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Performance of goat (Capra hircus) fed with Napier Grass (Pennisetum purpureum) as Affected by Processing and Supplementation

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Index Terms:

ad libitum, In vivo digestibility, substrates, ureamolasses silage, supplementation, soilage

Abstract. This study was conducted to determine the appropriate basal diet and supplementation strategy and to evaluate the effects of different supplements on voluntary feed intake and nutrient digestibility of Napier grass offered as soilage and silage. The experiment was laid out in a Randomized Complete Block Design (RCBD) with four blocks based on sex–period combinations, arranged in a 2 × 3 factorial treatment structure. Factor A consisted of two basal forage types: Napier grass urea–molasses silage and Napier grass soilage, while Factor B involved three supplementation strategies expressed as concentrate to mushroom substrate ratios (% body weight, dry matter basis): 1.0:0 (pure concentrate), 0.75:0.5, and 0.5:0.75. Each treatment was replicated four times. Experimental animals were subjected to a 30-day feeding period per block to assess voluntary intake and nutrient digestibility. Data collected were analyzed using two-way analysis of variance (ANOVA), and treatment means were compared using the Honestly Significant Difference (HSD) test.Results showed that Napier grass offered in silage form exhibited comparable voluntary feed intake and nutrient digestibility to Napier grass soilage. Furthermore, supplementation using mushroom substrates combined with concentrate at ratios of 0.75:0.5 or 0.5:0.75 % body weight (dry matter basis) produced intake and digestibility responses comparable to those observed in animals receiving pure concentrate supplementation at 1.25 % body weight. These findings indicate that mushroom substrates can effectively replace a portion of concentrate without compromising animal performance. The study highlights the potential of integrating mushroom substrates as an alternative supplement to improve feed efficiency and reduce reliance on conventional concentrate feeds.

Introduction

In the Philippines, ruminant production particularly smallholder goat farming relies heavily on native pasture grasses and crop residues that are generally low in digestibility and nutritive value, especially during the dry season (Patiga et al. 2025; Patiga et al., 2020; Babayemi & Bamikole, 2009). While forage availability improves during the rainy season, many native pastures rapidly become fibrous, seasonally scarce, and deficient in essential nutrients, thereby limiting rumen microbial activity and animal performance (Patiga et al., 2020; Sowande, 2004; Lamidi, 2009). During extended dry periods, farmers commonly utilize rice straw, corn stover, and low-quality rangeland grasses, which require appropriate management to sustain their feeding value (Patiga et al., 2020). Cogon grass (*Imperata cylindrica* L.), widely distributed in Philippine grasslands and marginal lands, serves as an important drought forage; however, its high lignin content restricts digestibility and voluntary intake (Samson & Capistrano, 1982).

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Despite the availability of diverse local feed resources, their effective utilization remains constrained by poor digestibility and intake, resulting in low productivity in smallholder systems (Patiga et al., 2020; Olafadehan & Adewumi, 2009). To address these limitations, supplementation with concentrates and higher-quality forages, along with chemical and biological treatments such as urea application and ensiling, has been employed to improve nutrient availability and intake (Patiga et al., 2020; Jackson, 1979; Wanapat et al., 2013).

However, limited information is available on the performance of goats fed poor-quality roughages improved through strategic supplementation under Philippine conditions. Thus, this study evaluated the performance of goats fed napier grass supplemented with varying levels of concentrates and mushroom substrates in a smallholder production setting.

Methodology

Preparation of materials

The materials used in the study were the following: experimental goats, chopping board, dagger, feeding and watering troughs, polyethylene bag (silage bag), and record book, weighing scale, ball pen, sharp knife, nail, Plywood, lumber, bamboo slats, broom and dust pan, and basal diets such as napier grass soilage and silage form.

