FINAL TECHNICAL REPORT

Project Number: R6340
XO291

Project Title: An evaluation of the gas production technique for identifying digestive interaction between high and low quality forages.

Start date: 1 April 1995 **Finish date:** 31 March 1996

Organisation and Project Leader: ADAS Feed Evaluation Unit
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Executive Summary

Whilst responses from ruminants to supplementing poor quality forages with small amounts of higher quality material have been observed, they are not well understood nor quantitatively predictable. The only way of measuring these effects is by way of *in vivo* experimentation involving expensive and lengthy digestibility studies under controlled conditions. Because of this, *in vitro* techniques have been developed to assess individual feeds, but the *in vitro* gas production technique appears to have the potential to study feed mixtures. The objective of the project was to evaluate the gas production technique for identifying digestive interaction between high and low quality forages. To do this sheep were fed low quality forage (wheat straw) with forages of higher quality (high temperature dried grass and lucerne) in terms of digestibility and voluntary intake. A low quality wheat straw was offered *ad libitum* to wether sheep either alone or with four inclusion rates of supplementary high quality forage, (0.1, 0.2, 0.3 and 0.4 dry matter (DM) basis). High temperature dried grass (HTDG) or high temperature dried lucerne (HTDL) were both tested in two concomitant 5 x 5 latin squares, for 14 d of acclimatisation and 7 d where voluntary intake and apparent digestibility of DM and organic matter (OM) were determined. In parallel with the animal studies the ten diet combinations were incubated in buffered rumen liquor (with and without supplementary nitrogen source) and the volume of gas produced with time was measured using a manual pressure transducer apparatus. Dry matter intake and apparent digestibility of OM increased with increasing inclusion of HTD forage, the response for DM intake was linear for HTDL ($P < 0.001$) and non-linear for HTDG ($P > 0.05$). The response was non-linear for both supplements for apparent digestibility of OM. The *in vivo* whole-animal digestibility models will be used to assess the value of the gas

production technique to predict the outcome of feeding these forage mixtures when the *in vitro* data are available.

Background

Ruminant animals have an extremely important role in animal production systems in developing countries and have both economic and social benefits. In addition, they often provide a key link between crop production and human food supply since they can convert low quality crop residues into food whilst their excreta can help sustain soil fertility.

Although in many developing countries the available forage is of low nutritional quality (e.g. high cell wall and low nitrogen contents) the scope for increasing the efficiency of feed utilisation is large. One of the components of this strategy is the supplementation of poor quality forages with small amounts of higher quality forage or agro-industrial by-products with the aim of increasing digestibility and voluntary intake of the poor quality material. Whilst responses to supplementing poor quality forages with small amounts of high quality material have been observed, they are not well understood nor quantitatively predictable. The only way of measuring these effects is by *in vivo* experimentation involving expensive and lengthy digestibility studies under controlled conditions. Because of this, *in vitro* techniques are required which can assess the interactions of one feed upon the other. Most *in vitro* techniques have been developed to assess individual feeds, but the *in vitro* gas production technique appears to have the potential to study feed mixtures.

Project Purpose

The obective of the project was to study in sheep the effect of supplementing low quality forages with those of higher quality in terms of digestibility and voluntary intake and to assess the ability of the *in vitro* gas production technique to predict these responses in the laboratory. If the technique proves successful this would provide a tool to aid decision making about the most efficient way of utilising low quality indigenous resources.

Research Activities

A low quality winter wheat straw was offered *ad libitum* to wether sheep (Clunn cross-bred, approximate liveweight 50 kg) either alone or with four rates (0.1, 0.2, 0.3 and 0.4 dry matter (DM) basis) of supplementary high quality forage, either high temperature dried grass (HTDG) or lucerne (HTDL) in two concomitant 5 x 5 latin squares. Each period lasted 21 d and consisted of 14 d acclimatisation and a 7 d collection period when all faeces and DM refusals were recorded, allowing determination of voluntary intake and apparent digestibility of DM and OM. Animals were fed in two equal meals at 08.45 and 16.45 h according to the latin square designs in Table 1. Initially, maintenance diets for each animal were calculated according to their liveweight at the beginning of each period and then the straw ration was offered at 1.25 of this and adjusted daily to continue to offer the diet at this rate. The amount of high temperature dried forage offered was calculated using the straw offered in the correct proportion and offered at 1.25 of this. A mineral/vitamin supplement for sheep was added to the daily ration at 7 g per sheep per d. Fresh water was freely available.

