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Nutrient intake, digestibility and growth performance of goats (*Capra hircus* Linn) fed with rice straw and concentrate supplement

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Abstract

An experiment was conducted to determine the effect of feeding concentrate supplement and urea treated rice straw on nutrient intake, apparent digestibility, and growth performance of goats. For this study, nine goats were assigned in individual cages according to Randomized Complete Block Design on a bodyweight basis. They were divided into three groups with one animal per replicate and each received dietary treatment as follow: (T1) Untreated rice straw with concentrate supplement at 1% of live weight (LW), (T2) urea treated rice straw with concentrate supplement at 1% of LW, (T3) urea treated rice straw with concentrate supplement at 1.25% of LW. Rice straw (RS) and urea treated rice straw (UTRS) were fed *ad libitum* with concentrate supplement in a separate feeding trough for 10 weeks. Five days digestibility trial was conducted at the end of the study. Results showed that the voluntary feed intake of RS and UTRS were similar for all treatments. Dry matter intake was highest in T1 comparable to T3 whereas intake of crude protein, organic matter and ether extract were similar across treatments. On the other hand, apparent digestibility of dry matter, organic matter and ether extract were significantly higher in T2 and T3. There were no significant differences in live weight gain for all treatments but reduced of weight was observed in T1. Thus, it can be concluded that concentrate supplementation at 1% and 1.25% LW on urea treated rice straw diet only promote better apparent nutrient digestibility of goats raised in complete confinement.

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Introduction

Goat production in the Philippines that is 99% backyard remains a viable income-generating enterprise for low – income farmers. However, the existing problem including long production cycle (9 mos.) lower conception rate (75%), higher pre-weaning mortality (25%) and slow growth rate generally contribute to lower productivity (Alo, 2017). Despite this, both commercial and backyard farms continue to increase by 1.4 and 11.4% respectively in its population due to higher demand for goat products in the market (PSA, 2020). Most goats predominantly the dairy type is raised under confinement and fed with a diet comprised of grass, legume forages and commercial concentrate feeds (Liang, 2019). With the increase of population and continuous industrial development in rural areas, land intended for pasture and forage production gradually decrease and this resulted to feed scarcity and shortage. Hence, relevant research has been tried utilizing crop residues such as rice straw as feed to goats and dairy buffalo (Rizi, 2005; Aquino *et al.*, 2016) to alleviate this problem.

Rice straw is an abundant crop residue and a cheap source of fodder for ruminants mainly fed in times when forage production is limited. It has a higher dry matter (92-96%) but has lower crude protein content (3 to 7%) (Shen *et al.*, 1998). Aside from poor nutrient and low palatability, the higher lignin and silica content limit digestibility and degradability of rice straw in the rumen. For that reason, pretreatment is necessary to break this structural component to improve the utilization of rice straw in the diet. Nguyen *et al.*, (2012) cited that physical and chemical treatment could be a possible option to improve the quality and utilization of crop residue.

Urea treatment is one of the efficient, safe and practical pretreatment methods to maximize the utilization of rice straw and increase its nitrogen content (crude protein) (Schiere and Ibrahim, 1989) and so observed as a highly suitable strategy for used by farmers (Hanafi *et al.*, 2012). In the past, several studies have been reported on the intake and digestibility of untreated and urea treated rice straw as fed to ruminants (Yulistiani *et al.*, 2003; Hossain *et al.*, 2010). On the other hand, concentrate supplementation improved nutrient intake, digestibility, and overall performance of ruminant animals in forage and rice straw-based diet (Ba *et al.*, 2008; Sultana *et al.*, 2012; Quang *et al.*, 2015). This was achieved in cattle supplemented with 2% and 1.2% concentrate on a live weight basis respectively (Ba *et al.*, 2008; Quang *et al.*, 2015). As feed intake of a ruminant with rice straw diet is relatively low, supplementation is necessary to complement and optimize rumen function. Also, since feeding of rice straw alone resulted in low productivity of animals, supplementation of feeds that could provide additional energy, protein and mineral requirement of the animal is essential (Devendra, 1997). Therefore, this study was conducted to determine the effect of concentrate supplementation on intake, digestibility and growth of goats fed with untreated and urea treated rice straw.

