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Estimated microbial protein yield from the rumen of sheep given cottonseed cake or ensiled poultry manure

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Introduction

The metabolizable protein (MP) system (Webster, 1989) partitions rumen degradable nitrogen (RDN) into quickly and slowly degradable nitrogen, QDN and SDN respectively. It is assumed that SDN may be converted into microbial protein nitrogen (MiN) at an efficiency of 1·0 when fermentable energy is not limiting but for QDN the efficiency may be less than 1·0.

Attempts to measure MiN using post-rumenal cannulae and microbial markers are invasive, expensive and slow. In recent years Chen, Hovell, Ørskov and Brown (1990) and Dewhurst and Webster (1992) have attempted to estimate MiN from urinary excretion of purine derivates (measured as allantoin, UAN). The results of Chen *et al.* (1990) suggest that when dietary intake exceeds maintenance the net contributions of endogenous purines and purine salvage are relatively constant so that *increments* of UAN can be equated with reasonable confidence to increments of MiN.

This approach is used here to relate MiN to intake of digestible dry matter (DDM) in sheep given diets in which crude protein was provided from ensiled poultry manure (EPM) and cottonseed cake (CSC) by-products chosen partly because of their importance to tropical agriculture and partly because they differ widely in the ratio QDN : SDN.

Material and methods

The composition of the two diets is shown in Table 1. The carbohydrate sources were wheat, starch and nutritionally improved straw so that EPM and CSC were overwhelmingly the main sources of dietary nitrogen. The ratios QDN : RDN were 0·88 and 0·44 for the EPM and CSC diets respectively. The ratios RDN : ME were designed to be approximately 1·3 : 1 for both diets.

Table 1 *Diet composition*

Composition	Ensiled poultry manure	Cottonseed cake
Estimated metabolizable energy		
ME (MJ/kgDM)	10·6	10·1
Total nitrogen (N) (g/kgDM)	18·3	26·5
Quickly degradable N	11·7	6·0
Slowly degradable N	1·6	7·7
Rumen degradable		
N : ME (g/MJ)	1·26	1·36

Two trials were conducted each with 12 wether sheep. In trial 1, groups of three sheep were given the EPM and CSC at 800 and 1600 g/day, calculated to provide, on average, maintenance (E_m) and twice maintenance ($2E_m$). In trial 2, the same diets were given to six groups of two sheep in amounts calculated to provide 1·0 ×, 1·5 × and 2·0 × E_m.

Each trial involved a 14-day adaptation period and 10-day total collections of urine and faeces. The autoanalyser method for measurement of urinary allantoin has been described by Dewhurst (1989).

Results

The most important mean values from trials 1 and 2 are given in Table 2. In both trials urinary allantoin nitrogen (UAN) was closely related to intake of DDM (g/day). The relationship between intake of DDM and excretion of UAN was the same for diets based on EPM and CSC.

This relationship was examined by linear regression of UAN in DDM for individual sheep. There were no significant differences in regression coefficient between EPM and CSC.

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Table 2. *Intakes of digestible dry matter (DDM), rumen degradable nitrogen (RDN) and urinary excretion of total nitrogen and allantoin nitrogen*

Trial 1	Ensiled poultry manure		Cottonseed cake	
	E_m	$2E_m$†	E_m	$2E_m$†
Intake, DDM (g/day)	498	1013	502	1117
RDN (g/day)	9·85	22·2	9·78	20·1
Urinary N (g/day)	9·88	11·7†	13·3	20·6†
Urinary allantoin N(mg/day)	405	1091†	461	1139†

Trial 2	Ensiled poultry manure			Cottonseed cake		
	E_m	$1{\cdot}5E_m$	$3E_m$	E_m	$1{\cdot}5E_m$	$2E_m$
Intake, DDM (g/day)	451	726	918	526	745	908
RDN (g/day)	9·60	14·5	19·4	10·1	15·3	20·3
Urinary N (g/day)	11·4	12·3	14·7	16·0	21·3	23·9
Urinary allantoin N(mg/day)	599	852	1162	491	844	1237

† In each case the data for one sheep were unreliable and have been excluded.

The pooled regressions (no. = 22) were as follows: (1) UAN (mg/day) = 1·18 DDM (g/day) – 65·5 (s.e. b = 0·15; r^2 = 0·76). (2) UAN (mg/kg$^{0.75}$ per day) = 1·19 DDM (g/day) – 2·89 (s.e. b = 0·15; r^2 = 0·77). The similarity between the error terms for these equations indicates that body size did not affect the relationship between DDM and UAN.

Discussion

Agricultural Research Council (ARC, 1980) recommended an optimal ration of 1·34 g RDN per MJ ME (thus 1·34 g MiN per MJ ME) based on results of trials conducted mostly close to maintenance with conventional diets where 0·65 of the digestible organic matter is assumed to be digested in the rumen. These results indicate that RDN from both diets was being used with equal efficiency for MiN synthesis despite the extreme difference between the two in the ratio QDN : RDN. EPM contains much 'apparent' QDN as uric acid which may release ammonia more slowly than urea. Alternatively, ARC (1980) may be correct in their assumption that when RDN is limiting, both QDN and SDN may be incorporated into MiN at an efficiency of 1·0.

When purine salvage and endogenous loss are constant, an increment of 1 g UAN corresponds to an increment of 17 g in MiN (Dewhurst, 1989). Applying this factor to equation 1, the yield of MiN becomes 20 g/kg DDM, or 1·4 g MiN per MJ ME. This is entirely consistent with the ARC (1980) estimate of the efficiency of microbial yield in circumstances where RDN is limiting. Since the nominal ratio of RDN : ME for the two diets was 1·3 : 1·0, these results imply an efficiency of capture of RDN of 1·07, not significantly different from 1·0, although efficiencies in excess of 1·0 (i.e. incorporation of endogenous nitrogen) are to be expected when RDN is limiting.

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