Preparation of napier grass silage

The napier grass was gathered from the pasture area about 90-110 days after the last cutting. The pasture area is located at Bohol Island State University Bilar Campus and Brgy. Canagong, Sikatuna Bohol. Napier grass was gathered early in the morning between 6:00 to 8:00 A.M. Freshly cut napier grass was properly wilted to 60-75% dry matter (DM) by air drying, and chopped into 2–3 cm long. Urea-molasses were used as silage additives to the napier grass silage. The parts for urea were computed based on its nitrogen content. Since molasses is five (5) times greater than that of urea, the part for molasses were multiplied 5 times to that of urea to get the proportion of urea and molasses at 2.1% of silage mass of the experimental forages before ensiling (Ubod and Bestil, 2018; Patiga et al. 2025; Patiga et al. 2020). The samples were compacted, thereafter. Air was withdrawn from the plastic pouches (silage bags) and the experimental forages were packed tightly. The silage samples were stored in a room with a temperature of about 27 to 30°C. After 21 days of anaerobic fermentation, the bags were opened for the feeding trial.

Formulation of concentrate mix

Supplemental feeds were composed of 100 kg, a 14% CP component was formulated. The concentrate was composed of 37.5% cassava meal, 15% rice bran, 25% corn grits, soy bean meal 22% and .5% of salt and mushroom substrates. The daily DM requirement was based on the age and weight of the animal and the level of concentrate was given at 1.25 % body weight. The Supplemental feeds were purchased at a local market in Sikatuna, Bohol and the mushroom substrates were collected at Bohol Island State University – Mushroom Production Area, Bilar Campus.

Preparation of the mushroom substrates

Mushroom Substrates were collected within the campus of the Bohol Island State University Bilar Campus, Bilar Bohol. All Substrates were collected from the mushroom production area. In preparing the substrates, these fodder air dried under the roof for five days and then grounded and stored in sacks. For proper storage and to avoid spoilage, the substrates were dried to 5-10% moisture content. The amount of substrates was needed to prepare one kilogram of mushroom substrate meal.

Preparation metabolism cages and experimental animals

The metabolism crates or cage described by MeCollum and Steenbock and by Forbes for swine were utilized for the small ruminants, with slight modifications, especially as to the size of the mesh of the wire screens used for the floor. Before the experiment started, the metabolism cages were cleaned and disinfected 7 days before the animals were placed. Twelve apparently healthy grower anglo-nubian goats that aged 3 months, weighing 20-25 kilograms body weight (BW), were used in this study.

They were divided into two blocks for the first run, the same goats were randomly assigned to the treatments used in the second run with another two blocks. Before the experiment started, the goats were dewormed with ivermectin and administered with multivitamins (B-Complex). The drugs were purchased from Agrivet store. The animals were placed individually in the metabolism cages that were equipped with individual feeder and waterers. The experimental goats were allowed to adjust the surrounding/environment for one week. There was gradual shifting from previous diets to the treatment diets.

Dietary treatments and experimental design

This experiment utilized both napier grass soilage and napier grass silage. The study utilized the supplementation of concentrates and mushroom substrates meal. The experiment was Randomize Complete Block Design (RCBD) with a 2 x 3 factorial treatment design: factor A with two types of base forage (napier grass soilage and napier grass silage), and factor B with different types of supplementation, replicated four (4) times, with 4 blocks based on sex period combination as follows (Table 1):

Types of Forage (A)	Types of Supplementation (B)
A_1 – Napier Grass - Urea Molasses Silage	B_1 = Concentrate (1.25% BW, DM basis) B_2 = Concentrate and Mushroom Substrate (0.75:0.5% BW, DM basis) B_3 = Concentrate and Mushroom Substrate (0.5:75% BW, DM basis)
A_2 – Napier Grass - Soilage	B_1 = Concentrate (1.25% BW, DM basis) B_2 = Concentrate and Mushroom Substrate (0.75:0.5% BW, DM basis) B_3 = Concentrate and Mushroom Substrate (0.5:75% BW, DM basis)

Table 1. Dietary treatments and experimental design

Each animal was given concentrates once a day, at 1.25 % of their body weight (BW), basal diet. Napier grass soilage and urea-treated corn stover were given *ad libitum* at 6:00 in the morning and 4:00 in the afternoon .The experimental animals have free access to water at all times.

Collection and measurements of fecal output

Feces were collected manually from each animal throughout the day during the collection period and were kept in individual bags to avoid the loss of volatile nitrogen and contamination with dirt and urine. Feed offered and refused were recorded daily during the duration of the experiment. Refusals were removed and weighed before the morning feeding. During the digestibility trial, refusals were removed daily, weighed, sampled, and bulked in individual bags.

