Tropical and Subtropical Agroecosystems

Short note [Nota corta]

IN SACCO DETERMINATION OF DRY MATTER, ORGANIC MATTER AND CELL WALL DEGRADATION CHARACTERISTICS OF COMMON VETCH (*Vicia sativa* L.)

[DEGRADACIÓN RUMINAL DE LA MATERIA SECA, MATERIA ORGÁNICA Y PAREDES CELULARES DE LA VEZA COMÚN (*Vicia sativa* L.)]

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SUMMARY

The objective of the study was to determine the nutritive value and rumen degradation parameters using the *in sacco* (nylon bag) technique of common vetch (*Vicia sativa* L.). Three mature female goats weighing an average of 28 kg and fitted with permanent rumen *cannulae* were involved. They were fed (*ad libitum*) a basal diet comprising of about 75:25 maize silage to dried cured Lucerne. Chemical composition was determined using the standard procedures. To determine degradability profiles, nylon bags were use. The incubation times were: 4, 6, 8, 12, 14, 24, 36, 48, 72, 96 and 120 h. Data for *in sacco* DM, OM, CP and cell walls degradation were fitted to the first order kinetics equation [$p = a + b\ (1 - e^{-ct})$]. Effective rumen degradation was calculated as: $ED = a + b \times [c / (c + k)]$, (k of 5% h^{-1}). DM (90.8%), OM (88.6%), CP (31.5%), NDF (46.5%), ADF (20.7%), hemicellulose (25.8%), cellulose (13.4%) and ADL (7.3%) of *V. sativa* L and its high estimated digestible dry matter (%DDM: 72.8) compares well with forage legumes (*Medicago sativa* and *Desmodium intortum*) commonly used in Kenya. The observed potential degradation (a + b) characteristics for DM (69.6), OM (69.8), CP (78.4), NDF (64.9), ADF (50.9), Hemicellulose (66.5), Cellulose (34) and ADL (26.9%) and their effective degradation (65.6; 65.8; 74.6; 60.7; 47.3; 61.8; 30.9 and 22.9%, respectively) showed that Common vetch is similar better than most forages commonly used by small farmers in Kenya. It was concluded that *Vicia sativa* could be incorporated in the smallholder farming systems as both ruminant livestock protein supplement and for soil fertility improvement purposes.

Key words: Nylon bag; Rumen degradation; protein supplement; Goats; smallholder farms; soil fertility; ruminant livestock

RESUMEN

La veza común (*Vicia. sativa L*) tiene el potencial para ser empleada como alimento para ruminates por los pequeños productores de Kenya. El objetivo del presente trabajo fue su evaluación nutricional empleando la degradación *in situ* (técnica de la bolsa de nailón). Se emplearon tres cabras hembras con un peso promedio de 28 kg con cánula permanente. Se alimentaron *ad libitum* una dieta basal de ensilado de maíz y alfalfa (75:25). Se determinó la composición química de *Vicia sativa* L y su perfil de degradación ruminal. Los tiempos de incubación fueron; 4, 6, 8, 12, 14, 24, 36, 48, 72, 96 y 120 h. Se describió la degradación potencial y efectiva de la MS, MO, PC y paredes celulares. Su composición química MS(90.8%), MO(88.6%), PC(31.5%), FDN(46.5%), FDA(20.7%), hemicelulosa (25.8%), celulosa (13.4%) y LAD(7.3%), así como la digestibilidad estimada dela materia seca (72.8%) de *V. sativa* L es comparable con otras leguminosas forrajeras (*Medicago sativa* y *Desmodium intortum*) comúnmente empleadas en Kenya. El potencial de degradación (a + b) y la degradabilidad efectiva de sus componentes (MS, MO, PC, FDN, FDA, Hemicelulosa, Celulosa y LAD) muestran que la Veza común es similar o mejor que la mayoría de los forrajes empleados por los pequeños productores de Kenya. Se concluyó que puede ser incorporada en los sistemas de producción como suplemento proteico y para mejorar la fertilidad del suelo.

Palabras clave: Bolsas de nailón; degradación ruminal; proteína; cabras; pequeño productor, rumiantes, fertilidad del suelo.