Materials and methods

Animals, Experimental Design and Treatments

Nine goats with an average weight of 18 kg were used in 70 days feeding trial. They were divided into three groups and assigned in individual cages based on live weight with one animal per replicate. All animals were subjected to a one-week adaptation period with the new diet and then dewormed using albendazole before the start of experiment. Multivitamins were also given to goats every month to prevent vitamin deficiency while they are in confinement. This experiment followed Randomized Complete Block Design (RCBD) with three dietary treatments: (T1) - Untreated rice straw + Concentrate feeds at 1%LW; T2 – Urea Treated Rice Straw (UTRS) + Concentrate feeds at 1%LW; T3 – Urea Treated Rice Straw (UTRS) + Concentrate feeds at 1.25% LW.

Urea Treatment and Feeding Regime

Rice straw was chopped into 3- 5 cm length before treatment. Pretreatment of rice straw with commercial urea was done according to the procedure of Ibrahim *et al.*, (1986). A 4% (400g) urea was

dissolved in 10 liters of water and then sprayed thoroughly in a 10kg rice straw. Treated rice straw was kept airtight in polyethylene bags for 7 days before feeding to the animals. After one week, the polyethylene bags containing the rice straw were opened before feeding to minimize the smell of ammonia. Urea treatment was done every week.

The untreated and urea treated rice straw were fed *ad libitum* to goats with a 20% increase based on the previous day's feed intake. Feeding was divided into two equal portions and offered daily every 8:30 am and 2:00 pm. On the other hand, commercial concentrate feeds containing 14% CP was fed once daily at 1% and 1.25% live weight. Basal diet and concentrate supplements were fed in a separate feeding trough. Feed residues were collected after twenty-four hours and weighed at 8:00 am before feeding to determine the daily voluntary feed intake of animals.

Digestibility trial

The digestibility trial was conducted five days before the end of the experiment. Daily sub-sample of feed given was collected, weigh, dried, put in a plastic cup and stored for subsequent analysis. Also, the total fecal output of goats was weighed daily and a ten percent sample from these feces was separated and stored. At the end of the collection period, representative of feed given, and fecal output retained daily were pooled separately and a composite sample of 10% was taken for succeeding analysis.

This representative sample of 10% from each treatment was mixed thoroughly, dried in a forced draft oven set at 60°C for 48 hours and ground through Willey-mill with 1mm sieve. A 5% subsample was used for dry matter analysis and the other 5% were utilized for organic matter, ether extract and crude protein analysis.

Laboratory analysis

Sampled feeds and fecal output were subjected to chemical analysis. Duplicate samples from each treatment were analyzed for Dry Matter (DM), Organic Matter (OM), Ether Extract (EE), and Crude Protein (CP) content. Dry matter content of untreated, urea treated rice straw and fecal output were estimated by drying duplicate samples in an air-draft oven at 105°C for 16 hours. On the other hand, ash content was determined by burning the sample in a muffle furnace set at 650°C for 4 hours and organic matter was calculated by subtracting dry matter with ash content. Nitrogen content was measured by Kjeldahl procedure and the amount of crude protein (CP) was calculated using the formula N x 6.25 while ether extract was determined using the standard Soxhlet fat extraction method.

Voluntary feed intake was calculated by subtracting the feed given to feed refuse and value was expressed in a fresh and dry matter basis while dry matter intake (DMI) was computed by multiplying voluntary feed intake with the percent DM present in the feed.

On the other hand, nutrient intake was computed based on the amount of DMI multiplied to the amount (%) of nutrients present in feces. Also, live weight gain was computed from the difference in final and initial weight. Apparent digestibility of DM, OM, EE, and CP were calculated as nutrient intake (kg/DM/day) minus nutrient in fecal output (kg DM/day) divided by the nutrient intake (kg/DM/day), the value was express in percentage. The following equation was used:

$$\text{NAD (\%)} = \frac{\text{Nutrient Intake} - \text{Nutrient in feces}}{\text{Nutrient Intake}} \times 100$$

Where: NAD =Nutrient Apparent Digestibility

Statistical tool and analysis

The effect of dietary treatment on intake, digestibility and growth performance of goats were analyzed using Statistical Tool for Agricultural Research (STAR) in one-way Analysis of Variance for Randomized Complete Block Design *(RCBD)*.

The least significant difference test was used to test differences *($P< 0.05$)* among treatment means.

