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Growth Performance and Ruminal Metabolic Variables of Goats Fed Rain Tree *(Samanea saman)* Pods

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ABSTRACT

The effect of rain tree pods (RTP) or acacia pods on the growth performance, rumen metabolites, and digestibility of dry matter (DM) and crude protein (CP) in goats was evaluated through feeding trial and *in situ* methods. Eighteen 7 month-old Philippine native goats with body weight range of 7.86±1.28 kg were divided into three groups consisting of six replicates and randomly assigned to one of treatment diets containing 0%, 50%, and 100% RTP in the concentrate portion of a ration containing 65% roughage and 35% concentrate. Three rumen-cannulated mature goats were used in the *in situ* studies to determine the dietary effects on rumen fluid pH, total volatile fatty acids (VFA), ammonia, and rumen DM and CP digestibilities. Differences (*P* values < 0.05) were observed on daily gain, total feed intake, and feed efficiency with diets having >50% RTP generally resulted in lower above-stated performance parameters. Rumen fluid pH of goats decreased after feeding and was lowest in goats fed with 50% RTP. Concentrations of VFA and ammonia were not significantly different. Slowly degradable DM of the test diets were higher in concentrate mixture without RTP. Degradable fractions of CP had highest value on concentrate mixture without RTP while lowest on 100% RTP. However, no differences were observed on potentially digestible fractions and degradability constants of DM and CP. It could be concluded that RTPs can be an alternative ingredient in concentrate mixtures given up to 50% in the mixture as part of a daily ration for goats.

Keywords: acacia pods, alternative feed source, legumes, nutrient evaluation

INTRODUCTION

Feeding and nutrition are limiting factors in ruminant production in tropical and subtropical regions due to the inconsistent supply and variable nutrient values of forage and browse species caused by fluctuating rainy and dry seasons. Forage, trees, and shrubs are inexhaustible nutrient source which greatly contributes to the improvement of an animal diet and therefore, could reduce the use of concentrates feeds (Delgado *et al.*, 2014). Goat production in Asia are predominantly operated by small-hold farmers. Raising goats requires lower capital investment and production costs. In addition, it is a good source of protein for household consumption for resource-poor communities.

It is recommended that ruminant production models should be based on the vegetation on a particular area minimizing dependence on external inputs with particular focus on fodder trees (Olivares *et al*., 2013, Rojas *et al*., 2012). There has been an increasing interest in the utilization of unconventional feed sources that could supply for the shortage of roughages and feeds (Nyamukanza *et al.*, 2008). Among the unconventional feed sources is the rain tree (*Samanea saman*) pods which is being considered as a potential source for animal feeds. The rain tree is a multipurpose tree often planted in parks and pastures, vacant lots, churches, and school grounds as well as in the roadsides and planned landscapes (Hagan *et al*., 2016). In Asia, rain tree provides green fodder supplement for goats, sheep, and cattle. The sweet pulp of the pods was observed to be eagerly eaten by cattle, hogs, horses, and goats (Staples & Elevitch, 2006). The rain tree has two flowering seasons which are during the months of February to May and September to November (Hagan *et al.*, 2016). An average of 200-250 kg of pods can be harvested from a mature tree after the flowering season which is roughly 500-600 kg of pods annually (Rath *et al.*, 2014).

Rain tree pods make an excellent feed supplement for livestock. It contains approximately 13.0% to 18.1% crude protein, 18.2% total sugar, 8.4% sucrose, and 4.0% condensed tannins, which makes it a potential feed for improving rumen function and improving ruminant productive performance as a whole (Flores, 2002; Staples & Elevitch, 2006). When utilizing an unconventional feed source such as rain tree pods (RTPs), it is important to conduct an evaluation on the nutrient composition, digestibility parameters, and its effect on the productive performance of an animal (Berhan & Getachew, 2009; Kumara-Mahipala *et al.,* 2009; Mokoboki *et al.,* 2011). This study aimed to determine the dietary effects of rain tree pods on the growth performance, rumen metabolites, dry matter, and crude protein digestibility of Philippine native goats (*Capra hircus* Linn).

