of dwarf elephant grass improved total volatile fatty acids (VFA) concentration, indicating that the small grass contained a higher fermentable carbohydrate. VFA as the source of energy for the ruminants played an important role. The result was within the normal VFA range. The level of structural and fermentable carbohydrate in feed significantly affected VFA concentration.

The results of this study showed that supplementation to the level of 50% of dwarf elephant grass (*Pennisetum purpureum* cv. Mott) in goat feed produced the highest VFA. The VFA concentrations between 140 to 170 mM were able to guarantee rumen microbial growth [9].

3.4 N-NH3production

N-NH3 of elephant grass (*Pennisetum purpureum*) was 1.3 – 1.5 mM and legume Leucaena was 1.45 – 1.65 mM [10]. Indigenous forage provided to the farmers in Gombong Karst mountain slope as goat feed consisted of six species of moss, four legumes, 10 browses and two tree plant. The most frequently offered forage were *Cynodon dactylon, Centrosoma pubescens, Hyptis capitata* and *Swietenia macrophylla*.
Figure 4. N-NH$_3$ production of feed with different supplementation levels of dwarf elephant grass (*Pennisetum purpureum cv. Mott*).

The results of this experiment produced N-NH$_3$ concentrations between 2.45 - 3.3 mM. The results of this study illustrate that dwarf elephant grass supplementation up to 75% level is able to provide the ideal NH$_3$ concentration for maximum rumen fermentation processes.

4. Conclusion
The supplementation of 25% dwarf elephant grass of the total forage could improve the kinetics of goat ruminal fermentation process on karst mountain region.

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