Results and discussion

Voluntary, Dry Matter and Nutrient Intake

Chemical analysis for untreated and urea treated rice straw (% DM basis) are shown in table 1. As presented in Table 2, there was a significant difference in total and daily dry matter intake (DMI) of goats in T1, T2 and T3. It appeared that concentrate supplementation at 1% LW with rice straw and 1.25% in urea treated rice straw stimulate an increase of feed intake, although both 1% and 1.25% level of concentrate supplemented to goats fed with urea treated rice straw were comparable with each other. However, when expressed as a percent of body weight to eliminate variations in DMI due to differences in body size, differences in DMI for all treatments were not significant. On the other hand, no significant differences were observed in the voluntary feed intake of rice straw and concentrate supplements.

As reflected in Fig. 1, the amount of total DMI has a minimum difference between treatments. Likewise, weekly voluntary dry matter intake (Fig. 2) stabilized at week 4 of feeding with goats in T1 consistently obtained the highest DMI. Intake of crude protein, organic matter and ether extract were similar across T1, T2 and T3.

Table 1. Chemical analysis of untreated and urea treated rice straw (% DM basis).

Diet	DM (%)	Composition			
		CP	OM	EE	Ash
Rice Straw	85.26	5.82	84.37	1.94	15.63
UTRS	79.27	8.07	87.22	2.08	12.78

According to Warly *et al.*, (1992) increasing the level of protein supplement did not affect voluntary feed intake of rice straw by the animals. Voluntary feed intake of ruminant depends mainly on palatability, physical and chemical characteristics of the forage. Normally, ruminants consumed a maximum of 1.2kg of rice straw per 100kg of live weight (Devendra, 1997). The result of the present study agreed with the findings of Yulistiani *et al.*, (2003) which revealed that the DMI/metabolic weight of sheep fed with RS and UTRS was similar. However, this observation contradicts the results of Gunun *et al.*, (2013) which indicate that feeding of urea treated rice straw improved total dry matter intake of dairy steers from 4.7 to 5.7 kg/d along with nutrient intake compared to untreated. Efficiency in concentrate utilization along with higher voluntary and dry matter intake could be responsible for the comparable nutrient intake of goats fed with RS and UTRS. Waldo (1986) pointed out that intake can be accurately predicted by the amount of cell wall present in the forage diet. Hence, intake is determined by metabolic control in diets that are energetically dense and highly digestible such as concentrates. There was no significant difference found in the intake of concentrate supplements which agrees with the findings of Wanapat *et al.*, (2013) who reported no significant difference in concentrate intake of dairy cows fed with untreated, urea treated and urea-calcium hydroxide treated rice straw.

Growth performance

The weight gain of goats was not affected either by supplementation of concentrate or feeding of urea treated rice straw. Although not significant, the result showed that goats fed with urea treated rice straw supplemented with concentrate feed at 1% and 1.25% LW were able to achieve an increase of live weight by 13.75%. and 3.47% respectively in contrast with untreated. This infers that concentrate supplementation at a minimum of 1% and 1.25% LW on urea treated rice straw-based diet is essential to maintain the bodyweight of goats.

The maintained and improved live weight of goats fed with UTRS and concentrate supplement at 1 and 1.25% of LW could be due to better digestibility and degradability of nutrients as urea treatment destroys structural polysaccharide allowing better bacterial fermentation on the rice straw and hence resulted to optimum nutrient utilization of animals leading to

live weight maintenance or weight gain. This is supported by Wanapat *et al.*, (2013) which suggests that animals fed with urea treated rice straw have higher numbers of bacteria and fungi zoospores (7.0 to 7.4 × 10^9 and 2.7 to 3.8 × 10^5) found in rumen compared to untreated. Comparable live weight gain of goats fed with UTRS and concentrate supplement at 1% and 1.25% found in this study is in agreement with the results of Gunun *et al.*, (2013) which states that feeding of rice straw with concentrate supplement at 1.2%, 1.8% and 2.4% in body weight basis had a similar effect on weight gain. On the other hand, reduced weight gain (-1.27kg) of goats fed with RS indicates that feeding of untreated rice straw even with concentrate supplement cannot support the maintenance requirement of the animals raised in complete confinement.

This means that concentrate supplementation must be increased in goats fed with only rice straw.

Table 2. Growth performance and nutrient intake of goats fed with untreated, urea treated rice straw and concentrate supplement at 1 and 1.25% LW.