INTRODUCTION

Inadequate feed is the major setback to livestock production in sub-Saharan Africa (Gebrehedhin *et al*., 2003). This has often led to low milk and meat production, high mortality of young stock, longer calving intervals and low animal weights (McIntire *et al*., 1992). Improved nutrition through adoption of sown forage could substantially increase livestock productivity (Gebrehedhin *et al*.. 2003). Common vetch (*V. sativa ssp. Sativa* L has a potential in alleviating dietary protein constraints for ruminant livestock in Kenya. In Australia and other parts of the world, common vetch is popularly grown for fodder, hay, green manure or seed production (Enneking, 2001; Sattell *et al*., 1998; Chowdhury *et al*., 2001; Rathjen, 1997). Vetches are also reputed for their beneficial compatibility with cereal crops when they are grown as mixtures. In Paskistan, oats/vetch mixture is popular for its high yields and ability to improve soil fertility on smallholder farms (Pariyar, 2002).

Fresh vetch herbage is reported to have high crude protein level (16.5 – 26.5%; Hadjipanayiotou and Economides 2001). Common vetch hay was also reported to be rich in essential nutrients (TDN: 59%; Phosphorus: 0.34% and calcium: 0.132%) compared to those from tropical grasses (Pinkerton & Pinkerton, 2000). Feeding vetch is also reported to increase milk yields of cows and goats and growth performance of beef cattle (Pinkerton & Pinkerton, 2000). It is also reported that, cows fed the barley-vetch grain mixture gained 0.2 kgd^{-1} more live weight than those fed the barley-lupin grain mixture (Valentine and Bartsch, 2004; Darnhofer, 1997). Aj-Ayed *et al*. (2000) reported that forage hay from the common vetch-oat intercrop is commonly used to meet the forage deficit and integrate crop and livestock production in Mediterranean region. Vetch seeds are particularly high in protein (28-35%) and are therefore often used as quality feed for livestock ruminant animals. However, their use as a monogastric feed is questionable because of presence of a neurotoxin gamma-glutamyl-beta-cyanoalanine (present only in the seeds). This toxin affects sulfur amino acid metabolism, specifically, the conversion of methionine to cysteine, which leads to an increased excretion of cystathionine (Enneking, 2001, Sattell *et al.,* 1998; Rathjen, 1997). Despite the presence of toxin, ruminant livestock fed on vetch-based diets perform very well. These attributes probably explain why common vetch has gained wide popularity in many parts of the world. However, in the east African highlands, particularly in Kenya, common vetch is not grown widely despite the apparent lack of feed (Gryseels and Anderson 1983).

This study was undertaken to further evaluate the feeding value of common vetch (*Vicia sativa* L) using *in sacco* technique as described by Ørskov and McDonald (1979), Ørskov *et al*. (1980 and 1988), Hungtington and Givens (1995), Madsen, (1985), Vérité and Peyrand, (1989) and Tamminga *et al*., (1994). The objective is to provide an alternative fodder crop for ruminant livestock production on smallholder mixed farming systems in Kenya where land for fodder production is fast diminishing. This in turn is further intensifying demand for forage legumes, which can integrate well with cereal food crops to enhance ruminant livestock feed production.

MATERIALS AND METHOD

This study was conducted at the animal experimental farm of Yangzhou University/Jiangsu/P. R. China. Three mature female goats weighing an average of 28 kg and fitted with permanent rumen cannulae were involved. They were housed together in a well-ventilated draft-free pen, with slatted wooden floor. The goats were fed *adlibitum* with a basal diet comprising of about 75:25 maize silage (360 g kg^{-1}DM and 80 g CP kg^{-1} DM to dried cured Lucerne (920 g kg^{-1} DM and 190 g CP kg^{-1} DM) in two equal meals (at 0800 and 1600 h) every day for 14 days before the study began and throughout the study period. Before each fresh feeding, the previous day's feed refusals were removed and discarded. The goats had a free access to a clean drinking water and mineral supplement. The sole feed tested in the current study was *Vicia sativa* L). Fresh seed free material, at below 50% flowering stage was harvested (2 cm above ground surface), chopped into small pieces of about 2 cm long and then mixed thoroughly. Thereafter, three composite samples of approximately 1 kg each were taken for dry matter determination, chemical analysis and rumen degradability studies, respectively.

