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Chemical Composition and *In Situ* Digestibility of Common Feed Resources for Ruminants in Marginal Uplands

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ABSTRACT

This study assessed the chemical composition and *in situ* degradation of predominant feed resources for ruminants in the marginal uplands of Inopacan, Leyte, Philippines. These feed resources included basal grasses such as guinea (*Panicum maximum*), humidicola (*Brachiaria humidicola*), and carabao grass (*Axonopus compressus*); supplemental legumes such as calopo (*Calopogonium muconoides),* *madre de cacao* (*Gliricidia sepium*) and centro (*Centrocema pubescens*); foliages of trees/shrubs such as jackfruit (*Artocarpus heterophylum Lamk*) and abgaw *(Premna odorata)*; and concentrates such as rice bran (D_2) and squeezed grated coconut. Chemical analyses followed standard procedures, while *in situ* trial was done by incubating the feed samples in rumen-cannulated steer fed 70% basal/grass and 30% of the supplements.

Crude protein (CP) contents were 15.83 to 18.23% in legumes, 10.17 to 11.91% in tree foliages, 5.16 to 8.51% in grasses, and 4.84 to 6.08% in concentrates on as-fed basis. Gross energy (GE) contents were high – 5097 kcal/kg in grated coconut (highest) and 2931 kcal/kg in *humidicola* grass (lowest). Calcium (Ca) and phosphorus (P) contents were low, ranging from 0.004 to 0.189% Ca and 0.026 to 0.037% P. Considering animal requirements, these indicated a potential adequacy in GE supply but a limitation in protein and Ca and P in marginal uplands. Dry matter degradation (DMD) was high in grated coconut, *abgaw*, calopo and *madre de cacao* (77.86 to 86.51%) among the supplements and in carabao grass (71.11%) of the basal, and low in humidicola and rice bran D_2 (46.52 to 47.51%). Crude protein degradation (CPD) was highest in *abgaw,* calopo, *madre de cacao,* jackfruit and grated coconut (86.87 to 90.97%), moderate in guinea and carabao grasses and rice bran D_2 (61.28 to 64.01%), and low in centro and humidicola (57.46 to 59.63%). Quantitatively, and across chemical composition and *in situ* degradation, the feeding of humidicola grass, centro legume, and rice bran D_2 is least recommended.

Keywords: marginal upland, feed resources, chemical composition, *in situ* degradation

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INTRODUCTION

Marginal upland areas in the Eastern Visayas region of the Philippines are quite many, and are characterized by low soil fertility and the inability to hold water because of slope and terrain which limit crop productivity. Employment for farmers is seasonal, and generation of cash income is very limited. Thus, livestock production in marginal uplands plays an important role as alternative source of cash income and food for the farmers and their families. It also serves as "shock absorber" of the impact of fluctuating prices and productivity of crops in the event of changing climatic conditions. Goat is the most common among ruminants raised in the uplands. However, ruminant production can be limited by the inferior quality of existing vegetation as a result of the deterioration of forests and pastureland (Husson *et al*., 2001). Several forestry management systems have been adopted, and two of these are the "silvo-pastoral system" where fodder crops and/or pasture grasses are planted as alley crops or as live fence for the supply of cut-and-carry fodder, and "agri-silvo-pastoral system", particularly "multi-story system", where free grazing under the trees is provided for livestock (Castillo and Pintor, 2010). Trees and shrubs provided valuable forage to herbivorous animals (Robinson, 1985 as cited by Gutteridge and Shelton, 1998). As trees and shrubs are pruned to control shading and achieved productive plantation underneath, the foliage are fed to livestock. Thus, assessment of the nutritive value of foliages from these trees/shrubs and the grasses and legumes grown underneath the trees should be part of the management system for ruminant livestock raised in these areas (Aban and Bestil, 2012).

Chemical analysis of feedstuff provides information on nutrient density, but its nutritive value should be coupled with information on digestibility as it correlates positively to voluntary intake (Chenost and Kayouli, 1997). One fast and easy method of assessing the digestibility of feed resources for ruminants is by *in situ* technique. Preston (1986) described the process as incubating feedstuffs placed inside a nylon bag in the rumen of a cannula-fitted animal. This process is also beneficial in evaluating the rate of degradation of nutritional parameters of different feed resources (Osuji *et al.*, 1993), or in evaluating the bypass (protein and energy) potential of feedstuffs (Atole and Bestil, 2013).

This study, focused on assessing the nutritive value of existing feed resources by chemical analyses and *in situ* digestibility trial so as to obtain a picture of nutrient limitations vis-à-vis animal requirements, to serve as basis in devising strategic supplementary feeding systems for ruminants that meet their nutritional needs and improve their resiliency to the impact of climatic change in marginal uplands.