Parameters	Treatments			Significance
	1	2	3	
Growth Performance (kg)				
Initial Liveweight	18.53	17.23	19.27	NS
Final Liveweight	17.27	19.60	19.93	NS
Total Liveweight Gain	-1.27	2.37	0.67	NS
Nutrient Intake				
Concentrate				
Total Intake (kg DM)	14.19	13.38	16.70	NS
Intake (g DM/d)	141.88	133.86	166.95	NS
Rice Straw				
Total VFI (kg)	29.94	29.34	30.38	NS
Average VFI (g/d)	427.73	419.11	433.92	NS
Total DM Intake (kg)	25.45^{a}	23.18^{b}	24.00^{ab}	*
Average DM Intake (%BW basis)	1.24	1.32	1.41	NS
Average DM Intake (g /d)	363.57^{a}	331.10^{b}	342.79^{ab}	*
Daily CP intake (g/d)	22.68	23.29	29.77	NS
Organic Matter Intake (g/d)	306.75	288.80	299.00	NS
Ether Extract Intake (g/d)	7.04	6.88	7.13	NS

Treatment means within each row having the same letter and with no superscripts are not significantly different from each other.

*significant (P<0.05), NS – not significant.

Table 3. Apparent digestibility of different experimental diets.

Parameters	Treatments			Significance
	1	2	3	
Nutrient digestibility				
DM Dry matter (%)	49.57^{b}	71.67^{a}	70.23^{a}	**
CP Crude Protein (%)	59.52	67.88	71.02	NS
OM Organic Matter (%)	51.51^{b}	73.40^{a}	72.74^{a}	**
EE Ether Extract (%)	59.57^{b}	86.52^{a}	87.36^{a}	*

Treatment means within each row having the same letter and with no superscripts are not significantly different from each other.

** Highly significant (P<0.01) *significant (P<0.05), NS – not significant.

Apparent nutrient digestibility of untreated and urea treated rice straw

Apparent digestibility of dry matter, organic matter, and ether extract as shown in Table 3 were significant except for crude protein in goats fed with urea treated rice straw supplemented with concentrate at 1% and 1.25% LW, respectively. On the other hand, an increase of concentrate supplementation from 1 to 1.25% LW did not promote the corresponding increase in nutrient digestibility of urea treated rice straw. Slow passage rate and fermentation of microorganisms in the rumen are two factors that affect digestibility of the straw (Aquino *et al.*, 2020).

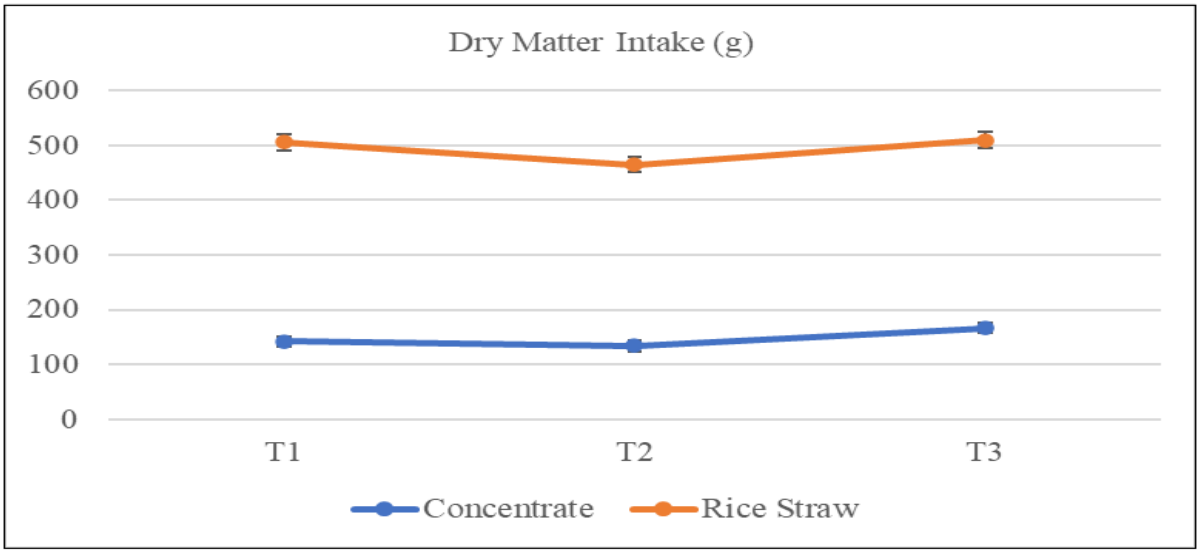

Fig. 1. Effects of concentrate supplementation on total dry matter intake (g) of untreated and urea treated rice straw measured across the whole experimental period.