MATERIALS AND METHODS

Experimental Design

Nine male and nine female Philippine native growing goats at seven months of age with an average body weight of 7.86±1.28 kg were used in the feeding trial. The goats were kept in holding crates and fed *ad libitum* roughage and concentrates with or without rain tree pods (RTPs). The basal feed was composed of Napier grass *(Pennisetum purpureum)* harvested at 45 days. The goats were randomly allotted into three treatment groups following a completely randomized design. The treatments consisted of Napier grass and a concentrate mixture of rice bran, copra meal, and RTPs. The concentrate mixtures were formulated to contain 0% RTPs (Treatment 1), 50% RTPs (Treatment 2), and 100% RTPs (Treatment 3). The percent inclusion of RTPs in a concentrate mix was presented in Table 1 along with the calculated analysis in DM basis.

Preparation of Experimental Diets

Mature rain tree pods (RTPs) were used in this study. Fallen RTPs were hand-picked within the campus of the University of the Philippines Los Baños and chopped to about 2-2.5 cm. These chopped RTPs were then dried and ground to pass 2 mm screen. Ground RTPs were mixed with rice bran and copra meal to constitute the dietary treatments. The chemical composition of the feed ingredients used in each concentrate mixtures is presented in Table 2.

Table 1. Ration composition and nutrient content of rain tree pods (RTP) concentrate mixtures in DM basis

Ingredients	%DM, Concentrate mixtures		
	0% RTP	50% RTP	100% RTP
Rain tree pods	0	50	100
Rice bran	70	35	0
Copra meal	30	15	0
Total	100	100	100
Nutrient content (%)			
Dry matter	91.62	91.62	91.61
Ash	9.28	6.77	4.26
Crude protein	14.13	14.33	14.54
Crude fiber	14.02	21.09	28.14
Crude fat	14.09	8.42	2.75
Nitrogen-free extract	34.51	38.21	41.92

Feeding System

The goats in all treatments were allowed free access to water, roughage, and concentrates. The animals were fed a ration of 65% forage and 35% concentrate mixtures at 3% of the live weight on dry matter (DM) basis. The experimental goats were also supplemented with mineral block (Phos-rich rockies) containing: Sodium (Na) 20%, Calcium (Ca) 8.5%, Magnesium (Mg) 0.5%, Iodine (I) 300 mg/kg, Selenium (Se) 10mg/kg, Manganese (Mn) 2500 mg/kg, Ash 86%, Phosphorus (P) 10%, Iron (Fe) 0.3%, Cobalt (Co) 50 mg/kg, and Zinc (Zn) 300 mg/kg.

Daily feed offered and refused were recorded. Samples of feed offered and refused were analyzed for DM, crude protein (CP), and fiber fractions as described in AOAC (2005); Van Soest & Robertson (1985); and Isah & Babyemi (2010). Voluntary intake was estimated by the difference between the feed offered and refused. Changes in weight of experimental goats were monitored every 14 days.

Collection of Ruminal Contents

Three rumen-cannulated goats were fed with Napier grass and RTP concentrate mixtures (0% RTP, 50% RTP and 100% RTP) at 3% of the live weight on DM basis following a 3×3 Latin Square Design. For each sampling period, rumen digesta was obtained manually from various sites within the rumen and then filtered through three layers of cheesecloth to obtain rumen fluid. Rumen pH was measured before and three hours after feeding. Rumen pH was determined using a portable pH meter. 100 mL of rumen fluid samples collected after feeding were preserved with 1 mL of a 10% (m/v) NaOH solution or 1 mL of a 50% H_2SO_4 solutions for rumen ammonia nitrogen (NH_3) concentration and total volatile fatty acid (VFA) analysis, respectively, as described by Holtshausen *et al.* (2000).

Ammonia-nitrogen (NH_3-N) concentration was measured using an ammonia electrode (Model 95-12) in conjunction with an Orion Ion Analyzer (Model 501 pH/mV meter). Rumen fluid was made alkaline (pH >11) by the addition of 1 mL of 10M NaOH per 100 mL sample. The sample ammonia nitrogen concentration was deter-

Table 2. Proximate chemical composition of feed ingredients (DM basis)

Chemical composition	Ingredients			
	Rain tree pods	Rice bran	Copra meal	Napier grass
Dry matter (%)	91.61	91.47	91.97	12.76
Ash (%)	4.26	10.09	7.38	20.61
Crude protein (%)	14.54	12.69	17.48	14.97
Crude fiber (%)	28.14	13.99	14.1	33.78
Crude fat (%)	2.75	15.58	10.6	3.53
Nitrogen-free extract (%)	41.92	31.12	42.41	60.13

mined from a calibration curve obtained using standard solutions of ammonium chloride.

