Effect of casein supplementation and hay quality on non-ammonia N flow to the abomasum in sheep

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A low quality *Eragrostis curvula* hay was supplemented with 30 or 80 g casein in the rumen with or without 70 g casein in the abomasum, and a medium quality *E. curvula* hay with 30 g casein in the rumen with or without 70 g casein in the abomasum. Six rumen and abomasal cannulated sheep were used in a Latin-square design. Hay intake and ADG were improved by an increase in hay quality and casein administration to the abomasum but not by an increase in casein supplementation to the rumen. Similarly, non-ammonia N flow to the abomasum was increased by an increase in hay quality and postruminal addition of casein but not by an increase in casein administered to the rumen. It was suggested that either the release of C-skeletons from a natural protein source in the rumen does not contribute much to microbial protein formation or that the protein source should not be highly soluble, i.e. slow releasing, to be effective. In contrast, microbial protein production should be increased by rumen-protected protein via recirculation of urea whether forage quality is low or high, and thereby cause a production response.

'n Lae-kwaliteit *Eragrostis curvula*-hooi is aangevul met 30- of 80 g kaseïen in die rumen met of sonder kaseïen in die abomasum, en 'n medium-kwaliteit *E. curvula*-hooi met 30 g kaseïen in die rumen in die teenwoordigheid of afwesigheid van 70 g kaseïen in die abomasum. Ses rumen- en abomasaalgekanuleerde skape is in 'n Latynse vierkantontwerp gebruik. Hooi-inname en GDT is verbeter deur 'n toename in hooikwaliteit en kaseïentoediening in die abomasum, maar nie deur 'n verhoogde kaseïenpeil in die rumen nie. Soortgelyk is nie-ammoniak-N-vloei na die abomasum verhoog met 'n toename in hooikwaliteit en kaseïentoediening in die abomasum, maar nie deur kaseïenpeil in die rumen nie. Daar is voorgestel dat, óf die vrystelling van C-skelette vanaf 'n natuurlike proteïenbron in die rumen nie veel bydra tot mikrobeproteïenproduksie nie, óf dat die proteïenbron stadig moet degradeer (derhalwe nie hoogs-oplosbaar moet wees nie). Daarenteen sal mikrobeproteïenproduksie verhoog word deur nie-degradeerbare proteïen via ureumhersirkulasie, ongeag die kwaliteit ruvoer, en derhalwe sal 'n produksierespons bewerkstellig word.

Keywords: Casein supplementation, hay quality, N flow, sheep

Supplementation of natural protein to the rumen may be beneficial because a slow release of amino acids in the rumen should increase the efficiency of microbial protein synthesis (Hume, 1974; Maeng, van Nevel, Baldwin & Morris, 1976). The beneficial effect results also because amino acid C-skeletons are used by the microbes as a source of energy (Redman, Kellaway & Leibholz, 1980). Non-protein nitrogen (NPN) supplementation, though, appears to be effective only if the forage is sufficiently digestible to act as an adequate source of energy for potential microbial production (Ørskov & Grubb, 1978), suggesting that utilization of very low quality forages and straws will not benefit much from NPN supplementation alone, but may benefit from natural degradable protein in the rumen. This question was addressed in the present study by contrasting a low quality hay with a higher quality one and using different levels of casein as rumen supplements. Casein was also administered postruminally for comparison.

Six rumen and abomasal cannulated Merino-type whethers were allocated to one of six treatments according to the prescribed procedures of a 6 × 6 Latin-square design. In four of the treatments a low quality *Eragrostis curvula* hay (IVDOM 45%, N in DM 0,62%) was used and in the remaining two a medium quality *E. curvula* hay (IVDOM 52%; N in DM 1,21%). The supplements were as follows: Low quality hay: 30 and 80 g casein in the rumen with or without 70 g casein in the abomasum; medium quality hay: 30 g casein in the rumen with or without 70 g casein in the abomasum. Additionally, a standard supplement consisting of 5,5 g urea, 11 g NaCl, 8 g K_2SO_4, 15 g dicalciumphosphate and 1 g of a vitamin-trace mineral premix was fed through the rumen cannula.