Dry matter (DM), crude protein (CP) and cell wall degradation characteristics were determined using the nylon bag technique as described by Ørskov and McDonald (1979) and Orskov *et al.* (1980). The feed material was oven-dried at 65°C for 24 hours and then grounded to pass a 2.5 mm sieve (Abdulrazak and Fujihara, 1999, Preston 1995). Representative samples of 5 g each were placed (in duplicates) into well-labeled and weighed nylon bags of pore size 40 µm and inner size of 6.5 cm x 12 cm. All the bags were inserted into the rumen at the same and withdrawn sequentially. The incubation times were: 4, 6, 8, 12, 14, 24, 36 48, 72, 96 and 120 h. After each incubation period, the respective bags were taken out of the rumen, dipped immediately into cold water to stop further microbial activity and then rinsed by cold tap water to remove the rumen matter from the outside of the bags. Thereafter, the bags were washed in a domestic washing machine with cold water for 30 minutes and dried at 65°C for 48 hours. To determine the washing loss 2 additional bags containing 5 g each of the test feed were soaked in water bath kept at 39°C for 1 h and then underwent the same washing and drying procedures as those incubated. After the 48 h drying period, the bags were cooled in a desiccator for 30 minutes and then weighed to determine their weights.

The dried fresh feed samples and the after incubation residues were subjected to chemical analysis (AOAC, 1990). Total DM was determined by drying samples in duplicates in an oven at 135°C for 2 h (Abdulrazak and Fujihara, 1999). Nitrogen (N) was determined according to the Kjeldahl method (AOAC, 1990) modified by using boric acid in the distillation process. Crude protein was calculated as %N x 6.25. The neutral detergent fibre (NDF), acid detergent fibre (ADF), and acid detergent lignin (ADL) contents were determined according to Van Soest and Robertson (1985), Goering and Van Soest (1970) and Abdulrazak and Fujihara (1999). Ash was determined by igniting 1g samples of the dried fresh feed materials in weighed porcelain crucibles in temperature-controlled muffle furnace preheated to 550°C for 3 h (Abdulrazak and Fujihara, 1999). Hemicellulose and cellulose were determined by the following formulae: Hemicellulose = NDF - ADF; Cellulose = ADF – ADL. The *in sacco* dry matter digestibility (%DMD) was determined as described by Kamalak, *et al*. (2003), DDM = Digestible Dry Matter as described by (Bath and Marble, 1989; Grant, 1994). *In sacco* DM, OM, CP and cell walls degradation were fitted to the first order kinetics defined by the exponential equation of the form $p = a + b\,(1 - e^{-ct})$; (Ørskov and McDonald, 1979; McDonald, 1981): where p represents degradation of DM, OM, CP and cell wall components at time t; (a + b) is their potential degradation and c is the rate of their degradation. Their effective rumen degradation were calculated as: $ED = a + (b \times c) / (c + k)$, assuming the rumen outflow rates (k) of 5% h^{-1} (Ørskov and Shand, 1997). Degradation constants *a, b* and *c* were derived using the statistical package SPSS (2003). Substrate disappearance and their residuals graphs were developed using curve fit nonlinear regression (user defined equation: $P = b\,x\,(1 - e^{-ct})$. Degradability correlations between components were also test (SAS, 2002 – Pearson correlation procedure was applied).

RESULTS

The crude protein (CP), dry matter (DM), organic matter (OM), cell wall components and digestible dry matter (DDM) (%) of common vetch (*Vicia sativa* L) as obtained in the current study are presented in table 1. The study revealed that common vetch is a protein rich legume (31.5%; Table 1) with high digestible dry matter (72.8%). The degradation profiles for DM, OM, CP, NDF, ADF, Hemicellulose, Cellulose and ADL are presented in figures 1.

Table 1. Mean chemical composition, estimated digestible dry matter (%) of common vetch (*Vicia sativa* L).

Component	Mean	% CV
Air dry matter (aDM)	22.5	10.2
Total dry matter (tDM)	90.8	12.91
Crude protein (CP)	31.5	9.39
Neutral detergent fibre (NDF)	46.5	9.75
Acid detergent fibre (ADF)	20.7	18.44
Acid detergent lignin (ADL)	7.3	23.22
Hemicellulose	25.8	11.35
Cellulose	13.4	8.54
Ash	2.6	28.19
Digestible Dry Matter (DDM)*	72.8	-

* DDM = 88.9 - (0.779 x %ADF) (Bath and Marble, 1989; Grant, 1994)

The results showed that much of the ruminal degradation of *Vicia sativa* occurred within the first 30 h. The model used (Exponential) to illustrate the degradation trend over incubation time, accurately described all the profiles (r^2 ranged from 0.6989 – 0.9988). The rumen degradation parameters of various feed components are presented in Table 2.