Total VFA was measured by steam distillation and titration of the distillate. Two mL of $H_2SO4/MgSO_4$ solution was added to 5 mL of rumen fluid and immediately followed by distillation process. The distillate was collected into a 250-mL conical flask, and generally 150-200 mL distillate was generated in 20 min. A few drops of phenolphthalein indicator solution were added to the distillate and titrated against 0.03N NaOH to a faint pink end-point (pH 8.3).

In Situ Digestibility

The same three rumen cannulated goats were fed Napier grass and RTP-concentrate mixtures (0% RTP, 50% RTP and 100% RTP) at 3% of the live weight on DM basis following a 3×3 Latin Square Design with period and animal as blocking factors. Each period include an adaptation, incubation, and "wash-out" schedule at 1-10, 11-12, and 13-19 days, respectively. Approximately 2 g of each of RTP-concentrate mixtures were weighed in duplicates and placed in nylon bags (Orskov *et al*., 1980; Isah & Babyemi, 2010). RTP concentrate mixtures were incubated to the corresponding goats fed with the same concentrate mixture. The bags were 5×13 cm in size, with a pore size of 41 μm. The bags were inserted via permanent ruminal cannulae in 3 native goats and left in the rumen for 3, 6, 12, 24, 36, and 48 hours. The animals were fed with Napier grass at 0700 and 1700 hours. The goats had free access to fresh and clean water. At the end of the incubation period, all bags were withdrawn at the same time. Bags were washed under running cold water until the rinse water was clear and then dried in an oven for 48 hours at 70°C. The dry bags were weighed and dry matter loss was calculated. The post-incubation residual samples were ground in a Wiley Mill with a 1 mm screen for crude protein determination.

Kinetic parameters of DM and CP degradations were estimated using the non-linear procedure of GraphPad Prism 7 (GraphPad Software, Inc., 2016) using the model of McDonald (1981):

$$Y = a + b\,(1-e^{-ct})$$

Wherein Y is ruminal DM or CP disappearance at time t, a is the readily degraded fraction (%), b is the slowly degraded fraction (%), a + b= potentially degradable fraction (%), c is the degradation rate constant at which b is degraded, e= 2.71828 (base of natural logarithm) and t is the time of incubation.

Statistical Analysis

Average daily gain, average daily feed intake, and feed efficiency were analyzed using the MIXED procedure of SAS University edition (SAS Institute, 2016) . The model included treatment as fixed effect and parameters for growth performance, rumen paramaters, and DM and CP digestibilities as dependent variables. Least square means was calculated for each independent variable. When diet is a significant source of variation, least square means were separated using the P value differences (PDIFF) option of SAS. Diets without RTP versus with RTPs were tested for contrast in growth performance of goats. Statistical significance and tendencies were set at $P \leq 0.05$.

RESULTS

Growth Performance of Goats

Growth parameters of goats fed concentrates with varying RTP inclusion levels were presented in Table 3. Differences in initial weights of goats were not significant in all treatments while final weights tended to be affected by the inlusion levels of RTP. Goats fed 0% RTP had greater gains and feed intake but had lesser feed efficiency compared to goats fed concentrates with RTP. Forage intake of goats fed 0% RTP was greater than those fed 50% RTP. Concentrate intake tended to be affected by inclusion of RTPs. Goats fed 100% RTP had the same weight gain, feed intake, and feed efficiency with goats fed concentrates with 0% and 50% RTP.

Rumen pH and Metabolites

The rumen pH before and after feeding, and concentration of rumen metabolites namely volatile

Table 3. Growth performance of Philippine native goats fed concentrates with different inclusion levels of rain tree (*Samanea saman*) pods (RTP)

Variables	Treatments			P- value	
	0% RTP	50% RTP	100% RTP	0% RTP vs RTPs	Treatment
Inittial wgt, (kg)	8.00±0.48	6.70±0.59	6.82±0.48	0.065	0.169
Final wgt, (kg)	9.31±0.54	7.42±0.66	7.31±0.54	0.015	0.041
Total wgt gain, (kg)	1.21±0.10[a]	0.72±0.10[b]	0.84±0.10[ab]	0.006	0.017
Daily gain, (g)	18.69±1.59[a]	10.36±1.94[b]	12.52±2.24[ab]	0.008	0.018
Daily feed intake, (g/day)					
Forage intake	205.41±11.52[a]	143.78±14.10[b]	170.30±11.52[ab]	0.006	0.014
Concentrate intake	123.52±6.58	107.57±8.06	100.24±6.58	0.036	0.073
Total Feed intake	328.93±16.05[a]	251.35±19.66[b]	270.54±16.05[ab]	0.018	0.018
Feed efficiency[1]	18.13±1.34[b]	24.46±1.64[a]	21.74±1.89[ab]	0.039	0.039

