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Effects of Protein and Roughage Sources in Total Mixed Ration on Voluntary Feed Intake, Nutrient Intake and Blood Metabolites in Black Bengal Goats

W. Polviset, N. Danopas

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ABSTRACT

Background: Agricultural productivity in Southeast Asian countries are important to produce food for human, thus the first priority to improve agricultural productivity is feed and feeding in livestock, especially in ruminants when rice straw and Napier grass are used as the roughage sources; in addition, cassava leaves and *Leucaena* leaves can be used as the protein sources. Interestingly, the strategy to improve feed in ruminant is through the use of total mixed rations (TMR) which are produced by combination of roughages, concentrates, minerals, vitamins and additives.

Methods: During the period 2020-2021 a study with 2 × 2 factorial, in 4 × 4 Latin square design with 21 days per period tested the following TMR's T1- 5% urea treated rice straw with dried *Leucaena* leaves, T2- 5% urea treated rice with dried cassava leaves, T3- fermented napier grass with dried *Leucaena* leaves and the T4- fermented napier grass with dried cassava leaves on voluntary feed intake, nutrient intake and blood metabolites in Black Bengal goats.

Result: All treatments did not affect voluntary feed intake (kgDM/head/day and % BW) (P>0.05), but feeding with 5% urea treated rice with dried cassava leaves, it was non significantly higher (0.71 kgDM/day). Furthermore, nutrient intake of organic matter (OM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and rumination were not affected among all the four treatments (P>0.05). Additionally, blood glucose, blood urea nitrogen and triglyceride concentrations in plasma were not influenced due to treatments (P>0.05). Nevertheless, Feed cost (USD/kg) was reduced T3 and T4. In conclusion, feeding Black Bengal goat with fermented napier grass with dried *Leucaena* leaves and fermented napier grass with dried cassava leaves in the TMR were suitable because of the lowest price (0.13 USD/kg) when compared to the other treatments.

Key words: Blood metabolites, Goat, Protein sources, Roughage sources.

INTRODUCTION

In the current scenario the factors of livestock production not only focus on feed quality but feed also on quantity; therefore, a balanced diet is very important for feeding animals of all ages. Globally different types of feeds are fed to different animals. In tropical climatic zones of the world there is an abundance of roughage sources for ruminants during the wet season, but during the dry season, ruminants are regularly fed low quality roughages (Kurihara *et al*. 1999; Wanapat *et al*. 2000). It is important to improve the nutritive value of low quality roughages and protein supplementation is essential to meet the maintenance and production requirement. In Thailand especially in the Northeast *Leucaena leucocephala* and *Manihot esculenta* plantations, are very popular and the bioresource such as *Leucaena* leaves and cassava leaves are important to reduce cost of feeding (Wanapat *et al*. 1997) The price of these bioresources is lower compared to the other protein sources such as soybean meal (SBM) (Phokha *et al*. 2010). Moreover, another bioresource commonly used for ruminant is rice straw, it has low protein (2%), which can be improved when treated with 3% urea. The protein can be increased from 2% to 6% (Wanapat *et al*. 2013).

Nevertheless, *M. esculenta* contains hydrocyanic acid and *L. leucocephala* -contains mimosine which are very toxic to animals (Hue *et al*. 2010), but when sun dried in both cassava and *leucocephala* leaves reduce-mimosine and hydrocyanic acid contents are reduced and they can be used as the good quality protein sources (Vongsamphan and Wanapat 2004; Dung *et al*. 2005; Khampa *et al*. 2009; Huang *et al*. 2010).

Harun *et al*. (2017) have mentioned that the goat diets could be use 25% of *L. leucocephala* leaves and 50% of *M. esculenta* leaves and this statement was in agreement with Van *et al*. (2001). Leketa *et al*. (2019) reported that using cassava leaves after root harvesting, as a protein source

Program in Animal Science, Faculty of Agricultural Technology, Rajabhat Maha Sarakham University, Maha Sarakham 44000, Thailand.

Corresponding Author: W. Polviset, Program in Animal Science, Faculty of Agricultural Technology, Rajabhat Maha Sarakham University, Maha Sarakham 44000, Thailand.
Email: polviset@hotmail.com

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for small ruminants and replacing *Leucaena* hay at 25% DM in total mixed ration (TMR) for goats increased feed intake and reduced the cost of feeding. Therefore, this current study was conducted to evaluate the effect of the addition of 5% urea treated rice straw (*Oryza sativa*) and fermented Napier grass (*Pennisetum purpureum*) with *L. leucocephala* and *M. esculenta* leaves in the TMR on the voluntary feed intake, nutrient intake and blood metabolites in Black Bengal Goats.