Improve apparent nutrient digestibility of UTRS compared to RS in the current study could be attributed to the swollen cell wall component of rice straw due to urea treatment that breaks the ester bonds between lignin, hemicellulose and cellulose which provide better access for the fermentation of microorganism in the rumen (Schiere and Ibrahim 1989).

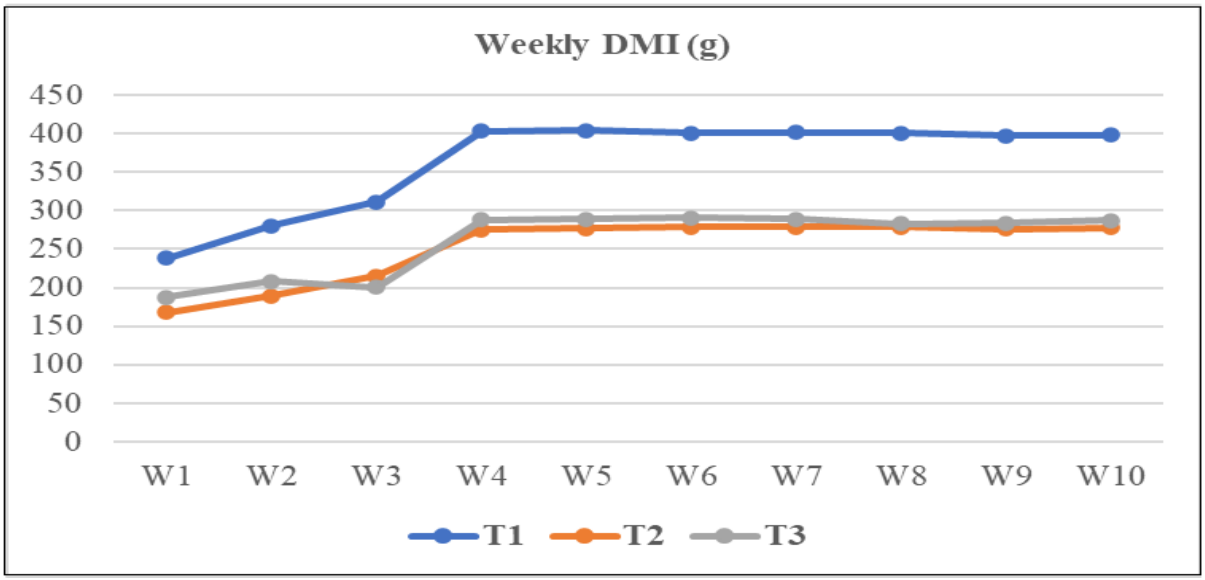

Fig. 2. Effects of concentrate supplementation on average weekly voluntary dry matter intake (g) of untreated and urea treated rice straw.

This result agreed with the previous findings of Wanapat *et al*., (2013). A similar result was likewise obtained by Gunun *et al*., (2013) claiming that DM and OM digestibility is better in animals fed with UTRS than RS. Conversely, Yulistiani *et al*., (2003) stated that DM digestibility is comparable between RS and UTRS diet. Digestibility determines the nutritive value of the rice straw. Higher digestibility of UTRS means more nutrients are deliberated for use by the animal which could contribute to better production performance. Besides, increase digestibility is coupled with an increase in nutrient intake due to better turnover rate in the rumen. According to Walli *et al*., (1995) increased rate and extent of cell wall degradation are responsible for higher digestibility and intake of rice straw. Hence, it is essential to provide nutrients for rumen microbes responsible for pre-gastric digestion to sustain their rapid multiplication for better degradability of cell wall in the straw and meet the optimum condition for the maintenance of good cellulolysis (Chenost and Kayouli, 1997). Since **i**mprovement in nutrient digestibility is correlated with an increase in live weight gained (Quang *et al*., 2015), complementary feeding will be necessary to meet the nutrient requirement of animals at certain production levels while supporting an optimum rumen environment for the microbes.

Conclusion

Concentrate supplementation did not improve voluntary feed intake, nutrient intake and growth performance of goat fed with urea treated rice straw but it promotes better apparent digestibility of dry matter, organic matter, and ether extract. Nevertheless, further study might be conducted by incorporating native and improved grasses to either treated or untreated rice straw with concentrate supplementation.

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