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Dry Matter Intake and Digestibility of Napier and Treated Rice Straw Diet in Goats

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Abstract

Plant by-products such as rice straw can be utilized to optimize ruminant feed resources and productivity. This study aimed to determine the intake and digestibility of the basal diet (Napier grass) and treated rice straw diet in goats. A total of 16 heads of male and female Philippine native goats were used in the study. Experimental animals were arranged in randomized complete block design with four treatments and four blocks – weight and sex were used as bases for blocking. The treatments were the following: Treatment 1 (T1): 60% Napier grass + 40% untreated rice straw (control); T2: 60% Napier grass + 40% urea-treated rice straw; T3: 60% Napier grass + 40% fish amino acid (FAA)-treated rice straw; and T4: 60% Napier grass + 40% fermented plant juice (FPJ)-treated rice straw. The gathered data were dry matter intake (DMI), DMI as percent body weight (% BW), total and percent dry matter digestibility (% DMD), rumen pH and weight gain. All data were analyzed using the analysis of variance for RCBD. Comparisons of treatment means were determined using the least significance difference test. The results showed that DMI and DMI as % BW were significantly ($p < 0.05$) affected by the treatments. Furthermore, total DMD and % DMD were significant ($p < 0.05$). FPJ treatment gave the highest DMI for rice straw. Moreover, goats fed with rice straw treated with urea, FPJ and FAA efficiently digested the diet compared with the control treatment.

Keywords*:* fermented plant juice, fish amino acid, goat performance, rice straw, urea

1. Introduction

Goats (*Capra hircus*) are regarded to be essential for the development of rural areas and people. Its number is increasing more rapidly than sheep, especially in the less developed parts of the world (Liang and Paengkoum, 2019). In the Philippines, as highlighted by the Philippine Statistics Authority (2021), the current total inventory of goats was estimated at 3.94 million heads from which 98.8% of the total population were raised in backyard farms.

Although goats are present on all continents, concerns related to the availability of forages for ruminants has become a problem as it is affected by the dry season, specifically in the Asian countries. Many factors influence the productivity of ruminants; two of the most essential ones are the quality and amount of the feed they consume. There are many different types of fodder accessible. Nevertheless, in particular species, anti-nutritive factors can be an issue (Nahand *et al*., 2012; Aban *et al*., 2015).

In feeding ruminants, the most popular forage species is Napier grass (*Pennisetum purpureum*). Utilizing Napier or elephant grass as basal diet to small and large ruminants by the local raisers in the country is apparent because of its popularity – which significantly contributes to the availability of the forage – its resistance to drought and high dry matter yield potential (Rusdy, 2016). Besides, feeding of Napier grass is quite ideal from other roughages since it requires a relatively lesser amount of inputs and area while taking benefit of its substantial growth rate if grown and use regularly (Negawo *et al*., 2017). Furthermore, the nutritional value of Napier grass is quite promising as it approximately contains 21% dry matter, 10% crude protein, 65% neutral detergent fiber, 37% acid detergent fiber, 1.95 ether extract and 8.8% ash when mature enough for forage use (Maleko *et al*., 2019). However, pasture establishment is quite challenging. Planting Napier would mean competition for the area for crops intended for human consumption. Meanwhile, as the dry season lasts, alternative feedstuff for ruminants plays a vital role in supporting their nutritional requirements. One of which is the provision of rice (*Oryza sativa*) straw as fodder. Rice straw is a common residue in most rice base farms in the Philippines. However, for particular reasons, this roughage is less utilized as feed in ruminant animals in the country as it is usually thrown or burned by the local farmers.

Rice straw is low in protein content, mineral and energy level (Oladosu *et al*., 2016; Aquino *et al*., 2020). In addition, its acceptability is less due to its palatability concern. Preferably, intake and digestibility constraints of feeding rice straw can be improved by the application of pre-treatment methods (physical, chemical and biological) or supplementation with other feedstuff components in the simplest way possible (Yulistiani *et al*., 2003; Sarnklong *et al*., 2010; Oladosu *et al*., 2016; Patra and Aschenbach, 2018). Rice straw under the pre-treatment process has a positive effect on the conversion of its chemical compositions that each procedure only differs according to preferred manipulation schemes (Maurya *et al*., 2015). Relatively, pre-treatment methods such as the use of urea or supplementation with high-quality feed like legumes can improve the low nutritional value and palatability of rice straw (Yulistiani *et al*., 2003; Ma *et al*., 2020). Moreover, Bata *et al.* (2020) further revealed that urea-treated rice straw ensiled with cassava pulp and supplemented with concentrate can improve production and reproduction performance in the case of heifer buffaloes. However, the issues on the use of urea under chemical or synthetic treatment on fodder contradict the concept of organic agriculture. Hence, it is in high interest of applying organically produced treatment instead.