MATERIALS AND METHODS

Animals, experimental design and treatments

Four Black Bengal Goats, two years old with live weight of 21.88±1.03 kg were used. The goats were treated for intestinal worms and were injected with a mixture of vitamins A, D_3 and E. The animals were randomly assigned to a 2 × 2 factorial, in 4 × 4 Latin square design with 21 days per period and during each period, animals were fed *ad libitum* of total mixed ration (TMR). All animals were kept in individual cages and received free access to water and mineral-salt block. The preliminary period was for 7 days after that the experiment period was for 84 days. The dietary treatments were two dietary roughage sources *viz.*, 5% urea treated rice straw and fermented Napier grass and two dietary protein sources were *L. leucocephala* and *M. esculenta* leaves. The feed was in form of TMR, which illustrated in Table 1.

Sample collections

The goats were fed the respective TMR, individually two times a day at 07:00 and 16:00 h in two equal portions. Voluntary feed intake was recorded daily by weighing the offered diets and was expressed as Dry matter intake (DMI). Feed samples were randomly collected once a week for assessing dry matter (DM) (AOAC, 1984) and samples were dried at 60°C for 48 h and ground (1 mm) for chemical analysis [DM, Ash, organic matter (OM), crude protein (CP), ether extract (EE), neutral detergent fiber (NDF) and acid detergent fiber (ADF)] using standard methods of AOAC. (1990) and Goering and Van Soest (1970).

Sampling and analysis of blood plasma

On the last day of each experimental period before feeding in the morning, 7 mL blood samples were obtained from the jugular vein into evacuated tubes with anticoagulant to obtain plasma. All samples were centrifuged at 2,500 × g for 15 min and the plasma was collected and frozen at -20°C until further analysis. Plasma samples were analyzed for the concentrations of blood glucose, blood urea nitrogen (BUN) and triglycerides (Labtest®Diagnóstica S.A., Lagoa Santa, MG, Brazil). All tests were carried out in duplicate.

Statistical analysis

Data were analyzed using a 2 × 2 factorials in 4 × 4 Latin square design with four periods and four treatments combinations together. The statistical model included the fixed effects of the square and treatment and the random effects of the period and animals. Statistical analyses were performed using PROC GLM of SAS (SAS 2009). When the treatment F-test was significant at $P<0.05$. The mean values were compared by applying the probability of difference option of the Duncan's New Multiple Rang Test (DMRT) (Steel and Torrie 1980).

RESULTS AND DISCUSSION

Chemical composition of experimental diets

The chemical compositions of four dietary treatments *viz.*, T1 = 5% urea treated rice straw with dried *Leucaena* leaves (UTRS+LL), T2 = 5% urea treated rice with dried cassava leaves (UTRS+CL), T3 = fermented napier grass with dried *Leucaena* leaves (FNPG+LL) and T4 = fermented napier grass with dried cassava leaves (FNPG+CL) are shown in Table 2. The CP was similar between the four treatments (12.03-12.23%) and feed cost (Kg/USD) was 0.20, 0.20, 0.13 and 0.13 respectively.

Total dry matter intake, nutrient and rumination

The results of total dry matter intake and nutrient intake revealed that it was not influenced by different roughage sources and protein sources supplementations (Table 3). The dry matter intake (DMI, kg/d and %BW) was similar among treatments with different roughage sources and protein sources supplementations, the mean dry matter intake (kg/d) in T1 (UTRS+LL), T2 (UTRS+CL), T3 (FNPG+LL) and T4 (FNPG+CL) was 0.63, 0.71, 0.69 and 0.66 respectively ($P>0.05$). DMI in this study was in agreement with previous report of Luthfi *et al.* (2014) who described that intake level increased DMI (0.50 kg/d) in Kacang goat. Furthermore, when fed goats were fed with FNPG+CL the %BW intake (2.34%) tends to be higher compared to the other treatments, but lower than that reported by Hue *et al.* (2010) who fed guinea grass (*Panicum maximum*) and cassava chips supplemented with wilted cassava foliage in lambs were the DM intake reported as %BW was 3.6.

