Effect of Various Plant Protein Sources in High-quality Feed Block on Dry Matter Intake, Digestibility and Rumen Fermentation in Swamp Buffalo

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Abstract: This study was designed to determine the effect of various plant protein sources in High-Quality Feed Block (HQFB) on feed intake, digestibility and rumen fermentation characteristic in swamp buffalo. Four, rumen fistulated swamp buffaloes (Bubalus bubalis) were randomly assigned according to a 4\times 4 Latin square design. Four kinds of plant protein sources [Coarse Rice Bran (CRB), Cassava Hay (CH), Phaseolus Calcaratus Hay (PCH) and Mulberry Hay (MH)] were mixed in the HQFB. HQFBs were allowed to be licked at free choice in a wooden box and Urea-Lime Treated Rice Straw (ULRS) were fed ad libitum. It was found that HQFB intakes were similar among treatments while ULRS intake in CH fed group was higher than those in other groups (p<0.05). Moreover, nutrient digestibility in terms of CP, NDF and ADF in CH fed group were significantly higher than those in other groups (p<0.05). Ruminal temperature, NH$_3$-N concentration, pH, BUN, acetate (C2), propionate (C3) but yrate (C4) and C2:C3 ratio were similar among treatments (p>0.05) while total VFA were highest in CH fed group (p<0.05). In addition, N absorption was highest in CH fed group (p<0.05). Based on this study it could be concluded that cassava hay, Phaseolus calcaratus hay and mulberry hay are potential to be used as protein sources in the HQFBs especially cassava hay which resulted in improved rumen fermentation efficiency and digestibility.

Key words: High quality feed block, rumen fermentation, microbial population, swamp buffalo, local feed resources, rice straw

INTRODUCTION

In the tropics, buffaloes and cattle are raised as an integral part of the crop production system, especially where rice is the main commodity (Chantaklathana, 2001). Wanapat et al. (2003) reported some differences between buffaloes and cattle in terms of nutrition and feed utilization. It was found that buffaloes could utilize feed more efficiently, particularly where the feed supply is of low quantity and/or quality, with the digestibility of feed about 3% units higher than in cattle. Wanapat (2000) suggested that this may be explained by buffaloes having a different rumen ecology than in cattle with higher population of cellulolytic bacteria and fungal zoospores, lower protozoa population and a greater capacity to recycle nitrogen to the rumen.

It was recognized that when animals are offered a low-nitrogen, high fiber roughage such as rice straw, one of the critical nutrients is fermentable nitrogen available to rumen microbes (ARC, 1980). The use of urea/molasses blocks is a convenient way for avoiding excessive intake of urea and will ensure an almost continuous supply of ammonia nitrogen in the rumen (Preston et al., 1965). Urea/molasses block feeding yielded positive results in many parts of the world (De and Singh, 2003; Rafiq et al., 2007).

High-quality feed block (HQFB) is one of strategic alternative feed block (Wanapat et al., 1999). Wanapat and Khampa (2006) reported that supplementation of HQFB could increase feed intake, nutrient digestibility and rumen VFA. Moreover, supplementation of HQFB in lactating dairy cows indicate that rumen ecology, milk yield and milk composition were significantly improved (Kaokhunthod et al., 2001). Furthermore, supplementation of leguminous feeds or tree fodder as well as leaf has been shown to improve rumen ecology and ruminant performance (Devendra, 1990).

Recently, cassava hay (Manihot esculenta, Crantz) has been grown as a protein foliage supplement in ruminant feeding especially for dairy cattle, beef and

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buffalo production (Wanapat, 2003; Khang and Wiktorsson, 2006). Cassava hay contains a high level of protein (18-25% of DM) and a strategic amount of condensed tannins (4% of DM; Wanapat et al., 1997; Dung et al., 2005; Hue et al., 2010). The use of cassava hay was successfully implemented in several ways by either direct feeding or as a protein source in concentrate mixtures (Hong et al., 2003; Kiyothong and Wanapat, 2004), as component with soybean meal and urea in feed supplements (Wanapat et al., 2007) and as an ingredient in high quality feed blocks (Wanapat and Khampa, 2006).

Other attractive crops are Phaseolus calcaratus (leguminous crop) and mulberry for ruminant feeding in the tropics. Phaseolus Calcaratus (PC) has quite a high protein content (15-20% in DM) and can grow well in poor soil and dry areas. The whole PC crop can be sun-dried as PC hay as an animal feed while the seeds can be a protein source for human consumption. Phaseolus calcaratus is therefore a promising legume for intercropping and hay making for animals and human food (food-feed system). There have been very few data on PC hay for use in ruminant feeding, research work with this plant is therefore warranted. Mulberry (Morus alba) has a high protein content (15-27.6% in DM) (Makkar et al., 1989), high palatability and high intake. Moreover, mulberry has 50% of rumen undegradable protein and net energy for milk production about 1.48 Mcal kg⁻¹. Bodthaïsong et al. (2008) reported that replacement soybean meal by mulberry hay could increase by-pass protein and milk production in lactating dairy cows.