MATERIALS AND METHODS

Preparation and Analysis of Feedstuffs

Feedstuffs analyzed and tested were identified from focus group discussions held with farmers and from preliminary results of a benchmarking study (Come *et al.* 2013). Foliage samples of the basal grass diet such as carabao grass (*Axonopus compressus*), humidicola (*Brachiaria humidicula*), guinea (*Panicum maximum*); legume supplements such as *madre de cacao* (*Gliricidia sepium*), centro (*Centrocema pubescens*), and calopo (*Calopogonium muconoides*), and supplemental shrubs/trees such as jackfruit (*Artocarpus heterophylus* Lam.) and abgaw (*Premna odorata*), from upland areas of Inopacan, Leyte were chopped to about half an inch, sundried, and then ground in a Wiley mill. The concentrate supplements such as rice bran (D_2) and squeezed grated coconut were sundried and stored ready for analysis and incubation. Enough samples were prepared to ensure sufficiency of supply and uniformity of samples for subsequent analysis and use in the *in situ* trial. Dry matter (DM) content was analyzed by putting feed samples in the oven set at 100^0C for 24 hours, crude protein (CP) by distillation and titration in the macro-Kjeldahl apparatus, gross energy (GE) by bomb calorimetry, and calcium (Ca) and phosphorus (P) contents by spectrophotometry following the standard procedures of AOAC (1990).

Preparation of the animal for in situ trial

A steer fitted with rumen cannula (Bar Diamond Lane, Parma, ID, U.S.A.) was used in the study. Approximately one month before the start of the experiment, the animal was closely monitored for any unhealthy conditions, and put on complete confinement for ease of handling. It was also dewormed against external and internal parasites using both Albendazole (at a dose of 1 ml/10 kg BW) administered orally and Ivermectin (at a dose of 1 ml/50 kg BW) injected subcutaneously.

Feeding the rumen-cannulated steer

During the *in situ* degradation trial, the steer was fed with 70% basal grass diet comprising of equal proportions of carabao grass, humidicola and guinea, and 30% of the supplement consisting of centro, calopo, madre de cacao, jackfruit, *abgaw*, rice bran and grated coconut. The animal was fed at *ad libitum* during the adjustment/conditioning period of ten days. Three days before incubation, the diet was reduced into half to adequately accommodate the nylon bags without adversely affecting rumen environment and to make the recovery of bags easier (Playne *et al*., 1978). Feeding of the steer was done daily at 7:00 AM and 4:00 PM with access to clean drinking water free choice.

Rumen incubation of feedstuffs

Nylon bags measuring 5x10 cm with a pore size of ±53 microns (Bar Diamond Lane, Parma, Idaho, USA) were oven-dried for 30 min at 65°C and then weighed immediately based on the procedures of Osuji *et al*. (1993). A 4-gram DM sample of each of the dried feedstuffs was placed inside the nylon bags and heat-sealed. These were then placed inside a lingerie bag weighted with stainless steel in order to prevent the nylon bags from floating on top of the rumen digesta and give variable degradation rates (Preston, 1986). The samples were incubated for 24 hours in the reticulo-rumen, withdrawn the next day, and the recovered nylon bags were washed for 30 min in a running tap water with gentle scrubbing between thumb and fingers until the water runs clear (Figure 1). The washed nylon bags containing feed samples were then oven-dried at 65°C for 48 hours and then weighed immediately to obtain the dry weight (Osuji *et al*., 1993). The samples were then analyzed for DM and CP following the standard procedures of AOAC (1990). The degradation trial had four replicates for each of the feed sample tested.

Data gathered and analysis

The *in situ* DM degradation of the feed sample was determined by subtracting the weight of the oven-dried residue plus nylon bag after incubation from the weight of the oven-dried sample plus nylon bag before incubation, divided by the original oven-dried weight before incubation and then multiplied by 100. Similar calculation was done with *in situ* CP

Figure 1. Incubation of the feed samples in the rumen and washing of the nylon bags.

degradation. The *in situ* DM and CP degradation were calculated following the formulae:

$$\text{DM Degradation (\%)} = \frac{\text{SWa} - \text{SWb}}{\text{SWa} - \text{Weight of nylon bag}} \times 100$$

Where:

SWa = Weight of dried sample + nylon bag before incubation
SWb = Weight of dried residue + nylon bag after incubation

$$\text{CP Degradation (\%)} = \frac{\text{Cpa} - \text{CPb}}{\text{CPa}} \times 100$$

Where:

CPa = CP of feed sample (g) before incubation
CPb = CP of feed residue (g) after incubation

Data were analyzed using one-way analysis of variance (ANOVA), and differences among treatment means were analyzed by Honestly Significant Difference (HSD) test using the Statistical Package for Social Sciences (SPSS) version 17.