The organic matter intake (OMI), the crude protein intake (CPI), the ether extract intake (EEI), the neutral detergent fiber intake (NDFI) and the acid detergent fiber intake (ADFI) followed the same trend as the DMI ($P>0.05$). Additional, the rumination, when fed goats were fed with FNPG+LL (51.00 times/bolus) tended to be higher than with the other diets (Table 3). CPI when fed FNPG+CL in goats was 0.09 kg/d this concurred with reports of Hue *et al.* (2010), who reported that feeding lamb with guinea grass and cassava chips supplemented with fresh cassava foliage CP intake was 0.09 kg/d. Findings of this study was in agreement with Vazquez *et al.* (2017); Hue *et al.* (2008) who suggested that *L. leucocephala* and cassava hay can be used as a protein source in crossbred heifers and lambs. In addition, Thang *et al.* (2010) suggested that an enhanced level of CP and Metabolized energy from cassava products improved digestibility of cattle fed low quality grasses.

However, the effects of harvesting method could be a result of differences in the ratio of leaves and stems, in this experiment cassava leaves without stems were used. On the other hand, the effects of energy and protein supply in the diets may be depend on the amount of nutrients delivery to the animal and digestion by the animal (Wanapat 2003; Chanjula *et al.* 2007).

The average rumination rate in this experiment when the goats were fed with UTRS+LL and UTRS+CL were 50.63 times/bolus and when fed with FNPG+LL and FNPG+CL were 50.75 times/bolus (Table 3). Additionally, chewing during eating or rumination are important to breakdown of feed particles. Feed particles cannot leave the rumen until less than 1.0 mm, for both sheep and goats (Reid *et al.*1979). The particle sizes, different forms of roughage and voluntary feed intake have affected the rumination (Van Soest 1982; Chai *et al.* 1984; Ulyatt *et al.* 1986).

Generally, rumination during the day was shorter than at night and the goats use an average of 7 hours 44 minutes ruminating in 24 hours (25% during the day and 75% at night); in addition, the pattern of rumination in goats are identical in sheep and cattle (Bell and Lawn 1956; Kennedy *et al.* 1986). Another studied by Domingue *et al.* (1991) who informed that goats spent more time eating and less time ruminating per 24 h than sheep when fed *ad libitum* with chaffed lucerne hay (*Medicago sativa*).

Table 1: Feed ingredients in the experimental diets.

Feed ingredients (%) Dry matter basis	T1 (UTRS+LL)	T2 (UTRS+CL)	T3 (FNPG+LL)	T4 (FNPG+CL)
5% Urea treated rice straw	40.00	40.00	-	-
Fermented Napier grass	-	-	40.00	40.00
Dried cassava leaves	11.00	-	11.00	-
Dried *Leucaena* leaves	-	10.00	-	10.00
Palm oil	2.00	2.00	1.00	1.00
Cassava chip	42.50	43.50	43.50	44.50
Molasses	3.00	3.00	3.00	3.00
Lime stone	1.00	1.00	1.00	1.00
Premix*	0.30	0.30	0.30	0.30
Salt	0.20	0.20	0.20	0.20
Total	100.00	100.00	100.00	100.00

T1 = 5% Urea treated rice straw with dried *Leucaena* leaves (UTRS+LL).

T2 = 5% Urea treated rice with dried cassava leaves (UTRS+CL).

T3 = Fermented Napier grass with dried *Leucaena* leaves (FNPG+LL).

T4 = Fermented Napier grass with dried cassava leaves (FNPG+CL).

Premix * = Premix for beef cattle consists of Vitamin AD_3E, Fe, Mn, Cu, Se and Co.

Table 2: Chemical compositions (%DMB) of total mixed rations (TMR).

Chemical composition (%)	T1 (UTRS+LL)	T2 (UTRS+CL)	T3 (FNPG+LL)	T4 (FNPG+CL)
		% Dry matter basis		
DM	92.55	90.89	91.56	91.88
CP	12.11	12.23	12.12	12.03
OM	91.55	90.80	92.33	91.90
EE	4.42	4.44	3.55	3.57
NDF	45.24	46.27	42.56	42.92
ADF	28.96	30.17	23.82	24.37
Ash	8.45	9.20	7.67	8.10
TDN	69.40	69.34	69.09	69.31
Feed cost kg/USD	0.20	0.20	0.13	0.13

DM = Dry matter; CP= Crude protein; OM= Organic matter; EE= Ether extract; NDF= Neutral detergent fiber; ADF= Acid detergent fiber; TDN = Total digestible nutrient.