All these leguminous feeds or tree fodders are potential sources of protein for ruminants. However, using these plants protein sources in HQFB in swamp buffaloes have been quite limited. Therefore, this present study was conducted to investigate the effect of various plant protein sources in high-quality feed block on feed intake, digestibility and rumen fermentation characteristic in swamp buffaloes fed on urea-lime treated rice straw.

**MATERIALS AND METHODS**

**Animals, diets and experimental design:** Four, ruminally fistulated swamp buffalo male with initial BW of 276±26 kg were randomly assigned to receive four dietary treatments according to a 4x4 Latin square design. The feed ingredients and chemical composition of experimental diets and Urea-Lime (2% urea +2% lime) treated Rice Straw (ULRS) are shown in Table 1. All animals were kept in individual pens, mineral block and water were available for ad libitum consumption. Four dietary treatments were as follows: High-Quality Feed Block (HQFB) with Coarse rice Bran (CRB), Cassava Hay (CH), Phaseolus calcaratus Hay (PCH) and Mulberry Hay (MH), respectively.

### Table 1: Ingredients and chemical compositions of diets in the experiment

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>CRB (T1)</th>
<th>CH (T2)</th>
<th>PCH (T3)</th>
<th>MH (T4)</th>
<th>ULRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical composition (%)</td>
<td>75.3</td>
<td>78.5</td>
<td>78.9</td>
<td>78.3</td>
<td>49.6</td>
</tr>
<tr>
<td>OM</td>
<td>72.8</td>
<td>76.1</td>
<td>70.6</td>
<td>74.1</td>
<td>84.2</td>
</tr>
<tr>
<td>CP</td>
<td>35.7</td>
<td>37.6</td>
<td>39.8</td>
<td>37.2</td>
<td>5.7</td>
</tr>
<tr>
<td>NDF</td>
<td>26.1</td>
<td>30.7</td>
<td>42.5</td>
<td>21.7</td>
<td>75.2</td>
</tr>
<tr>
<td>ADF</td>
<td>22.7</td>
<td>18.0</td>
<td>29.1</td>
<td>19.0</td>
<td>59.8</td>
</tr>
<tr>
<td>Ash</td>
<td>27.2</td>
<td>23.9</td>
<td>29.4</td>
<td>25.9</td>
<td>15.8</td>
</tr>
</tbody>
</table>

CRB = Coarse Rice Bran, CH = Cassava Hay, PCH = Phaseolus calcaratus Hay, MH = Mulberry Hay; ULRS = Urea-Lime (2% urea +2% lime) Treated Rice Straw, OM = Dry Matter, CP = Crude Protein, NDF = Neutral Detergent Fiber, ADF = Acid Detergent Fiber

Urea-Lime treated Rice Straw (ULRS) was prepared by using 2% (w/w) urea and 2% calcium hydroxide mixed with 100 kg of water, 100 kg of Rice Straw (RS) (50:50, water to straw) and poured over a stack of straw and then covered with a plastic sheet for 10 days before feeding to animals.

The CH, PCH and MH were prepared from whole fresh crop, chopped and sun-dried for 2-3 days, ground to pass a 1 mm screen using a Cyclotech Mill (Tecator, Hoganas, Sweden) and then mixed with other ingredients in respective HQFBs mixture. The mixture was put in a hydraulic compressive machine and left to sun-dry for 2-3 day to reduce moisture. HQFB were allowed to be laked all days in wooden box while ULRS were fed ad libitum. The experiment was conducted for 4 periods and each period lasted 21 day. During the first 14 day, all animals were fed with respective diets whereas during the last 7 day, the animals were moved to metabolism crates for total collection of urine and feces.

### Data collection and sampling procedures:

Feeds were sampled and fecal samples were collected from the total collection of each individual swamp buffalo on each treatment during the last 7 day of each period at the morning and afternoon feeding. Composted samples were dried at 60°C, ground (1 mm screen using Cyclotech Mill, Tecator, Sweden) and then analyzed for DM,
Results and Discussion

Chemical composition of diets: Chemical compositions of HQFB and ULRS are shown in Table 1. HQFB with CRB, CH, PCH and MH contained 35.7, 37.6, 39.8 and 37.2% CP, respectively. Similar CP content for HQFB with CRB have been previously reported by Koakhunthod et al. (2001) and Khampa et al. (2009) with values of 36.0 and 36.6% CP, respectively while Wanapat and Khampa (2006) reported at 37.8% CP.