Note: Means in the same row with different superscripts differ significantly (P<0.05). [1]Feed efficiency computed as g of feeds/ g of gain.

fatty acid and ammonia were presented in Table 4. The rumen pH of goats fed concentrate with or without RTP did not differ among treatments before feeding. However there was a significant decrease in rumen pH in goats after feeding. Goats fed concentrate with 50% RTP had lower rumen pH than goats fed concentrates with 0% RTP after feeding. Moreover rumen pH of goats fed 100% RTP were the same in goats fed concentrates with 0% and 50% RTP. Total volatile fatty acids (VFA) and ammonia concentration in goats did not differ significantly among treatments. Concentrations of VFA in goats in this study ranged from 81.60 to 124.80 mg/L while ammonia ranged from 163.75 to 210.84 mg/L.

In Situ Dry Matter and Crude Protein Digestibility

In situ rumen DM and CP digestibility in goats were presented in Table 5. Concentrate mixture without RTPs had higher values for slowly degradable DM in than in concentrate mixture containing 50 and 100% RTP. Degradable fractions of CP had the highest value on concentrate mixture without RTP while the lowest on 100% RTP. However, no differences were observed on potentially digestible fractions and degradability constant of DM and CP.

Table 4. Least square means of rumen metabolites of Philippine native goats as affected by different levels of rain tree (*Samanea saman*) pods (RTP)

Ruminal parameters	Treatments			MSE	P-value
	0% RTP	50% RTP	100% RTP		
Rumen pH before feeding	6.88	6.89	7.34	0.17	0.301
Rumen pH after feeding	6.83^{a}	6.11^{b}	6.43^{ab}	0.06	0.023
Volatile fatty acid (mg/L)	124.80	85.20	81.60	32.00	0.614
Ammonia concentration (mg/L)	181.81	163.75	210.84	29.99	0.64

Note: Means in the same row with different superscripts differ significantly (P<0.05).

DISCUSSION

Growth Performance of Goats

It was observed by Barcelo *et al*. (2003) that goats fed with 100% rain tree pods had the lowest gain in weight. However, in this study, goats fed concentrate with 50% RTP had the lowest total weight gain. Albino rats fed 30% RTP were found to have the highest weight gain compared to rats fed 0% RTPs (Idowu *et al.* 2006). Bali cattle fed rain tree foliage supplemented with rice bran, copra meal, or *Gliricidia* to the basal diets resulted in increased body weight gain from 0.225 to 0.402 kg/day (Marsetyo *et al.*, 2011).

Lower feed intake of goats fed RTP was probably due to tannin content of RTP. Tannin can bind with proteins in the mouth reducing the palatability of the feed and subsequently decreases feed intake (Cheema *et al*., 2011). Reduced feed intake of forage legumes are usually due to tannins that affect palatability (Krebs *et al.*, 2007; Provenza *et al.*, 2000).

The nutritive value of RTP was observed to be equivalent to cereal grain byproducts such as deoiled rice bran. Rain tree pods can be incorporated in the diet of ruminants as replacement for concentates to reduce feed cost (Hosamani *et al*., 2004). Anantasook & Wanapat (2011) observed that RTP can be a potential supplement for improving rumen fermentation.

Rumen pH and Metabolites of Goats

The rumen pH dereased in goats fed 50% RTP after feeding. Rumen pH decreases with increasing crude protein levels in the diet (Mathis *et al*., 2000). Changes in pH are results of changes in ruminal fermentation wherein protein content in the diet may affect ruminal fermentation (Chen *et al.*, 2010).

Total volatile fatty acid for all treatments ranged from 81.60 to 124.80 mg/L (Table 4). Anantasook &

Table 5. Rumen degradation characteristics for dry matter (DM) and crude protein (CP) of different levels of rain tree (*Samanea saman*) pods (RTP) in Philippine native goats

Digestibility, (%)	Treatments			MSE	P- value
	0% RTP	50% RTP	100% RTP		
Dry matter					
Readily degradble	38.67	48.33	49.33	2.41	0.14
Slowly degradable	30.00^{a}	21.00^{b}	17.33^{b}	0.51	0.003
Potentially degradable	74.67	69.33	66.67	2.8	0.32
Degradation constant	0.07	0.07	0.07	0.02	0.99
Crude protein					
Readily degradble	12.67^{a}	28.33^{ab}	48.33^{b}	3.47	0.04
Slowly degradable	57.67^{a}	37.00^{ab}	18.67^{b}	4.07	0.04
Potentially degradable	70.33	65.33	67	0.69	0.07
Degradation constant	0.04	0.09	0.1	0.03	0.35

Note: Means in the same row with different superscripts differ significantly (P<0.05). MSE= Standard error of means.