T1 = 5% Urea treated rice straw with dried *Leucaena* leaves (UTRS+LL).

T2 = 5% Urea treated rice with dried cassava leaves (UTRS+CL).

T3 = Fermented Napier grass with dried *Leucaena* leaves (FNPG+LL).

T4 = Fermented Napier grass with dried cassava leaves (FNPG+CL).

Table 3: Effect of roughage and protein supplementations on total dry matter intake (kg/day), nutrient intake (kg/day) and rumination in goat.

Items	Diets				SEM	P-value		
	5% Urea treated rice straw		Fermented napier grass					
	Leucaena leaves	Cassava leaves	*Leucaena* leaves	Cassava leaves		RS	PS	RS*PS
Total DM intake								
kg/d	0.63	0.71	0.69	0.66	0.002	ns	ns	ns
%BW	2.24	2.33	2.26	2.34	0.04	ns	ns	ns
Nutrient intake (kg/day)								
OM	0.58	0.64	0.62	0.61	0.02	ns	ns	ns
CP	0.08	0.08	0.08	0.09	0.01	ns	ns	ns
EE	0.04	0.04	0.04	0.03	0.002	ns	ns	ns
NDF	0.34	0.39	0.37	0.34	0.012	ns	ns	ns
ADF	0.17	0.18	0.17	0.18	0.008	ns	ns	ns
Rumination (times/bolus)								
Rumination	50.50	50.75	51.00	50.50	0.61	ns	ns	ns

SEM = Standard error of the mean.
RS = Roughage sources; PS = Protein sources; OM = Organic matter; CP = Crude protein.
EE = Ether extract; NDF = Neutral detergent fiber; ADF = Acid detergent fiber.
ns = Not significant.

Table 4: Means of blood metabolites (mg/dl) in goat.

Items	Diets				SEM	P-value		
	5% Urea treated rice straw		Fermented napier grass					
	Leucaena leaves	Cassava leaves	*Leucaena* leaves	Cassava leaves		RS	PS	RS*PS
Blood glucose	60.25	54.75	53.25	49.75	2.28	ns	ns	ns
BUN	19.00	13.00	12.73	14.90	1.29	ns	ns	ns
Triglyceride	50.50	20.75	36.75	44.00	3.67	ns	ns	*

SEM = Standard error of the mean.
BUN = Blood Urea Nitrogen.
ns = Non significance,* P<0.05.

Blood metabolites

The different roughages and protein sources supplementations did not affect (P>0.05) blood glucose, blood urea nitrogen (BUN) and triglyceride values (P>0.05). There was significant effect of the interaction between the roughages and proteins supplementations on triglyceride value in Table 4.

Blood glucose value ranged between 53.25 to 60.25 mg/dl according to USDA (2020) the normal blood glucose value for the Goat is 40-60 mg/dl. Additionally, this result agrees with Luthfi *et al*. (2014) who fed Kacang goat with high and low intakes level are reported blood glucose of 56.39 to 64.48 mg/dl.

BUN in all treatments ranged between 12.73 to 19.00 mg/dl and all treatment were at optimal level range. BUN in FNPG+LL was 12.73 mg/dl and this agreed to Petlum *et al.* (2011), who fed cassava hay supplement at 0.5% BW and found that BUN was 10 mg/dl in beef cattle. Another study by Wanapat and Khampa (2007) demonstrated feeding 15.70% CP in concentrate with urea treated rice straw in beef cattle had difference BUN values among 12.30-14.50 mg/dl.

Triglyceride levels, observed were between 20.75 to 50.50 mg/dl and was higher than reported by Sidik *et al.* (2019) who fed grass silage and concentrate containing 5.1% Omega-3 PUFA in male filial Etawah goats, triglyceride was 10.80 mg/dl. However the other factors as breed, age, sex, nutrition, health, disease, farm management, environment and biosecurity have effect on triglyceride value (Romziah *et al.* 2011; Sidik *et al.* 2019), blood glucose and BUN values.

CONCLUSION

The results indicated that the adding of roughage sources from either 5% urea treated rice straw or fermented Napier grass (40%) in the TMR containing concentrate (60%) with dried *Leucaena* leaves or dried cassava leaves caused no detrimental effect towards the goat on DMI, Nutrient intakes and blood metabolites. Nevertheless, using Fermented Napier grass with dried *Leucaena* leaves and Fermented Napier grass with dried cassava leaves were suitable in goat diets due to the lowest price (0.13 USD/kg).

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