The total quantity of feces voided were weighed and recorded in every animal. About 10% feces were mixed every day from each animal. At the end of the collection period the fresh feces were compiled together and oven dried and were used for percent dry matter analysis.

Recording of body weight

The animals were weighed at the beginning of the experiment and at every week thereafter. All weighing were made at 6:00 in the morning.

Chemical analysis

Feed and fecal samples were analyzed for its dry matter (DM), organic matter (OM) contents according to the methods of Association of Official Analytical Chemists (AOAC 1990) at the Biodiversity, Environment and Natural Resources Research Center (BENRC) – Cebu Technological University Argao Campus, Argao Cebu, Philippines.

Digestibility trial

The following were the schedule of activities followed during the conduct of the study:

Day	Activity
1-5	Gradual shifting from previous diet to treatment diets
5- 25	Feeding Trial. Ad libitum feeding of basal diet (cogon grass silage and urea-treated corn stover) with supplemental concentrates and Ipil-Ipil leaf meal will be given at 1.25% of body weight, dry matter basis. Initial Weight measured at Day 5. Weekly monitoring of weight changes and Voluntary Feed Intake.

26-29 30-35	Digestibility Trial. Reduce basal diet offering to 90% *Ad libitum*. Recording of fecal output, feed intake, sampling of feces and feeds for analysis in Day.

Table 2. Schedule of activities

Data gathered

1. Voluntary DM Intake
   For concentrate and ipil-ipil legume leaf meal and urea-treated

$$\text{DMI} = \text{Feed Intake x \% Dry Matter of Feed}$$

   For silage:

$$\text{DMI} = (\text{Feed Given x \%DM of feed Given}) - (\text{Feed Refused x \%DM of Feed Refused}$$

2. Dry Matter Degradation (DMD)

All samples including the treatments were first subjected in the oven with 100 ^{0}C for 24 hours to get its dry matter value that can be used for the following computations. Dry matter digestibility of the basal diet which is the corn stover and cogon grass silage will be determined using the following formula:

$$\text{DMD (\%)} = \frac{(\text{Dry Matter Intake} - \text{Dry Matter Excreted}}{\text{Dry Matter Intake}} \text{ x100}$$

Where:

$$\text{DM Excreted} = \text{Fecal Output x \% Dry Matter of Feces}$$

3. Organic Matter Intake

$$\text{OMI} = \text{Dry Matter Intake x \% Organic Matter of Feed}$$

   Where: $\% \text{ OM} = 100 - \% \text{ Ash}$

4. Organic Matter Digestibility

$$\text{OMD (\%)} = \frac{\text{Organic Matter Intake} - \text{Organic Matter Excreted}}{(\text{Organic Matter Intake})} \text{ x100}$$

Where: Organic Matter Excreted = Fecal DM Output x % Organic of Feces

Analysis of data

Data were analyzed by two-way Analysis of Variance (ANOVA) for a Randomized Complete Block Design, and comparison of treatment means was done using Honestly Significant Difference (HSD) Test with the Statistical Package for Social Sciences (SPSS) version 20 software.

Results and Discussion

Dry matter intake and digestibility

Table 3 presents the dry matter intake (DMI) and dry matter digestibility of goats fed basal diets of Napier grass soilage and silage with varying concentrate levels. No significant differences ($p > 0.05$) were observed among forage types and supplementation treatments, indicating comparable effects on intake and digestibility. The highest DMI was recorded in goats fed Napier grass silage supplemented with 0.75% concentrate and 0.5% mushroom substrate, suggesting that higher concentrate inclusion with lower substrate levels enhances intake. These findings are in consonance with previous reports showing improved digestibility and energy values in silages supplemented with mushroom substrates through enhanced nutrient availability, particularly nitrogen for rumen microbial activity (Sruamsiri et al., 2007). Mushroom substrate meal has been reported to support feed intake and animal performance due to its favorable palatability and nutrient composition (Akingbade et al., 2002; 2004; Kanani et al., 2006). However, its replacement value remains limited in diets formulated with high-quality protein sources such as soybean and fish meal (Tangendjaja et al., 1990).

