Short Communications/ Kort Mededelings

The influence of roughage on the digestibility of whole maize grain diets

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Four rumen-cannulated steers were fed a diet consisting of whole maize grain, high protein concentrate and molasses. Two of the four animals received 10% ground *Eragrostis curvula* hay in addition to the whole maize grain diet. The feeding period was divided into four periods of 11 days to determine the effect of adaptation on digestibility. In a further final period of 11 days, the diets were fed manually via cannulae to avoid initial mastication of the grain. For the animals receiving no roughage, the *in vivo* dry matter digestibility values for the five periods were as follows: 83,7; 84,4; 81,8; 80,0 and 81,4%, whereas for animals receiving additional roughage, corresponding values were 73,7; 71,8; 70,2; 71,6 and 67,7%.

Vier rumengekannuleerde osse het 'n dieet bestaande uit heel mieliegraan, hoë-proteïenkonsentraat en melasse ontvang. Twee van die vier diere het ook 10% gemaalde *Eragrostis curvula*-hooi bykomend tot die heel mieliegraandieet ontvang. Ten einde die invloed van aanpassing op verteerbaarheid te ondersoek is die voerperiode in vier periodes van 11 dae elk verdeel. Gedurende 'n verdere finale periode van 11 dae is die diëte met die hand deur die kannula aan die diere gevoer. Sodoende is aanvanklike kou van die graan uitgeskakel. In die geval van die diere wat geen ruvoer ontvang het nie, was die *in vivo* droëmateriaal-verteerbaarhede vir die vyf genoemde periodes as volg: 83,7; 84,4; 81,8; 80,0 en 81,4%. Die ooreenstemmende waardes vir die diere wat wel ruvoer ontvang het, was 73,7; 71,8; 70,2; 71,6 en 67,7% respektiewelik.

Keywords: Whole maize, feeding, roughage, digestibility, beef cattle

The extent to which maize grain is digested in the rumen depends largely on the physical form in which it occurs in the rumen. Both Mehrez & Ørskov (1977) and Liebenberg, Meissner & Pienaar (1979), clearly demonstrated that virtually no whole maize grain (WMG) organic matter disappeared from dacron bags suspended in the rumen for periods of up to 96 h. These authors, as well as Itakawa, Hoshino & Itoh (1964) and Wilson, Adeeb & Campling (1973) concluded that, at normal digesta passage rates, microbes are unable to penetrate the testae of whole grain. The animal is therefore dependent on chewing and rumination to release the readily available carbohydrates. However, one of the many factors influencing the chewing and rumination of WMG diets, is roughage inclusion. Cole, Johnson & Owens (1976), Lofgreen (1980) and Rust & Owens (1981a,b) found that the inclusion of roughage at various levels adversely affected total diet digestibility. It seems therefore that total exclusion of roughage, as successfully implemented by Hixon, Hatfield & Lamb (1976); Fain, Backus, Johnson, Anderson, Bryan & Robinson (1979); Lofgreen (1980); Ørskov, Barnes & Lukins (1980); Lyle, Johnson & Backus (1981) and Lyle, Johnson, Wilhite & Backus (1981), should be practised in WMG feeding systems, provided that metabolic disorders can be avoided. Unfortunately all the zero roughage experiments have been of such a nature that the reason for the negative influence of roughage cannot be accurately assessed. Although the positive relationship between roughage inclusion and rumination has been well established on meal type of diets, Nicholson, Gorrill & Burgess (1971) confirmed this relationship in the case of WMG diets. However, in spite of this, these workers found no increase in apparent digestibility and it would therefore seem that a significant amount of time is spent on the mastication and rumination of roughage, rather than WMG.

The aims of this study were firstly to investigate the influence of added roughage on total diet digestibility; secondly, to determine whether total diet digestibility changes as the animals adapt to WMG feeding; and thirdly to quantify the influence that rumination *per se* has on total diet digestibility. Four rumen-cannulated steers (*ca* 600 kg livemass), with extensive previous exposure to WMG feeding, were fed *ad libitum* on a diet consisting of 94% WMG, 3% high protein concentrate (Table 1) and 3% molasses. The purpose of the molasses was to coat the WMG with the high protein concentrate. The animals received only *Eragrostis curvula* hay prior to the experiment and no adaptation period from hay to WMG was allowed. However, the intake data obtained during the first 3 days on the WMG and the WMG with additional roughage diets, were not included.

In addition to this WMG diet, two of the four animals also received 10% (determined as a percentage of the WMG intake on an 'as fed' basis) 25 mm-hammermilled *Eragrostis curvula* hay throughout the experimental period. All animals were fed twice daily. Faeces were collected from the floor. The bulked amount was weighed and sampled daily. In order to demonstrate possible adaptational changes in either dry matter digestibility (DMD), roughage intake or organic matter retention time in the rumen, the 44-day feeding period was divided into four 11-day periods. The ruminal contents were manually emptied twice during each period for each animal. The rumen contents were weighed and sampled for dry matter and organic matter analyses. Upon completion of this phase the animals were fed, via the cannulae, an amount of diet equal to their mean individual free choice daily intake ('as fed' basis) as determined during the previous phase (44-day feeding period). The daily feed allowance was divided into two equal