RESULTS AND DISCUSSION

Dry matter and nutrient contents of feed resources

The DM, CP, GE, Ca and P contents of the grass species, legumes and shrubs, and concentrate feeds in the marginal uplands in Inopacan, Leyte are presented in Table 1. Chemical composition (as-fed basis) showed highest CP contents (15.83 to 18.23%) in legume forages, medium CP contents in shrubs/trees (10.17% in jackfruit and 11.91% in *abgaw*), and lowest in the grasses (5.16 to 8.51%) and the energy-concentrates (4.84% in RBD_2 and 6.08% in squeezed grated coconut) tested. It should be noted that these CP contents, even those from the predominant legume forages in the upland site appeared to be 3-5% lower than those obtained from legume forages in lowland areas, indicating a potential limitation of protein for livestock feeding in marginal uplands. Gross energy contents across all types of supplements appeared to be high, indicating adequacy of energy supply in marginal uplands. The highest was with squeezed grated coconut. Among grass species, lowest GE content was with humidicola while that of carabao grass was the highest. The Ca and P contents were low, indicating a potential mineral deficiency, but Ca was highest in trees/shrubs including *madre de cacao* (a tree legume) and lowest in grated coconut, while P contents were more or less similar across all feed types.

Dry matter degradation of feed resources

The *in situ* DM and CP degradation of feed resources in the marginal uplands of Inopacan, Leyte is presented in Table 2. Across feedstuffs, highest dry matter degradation (DMD) was obtained from squeezed grated coconut (86.51%), followed by the forages of *abgaw,* calopo and *madre de cacao* (77.86 to 81.61%). Among the grasses, differences in DMD were significant, and carabao grass had the highest (71.11%) while humidicola had the lowest (46.52%). The DMD value of jackfruit foliage (74.32%) appeared to be comparable to that of *madre de cacao* and calopo, but the lowest DMD value was obtained from RBD_2 (47.51%). Among the dominant legume leaf meals tested, the DMD of centro was lowest (55.95%). A similar pattern of differences was observed with DM degradation rates (DMDR).

The significantly low DMD of RBD_2 could be due to its high contents of crude fiber and silica (DePeters *et al.,* 1997). Coupled with seasonality of supply (only at times when upland rice is produced), the potential therefore of RBD_2 as a major feed resource in the marginal uplands appeared to be less. The low DMD value in centro is most likely be due to its high contents of neutral detergent fiber (NDF) (Evitayani *et al*., 2004).

Table 2. Dry matter and crude protein degradation of grasses and supplements in marginal uplands incubated for 24 hours in rumen-cannulated steer

Feed Resource	DMD (%)	DMDR (%/hr)	CPD (%)	CPDR (%/hr)
Supplements				
Legumes				
Centro (*Centrocema pubescens*)	55.95[b]	2.33 [b]	57.46[a]	2.39[a]
Calopo (*Calopogonium muconoides*)	80.81[cde]	3.37[cde]	90.32[b]	3.76[b]
Madre de cacao (*Gliricidia sepium*)	77.86[cd]	3.24[cd]	87.13[b]	3.63[b]
Trees/Shrubs				
Jackfruit (*Artocarpus heterophylus Lamk*)	74.32[c]	3.10[c]	86.87[b]	3.62[b]
Abgaw (*Premna odorata*)	81.61[de]	3.40[de]	90.97[b]	3.79[b]
Concentrates				
Rice bran (D_2)	47.52[a]	1.98[a]	61.98[a]	2.58[a]
Grated coconut	86.51[e]	3.60[e]	86.87[b]	3.62[b]
p-value	*0.000*	*0.000*	*0.000*	*0.000*
Grasses				
Carabao (*Paspalum conjugatum*)	71.11[c]	2.96[c]	61.28[ns]	2.55[ns]
Humidicola (*Brachiaria humidicola*)	46.52[a]	1.94[a]	59.63[ns]	2.48[ns]
Guinea grass (*Panicum maximum*)	55.32[b]	2.31[b]	64.01[ns]	2.67[ns]
p-value	*0.000*	*0.000*	*0.683*	*0.683*

Means within a column of either "Supplements" or "Grasses" having similar letter superscripts are not significantly different; ns – not significant

Crude protein degradation of feed resources

In situ crude protein digestibility (CPD) among the grass species were high and differences were not significant; the highest was with guinea grass (64.01%) and lowest with humidicola (59.63%). Across supplements (forages of legumes and trees, and concentrates), differences in CPD were significant; higher in *abgaw,* calopo, *madre de cacao*, jackfruit foliage and grated coconut (86.87 to 90.97%) and lower in RBD_2 (61.98%) and centro (57.46%).