TREATMENTS	DMI (g)	DMI (%BW)	DMD (%)
Factor A (Types of Diet)			
A_1- Napier Grass Silage	488	5.05	31.49
A_2- Napier Grass Soilage	442	5.38	29.86
p-value	*0.06^{ns}*	*0.650^{ns}*	*0.598^{ns}*
Factor B (Types of supplementation)			
B_1 - Concentrate (1.25% BW, DM basis)	344	4.01	19.23
B_2- Concentrate: MSM (0.75:0.5% BW, DM basis)	373	4.43	22.37
B_3- Concentrate: MSM (0.5:0.75% BW, DM basis)	362	3.97	21.93
p-value	*0.827^{ns}*	*0.323^{ns}*	*0.118^{ns}*
Interaction Factor AxB			
p-value	*0.294^{ns}*	*0.316^{ns}*	*0.110^{ns}*

^{ns} Not significant

Table 3. Dry matter intake (DMI) and dry matter digestibility (DMD) of napier grass soilage and silage with varying types of supplementations in goats.

Organic matter intake and digestibility

Table 4 presents the effects of dietary treatments on organic matter (OM) digestibility, which reflects the proportion of organic matter apparently digested in the ruminant gastrointestinal tract and is used to estimate energy availability and microbial protein synthesis (Anam et al., 2017). No significant differences were observed among treatments ($p > 0.05$), indicating comparable responses. Supplementation of low-quality roughages with protein and energy sources is recommended to support intake and nutrient utilization (Jackson, 1979; Patiga et al., 2020). Inclusion of protein or non-protein nitrogen (NPN), such as urea, enhances rumen fermentation and nutrient digestibility (McGuire et al., 2013; Khattab et al., 2013; Cappellozza et al., 2013; Sweeny et al., 2014; Benedeti et al., 2014; Holder et al., 2015; Kang et al., 2015; Ampapon et al., 2016). Urea-treated maize stover exhibits higher crude protein content due to increased microbial biomass (Elias and Fulpagare, 2015), and the combined use of treated roughages, leguminous forages, and commercial concentrates presents a practical approach to improve protein supply and support sustainable goat production.

TREATMENTS	**OMI (g)**	**OMD (%)**
Factor A (Types of Diet)		
A_1- Napier Grass Silage	532	63.57
A_2- Napier Grass Soilage	421	66.09
p-value	*0.06^{ns}*	*0.616^{ns}*
Factor B (Types of supplementations)		
B_1 - Concentrate (1.25% BW, DM basis)	375	85.31
B_2- Concentrate: MSM (0.75:0.5% BW, DM basis)	404	82.67
B_3- Concentrate: MSM (0.5:0.75% BW, DM basis)	398	83.50
p-value	*0.890^{ns}*	*0.117^{ns}*
Interaction Factor A x B		
p-value	*0.293^{ns}*	*0.085^{ns}*

^{ns} Not significant

Table 4. Organic matter intake (OMI) and Organic matter digestibility (OMD) of napier grass silage and napier grass soilage with varying types of supplementations in goats

Conclusion and Implications

This study established that napier grass ensiled as a basal roughage is nutritionally comparable to napier grass soilage in terms of voluntary feed intake and nutrient digestibility. In addition, supplementing either Napier grass silage or Napier grass soilage with a mixture of concentrate and mushroom substrate meal at ratios of 0.75:0.5 or 0.5:0.75 % body weight (dry matter basis) resulted in intake and digestibility responses similar to those obtained with an all-concentrate supplement at 1.25 % body weight. These outcomes confirm that alternative forage processing methods and partial replacement of concentrate with mushroom substrate do not adversely affect feed utilization.

Given these results, integrating Napier grass silage with a combined concentrate–mushroom substrate supplement presents a feasible and economical feeding option for ruminant production systems. The comparable performance observed between mixed supplements and all-concentrate feeding underscores the potential for reducing concentrate use and overall feed costs. Moreover, the utilization of mushroom substrate meal supports the efficient recycling of agro-industrial residues, contributing to more sustainable livestock production. Adoption of this feeding strategy can improve farm profitability while maintaining adequate animal nutrition, particularly under tropical conditions where conventional feed resources are costly or limited.

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Competing Interests Statement

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 article.

Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study; all data used were obtained from previously published sources as cited in the reference list.

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Appendices

No appendices are included in this article.