Biological or organic treatment was thought to be a useful alternative instead of urea-based treatment like in the probiotic preparations that keep primarily common micro-organisms of *Lactobacillus* and *Bifidobacterium* species (Gupta and Abu-Ghannam, 2012). Similarly, according to Hu *et al*. (2020), rice straw co-fermented with probiotics and enzymes was effective in improving the rumen microbial community, thereby increasing the release of the volatile fatty acids (VFAs) leading to feeding energy conversion efficiency in the rumen. The nutritive value and in vitro ruminal digestibility of rice straw can be improved by ensiling with lactic acid bacteria (LAB) particularly those that are capable of degrading the substrate. Moreover, the prospect of the use of organically-produced fermented juices as a low-cost ensiling agent to favor the capacity of smallholder farmers will be ideal. However, limited information is a challenge to support its use.

Hence, this study was carried out to evaluate the effect of synthetically and organically treated rice straw diet in goats for dry matter intake (DMI), DMI as percent body weight (% BW), total and percent dry matter digestibility (% DMD), rumen pH and weight gain.

2. Methodology

This study followed the Animal Welfare Act 8485 of the Philippines. Before the conduct of the experiment, the study protocol, dated January 10, 2020, was reviewed and approved by the Iloilo Provincial Veterinary Office, Iloilo City, Philippines.

2.1 Study Location and Animal Subjects

The study was conducted for two months at the goat house of the Capiz State University (CapSU) – Tapaz Campus, Tapaz, Capiz, Philippines. General cleaning and disinfection of the house were done two weeks before the conduct of the experiment. A total of sixteen (16) heads of male and female Philippine native goats were used and placed in the individual metabolism cages following the recommended space requirement of 1 x 1 m. The initial average live body weight (LBW) of goats that were used was 10.39 kg.

2.2 Treatments

There were four treatments utilized: treatment 1 (T1): 60% Napier grass (basal) + 40% untreated rice straw (control group); T2: 60% Napier grass (basal) + 40% urea-treated rice straw; T3: 60% Napier grass (basal) + 40% fish amino acid (FAA)-treated rice straw; and T4: 60% Napier grass (basal) + 40% fermented plant juice (FPJ)-treated rice straw. The study was laid out in a randomized complete block design (RCBD) with four blocks and with the sex and weight of the experimental animals as bases for blocking.

2.3 Treatment of Plant Materials

Rice straws were obtained from local growers while Napier grass was harvested in the vicinity of CapSU – Tapaz Campus. For urea-treated rice straw, a ratio of 1 kg of urea fertilizer to 10 mL of water to 20 kg of rice straw (1 kg urea:10 mL water:20 kg of rice straw) was utilized. After which, rice straw and urea were thoroughly mixed and were placed in polyethylene plastic, which was then compressed and sealed to keep the container bag airtight. Treated straw is ready for consumption after two weeks of preservation (Ministry of Food and Agriculture, n.d.). For FAA- and FPJ-treated rice straw, ensiling steps were made the same as that of urea-treated rice straw except in dilution of the organic concentrates. These organic concentrates were diluted following the recommended ratio or protocol in organic rice production which is 10 mL FAA/FPJ in every liter of water to 20 kg of rice straw (10 mL FAA/FPJ: 1-L water: 20 kg of rice straw). The preparation of FAA and FPJ was adapted from the procedure of the Department of Agriculture – Agricultural Training Institute (2011).

Purposely, the use of FAA and FPJ as ensiling agents for dried rice straw was based on their use as alternative counterparts of urea fertilizer in the organic farming setup, with the anticipation that the contained living microorganisms of the organic concentrates would further hasten the fermentation process.

2.4 Initial Body Weight Measurement, Dry Matter Requirements and Digestibility Evaluation

The initial body weight of the goats was measured before the conduct of the experiment. Initial weights were needed in the computation of the daily feed requirements of the goats. Deworming of the animals was performed one week before the start of the experiment. One-week acclimatization was also performed for the animals to adapt to the environment and feeding system.

Dry matter (DM) requirements of the animals were set at 3% of their body weight and were proportioned to both Napier grass and treated rice straw to compose the actual amount to be fed at 60 and 40%, respectively. The goats were fed a percentage of treated rice straw in each treatment followed by a 1-h interval of fresh Napier grass as a basal diet placed in a separate feeding trough. Each goat was fed twice a day (6:00 AM and 4:00 PM). The feed-given and the feed-refusal were weighed every day. The animals were also given drinking water (ad libitum) all over the experimental period.

