

The Effect of the Roughage to Concentrate Ratio on Ruminal pH and Ammonia Nitrogen Concentration

Z. Ilić, J. Stojković

Faculty of Agriculture, ZubinPotok, Serbia

R. Đoković, V. Kurćubić

Faculty of Agronomy, Čačak, Serbia

Abstract: The experiments included three fistulated rams that were approximately 18 months of age. Three weight ratios of roughage to concentrate were used in the experiment. The animals were fed twice a day at 7 A.M. and 3 P.M. The contents of the rumen were taken just before feeding and again every two hours before the next feeding.

The roughage to concentrate ratio affected ruminal pH. The highest ruminal pH was reported for the ration with the largest proportion of roughage. A reduction in the proportion of roughage in the ration induced a decrease in ruminal pH.

The dynamics of ammonia release in the rumen contents was also dependent on the roughage to concentrate ratio. The fastest dynamics of ammonia release in the rumen contents was established in the rams fed ration containing 80% roughage and 20% concentrate feed.

Key words: rams, rumen, pH, ammonia nitrogen

Introduction

Dietary proteins entering the rumen undergo the proteolytic activity of microorganisms. As a result of this activity, most proteins are broken down into peptides and amino acids which, subsequently, undergo desamination. The ensuing ammonia is used as a source of nitrogen for microbial protein synthesis. For this reason, proteins of microbial origin and food proteins which have evaded decomposition in the rumen enter the small intestine, where most amino

acids are being absorbed. Each of these protein sources for the cuds has its own significance and its biological value. (Hahemeister *et al.* 1980).

Decomposition of raw proteins would be optimal if the nitrogen from the compounds developed through protein decomposition satisfied the needs of microorganisms for maximum progress (Orskov 1982).

The symbiosis between the cud and the microorganisms settled in the rumen of the host animals enables feed utilization which is of minor or no significance for the nutrition of the non-cuds.

Cellulose bacteria produce a cellulase enzyme, which has a devastating effect on cellulose, thus making nutrients available for nourishment. Microorganisms are capable of using non-protein sources of nitrogen, and by incorporating it into their own cell bodies they become a source of protein for the cuds.

Several works have been published on the effect of the roughage to concentrate ratio on ruminal pH and ammonia nitrogen concentration as observed from different points of view. It has been proved that ruminal pH (Lindberg 1983, Lee *et al.* 2006, Pawel *et al.* 2006) and ammonia nitrogen concentration (Stern *et al.* 1978, Lee *et al.* 2006, Suarez *et al.* 2007) are affected by different roughage to concentrate ratios.

The objective of this work was to show the effect of different roughage to concentrate ratios in the diet on ruminal pH and ammonia nitrogen concentration.

Material and Methods

The experiments included three fistulated rams approximately 18 months of age. The animals were of similar weight of 65 kg (more precisely, two rams weighing 65 kg each and one 66 kg). Permanent plastic fistulas were surgically inserted into the rumen of the rams. The rams were placed in individual cages which enabled individual feeding and watering and complete control of the examined animals.

The animals were fed twice a day at 7 AM and 3 PM. Daily rations consisted of two completely equal parts of lucerne hay as roughage and a concentrate mixture of corn, sunflower meal, wheat bran, dicalcium phosphate, salt and a mineral-vitamin premix. Three weight ratios of roughage to concentrate were used during the experiment, being 80:20; 50:50 and 20:80.

Rumen contents were taken just before feeding and again every two hours before the next feeding. Determination of ruminal pH was done instantly after the rumen sampling. About 30 ml of the ruminal contents were taken through the fistula using pipettes specifically adjusted to the procedure. pH was measured by a Radiometer Copenhagen pH meter.

The Conway microdiffusion method was used to determine the ruminal concentration of ammonia nitrogen.

In order to affirm the validity of differences in ruminal pH during the digestive process, a statistical data processing was carried out by a double-factor analysis of variance for identification of the level of significance of differences between treatment environments. The established differences between the treatment environments were tested by LSD-test.

Results and Discussion

The average ruminal pH for the three roughage to concentrate ratios in the diet are given in Table 1 and Figure 1.

The values given represent the average results for six replications.

The highest pH was reported for the ration containing 80% roughage and 20% concentrate and lower pH for the ration composed of 50% roughage and 50% concentrate at all samplings. The lowest ruminal pH was identified in the ration consisting of 20% roughage and 80% concentrate, four hours after feeding.

The test showed significant differences ($P < 0.01$) between the rations used, suggesting that the ration composition affected ruminal pH.