Table 1. Experiment Design

	Animal									
	Latin Square 1 (HTDG)					Latin Square 2 (HTDL)				
Period	1	2	3	4	5	6	7	8	9	10
1	A	E	D	B	C	D	E	C	B	A
2	D	B	C	A	E	C	D	A	E	B
3	E	D	B	C	A	E	B	D	A	C
4	B	C	A	E	D	B	A	E	C	D
5	C	A	E	D	B	A	C	B	D	E

A = 100% straw; B = 0.9 : 0.1 Straw : either HTDG or HTDL
C = 0.8 : 0.2 " : " " " "
D = 0.7 : 0.3 " : " " " "
E = 0.6 : 0.4 " : " " " "

The results were analysed statistically by analysis of variance and response in voluntary feed intake and apparent digestibility of DM and OM were assessed for linearity using Genstat 5.

In parallel with the animal studies, the ten diet combinations were incubated in buffered rumen liquor (with and without a supplementary nitrogen source) and the volume of gas produced with time was measured using a manual pressure transducer apparatus (carried out at NRI, Wye). The volumes and pattern of gas produced will be assessed for their ability to predict the animal responses.

This preliminary final report covers only Activity 1.1, "Animal Studies to establish the effect of supplementing low quality forage with that of high quality". For Activity 1.2 "Lab Studies to establish whether the gas production technique can identify animal responses", the data were not available at the time of writing. Planned inputs to project XO291 were achieved to schedule.

Outputs

The chemical composition of the wheat straw, HTDG and HTDL are shown in Table 2 below:

Table 2. The chemical composition of the three forages and calculated nutritive value ($g\ kg^{-1}$ DM or as stated)

	Wheat straw	HTDG	HTDL
Dry matter ($g\ kg^{-1}$ fresh)	952	922	909
Ash	73	76	100
Crude protein	34	178	164
NCGD	370	738	636
ME ($MJ\ kg^{-1}$ DM)	3.0[1]	10.8[2]	8.9[3]

[1] Calculated from Givens *et al.* 1991
[2] Calculated from Givens *et al.* 1992
[3] Calculated from Givens *et al*. 1989

The wheat straw was of very low protein content and low digestibility determined by the neutral detergent cellulase and gammanase method. Both the HTDG and HTDL had typical chemical analysis.

Table 3 shows the effects of supplementing low quality forage with varying proportions of either HTDG or HTDL on voluntary feed intake and the apparent digestibility of DM and OM. The 100 per cent straw ration was common for both squares, therefore a two sample t-test was performed for all the parameters and no significant difference was found for any of the digestibility values. It was therefore assumed that the two sets of animals used in the latin squares behaved in a comparable way. There was a significant difference ($P < 0.05$) for straw DM intake ($g\ kg^{-1}$ metabolic bodyweight) between the two squares. For intake the two sets of animals behaved differently though the reason for this is unclear.

Table 3. The effects of supplementing low quality forage with varying proportions of either high temperature dried grass or high temperature dried lucerne on voluntary feed intake and the apparent digestibility of dry matter and organic matter.

	Treatment Straw : HTDF[1]					
	1.0:0	0.9:0.1	0.8:0.2	0.7:0.3	0.6:0.4	SED
<u>HTDG Forage</u>						
Straw inclusion	1.00	0.873	0.758	0.643	0.542	0.0029***
Dry matter intake ($g\ d^{-1}$)	798	907	1054	1256	1457	51.6***
Dry matter intake ($g\ kg^{-1}$ metabolic bodyweight)	43.8	49.3	57.5	68.2	81.2	2.91***
Dry matter digestibility	0.44	0.49	0.51	0.53	0.53	0.017***
Organic matter digestibility	0.47	0.51	0.53	0.55	0.55	0.016***
Digestible organic matter in the dry matter ($g\ kg^{-1}$)	430	476	493	513	510	15.0***
<u>HTDL Forage</u>	1.00	0.877	0.761	0.644	0.568	0.0154***
Straw inclusion	701	846	948	1086	1235	48.5***
Dry matter intake ($g\ d^{-1}$)	36.7	43.4	49.0	56.4	63.8	2.51***
Dry matter intake ($g\ kg^{-1}$ metabolic bodyweight)	0.46	0.49	0.49	0.49	0.49	0.009**
Dry matter digestibility	0.48	0.51	0.52	0.51	0.51	0.009*
Organic matter digestibility	445	469	475	466	465	8.2*
Digestible organic matter in the dry matter ($g\ kg^{-1}$)						

