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# Influence of roughages on rumen retention time of concentrates

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The effect of roughages on the retention time of concentrates in the rumen was studied in cattle and sheep fed diets with different concentrate:roughage ratios. The organic matter retention times were calculated from the ratio, OM content in the rumen/mean daily OM intake. In general, the retention time of the maize meal based concentrate diet increased with decreasing roughage inclusion level although the actual retention time was regulated by the nature of the roughage source.

Die effek van ruvoer op die retensietyd van konsentrate in die grootpens is bestudeer by beeste en skape wat rantsoene met verskillende verhoudings kragvoer tot ruvoer ontvang het. Die retensietyd van organiese materiaal is bereken van die verhouding organiese materiaal in die grootpens/gemiddelde daaglikse inname van organiese materiaal. In die algemeen het die retensietyd van 'n mieliemeel gebaseerde dieet toegeneem namate die hoeveelheid ruvoer verminder het, hoewel die werklike retensietyd gereguleer is deur die aard van die ruvoerbron.

**Keywords:** Roughage, concentrate, retention time, rumen flow, rumen biokinetics

## Introduction

Although some work was done on the rumen biokinetics of leaf and stem fractions of legumes and grasses (Hendricksen, Poppi & Minson, 1981; Poppi, Minson & Ternouth, 1981 a, b), little is known of the effect that roughages have on the retention time of concentrates which obviously has an important influence on animal productivity. Campher (1983) determined the optimal concentrate:roughage ratios for different roughage sources in high maize fattening diets for steers. It was found that for similar animals maximum DOM intake differed little at the optimal concentrate:roughage ratios between divergent roughage sources. Hence it would seem that the roughages, in conjunction with the concentrate, led to similar rumen environments in spite of widely different physical characteristics. It was found for instance that a 90:10 concentrate to sunflower hulls ratio gave similar DOM intake and growth results to a 65:35 concentrate to *Eragrostis curvula* (6 mm hammer-milled) hay ratio diet.

## Experimental

The data used in this paper were obtained from Campher (1983) and Meissner, Campher, Van Staden & Shelby (1982). Campher (1983) determined the organic matter (OM) content in the rumens of growing steers at slaughter. The same determinations were also performed on cannulated mature

steers (Campher - unpublished data) while Meissner *et al.* (1982) used heifers and wethers at slaughter. The organic matter retention times were in all instances calculated from the relationship (OM content in the rumen)/(Mean daily OM intake).

The roughages and their ranges of inclusion (values in brackets) used in these experiments were sunflower hulls (5 – 40% for intact and 5 – 14% for cannulated steers); cotton seed husks (9 – 18% for cannulated steers); 51 mm *Eragrostis curvula* hay (0 – 100% for heifers and wethers and 5 – 35% for intact steers); 25, 13 and 6 mm *Eragrostis curvula* hay (5 – 35% for intact steers); pelleted and unpelleted bagasse (6 – 36% for intact steers); 51 mm wheat straw (6 – 36% for intact and 12 – 21% for cannulated steers); 25 and 13 mm wheat straw (6 – 36% for intact steers) and finally 6 mm wheat straw (6 – 36% for intact and 26 – 35% for cannulated steers).

## Results and Discussion

Linear relationships were found between OM retention time in the rumen and level of roughage inclusion. These relationships clearly indicated a reduced OM retention time with increases in the maize meal based concentrate. A covariance analysis revealed highly significant differences ($P < 0,01$) in intercepts and non-significant ($P < 0,05$) differences in slopes between groups. The preferred estimate for the single univariate slope for all groups was 0,97 ± 0,10 and all cattle data in Table 1 were taken into account in its estimation. The sheep estimate did not differ significantly from the cattle estimate.

The OM retention time of the concentrate (intercept) was obtained by extrapolation to 100% concentrate. In most cases extrapolation was only five or six percentage units beyond the lowest roughage inclusion level. Hence, the uncertainty owing to extrapolation is small. The retention time of each roughage *per se* can be estimated by adding the hypothesized constant slope to the intercepts shown in Table 1.