Tab. 1. Average ruminal pH

Ration	Time of rumen sampling (h)				
	7 a.m.	9 a.m.	11 a. m.	1 p.m.	3 p. m.
80 : 20	6.69	6.48	6.37	6.49	6.55
50 : 50	6.59	6.37	6.23	6.19	6.44
20 : 80	6.52	6.25	5.98	6.21	6.33

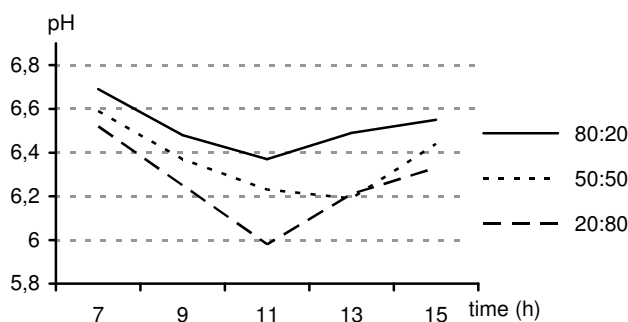


Fig. 1. The effect of the roughage to concentrate ratio on ruminal pH

Considerable differences ($P < 0.01$) were also established between time intervals of rumen sampling after different rations had been fed, except between pH values established six hours after feeding the 50:50 ration and during the same time interval but after the 20:80 ration had been fed, with the differences being non-significant. The LSD-test showed differences between ruminal pH established after feeding the rams the 50:50 ration and pH determined after the 20:80 ration had been fed, the differences in ruminal pH being significant at ($P < 0.05$).

Significant differences were identified as well ($P < 0.01$) between pH values at all periods of sampling for each ration fed except 4 and 6 hours after the 50:50

ration had been fed and 2 and 6 hours after the 20:80 ration, the measured ruminal pH being significant at ($P < 0.05$).

Lindberg (1983) reported that the highest pH was produced by the ration consisting of hay, whereas a reduction in hay proportion of the ration induced a decrease in ruminal pH. This study conformed to the results obtained by the cited authors, as well as by Suarez *et al.* (2007) who determined that ruminal pH declined with increasing concentrate proportion of the ration.

The intensity of albumen proteolysis and desamination of amino acids during the protein decomposition in the rumen contents could successfully be followed by identifying ruminal concentration of ammonia nitrogen, apparently the final product of dissolution of dietary nitrogen (Santoso *et al.* 2004).

The obtained results on the ruminal concentration of ammonia nitrogen as dependent on different roughage to concentrate ratios are given in Table 2 and Figure 2.

Tab. 2. Ammonia nitrogen concentration in the rumen contents (mg%)

Ration	Time of ruminal sampling (h)				
	7 a.m.	9 a.m.	11 a.m.	1 p.m.	3 p.m.
80 : 20	19.48	22.16	17.61	16.34	14.12
50 : 50	15.29	15.31	11.53	10.3	8.16
20 : 80	9.36	7.26	6.44	4.99	3.88

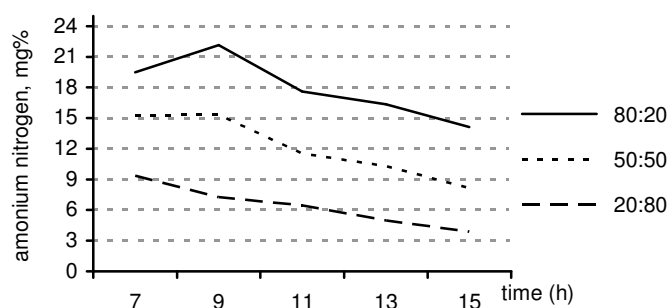


Fig. 2. Ammonia nitrogen concentration in the rumen contents, mg%

The given values represent average results for six replications. The level of ammonia nitrogen in the rumen contents was the highest with the first ration. The portion comprising 50% roughage and 50% concentrate showed weaker dynamics of ammonia release during the food digestion process and at all intervals of sampling. The lowest level of ruminal ammonia nitrogen was established for the third ration.

A two-factor analysis of variance was used to confirm the validity of the observed differences. The established differences between the treatment environments were tested by LSD-test.

The test showed highly significant differences ($P < 0.01$) in ammonia nitrogen concentration obtained after different rations had been fed. Likewise, there were significant differences ($P < 0.01$) in ruminal ammonia nitrogen concentrations recorded at the same interval but after different rations had been fed. Significant differences were reported as well ($P < 0.01$) between the results gained at different time intervals for each ration except for the interval at which the rumen contents were sampled before feeding and two hours after feeding on the ration containing 50% roughage and 50% concentrate, the observed differences being, however, not statistically significant.

The obtained results conformed to those of Santoso *et al.* (2004), Lee *et al.* (2006), Suarez *et al.* (2007).

The rate of protein decomposition in the rumen is dependent on both the protein size and the type of ration. With respect to the fact that ammonia is the final product of protein decomposition, it was believed that ruminal ammonia levels are among indicators of ammonia use efficiency in animals. However, recent studies suggest that successful dietary protein decomposition is not always followed by low utilization of ammonia.