Wanapat (2011) found that interaction of roughage to concentrate and RTP inclusion in diets significantly increased total volatile fatty acid and propionate concentration, whereas it lowered acetate, acetate to propionate ratios, and methane (CH_4) production. Moreover, Ruiz *et al*. (2004) observed an increase total VFA concentration reflecting a stimulated microbial activity.The fiber in the diet can also influence VFA concentration in the rumen wherein fiber hydrolysis are one of the sources of energy for microbial growth in the rumen. Fiber degradation at low pH can be used to predict VFA production (Djikstra *et al*., 2012).

Estimates of the rumen ammonia concentration required for optimal microbial fermentation and growth in the rumen vary (Chantai *et al*., 1987) where in the ammonia pool in the rumen are coming from both dietary and endogenous sources which would include the degradation of endogenous urea as well as the assimilation of urea by microorganisms and absorption and removal of ammonia in digesta (Darlis *et al*., 2000).

Ammonia levels can be affected by supplementation in the diets which may alter the ratio of protein and carbohydrates in the diet. A diet reach in soluble carbohydrates decreases the concentration of ammonia in the rumen (Philippson, 1970). Additional carbohydrate sources may result in better synchrony of energy and ammonia-N for microbial protein synthesis (Darlis *et al*., 2000). Ruminal ammonia N concentrations were generally lower in goats than in sheep (Ruiz *et al*., 2004) although in both animal species, values were within the range (5.90 to 12.0 mg/100 mL) indicating an optimal microbial activity.

In Situ Dry Matter and Crude Protein Digestibility

Lower slowly degradable DM in diets containing RTP maybe due to the nature of structural and functional components of the pod. It is naturally rich with bioactive compounds intended to protect the seed from pests. CP fraction of RTP are likewise poorly unavailable as suggested by the decreasing slowly degradable values as RTP is increased in the diet. Tannins in RTP is at 40 g/kg, hence, might have caused detrimental effects on microbial activity in the rumen (Staple & Elvitch, 2006).

In sacco losses of protein may not necessarily correlate with degradability when applied to tanniferous feeds because part of the protein loss from the nylon bags may be in the form of tannin-protein complexes which are not degradable in the rumen (Nsahlai *et al*., 1999; McNabb *et al*., 1996; Perez-Maldonado & Norton, 1996) hence, reducing the protein availability to rumen microbes (Ngwa *et al*., 2001). Crude protein in diets results in increased ruminal ammonia nitrogen concentration. Increased ruminal ammonia nitrogen enhances microbial activity and growth, resulting in greater dry matter digestibility (Cheema *et al*., 2011).

Lower degradation values of CP in concentrates with RTP may be due to the other anti-nutritional factors normally contained in leguminous pods which are known to be detrimental to rumen microbial population and consequently the host animal (Ngwa *et al*., 2001).

The constant of degradation rate for DM and CP were the same in goats. Moreover, the rate of digestion of rain tree pods (0.07%) for DM was lower than the rate of digestion of *Leucaena leucocephala* (0.16%) after cross inoculation as reported by Pamungkas *et al*. (2005). In contrast, the rate of digestion of rain tree pods (0.10%) for CP was higher than the rate of digestion of Leucaena *leucocephala* (0.03%) as reported by Sevilla & Purbojo (2005).

CONCLUSION

Gain, feed intake, feed efficiency as well as rumen pH were affected by the presence of RTP in concentrate mixture while VFA and ammonia concentrations in the rumen were not influenced by treatments. Generally, slowly degradable DM and CP portions in concentrate mixture with increasing level of RTP. Rain tree pods can be used as source of nutrients for goats at 50% RTP in the concentrate mixture for goats. Feeding trial and *in situ* study are considered useful indicators for the evaluation of the nutritive value of the particular feed. Antinutritional factors in RTP should be further evaluated in order to know the extent of inclusion of RTP in animal feeds and determine the potential feed processing for optimum nutrient utilization.

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