The supplements were administered through the cannulae as pulse doses in two equal portions at 08h00 and 14h00, respectively. Reasons for pulse dosing instead of continuous infusion are given by Meissner & Todtenhöfer (1989). The casein to the abomasum was administered by means of 150 ml 0,9% NaCl solution (saline) and where treatments did not require casein in the abomasum, a similar amount of saline was administered.

The animals were fed four times daily, equally spaced, and voluntary intake of hay was measured for nine days following an adaptation phase of seven days. Between treatments all sheep were returned to a standard treatment of the low quality hay, the standard supplement and 30 g casein in the rumen for five days. The aim was to minimize carry-over effects.

In addition to intake, ADG, N and non-ammonia (NAN) flow to the abomasum, rumen NH_3-N and volatile fatty acids (VFA) were observed. Rumen NH_3-N and VFA were determined from a pooled sample, but collected as six samples per day over three days. ADG was calculated following fasted weight determinations on days 8 and 17 of a treatment. Flow of digesta from the rumen to the abomasum was measured between days 8 and 16 using Cr-EDTA as a marker (Faichney, 1980). Rumen and abomasal NH_3-N concentration was determined by the micro-Kjeldahl method (Markham, 1942). To avoid contamination with casein, abomasal samples for these determinations were spaced to the effect that any particular sampling period was at least 4 h postadministration. Non-ammonia N was calculated as the difference between total N flow and NH_3-N flow. Volatile fatty acids were determined by gas chromatography.

The Latin square was statistically analysed as prescribed (Fisher & Yates, 1963) using Tukey's *t* test for differences between treatments.

The results are shown in Table 1.

Intake of hay was not significantly altered by level of casein administered to the rumen. It was, however, significantly increased by casein supplementation to the abomasum and by an increase in quality of hay. A response to intake with postruminal casein was reported also by Egan (1965), Kempton & Leng (1979), and in one experiment of Meissner & Todtenhöfer (1989), but not in the others. Contrasting results on this issue are often found in the literature, the reasons being unclear (Meissner & Todtenhöfer, 1989).

The response to intake with rumen-protected protein is related to the amount of amino acids being absorbed from the gut. If more is absorbed, which is usually the case with rumen-protected protein, indispensable amino acids and glucogenic precursors are supplied (Kempton & Leng, 1979; Leng, 1981) and the effects of slow fermentation in the rumen are alleviated through continuous recirculation of urea (Leng, 1984; Meissner & Todtenhöfer, 1989). Significantly more NAN flowed to the abomasum on treatments with casein supplemented in the abomasum than on treatments without. In contrast, level of casein supplementation in the rumen did not significantly affect NAN flow to the abomasum and consequently, in accordance with the argument above, intake was not significantly influenced.

Table 1 Effect of site of casein supplementation and quality of hay on hay intake, ADG, VFA production and N flow to the abomasum