As expected, the rumen degradation of various components varied widely (table 2). The obtained results showed that crude protein is highly degradable (a: 54.3 ± 6.2; a + b: 78.4 ± 0.7 and ED: 74.6%). High correlation was observed between degradation of these components and incubation period. The study also tested pair-wise correlations between DM and OM (r^2 = 0.9999, P = 0.0001), DM and CP (r^2 = 0.9992, P = 0.0001), CP and Cell wall components (NDF: r^2 =0.9911, P = 0.0001; ADF: r^2 =0.9744, P = 0.0001; ADL: r^2 = 0.8568, P = 0.0001; Hemicellulose: r^2 =0.9782, P = 0.0001 and Cellulose: r^2 =0.9247, P = 0.0001).

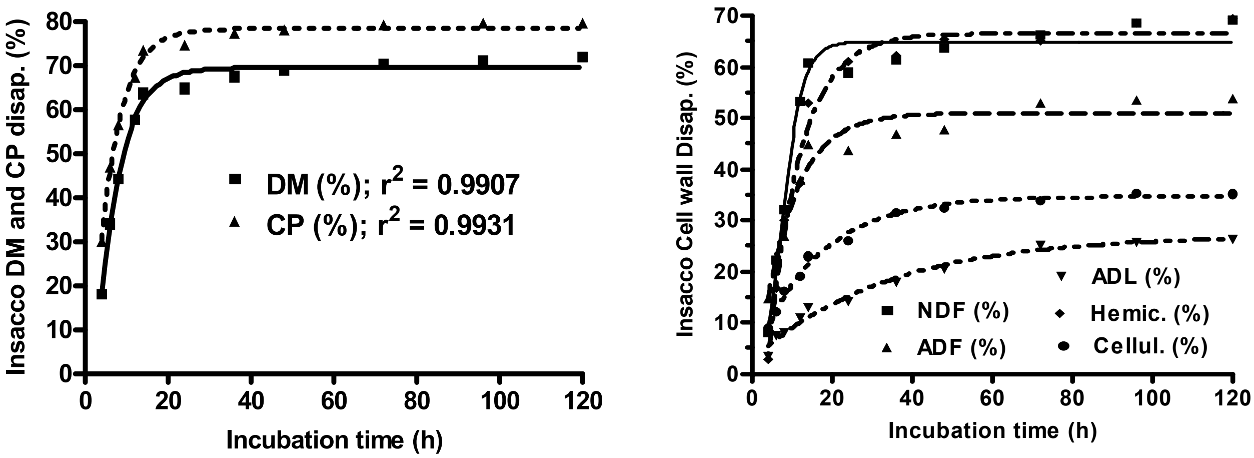

Figure 1. *In sacco* Dry matter (DM), crude protein and cell wall components' degradation for Common vetch (*Vicia sativa L.*)

Table 2. *In sacco* DM, OM, CP and Cell wall degradation parameters for Common vetch (*Vicia sativa*)

	In sacco degradability parameters					
Component	*a*	*b*	*(a + b)*	*c*	R^2	ED
DM (%)	41.81	27.77	69.58	0.2985	0.9907	65.6
OM (%)	41.83	27.95	69.78	0.3011	0.9901	65.8
CP (%)	54.29	24.12	78.41	0.2671	0.9931	74.6
NDF (%)	30.36	34.59	64.95	0.3589	0.9788	60.7
ADF (%)	28.29	22.69	50.98	0.2598	0.9568	47.3
ADL (%)	8.01	18.98	26.99	0.1855	0.9808	22.9
Hemicellulose (%)	21.81	44.72	66.53	0.4242	0.9838	61.8
Cellulose (%)	15.9	18.77	34.67	0.2025	0.9910	30.9

a = Immediately soluble fraction; **b** = Insoluble but rumen degradable fraction; **c** = Rate of degradability;
(a + b)=potential degradation; ED = Effective degradability of the components expressed by: a + b*c/(c + 0.05)