[1] High temperature dried forage

* $P < 0.05$ ** $P < 0.01$ *** $P < 0.001$

The responses in the *in vivo* measurements to increasing inclusion of a high temperature dried forage was assessed for linearity by regression analysis. The regressions are reported in Table 4. For all the parameters the model of best fit is presented. For HTDG, all the responses in animal performance were significantly non-linear and quadratic models were required. With HTDL rations the response for DM intake was linear whereas the response for digestibility could best be described by polynomial models. The models for DM intake and OM digestibility are shown graphically in Figures 1 and 2 respectively.

The whole-animal digestibility models developed here will be used to assess the value of the gas production technique to predict the outcome of feeding these forage mixtures.

Contribution of outputs

An assessment of the contribution of these outputs towards the ODA's developmental goals can not be made in this preliminary final report as the comparison between the animal model and the laboratory technique is not complete. This will be discussed in the finalised report and be published in a scientific journal.

Table 4. Regression analysis of linearity for independent variables (Y) measured *in vivo* and straw inclusion level as treatment code (X)[1]

Independent variable (Y)	Regression Equation	R^2	SEP
<u>HTDG Forage</u>			
Straw inclusion	$Y = 1.107 - 0.1146X$	99.8	0.0083
Dry matter intake (g d^{-1})	$Y = 712.6 + 65.3X + 16.89X^2$	99.8	10.8
Dry matter intake (g kg^{-1} metabolic bodyweight)	$Y = 40.559 + 1.95X + 1.235X^2$	100.0	0.093
Dry matter digestibility	$Y = 0.384 + 0.06431X - 0.00685X^2$	98.5	0.0048
Organic matter digestibility	$Y = 0.4089 + 0.06494X - 0.0073X^2$	97.8	0.0054
Digestible organic matter in the dry matter (g kg^{-1})	$Y = 378.4 + 60.18X - 6.78X^2$	97.8	4.94
<u>HTDL Forage</u>			
Straw inclusion	$Y = 1.099 - 0.1098X$	99.2	0.0160
Dry matter intake (g d^{-1})	$Y = 570.7 + 130.79X$	99.5	14.1
Dry matter intake (g kg^{-1} metabolic bodyweight)	$Y = 31.237 + 5.381X + 0.225X^2$	99.8	0.46
Dry matter digestibility	$Y = 0.379 + 0.1024X - 0.02979X^2 + 0.00278X^3$	98.8	0.00185
Organic matter digestibility	$Y = 0.4128 + 0.0919X - 0.0264X^2 + 0.002378X^3$	97.5	0.00221
Digestible organic matter in the dry matter (g kg^{-1})	$Y = 382.9 + 83.7X - 24.45X^2 + 2.2X^3$	96.7	2.10

1. Straw inclusion level coded 1 = 1.0; 2 = 0.873, 0.877; 3 = 0.758, 0.761; 4 = 0.643, 0.644; 5 = 0.542, 0.568 (for HTDG and HTDL latin squares respectively)

SEP, Standard error of prediction

Figure 1 Response of supplementing straw with either high temperature dried grass or lucerne on dry matter intake (g kg^{-1} metabolic bodyweight)