From Table 1 it is of some interest to observe that, with intact steers, sunflower hulls, 51 and 25 mm hammer-milled *Eragrostis curvula* and 51 mm wheat straw had similar intakes of DOM (17 g/kg day) when associated with significant differences in retention time of the concentrate. In the case of *Eragrostis curvula* (Ec) hay, smaller roughage particles consistently induced shorter retention times of the concentrate, although the 13 mm hammer-milled particles resulted in the highest DOM intake (18g/kg day) which was higher than that of the 6 mm particles. This relationship between sieve size and retention time of Ec was, however, not repeated for wheat straw. On wheat straw based diets the

**Table 1** Effect of roughages on the retention time of roughages in the rumen

| Roughage Source | *Type of animal | +Retention time of concentrate (day) | Concentrate: roughage ratio at maximum DOM intake | OM content in rumen per kg live mass at maximum intake (g/kg W) | Maximum DOM intake (g/kg W/day) |
|---|---|---|---|---|---|
| Sunflower | | | | | |
| hulls | IS | $0,63^{a}$ | 90:10 | 17 | 17 |
| | CS | $0,60^{ab}$ | 89:11 | 11 | 8 |
| Cotton seed | | | | | |
| husks | CS | $0,57^{ab}$ | 85:15 | 16 | 11 |
| *Eragrostis curvula* | | | | | |
| 51 mm | H | $0,43^{bc}$ | 80:20 | 13 | 14 |
| 51 mm | W | $0,54^{ab}$ | 100:0 | 15 | 21 |
| 51 mm | IS | $0,54^{bc}$ | 85:15 | 15 | 17 |
| 25 mm | IS | $0,50^{bcd}$ | 75:25 | 12 | 17 |
| 13 mm | IS | $0,41^{de}$ | 75:25 | 12 | 19 |
| 6 mm | IS | $0,31^{fgh}$ | 65:35 | 12 | 18 |
| Bagasse | | | | | |
| Unpelleted | IS | $0,39^{ef}$ | 88:12 | 10 | 18 |
| Pelleted | IS | $0,44^{de}$ | 88:12 | 12 | 15 |
| Wheat straw | | | | | |
| 51 mm | CS | $0,43^{cde}$ | 82:18 | 12 | 10 |
| 51 mm | IS | $0,30^{gh}$ | 88:12 | 6 | 17 |
| 25 mm | IS | $0,22^{h}$ | 76:24 | 6 | 15 |
| 13 mm | IS | $0,38^{efg}$ | 76:24 | 8 | 18 |
| 6 mm | IS | $0,28^{h}$ | 70:30 | 11 | 16 |
| 6 mm | CS | $0,44^{cde}$ | 71:29 | 13 | 9 |

* H = Heifers (growing)
W = Wethers (growing)
CS = Cannulated steers (mature)
IS = Intact steers (growing)

+Values with same superscript(s) do not differ significantly ($P > 0,05$)

13 mm hammer-milled roughage had the highest intake for intact steers, but was associated with the longest retention time. This observation is in accord with the generalization that both too long and too short retention times may reduce intake. The highest DOM intakes of the intact steers were associated with retention times between 0,3 and 0,4; the majority being nearer to 0,4 than 0,3. However, a retention time of 0,4 is by itself no guarantee of a high intake, as is illustrated by the pelleted bagasse based diets.

The mature cannulated steers showed large differences from the growing intact ones, either owing to cannulation or to degree of maturity. It is also evident that the OM content of the rumen can vary widely between roughage and concentrate inclusion levels. There also seemed to be a slight tendency for maximum DOM intake to occur at lower levels of roughage inclusion when the roughages had longer retention times.

In conclusion it can be said that the maize meal based concentrate caused constant increases in retention time with decreasing roughage inclusion levels, but that the overall level or range of retention times of mixtures is regulated by the nature of the roughage.

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