	Low quality hay				Medium quality hay		
	$30C_R$*	$30C_R$ $70C_A$**	$80C_R$	$80C_R$ $70C_A$	$30C_R$	$30C_R$ $70C_A$	SE_m
Hay intake							
(g OM.d^{-1})	710^{a}	813^{b}	691^{a}	775^{ab}	942^{c}	1073^{d}	50,3
N intake from hay							
(g.d^{-1})	$4{,}62^{a}$	$5{,}28^{a}$	$4{,}49^{a}$	$5{,}04^{a}$	$12{,}0^{b}$	$13{,}6^{c}$	0,54
+ N supplem.(g.d^{-1})	$11{,}0^{a}$	$20{,}7^{d}$	$17{,}3^{b}$	$26{,}9^{e}$	$18{,}4^{c}$	$29{,}0^{f}$	0,54
ADG (g)	$-46{,}2^{ab}$	$83{,}2^{bc}$	-115^{a}	$98{,}3^{bc}$	$18{,}7^{abc}$	178^{c}	89,0
Rumen NH_3-N							
(mg.100ml^{-1})	$18{,}6^{a}$	$18{,}9^{a}$	$27{,}6^{c}$	$29{,}0^{c}$	$22{,}4^{ab}$	$23{,}1^{b}$	2,32
Rumen VFA							
(mmol.100ml^{-1})	10,0	10,1	10,0	10,1	10,5	10,5	0,50
C_2 (%)	$80{,}0^{c}$	$79{,}3^{c}$	$75{,}7^{a}$	$76{,}4^{ab}$	$77{,}4^{b}$	$77{,}6^{b}$	0,74
C_3 (%)	$12{,}6^{a}$	$12{,}9^{ab}$	$13{,}8^{c}$	$13{,}5^{c}$	$13{,}7^{c}$	$13{,}4^{bc}$	0,32
n–C_4 (%)	$4{,}70^{a}$	$5{,}13^{ab}$	$5{,}61^{bc}$	$5{,}44^{b}$	$6{,}05^{cd}$	$6{,}25^{d}$	0,29
Abomasal flow:							
Water (1.d^{-1})	$9{,}76^{ab}$	$9{,}73^{a}$	$9{,}53^{ab}$	$9{,}05^{a}$	$10{,}2^{ab}$	$11{,}6^{b}$	1,08
DM (g.d^{-1})	341^{a}	426^{a}	352^{a}	394^{a}	472^{ab}	613^{b}	92,4
N (g.d^{-1})	$7{,}90^{a}$	$16{,}8^{b}$	$9{,}13^{a}$	$16{,}3^{b}$	$12{,}6^{ab}$	$22{,}8^{c}$	2,93
NAN (g.d^{-1})	$6{,}56^{a}$	$15{,}4^{b}$	$7{,}13^{a}$	$14{,}5^{b}$	$11{,}1^{ab}$	$20{,}9^{c}$	2,88

* C_R = casein in rumen.

** C_A = casein in abomasum.

[abc] Figures in the same line with different superscripts differ at the 5% level of probability.

Average daily gain was, similarly to intake, significantly altered by postruminal addition of casein and hay quality, but not by level of casein in the rumen. These results were also supported by the pattern of NAN flow to the abomasum. Meissner & Todtenhöfer (1989) showed that supplementation with casein in the rumen instead of NPN with or without energy may improve N retention and production parameters. The present results suggest that the improvement is probably limited as NAN flow to the gut was not increased by an increase in level of casein supplementation to the rumen. The reason may well be the high solubility of casein in rumen fluid (here substantiated by the high rumen NH_3-N levels), which would not be conducive to a slow release of amino acids. The positive effect of amino acid C-skeletons as an energy source for microbial production (Redman *et al.*, 1980) does not appear to be of much practical significance. This is supported by Mackie (1988).

Consequently, if natural protein supplementation to the rumen is to be advantageous for utilization of low quality forages, as suggested above, it can only be if the protein source is highly degradable but not highly soluble, that is slow releasing. This hypothesis, though, needs to be tested.

Non-ammonia N flow to the abomasum on the medium quality hay in comparison to the low quality hay was higher, as a result of significantly higher abomasal fluid and DM flows in response to the significantly higher hay intake. Presumably the higher fermentability of rumen contents on the medium quality hay yielded more energy substrates per unit of time for microbial growth. However, it would appear that the efficiency of microbial production (crudely calculated here as $g.NAN.gIVDOM^{-1}$) must have been very similar, suggesting that even with better quality forages amino acid availability in the gut would be limiting because intake is still limited by rumen distension. Therefore, it is expected that rumen-protected protein, depending on amino acid composition, would yield a production response irrespective of forage quality as shown here and demonstrated by Miller & Pike (1984) when feeding fish meal to steers on high quality pasture in the UK.