Lanting (2004) explained that the low CPD of legume leaf meals in the rumen is likely due to the tannin content, which made the leaf meal a good source of bypass protein in ruminants. Although tannin binds with protein and decreases the nutritive value of the plant, Min and Hart (2003) stressed that its effect increases post-rumen protein supply, and even though tannins are known to reduce the fraction of protein digested in the rumen, there appeared to be a fast reaction of increasing availability of the bypass protein in the small intestine. In this study, centro showed a great potential for bypass protein. Leng (1997) provided support by saying that

While centro is actively growing in the marginal upland site, its forage yield per unit area is not much, and coupled with its low DMD, its potential therefore as a major feed resource for ruminants in the marginal uplands appeared to be less, like RBD_2.

The significantly lower DMD value of jackfruit leaf meal compared to that of *abgaw* could be due to its higher levels of condensed tannin (Reddy and Elanchezhian, 2008), although it is comparable to *madre de cacao* and calopo legume forages that showed very high DMD values with similar pattern of differences as that found by Atole and Bestil (2013). Kumar and Singh (1984) reported that tannins affect mainly the digestibility of protein, but Leng (1997) stated that a little tannin has been usually accepted as being able to protect the protein of forages, allowing a higher efficiency of feed utilization by the animal. The lowest DMD value in humidicola grass compared to that of guinea grass and carabao grass, could be due to the high levels of NDF especially when cutting interval is between 35 and 65 days (Feedipedia, 2011 as cited by Heuze *et al.*, 2011).

Table 1. Dry matter and crude protein contents of dominant grasses and supplements fed to ruminants in marginal upland areas

Treatments	Dry Matter (%)	Crude Protein* (%)	Gross Energy* (kcal/kg)	Ca* (%)	P* (%)
Legume Supplements					
Centro (*Centrocema pubescens*)	86.87	18.23	4057	0.067	0.032
Calopo (*Calopogonium muconoides*)	85.31	16.19	4524	0.077	0.030
Madre de cacao (*Gliricidia sepium*)	84.30	15.83	4400	0.189	0.030
Supplemental Trees/Shrubs					
Jackfruit (*Artocarpus heterophylus Lamk*)	87.67	10.17	3631	0.182	0.030
Abgaw (*Premna odorata*)	85.59	11.91	3560	0.163	0.033
Concentrate Supplements					
Rice bran (D_2)	90.10	4.84	4110	0.006	0.037
Grated coconut	92.68	6.08	5097	0.004	0.026
Grasses					
Carabao (*Paspalum conjugatum*)	87.31	8.51	3612	0.058	0.030
Humidicola (*Brachiaria humidicola*)	88.66	5.16	2931	0.025	0.034
Guinea grass (*Panicum maximum*)	86.34	7.40	3389	0.046	0.033

* As-fed basis

legumes and tree foliages provide nutrients deficient in the diet, enhancing microbial growth and digestion of cellulosic biomass in the rumen, protein that escapes rumen degradation to be digested in the intestines to enhance the protein status of the animal, and vitamins and minerals to complement deficiencies of the basal diet.

CONCLUSION AND RECOMMENDATION

Looking at the results of the laboratory analyses of the chemical composition of dominant feed resources in the marginal uplands vis-a-vis animal requirements especially during lactation stage, energy content is adequate but protein/nitrogen and minerals are limited.

Based on the *in situ* degradation of the grass species, guinea and carabao grasses have greater potential as ruminant feed than *humidicola* grass. However, the quantity of forage that can be obtained from carabao grass, and its versatility to grow in marginal areas, is very limited, thus, the use of guinea grass in ruminant feeding in marginal upland areas is highly recommended. Based on the in situ degradation of the legume species, *madre de cacao* and calopo have greater potential as source of amino acids and NH_3 for the synthesis of rumen microbial cell protein, and their use in ruminant feeding is, therefore, highly recommended. On the other hand, feeding of centro is also highly recommended, although it has a lower rumen degradation rate, as source of bypass protein that provides amino acids at the intestinal level especially for high-producing animals. Looking at the potential of supplemental foliage from trees/shrubs based on in situ degradation, *abgaw* is highly recommended for supplying the nutrient needs of rumen microbes, but jackfruit may provide greater bypass nutrients for utilization at the intestinal level. Between concentrate supplements, the feeding of grated coconut has greater potential for supporting higher levels of livestock performance than RBD_2. Besides, the supply of RBD_2 in marginal upland areas is seasonal (only from upland rice), although the feeding of grated coconut is not a common practice because farmers opt to process coconut into copra in order to generate cash income.

Therefore, in order to achieve higher levels of performance in ruminant production in marginal upland areas, supplementary feeding regimes that satisfy nitrogen and mineral deficiencies and imply practical application, e.g. the use of urea-molasses-mineral block, must be resorted to.

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