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RUMEN DEGRADABILITY AND CHEMICAL COMPOSITION OF THE VELVET BEAN (*Mucuna* spp.) GRAIN AND HUSK

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SUMMARY

Velvet bean (*Mucuna* spp.) not only improves the fertility of soils, but it also produces grain and husk that can be used as a supplement to ruminant livestock. This study evaluated the chemical composition and rumen degradability characteristics of both fractions. Rumen degradability was evaluated using three rumen cannulated cows with a basal diet of forage. The crude protein content of the grain was high (279 g kg^{-1} DM) in comparison to the husk (44 g kg^{-1} DM). Neutral detergent fiber was higher in the husk (597 g kg^{-1} DM) than in the grain (260 g kg^{-1} DM). Potential degradability of both grain (100%) and husk (94%) was high. However, the rate (% h^{-1}) of rumen degradation was lower for the husk (3%) than for the grain (10%). These characteristics confirm the high potential of velvet bean grain and husk as a supplement for ruminant livestock.

Key words: *Mucuna*, rumen degradability, nutritional composition.

INTRODUCTION

Velvet bean (*Mucuna* spp.) is a crop that has been increasingly adopted in the tropics to improve the fertility of agricultural soils. Velvet bean pods, which have a good potential as a supplement for ruminant livestock, can be harvested without sacrificing the beneficial impact on soil.

The pods of velvet bean are composed of 60% grain and 40% husk (Castillo and Ayala, 2001, unpublished data). It can be expected that velvet bean grain is rich in energy and protein but on the other hand, husk may have a nutritional value similar to that of cereal straw. Nevertheless, velvet bean grains contain several anti-nutritive compounds (Josephine and Janardhanan, 1992; Buckles *et al.*, 1999; CIDICCO, 1999), in particularly, the content of L-Dopa (3-4-dihydroxy-L-phenylalanine) is high.

To study the nutritional value of feedstuffs such as the velvet bean in ruminants, it has been suggested that the nylon bag technique is a quick, cheap and useful tool to evaluate rumen utilization and therefore animal performance (Orskov *et al.*, 1980; Vanzant *et al.*, 1998). Considering the possibility that the anti-nutritional compounds present in velvet bean may depress the degradation activity of rumen micro-organisms, the objective of this work was to characterize the chemical composition of velvet bean grain and husk and to evaluate their rumen dry matter (DM) degradability in ruminants consuming a basal diet of forage.

MATERIALS AND METHODS

The trial was conducted at the laboratory of Animal Nutrition at the University of Yucatan, Mexico, during 2001. The animals used in the experiment were three rumen cannulated cows (*B. indicus X B. taurus*) of approximately 4 years old and 450 ± 35 kg live weight (LW). The rumen surgery of the animals was made a year before the initiation of the trial, using a flexible rubber cannula with 10 cm internal diameter (Bar Diamond, Idaho, USA). Each animal was individually penned in stalls with a concrete floor, a metal roof and an independent trough for feeding. Water was always available. All animals received a basal diet of fresh chopped Napier grass (*Pennisetum purpureum*) offered *ad libitum*. The Napier grass was harvested daily at approximately 10 wk of re-growth and 2 m height. In addition, each cow was supplemented with 2 kg (FM) per day of a concentrate (90% DM) of ground sorghum, soybean meal, and minerals for a balanced supply of 160 g CP and 13 MJ ME per kg DM.

The velvet bean type used probably came from Central America and has grey-brown light seed colour. The pods that had been harvested in 2001 at the University of Yucatan were separated into grain and husk. A portion of each fraction was finely ground in a hammer mill with a sieve of 1 mm diameter for the laboratory analysis. These fractions were analyzed for crude protein, ash, gross fat, calcium and phosphorus according to the methods of AOAC (1980) and for neutral and acid detergent fiber, lignin and acid detergent insoluble nitrogen according to the methods of Van Soest (1994).

