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Forage evaluation by analysis after fermentation *in vitro*

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Different forages were analyzed after *in vitro* fermentation for amino acid and metabolizable energy content, in order to evaluate their potential as ruminant feeds. Least-cost formulations of supplemental by-pass proteins provide the balance of amino acids required for duodenal amino acid supply. VFA produced in a batch *in vitro* system provides a measure of the ME of a forage.

Verskillende voere is ontleed vir aminosure en metaboliseerbare energie-inhoud na *in vitro* fermentasie om hulle potensiaal as herkouervoer te evalueer. Laagste kostesamestellings van aanvullende deurlaat proteïene voorsien die balans van aminosure wat benodig word vir duodenale aminosuur toevoer. Vlugtige vry vetsure wat in 'n *in vitro* lotssisteem geproduseer is, voorsien 'n maatstaf van die ME van 'n voer.

Keywords: Forage evaluation, amino acids, metabolisible energy, VFA

Introduction

In the nutrition of monogastric animals, analysis of feeds for amino acid and metabolizable energy content, is recognized as the most practical way of assessing the value of the feed, in respect of its macronutrients.

In the case of ruminants, rumen fermentation is interposed between the ingested feed and the animal and so analysis of the feed *per se* is of little value. Rather, by analogy with monogastric animals, analysis of the feed after rumen fermention for amino acid and metabolizable

energy content, should provide more information on the feed as it is made available to the animal.

In many cases the amount of feed available for testing is limited and *in vitro* methods are thus favoured. The studies reported here were consequently aimed at devising a useful method of evaluating forages in the laboratory.

Results and Discussion

Amino acids

In a previous communication (Dennison & Phillips, 1983a) it was argued that the duodenal amino acid supply provided by forages, can be estimated by amino acid analysis of the products of fermentation *in vitro*. Typical results of such analyses are presented in Table 1. These results indicate that after fermentation the amino acid balance of forages is not optimal for either milk or meat production, with histidine usually being the first limiting amino acid.

Practical feed ingredients appear to offer the best prospect for economic balancing of the duodenal amino acid supply, provided their protein can be made to by-pass the rumen. In a study aimed at identifying which ingredients should be considered as candidates for such by-pass studies, the results in Table 1 have been used, together with a matrix of feed ingredient amino acid values and prices, in a series of least-cost computations of the optimal supplement for each fermented forage for milk production (Dennison & Phillips, 1983b). The results of this study (Table 2) reveal that fishmeal, which *per se* by-passes the rumen to a large extent, was a preferred supplement in most cases. Miller, Galwey, Newman & Pike (1982) have independently reported that fishmeal has a beneficial effect upon the economic yield of milk when included in dairy cow rations, a result which tends to support our approach.

Table 1 Amino acid (g) supplied after fermentation of 1 kg of feed

Amino acid	Pasture grass species		
	Dactylis glomerata	*Pennisetum clandestinum*	*Eragrostris curvula*
THR	7,43	9,64	6,20
VAL	10,25	12,91	10,10
MET	2,35	3,25	1,90
ILE	6,64	8,80	6,05
LEU	11,46	15,56	9,98
TYR	6,81	6,62	4,46
PHE	7,87	8,92	6,36
HIS	1,52	2,45	1,49
LYS	5,00	8,47	5,46
ASP	15,54	20,46	13,07
SER	6,52	9,11	5,67
GLU	15,74	20,72	11,37
PRO	5,7	7,59	4,72
GLY	7,61	9,97	6,50
ALA	10,13	13,22	8,29
ARG	5,58	8,61	4,13

Metabolizable energy (ME)

ME patently cannot be measured directly by any *in vitro* method but in this communication we wish to put forward arguments suggesting that simple measurement of the VFA produced during fermentation *in vitro* should provide an estimate of the ME provided by forages.

In a study of the effect of artificial saliva buffer salts, (Dennison & Marais, 1980) it was discovered that the activity of the cellulase enzymes could be 'throttled' by varying the salt concentration. Such 'throttling' of the cellulases revealed that for each forage, cellulose digestion and VFA production were highly correlated ($r = 0,88-0,99$) (Figure 1) and, in agreement with the known stoicheiometry of the conversion of cellulose to VFA, the regression lines shared a common slope which was not significantly

Table 2 Least-cost feed formulations to balance the amino acid supply (for milk production) to protein of milk dry matter at the 15% level

Fermented ingredients (g/100 g)	By-pass proteins (g/100 g)				
	Blood meal	Carcass meal	Poultry by-product meal	Fish meal	Imported fish meal
Eragrostis curvula					
84,9	1,8	—	—	7,4	6,0
81,0	* Excl	8,0	—	8,9	2,1
83,0	Excl	Excl	—	14,3	2,8
Dactylis glomerata					
86,1	3,8	—	—	—	10,2
78,5	Excl	16,2	—	1,9	3,4
82,5	Excl	Excl	—	12,7	4,8
Pennisetum clandestinum					
92,8	5,6	—	—	1,2	0,4
85,7	Excl	14,0	—	—	0,2
89,4	Excl	Excl	—	9,2	1,4

*Excl = ingredient excluded from consideration.