The CP content for HQFB with CH similarly with Khampa et al. (2009), (37.3% CP) but lower than Wanapat et al. (1999) (43.6% CP) and higher than Koakhunthod et al. (2001) (33.2% CP). This could be due to CH was harvested at a younger stage of growth (3-4 months) or regrowth (2-3 months) for having higher nutritive value and/or difference in cultivars, age of plant, plant density, soil fertility, harvesting frequency and climate (Gomez and Valdivieso, 1984). In whole cassava plant, the forage especially leaf is usually less than stem (Ravindran, 1993).

Therefore, this variation may have resulted from ratio of stem: leaf. As the leaf and stem fraction in CH differed greatly in their nutrient content. In addition, NDF content was greatest in HQFB with PCH treatment. The differences could be attributed to age of plant because the amount of NDF in whole plants increased linearly with age of plant, especially increased in NDF and ADF in stems and indicated the formation of tannin-fiber complexes that were not solubilized in the acid detergent solution (Getachew et al., 2001). The ULRS contained 5.7% CP, 75.2% NDF and 59.8% ADF on a DM basis and was similar to that reported by Wanapat et al. (2009).

Effect on feed intake and nutrient intake: Table 2 shows data on feed intakes and nutrient intakes. HQFB intakes in terms of BW% and g kg⁻¹ BW⁰.⁷⁵ were not significantly affected (p>0.05) by treatments while ULRS and total intakes was highest in HQFB with CH (p<0.05) but lowest in HQFB with CRB fed group.

These data were in accordance with the report by Wanapat et al. (1997) that CH had are markable high DM digestibility (71%) and high ruminal by pass protein since it contained tannin-protein complex. Moreover, medium CT concentrations (30-40 g kg⁻¹ DM) had no effect upon voluntary feed intake (VFI) (Terral et al., 1992; Wang et al., 1996) but could reduce protein solubility and degradation in the rumen increased the absorption essential amino acids (EAA) from the small intestine (Waghorn, 2008; Barry and McNabb, 1999).
Nutrient intakes in term of OM, NDF and ADF were highest in HQFB with CH fed group (p<0.05) while CP intake was not significantly different (p>0.05).

**Effect on digestibility and nitrogen balance:** Apparent digestibility of CP, NDF and ADF were highest in HQFB with CH fed group as compared with other treatment groups (p<0.05). These data were in accordance with the report by Phengvichith and Ledin (2007) that supplementing Wilted Cassava Foliage (WCF) in the diet could increase the apparent digestibility of DM and resulted in a higher N retention and weight gain of growing goats.

N intake, Urinary N and N retention were not affected (p>0.05) by treatments while Fecal N was lowest and N absorption was highest in HQFB with CH fed group (p<0.05). With regards to N utilization, Owens and Zinn (1988) stated that N excretion and N retention should reflect differences in N metabolism, because N retention was the most important index of the protein nutrition status of the ruminants.

**Characteristics of ruminal fermentation and blood metabolites:** Measured rumen variables included temperature, pH, NH₃-N and VFA. Plasma urea N was also determined to investigate the relationship with rumen NH₃-N and protein utilization.

The pattern of ruminal fermentation and overall means are shown in Table 3. Rumen fluid pH and temperature were not altered among treatments and the values were stable at pH 6.6-6.7 and temperature of 38.8-39°C and the pH was within the range considered optimal for microbial digestion of fiber and protein [6.0-7.0; Lyle et al. (1981); Hoover (1986); Firkens (1996), Wanapat (1990)]. Rumen NH₃-N is a major source of N for microbial protein synthesis (Erdman et al., 1986). Rumen NH₃-N concentrations were 11.35-11.85 mg dL⁻¹ and were close to those previously reported by Wanapat and Pimpa (1999) for improving rumen ecology, microbial protein synthesis, digestibility and voluntary feed intake. Decreasing rumen NH₃-N concentrations also resulted in decreasing concentrations of blood urea N. Concentrations of blood urea N are highly correlated to the concentration of NH₃ production in the rumen (Preston et al., 1965). This study revealed that HQFB with CH has been higher in NH₃-N concentration. This would indicate that available rumen NH₃-N could be used and/or absorbed in the rumen for further synthesis. There were no significant differences (p>0.05) in acetic acid, propionic acid and butyric acid proportions and acetic:propionic
ratio (Table 4). However, total VFA concentrations was highest in HQFB with CH fed group and ranged from 102.2-116.0 mmol L$^{-1}$. These values were similar to those reported by Koakhunthod et al. (2001).

CONCLUSION

Based on this experiment it could be concluded that cassava hay, *Phaseolus calcaratus* hay and mulberry hay are potential to be used as protein sources in HQFB especially cassava hay which can improve rumen fermentation efficiency by increasing total VFA.

Moreover, CP, NDF and ADF digestibilities and ULRS and nutrient intakes were significantly improved by cassava hay as protein sources in HQFB. HQFB are therefore recommended as lick-blocks for ruminants fed on low-quality roughages such as rice straw.

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