For rumen dry matter degradability analyses, additional velvet bean grain and husk samples were ground in a hammer mill with a sieve of 2 mm. The rumen incubation of the grain and husk were made separately using polyester bags with a pore size of 50 µm and dimensions of 7 by 14 cm (Bar Diamond, Idaho, USA). The fresh weight of grain and husk in each bag was around 5 and 3 g, respectively. The harvest moisture content was about 90% DM, but the particular DM content of each fraction was determined by oven drying at 60 ºC for 48 h. The actual DM content was then used to correct final calculations of the DM incubated in the rumen.

The method used for the rumen incubation was based on the recommendations of Orskov *et al.* (1980) as modified by Ayala and Rosado (2001). In short, an inverse sequence of the incubation times was used. The small bags were placed in the rumen in another, larger bag (25 by 40 cm) of nylon mesh with pores of 1-2 mm and a plastic zipper. This bag was hung 40 cm into the cow rumen using a plastic cord attached to the external side of the cannula. All incubation times were evaluated in duplicate and were the following: 3, 6, 12, 24, 36 and 48 h (for the grain) and 6, 12, 24, 36, 48 and 72 h (for the husk). When the incubation times were completed, the bags with the residual samples were withdrawn from the rumen and washed in tap water to remove the excess of digesta. Bags were then washed in an automatic washing machine (heavy washing cycle) to a point where the water flowing from the machine was clear. To quantify the DM loss during the washing, two additional bags with samples of the grain and husk were also washed. The truly soluble fraction of samples was measured in the laboratory using filter paper according to the method of Capetillo-Leal and Ayala-Burgos (1999). The rumen degradability at these incubations times was calculated as the difference between the incubated DM weight minus the residual DM weight multiplied by a hundred. Values of the rumen DM degradability were fitted to the exponential equation recommended by Orskov and McDonald (1979):

$D = a + b(1 - \exp^{-c*t})$
where:
"a" = the intercept on "y" of the fitted line.
"b" = the potential degradable fraction that is not soluble.
"c" = the fractional rate at which "b" is degraded with time and
a+b = the potential degradability (PD) of the substrate when time is not limited.

From the rumen degradability parameters described above, the expected effective degradability (ED) of the grain and husk at practical feeding conditions was calculated assuming a rumen digesta flow of 2 and 5% (Harbron, 1994). Parameters of the rumen DM degradability were analyzed with the analysis of variance according to a completely randomized design (Mead and Curnow, 1983).

RESULTS AND DISCUSSION

The chemical composition of the grain and husk is presented in Table 1. The protein content of the grain is high (278 g CP kg^{-1} DM) indicating that the grain could play an important role as a protein supplement for ruminants. In contrast, the husk had a low protein content (44 g kg^{-1} DM) and a high content of lignin (77 g kg^{-1} DM) and fiber (598 g NDF kg^{-1} DM), qualifying it as a roughage (AFRC, 1993).

The nitrogen free extract (NFE) represents the content of starch in the proximate analysis (AOAC, 1980) and indicates the soluble fraction in a feedstuff. For the grain we found a NFE of 395 g kg^{-1} DM (Table 1) which is close to the value reported for the grain of *Canavalia ensiformis* (357 g kg^{-1} DM), another legume previously studied as a potential animal food (León *et al.*, 1991). It should be noted that NFE values in grain agree well with the measured truly soluble DM shown in Table 3. This similarity has practical and economical advantages since the last measurement is cheaper and easier to make. To our knowledge, this is the first report in velvet bean on the content of acid detergent insoluble N (ADIN), which represents the protein fraction that is unavailable for rumen or post-ruminal digestion (AFRC, 1993; Van Soest, 1994). The ADIN contents in velvet bean were 28 and 4 g of crude protein for the grain and husk, respectively. Both values were similar to those reported for other protein feeds (AFRC, 1993).

The values of the rumen DM degradability are presented in Table 2. Clearly, the grain is degraded quicker that the husk. Thus, at 36 h of incubation, the grain was completely degraded while the husk was only 74% degraded. Furthermore, after 72 h of incubation, only 85% of the husk DM had been degraded.