For digestibility evaluation, the feces of goats were collected individually one week before the termination of the study; they were then weighed and recorded each day. Fecal samples in each treatment were also secured and subjected to drying at 105 °C overnight in a convection oven (ED400, Binder Kisker Biotech & Co., Germany). The resulting values were used in determining the DMD.

2.5 Data Collection

2.5.1 Ruminal pH of Goat

Rumen fluid was collected a day before the application of treatment and during the termination of the study. Rumen fluid was obtained through the stomach tubing procedure; the fluid was then strained using a four-layer cheesecloth. After straining, the pH was measured immediately with the use of a digital pH meter (HI 98108, Hannah Instruments, United States).

2.5.2 Voluntary DMI

Voluntary DMI was measured by determining the daily total feed intake of and total feed refused by the goat. This was computed using Equation 1.

$$DMI\ (g) = [(Feed\ given \times \%\ DM\ of\ given) - (Feed\ refused \times \%\ DM\ of\ refused)] \quad (1)$$

2.5.3 DMI as % BW

DMI as % BW was computed using Equation 2 to account for the differences in body size affecting voluntary intake.

$$DMI,\ \%\ BW = \frac{DMI\ (g)}{Initial\ weight\ (g)} \quad (2)$$

2.5.4 % DMD

DMD is the amount of feed being digested by the animals. This was computed using Equation 3.

$$\%\ DMD = \frac{DM\ of\ feed\ intake - DM\ of\ excreta}{DM\ of\ feed\ intake} \times 100 \quad (3)$$

2.5.5 Mean Gain in Weight (kg)

To get the mean gain in weight, the initial and final weight was recorded. The difference between the goat’s mean final weight and its mean initial weight was the resulting weight gain. The initial weight of the goat was taken before the conduct of the experiment while the final weight was obtained at the end of the experiment. This was computed using Equation 4.

$$Mean\ gain\ in\ weight = Mean\ final\ weight - mean\ initial\ weight \quad (4)$$

2.6 Statistical Analysis

The means of each parameter were analyzed using analysis of variance for RCBD using Statistical Tool for Agricultural Research (STAR) version 2.0. A comparison of treatment means was done using least significance difference (LSD) test at a 5% level of significance.

3. Results and Discussion

3.1 DMI and DMI as % BW of Goats for Napier Grass and Rice Straw Diets

For the basal diet (Napier grass), the DMI and DMI as % BW of goats showed no significant result (Table 1). However, for the rice straw diet, DMI showed a significant result at 5% alpha. Goats fed with FPJ treated rice straw diet was statistically higher in DMI and DMI % BW compared with goats fed with FAA, untreated and urea-treated rice straw diets. This implied that DMI of goats and the equivalent percentages accounting for the differences in body size affecting dry matter intake were significantly affected by the treatment approach.

Table 1. Voluntary DMI and DMI as % BW of goats for Napier grass and rice straw diets

Treatments	DMI (g) of goats to Napier grass	DMI (g) as % BW of goats to Napier grass	DMI (g) of goats to rice straw diet	DMI (g) as % BW of goats to rice straw diet
T1: 60% Napier grass + 40% untreated rice straw (control)	175.58	17.39	23.25[c]	2.43[c]
T2: 60% Napier grass + 40% urea-treated rice straw	181.71	16.92	13.75[d]	1.29[c]
T3: 60% Napier grass + 40% FAA-treated rice straw	178.62	17.23	62.54[b]	6.29[b]
T4: 60% Napier grass + 40% FPJ-treated rice straw	176.00	16.59	81.19[a]	7.82[a]
Grand mean	177.98	17.03	45.18	4.46
CV (%)	13.46	14.31	11.56	17.34
Computed F-value	0.06[ns]	0.08[ns]	149.8**	64.28**
Tabular F-value (5%)	3.86	3.86	3.86	6.99

ns – not significant; ** – highly significant; mean in a column followed by the same letter is not statistically different by LSD at 0.05 significance level.

Similar intake for Napier grass could be attributed to its nutrient composition, where it was shown to have lower dry matter (16. 5 to 24.4%) (Negawo *et al*., 2017) and crude fiber (26.5%) (Perez *et al*., 2010) content than the rice straw which reached 90.6 to 96.3% dry matter and 35.1% crude fiber content (Shen *et al*., 1998; Aquino *et al*., 2020). Moreover, higher crude protein was recorded in Napier grass (9.9 to 15.8%) (Rusdy, 2016; Negawo *et al*., 2017) compared with rice straw, which contained only 4.2% (Shen *et al*., 1998; Aquino *et al*., 2020).