Table 1 Composition of the high protein concentrate

Component	%
Urea	28,8
Limestone	25,4
Dicalcium phosphate	15,2
Salt	17,8
Sodium bicarbonate	5,1
Potassium sulphate	5,1
Vitamin and mineral premix[a]	2,6
Concentrate of Lasalocid[a]	0,6
Concentrate of Terramycin[a]	0,2

[a]Commercial products

Table 2 Effect of feeding method, period and level of roughage (0 and 10%) on mean DM intake, DM digestibility and roughage intake of steers fed WMG diets

	Fed *per os* over the period:								Fed *per cannula*	
	3 – 14 days		15 – 25 days		26 – 36 days		37 – 47 days		51 – 61 days	
Measurement	0%	10%	0%	10%	0%	10%	0%	10%	0%	10%
Mean DM intake (kg/day)	*7,33[a]	8,21[abc]	7,85[ab]	10,38[bcd]	8,73[ab]	10,90[bcd]	10,22[bcd]	11,88[cd]	8,48[bcd]	9,68[bcd]
DM digestibility (%)	83,7[a]	73,7[b]	84,4[a]	71,8[b]	81,8[a]	70,2[b]	80,0[a]	71,6[b]	81,4[a]	67,7[b]
Roughage intake as percentage of DM intake	–	9,4	–	8,7	–	5,7	–	3,8	–	10,81
OM content in rumen (kg)	13,7	11,3	14,1	11,5	13,8	11,3	13,7	11,4	13,8	10,2
Range	(12,7 – 15,1)	(8,1 – 14,6)	(11,7 – 15,9)	(9,1 – 15,0)	(11,1 – 15,9)	(8,6 – 14,2)	(12,8 – 14,7)	(8,3 – 14,6)	(11,8 – 15,1)	(7,6 – 12,6)
OM retention time in rumen (h)	49,4	36,7	49,7	29,0	41,8	26,6	34,8	24,5	43,4	27,5
Range	(40,0 – 57,5)	(32,1 – 43,1)	(40,2 – 61,8)	(27,3 – 32,7)	(35,9 – 50,8)	(24,8 – 28,1)	(30,9 – 37,9)	(21,6 – 27,2)	(35,9 – 54,6)	(24,9 – 31,4)

*Values in the same row with different superscripts differ significantly ($P < 0,05$)

portions, which were then placed in the rumen at 08h00 and 15h30. This procedure continued for 14 days. The first 3 days were once again considered as an adaptation period and the data obtained during this period were not included. As in the case of the first four periods, the ruminal contents were emptied twice and the same procedures followed.

From the results shown in Table 2 it is evident that apparent *in vivo* DMD differed significantly between the no-roughage (0 – R) and the roughage-added (10 – R) diets, but not between periods. The mean apparent *in vivo* DMD value for the whole 44-day feeding period was 82,5% for the 0 – R diet and 71,8% for the 10 – R diet. This difference is greater than the percentage of roughage inclusion, so even if the roughage in the 10 – R diet was totally indigestible, the added roughage had a further detrimental effect on the digestibility of the grain. Furthermore, in the 10 – R treatment there was a significant ($P < 0,05$) decrease in the free choice intake of roughage as a percentage of total DM intake from 9,4% during period 1 to only 3,8% during period 4. This is in accordance with the findings of Van Niekerk & Tarr (1982) and Campher, Shelby, Meissner & Janse van Rensburg (1983). This decrease is associated with an increased energy density of the diet consumed, which should in turn lead to higher apparent *in vivo* DMD values. Because the present results contradict this, it is a further indication that the decrease in apparent *in vivo* DMD is not primarily due to the additive effect of the lower digestibility of the roughage in comparison to that of the WMG.

Total DM intake of both animals in the 0 – R treatment increased significantly ($P < 0,05$) with time from a mean of 7,33 kg/day during period 1 to 10,22 kg/day during period 4. This same trend, although not significant, was evident in the animals of group 10 – R where the mean daily DM intake increased from 8,21 to 11,88 kg over the 44-day feeding period.

In the second phase when the animals were fed via the cannula the different parameters remained virtually the same. *In vivo* apparent DM digestibility was 81,4% for the 0 – R treatment, which was significantly ($P < 0,05$) higher than the 67,7% for the 10 – R treatment. These values did not differ significantly within treatment from the mean value attained during the first four periods. The slightly lower apparent DM digestibility of 67,7% for the 10 – R treatment, although not significantly different from the 71,8% over the first four periods, could be linked to the manual roughage inclusion level of 10,81% (DM basis). This was in excess of that consumed by the same animals when fed *per os*. Mean DM intakes, mean OM content in the rumen and mean OM retention time in the rumen were similar to the mean values attained during the previous four periods.

Interpretation of values pertaining to organic matter (OM) content in the rumen as well as OM retention time in the rumen was difficult due to variation between animals within treatments. There was, however, a tendency for the OM content to be lower and the OM retention time in the rumen to be shorter on the 10 – R treatment than on the 0 – R treatment.

From the results it is evident that roughage inclusion suppressed the apparent DM digestibility of WMG in the diet. The adaptation to the diets over time that led to increased levels of intake of both groups and decreased levels of roughage in the diet 10 – R did not influence apparent DM digestibility. The fact that feeding *per os* or *per cannula* had no influence on any of the parameters clearly indicates that the animals could compensate fully for lack of initial chewing (mastication) by rumination later on.

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