The parameters of the rumen degradability derived by fitting these degradability values to the exponential equation (Orskov *et al.*, 1980; Harbron, 1994) are presented in Table 3 where the potential DM degradability, "a+b," and the rate of degradation, "c," are the two parameters of major interest. Although the potential degradability is 100% for the grain and 94% for the husk, it was surprising not to find a statistical difference between them (Table 3). This potential degradability of the husk is very high for roughage and means that the rumen degradation of the husk continues beyond the maximum time we studied, i.e., 72 h. In contrast, the rate of DM degradation was three times higher for the grain than for the husk ($P<0.05$), signifying the faster degradation of the grain. The difference between grain and husk also agrees with the soluble fraction measured either as the wash loss from the polyester bag or as the soluble DM measured with filter paper.

The potential degradability of a substrate is a theoretical value. Because the food is always flowing from the rumen, the potential degradability is never reached under practical feeding conditions. A likely rumen digesta flow in small ruminants is around 5% (Van Soest, 1994), thus, adjusting the potential degradability to this kinetic value, we can derive an effective degradability (ED 5% in Table 3), which is also a close estimation of the *in vivo* digestibility (Ayala-Burgos, 1997).

On this basis, it can be expected that the digestibility of the grain DM is around 81% whereas that of the husk may only be 53% (Table 3). The effective degradability can be used to estimate the mean rumen retention time of the feed (Hovell *et al*., 1986). This parameter is in close association with intake since digesta remaining for longer time in the rumen will have a filling effect on the rumen which, in turn, reduces the intake (Minson, 1990). On this basis, the mean rumen retention of the grain was estimated to be 11 h whereas that of the husk was 16 h. As a comparison, Ayala-Burgos (1997) found an effective DM degradability of young (1.5 months) and mature (7 months) *Pennisetum purpureum* to be 61 and 43%, respectively, and estimated corresponding mean rumen retention times as 23 and 61 h, respectively. Another study with 35-d regrowth of Guinea grass (*Panicum maximum*), a common grass in Yucatán, reported a potential degradability (a+b) of 59 % with a “c” rate of 3% (Aranda-López, 2001).

Table 1. Chemical composition (g kg^{-1} DM) of the grain and husk of the velvet bean (*Mucuna* spp.) harvested in 2001 at the University of Yucatan, Mexico.

Chemical fraction	Grain	Husk
Ash	35.3	58.0
Crude protein	278.5	44.0
Gross fat	25.1	11.0
Neutral detergent fiber	259.5	597.7
Acid detergent fiber	88.0	369.5
Lignin	ND	77.5
Acid detergent insoluble N	4.5	0.6
Calcium	4.6	9.5
Phosphorus	2.4	0.3
Nitrogen free extract	394.6	202

ND: Not Determined

Table 2. Rumen DM degradability (%) of the velvet bean grain and husk, evaluated in three rumen cannulated cows fed with a basal diet of *Pennisetum purpureum*.

Incubation time (h)	Grain	Husk	Standard Error
3	61.5	ND	---
6	68.0	40.8	2.79
12	78.3	46.7	1.63
24	99.4	61.0	1.03
36	100	73.6	2.65
48	100	81.0	1.53
72	ND	84.8	---

ND: Not Determined

Table 3. Parameters of the rumen DM degradability of the velvet bean grain and husk according to the equation $D = a + b(1\text{-}exp^{-ct})$, and the estimated effective degradability at a rumen outflow rate of 5% (ED5%).

Degradability Parameter (%)	Grain	Husk	Standard Error	Probability
A	45.3	27.7	5.80	NS
B	54.8	66.7	2.79	NS
C	9.7	3.0	1.18	0.04
A+b	100	94.4	2.36	NS
ED5%	81.3	53.2	0.71	0.001
DM wash loss (SD)	28.1 (7.6)	13.0 (4.5)		
Truly soluble DM (SD)	35.8 (7.6)	26.9 (4.0)		

NS : Not a significant difference ($P > 0.05$)
SD: Standard deviation

To summarize, the chemical composition of the grain and husk confirms their potential as a supplement for ruminants. Regarding their degradability characteristics, the grain has a higher availability in the rumen and can therefore be considered an excellent source of fermentable nitrogen and energy to the rumen microorganisms. Although the degradability characteristics of the husk are inferior, they are still higher than those of the common grasses used for ruminant livestock in many tropical areas of Mexico.

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