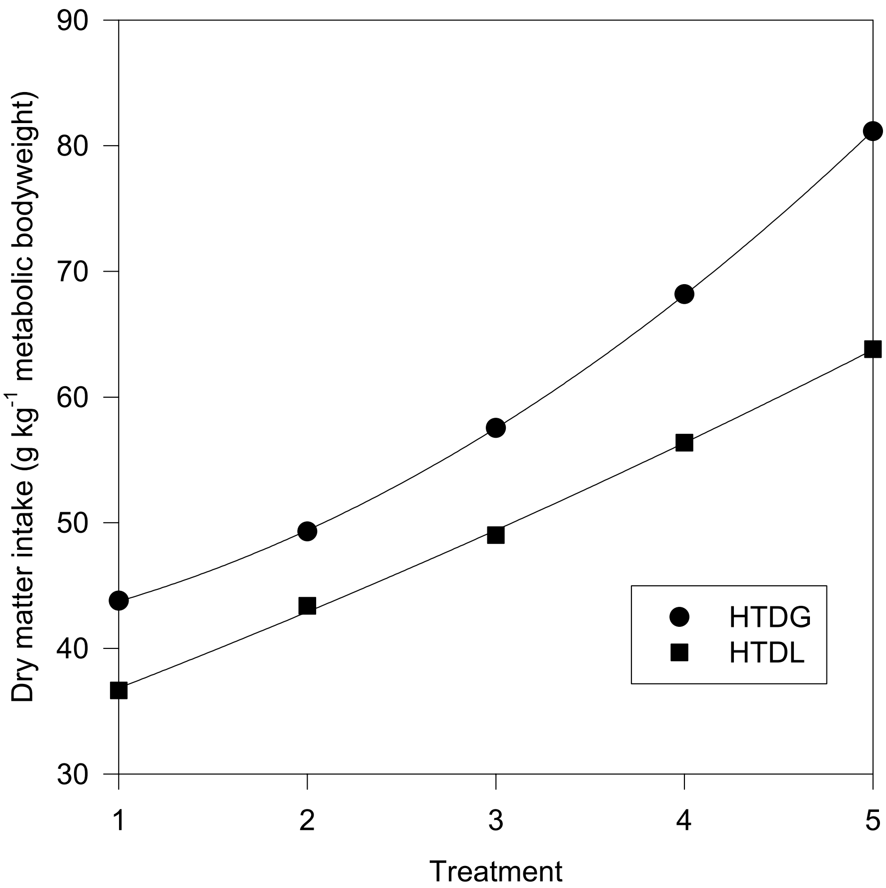
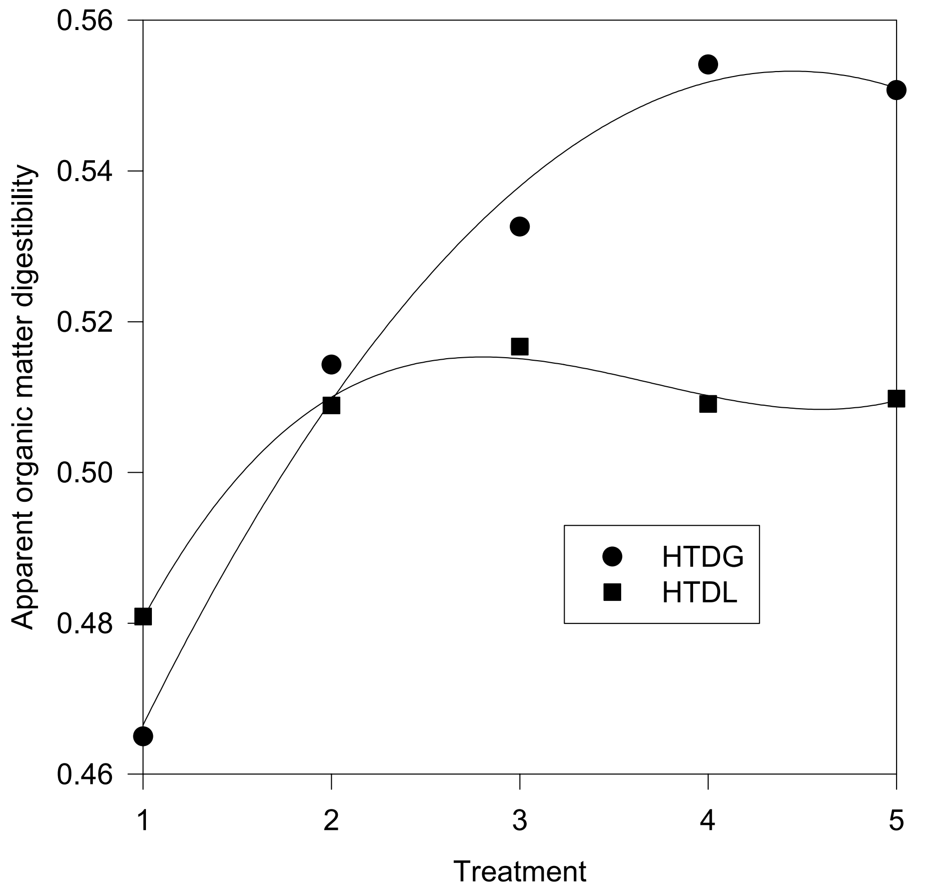


Figure 2 Response of supplementing straw with either high temperature dried grass or lucerne on apparent organic matter digestibility



References

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