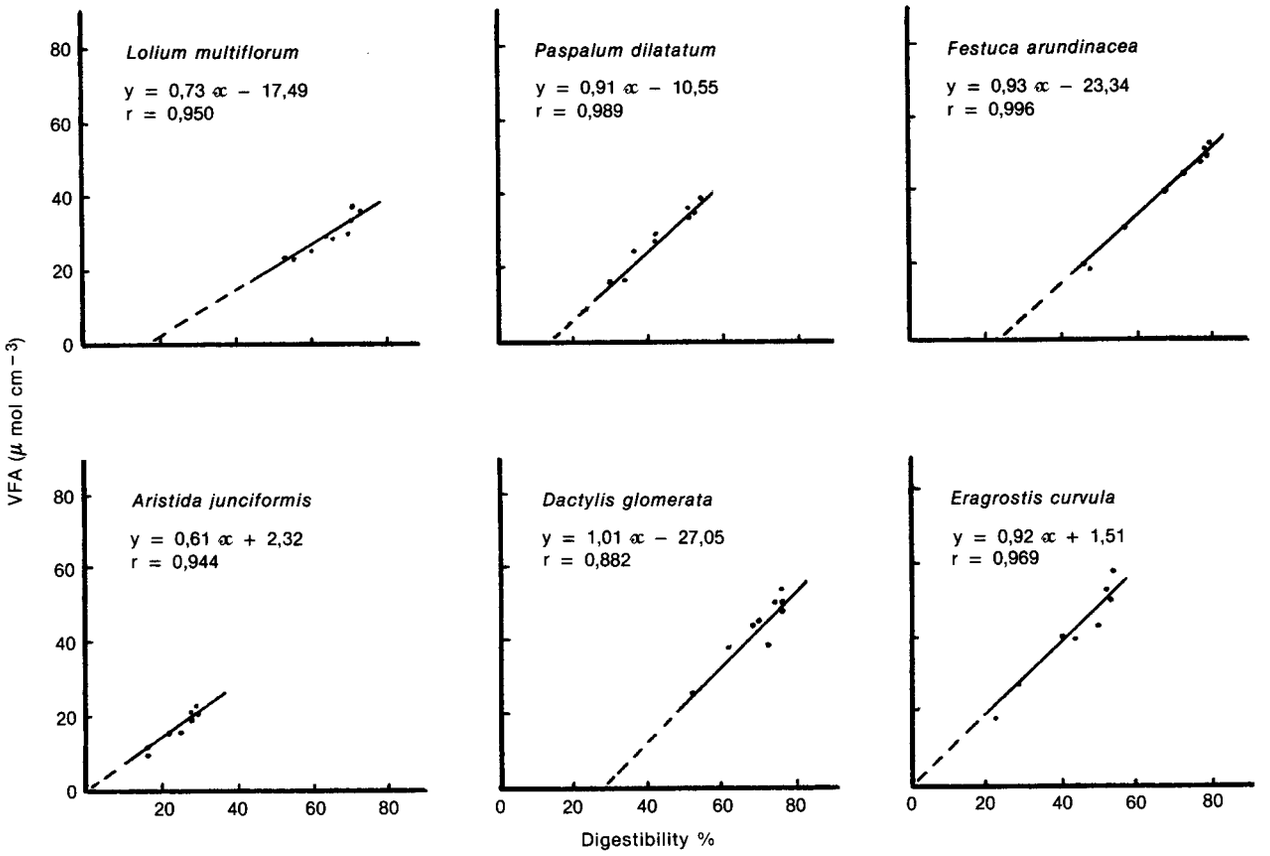

Figure 1 The correlation between digestion of dry matter *in vitro* and *in vitro* yield of VFA from six grass species, different extents of digestion were obtained with different concentrations of artificial saliva buffer (From Dennison & Marais, 1980).

different from the theoretical slope. Non-cellulosic digestible carbohydrates have a similar stoicheiometry of conversion to VFA (Leng, 1973) and since a similar slope should thus apply it should be valid to extrapolate the regression lines observed for cellulose digestion.

The resultant intercept values (x axis) varied markedly between forages, (Figure 1) a difference which we have tentatively ascribed to the presence of soluble material which is not digestible and thus does not yield VFA. It should be pointed out that although 'digestibility' and 'solubilisibility' are often tacitly assumed to be equivalent, not all soluble compounds are necessarily digestible, the soluble but indigestible lignin-carbohydrate complex reported by Nielsen & Richards (1978) being a case in point.

This latter observation provides an explanation of the poor correlation (r = 0,52–0,58) observed between digestibility and animal performance and also the relatively poor correlation (r = 0,71) between DMD and VFA produced *in vitro* when a number of different forages were tested at a single buffer concentration (Barnes, 1973). The above observations also suggest a different approach to the estimation of ME and animal performance.

After fermentation the ME is embodied in the VFA and in microbial cells (Leng, 1973), the amounts of which are stoicheiometrically linked through the ATP molar growth yield or Y_{ATP}. In simple batch fermentation *in vitro* systems the Y_{ATP} is the same as it is *in vivo* and therefore simple measurement of the VFA produced in a batch *in vitro* system should provide a measure of the ME of a forage.

Conclusion

The productive potential of a forage can be estimated by analysis of the products of its fermentation *in vitro* for amino acids and total VFA.

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