DISCUSSION

The obtained results of chemical composition of *Vicia sativa* were comparable to those reported by past research studies. The DM, OM, CP, NDF, ADF, Hemicellulose, Cellulose and ADL as obtained in the current study were 90.8, 88.6, 31.5, 46.5, 20.7, 7.3, 25.8, and 13.4%, respectively. Other researchers (Aj-Ayed, *et al.***,** 2001 and 2000; Hadjipanayiotou and Economides, 2001, Onzáles and Ndres, 2003 and Arieli *et al*., 1999) have reported a range of OM, CP, NDF, ADF, and ADL from 87.3 – 89%; 16.8 – 26.5%, 44 - 55%, 30.9 - 34% and 9.3 – 9.7%, respectively. These authors also reported digestible protein and NDF ranging between 68.8 – 76.7% and 48.7 – 64.5%, respectively, which are comparable to the results of the current study. Its protein concentration also compares well with those of protein supplementary forages (*Desmodium intortum*): 16.3 - 24%; *Leucaena leucocephala*: 27.2%; *Sesbania sesban*: 27.6%; *Neonotonia wightii*: 22.7% *Pueraria phaseoloides*: 15.1%; *Medicago sativa*: 16.5 – 25.3%; *Ipomoea batatus*: 16.2%) (Mupangwa, *et al*., 2003; Thandei *et al*., 2001; Giang, *et al*, 2004) commonly used on smallholder farms in Kenya. The differences observed between various research findings, can be attributed to the differences in soil related factors, climate and probably the physiological stage of the plant at harvest (Mason *et al*., 1991). The potential for forage dry matter intake and energy depends on cell wall concentration and digestibility (Jung and Allen, 1995). The relatively low content of fibre (NDF: 46.5% and ADF: 20.7%) and the high degradability observe in the current study (Table 1) are positive indicators of the good feeding value of Common vetch. Thus, the low level of fibre can facilitate the colonization of the vetch feed by the rumen microbial population, which in turn might induce even higher fermentation rate, therefore improving its digestibility (Van Soest, 1994). The obtained degradability parameters of common vetch (Table 2) were also observed to be strongly concurring with those obtained in previous studies. It is well known that, the soluble fraction of the protein 'a' includes small water-soluble molecules (NPN, free AA and small peptides), which are released after the feeds reach the rumen and are rapidly converted to ammonia – N (NRC, 1985); the contribution of these compounds to the non degradable protein in the rumen is negligible (Klopfenstein, *et al*., 2001). A criteria to know if the proportion of this fraction is physiologically acceptable, is that it should not be greater than 40% of the protein effectively degraded (AFRC, 1993). In the current study, this fraction was greater than 40% of the protein effectively degraded which may indicate that the capacity to uptake these compounds by the rumen micro-organisms has been overwhelmed during the first phases of the protein degradation. The amount of insoluble but rumen degradable feed protein 'b' depends on the time it is exposed to rumen microorganisms. This fraction represents the consumed protein that potentially may escape rumen degradation but that is absorbed in the small intestine (NRC, 1985) and contributes mostly to the potential degradation 'a + b', which corresponded to the 78.4% in this study. The fraction 'b' of various components as obtained in this study (DM: 27.77; OM: 27.95; CP: 24.12; NDF: 34.59; ADF: 22.69; ADL: 18.98; hemicellulose: 44.72 and cellulose: 18.77%) is comparable to those reported by others (Arieli, *et al*., 1999; Aj-Ayed, *et al***.,** 2001 and 2000). The effective degradation (ED) of the protein is an estimate of the total amount of nitrogen captured and utilized by the rumen microbiota for growth and synthesis of microbial protein (AFRC, 1993). It is reported that proteins in most forages is susceptible to rapid degradation in the rumen (Klopfenstein, *et al*., 2001) especially green forages (Preston and Leng, 1989) amongst which the protein is often degraded up to 73% (Vérité, *et al*., 1987). The ED of plant components as obtained in this study (Table 2) indicated that Common vetch has high protein degradability efficiency (74.6%). Results in the current study, further revealed that, most of the DM, OM, CP and cell wall (NDF, ADF, Hemicellulose and Cellulose) components were lost within the first 8 and 30 h after incubation (Figures 1) suggesting high ruminal degradability of this material.

CONCLUSION

The current study showed that, common vetch contained five times more protein than there is in cereal crop residues. It therefore offers the most practical means of eradicating protein deficiency in ruminant livestock diets on smallholder farms, particularly during the dry season when large proportion of ruminant livestock diets comprise of crop residues. The observed high degradability efficiency further indicates that Common vetch has a potential for improving performance of ruminant livestock on smallholder resource-poor farms in Kenya. It is therefore concluded that Common vetch can be incorporated in the smallholder farming systems as ruminant livestock protein supplement on smallholder resource-poor farms in Kenya.

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