In view of the above fact, it should be pointed out that a very rapid increase in ammonia concentration in the rumen induces a considerable increase in the blood levels of ammonia and its excretion as urine or ammonia salts.

Conclusions

The roughage to concentrate ratio affected ruminal pH. The highest ruminal pH was reported for the ration with the largest proportion of roughage. A reduction in the proportion of roughage in the ration induced a decrease in ruminal pH. The highest measured pH of 6.69 was established before feeding on the ration having the largest proportion of roughage, whereas the lowest pH of 5.98 was determined 4 hours after feeding on the ration with the smallest roughage proportion.

The above suggested that all rations provided optimal conditions for the protease and peptidase activities to occur since optimal pH for the activities was 5.5-7.

The dynamics of ammonia release in the rumen contents was also dependent on the roughage to concentrate ratio in the diet. The fastest dynamics of ammonia release in the rumen contents was established in the rams fed ration containing the highest proportion of roughage. A decrease in roughage proportion induced a slower dynamics of ammonia release in the rumen. Therefore, the slowest dynamics of ammonia release was established after the rams had been fed the ration containing the lowest proportion of roughage.

References

- Hahemeister H., Luping W., Kaufmann W. (1980): Microbial protein synthesis and digestion in the high-yielding dairy cow. In Haresinh W. (eds), Recent advances in animal nutrition, Butterworths, 67-84 pp.
- Lee M. R. F., Tweed J. K. S., Dewhurst R. J., Scollan N. D. (2006): Effect of forage: concentrate ratio on ruminal metabolism and duodenal flow of fatty acids in beef steers, *Animal Science*, **82**: 31-40 Cambridge.
- Lindberg J.E. (1983): *Factor affecting predictions of rumen degradability using the nylon bag (in sacco) technique and a comparison between in vivo and in sacco degradability measurements*. Ph.D. diss., Swedish University of Agric. Sci, Uppsala.
- Orskov E. R. (1982): *Protein nutrition in ruminants*. Academic Press Inc., London.
- Pisulewski P.M., Okorie A.U., Buttery P.J., Haresign W., Lewis D. (2006): Ammonia concentration and protein synthesis in the rumen. *Journal of the Science of Food and Agriculture*, **32**: 759-766.
- Santoso B., Mwenya B., Sar C., Gamo Y., Kobayashi T., Morikawa R., Takahashi J. (2004): Effect of *Yucca schidigera* with or without nisin on ruminal fermentation and microbial protein synthesis in sheep fed silage- and hay-based diets. *Animal Science Journal*, **6**: 525-531.
- Stern M. D., Hoover H., Sniffen C. J., Crooker B. A. Knowiton P. H. (1978): Effect on structural carbohydrate, urea and soluble protein levels on microbial protein synthesis in continuous culture of rumen contents, *J. Anim. Sci.*, **47**: 944-956.
- Suarez B. J., Van Reenen C. G., Stockhofe N., Dijkstra J., Gerrits W. J. J. (2007): Effect of Roughage Source and Roughage to Concentrate Ratio on Animal Performance and Rumen Development in Veal Calves, *J. Dairy Sci.*, **90**: 2390-2403.

UTICAJ ODNOSA KABASTE I KONCENTROVANE HRANE NA pH VREDNOST I KONCENTRACIJU AMONIJAČNOG AZOTA U SADRŽAJU RUMENA

-originalni naučni rad-

Z. Ilić, J. Stojković

Poljoprivredni fakultet, Zubin Potok

R. Đoković, V. Kurćubić

Agronomski fakultet, Čačak

Rezime

Ogledi su izvedeni na tri fistulirana ovna starosti oko 18 meseci. U ispitivanjima su korišćena tri težinska odnosa između kabaste i koncentrovane hrane. Hranjenje životinja je obavljano dva puta dnevno i to u 7 i 15 sati. Sadržaj buraga je uziman neposredno pre hranjenja i na svaka dva sata do sledećeg hranjenja.

Odnos kabaste i koncentrovane hrane je imao uticaja na pH vrednosti buražnog sadržaja. Na obroku sa najvećim udelom kabastog dela ustanovljene su i najviše pH vrednosti buražnog sadržaja. Smanjenje učešća kabastog dela obroka dovelo je do opadanja pH vrednosti buražnog sadržaja.

Dinamika oslobađanja amonijaka u sadržaju buraga takođe je bila u zavisnosti od odnosa kabaste i koncentrovane hrane u obroku. Najbrža dinamika oslobađanja amonijaka u sadržaju buraga ustanovljena je na obroku sa 80% kabaste i 20 % koncentrovane hrane.