Significant differences in DMI in rice straw were therefore affected by the treatment applied. This is supported by Dulphy *et al*. (1992) stating that the rate of intakes of straw enriched with molasses similar to FAA and FPJ was higher than the control (without molasses). They also added that urea treatment decreased the straw intake because urea hydrolysis was too low owing to feed unpalatability and perhaps to high ammonia content as well as the high lignin content, pH level and odor (Aban and Bestil, 2013). The link between cellulose, hemicellulose and lignin must be disrupted to allow lignified tissue to separate from non-lignified tissue, which will improve crop residue intake and digestibility (Abd El-razik *et al*., 2012). These processes make it easier for the rumen microbe to attack the rice straw's structural carbohydrates, thereby enhancing its digestibility and palatability (Selim *et al*., 2004). Treated roughages like dried rice straw with a natural ensiling agent like the fermented plant juice have higher digestibility for both cell walls and cell soluble than the untreated material ensuring more fermentable substrates in the rumen (Mahesh and Mohini, 2013).

In addition, in vitro ruminal digestibility of rice straw was improved by ensiling with LAB potentially found in fermented plant juice particularly those that are capable of degrading the substrate (Marbun *et al*., 2020). Besides, the incorporation of stimulant sugar (molasses) will serve as food in the form of soluble carbohydrates that enhance the growth of LAB, which further improves the quality of the silage in terms of fast acidification (low pH), reduce ammonia nitrogen (NH_3-N), decrease organic matter and lower the level of volatile basic nitrogen (Oladosu *et al*., 2016).

3.2 Total and % DMD, Weight Gain and Ruminal pH of Goats

The total DMD was higher in goats fed with FAA- and FPJ-treated rice straw diet compared with urea-treated rice straw and the control group (Table 2). Similarly, a significant result was obtained on the % DMD of goats. Percent digestibility was comparably higher in goats fed with FAA-, urea- and FPJ-treated rice straw than the control treatment. With the observation in the increased digestibility among diets, it was mentioned by Thu and Udén (2001) that urea-molasses supplementation would result in a significant increase in rumen ammonia, which also favors the growth of rumen microorganism that facilitates digestion of the fibrous diet (Aban *et al.,* 2015).

Goat's weight gain was not statistically affected by the treatment application. Although statistically not significant, mean values for goats fed with urea-, FAA- and FPJ-treated rice straw were higher compared with the control. This can be explained by the short duration of the experiment which is only two months. Short duration study is not reliable in getting a significant result on weight gain. Moreover, although weight gain was not statistically significant, it supported the results of DMD where higher weight gain was recorded on goats with higher DMD.

Table 2. Total and % DMD, weight gain and ruminal pH of goats as affected by the feeding of the basal diet (Napier) and treated rice straw

Treatment	Total DMD (g)	DMD (%)	Weight gain (kg)	Final ruminal pH
T1: 60% Napier grass + 40% untreated rice straw (control)	107.83[c]	56.98[b]	0.55	7.05
T2: 60% Napier grass + 40% urea-treated rice straw	140.45[b]	73.69[a]	0.72	7.07
T3: 60% Napier grass + 40% FAA-treated rice straw	184.40[a]	76.53[a]	0.60	7.10
T4: 60% Napier grass + 40% FPJ-treated rice straw	181.54[a]	70.41[a]	0.67	7.37
Grand mean	152.69	69.40	0.63	7.15
CV (%)	13.31	10.13	12.54	3.06
Computed F-value	12.31**	6.06**	3.78[ns]	1.88[ns]
Tabular F-value (5%)	3.86	3.86	3.86	3.86

ns – not significant; ** – highly significant; mean in a column followed by the same letter is not statistically different by LSD at 0.05 significance level.

Lastly, the ruminal pH ranged from 7.05 to 7.35 to represent the final reading. Statistical analysis revealed that both values of the initial and final rumen pH were not affected by the feeding of synthetically and organically treated rice straw diet. The rumen is a continuous anaerobic culture system in which a pH is maintained between 5 to 7 (Gebeyehu and Mekasha, 2013). In this study, the pH value was high because ruminal fluid samples were collected before the morning feeding. It was observed that the pH of the rumen is alkaline during the morning feeding because of the rigorous rumination and restricted feed intake at night. Additionally, during rumination, there is a considerable production of saliva which has a buffering effect that neutralizes or increases the pH level in the rumen (Beauchemin, 2005; Aban *et al*., 2015).

4. Conclusion

The different treatments used significantly affect the goats' DMI and DMI as a percent body weight, total DMI and percent DMI but no significant effect on rumen pH and weight gain. Moreover, goats fed rice straw treated with FAA, urea and FPJ efficiently digested the diet showing higher dry matter digestibility compared with the goats fed with untreated rice straw diet. Therefore, treating rice straw with FAA, urea and FPJ was helpful in improving the dry matter intake and digestibility. Improved intake and digestibility implied efficient utilization.

5. Acknowledgement

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