Volatile fatty acid concentration was not significantly altered by level of casein in the rumen or quality of hay, although the VFAs on the medium quality hay tended to be higher than on the low quality hay. The proportion acetic acid in the VFA's was significantly influenced by level of casein in the rumen and by hay quality. Acetic acid was reduced by an increase in casein level and hay quality while the reduction was compensated for by a corresponding significant increase in the proportion propionic and n-butyric acids. The shift in VFA production away from acetate and towards propionate and maybe butyrate, with an increase in hay quality, is usual. The ratio between C2 and C3 + C4 narrows if the fermentability of the rumen content increases. Being the case, the supply of C-skeletons from casein (Redman *et al.*, 1980), presumably, would narrow the C2:C3 + C4 ratio accordingly, which would explain the VFA production response to casein administered to the rumen.

References

EGAN, A.R., 1965. Nutritional status and intake regulation in sheep. 2. The influence of sustained duodenal infusions of casein or urea upon voluntary intake of low-protein roughages by sheep. *Aust. J. Agric. Res.* 16, 451.

FAICHNEY, G.J., 1980. The use of markers to measure digesta flow from the stomach of sheep fed once daily. *J. agric Sci. Camb.* 94, 313.

FISHER, R.A. & YATES, F., 1963. Statistical tables for biological, agricultural and medical research. Oliver and Boyd, Edinburgh, Tweedale Court, 6th edn.

HUME, I.D., 1974. The proportion of dietary protein escaping degradation in the rumen of sheep fed on various protein concentrates. *Aust. J. Agric. Res.* 25, 155.

KEMPTON, T.J. & LENG, R.A., 1979. Protein nutrition of growing lambs. 1. Responses in growth and rumen function to supplementation of a low-protein cellulosic diet with either urea, casein or formaldehyde-treated casein. *Br. J. Nutr.* 42, 289.

LENG, R.A., 1981. Modification of rumen fermentation. In: Nutritional limits to animal production from pastures, ch. 6. Ed. Hacker, J.B., Commonwealth Agricultural Bureaux, pp.427.

LENG, R.A., 1984. Supplementation of tropical and subtropical pastures for ruminant production. In: Herbivore nutrition in the subtropics and tropics. Ed. Gilchrist, F.M.C. & Mackie, R.I., The Science Press, Craighill, pp.129.

MACKIE, R.I., 1988. Personal communication. Department of Animal Sciences, University of Illinois, Urbana, IL 61801, USA.

MAENG, W.J., VAN NEVEL, C.J., BALDWIN, R.L. & MORRIS, J.G., 1976. Rumen microbial growth rates and yields : effect of amino acids and protein. *J. Dairy Sci.* 59, 58.

MARKHAM, R., 1942. A steam distillation apparatus suitable for micro-Kjeldahl analysis. *Biochem J.*, 36, 790.

MEISSNER, H.H. & TODTENHÖFER, U., 1989. Influence of casein and glucose or starch supplementation in the rumen or abomasum on utilization of *Eragrostis curvula* hay by sheep. *S.Afr. J. Anim. Sci.* 19, 43–49.

MILLER, E.L. & PIKE, I.H., 1984. Feeding for profitable beef production : Use of fish meal to improve feed efficiency and reduce feeding costs. IAFMM, Hoval House, Herts, England.

ØRSKOV, E.R. & GRUBB, D.A., 1978. Validation of new systems for protein evluation in ruminants by testing the effect of urea supplementation on intake and digestibility of straw with or without sodium hydroxide treatment. *J. agric. Sci. Camb.* 91, 483.

REDMAN, R.G., KELLAWAY, R.C. & LEIBHOLZ, JANE, 1980. Utilization of low quality roughages : Effects of urea and protein supplements of differing solubility on digesta flows, intake and growth rates of cattle eating oaten chaff. *Br. J. Nutr.* 44, 343.