

EFFECT OF LARGE DOSES OF ZINC BACITRACIN ON VOLUNTARY INTAKE, MASTICATION AND DIGESTIBILITY OF HAY IN ADULT RUMINANTS

LIISA SYRJÄLÄ

University of Helsinki, Department of Animal Husbandry

Received July 15, 1970

Abstract. Two cows were used in the trials. They received timothy hay as their only feed. As the antibiotic doses were increased during the experiment, the cows' hay consumption decreased. The maximum zinc bacitracin doses were 80—100 mg per kg live weight.

Sieve fractionations of the faeces were made to investigate the efficiency of the mastication of the feed. The crude faeces fractions increased with increases in the zinc bacitracin doses, indicating that the mastication of the food was depressed.

Lignin was used as an indicator when investigating the digestibility of the food. The results show that zinc bacitracin depressed the digestibility of the plant cell wall substances. There was also a decrease in the digestibility of the other constituents of the hay.

It has been known for about twenty years by now that antibiotics, in very small doses, improve the utilization of food and increase growth in chickens and pigs. Antibiotics have also been shown to have a favourable effect on the growth of calves (CUNHA 1955). The case of ruminants is in a class by itself as regards antibiotics given as a feed supplement. The digestion of ruminants depends to a great degree on the activity of the rumen microbes and antibiotics may cause changes in the composition of this microflora and -fauna (MUNCH-PETERSEN and ARMSTRONG 1968, PURSER *et al.* 1965). Many *in vitro* trials (HUNGATE 1966, FULGHAM *et al.* 1968, PRINS 1969) have shown that antibiotics are injurious to the protozoa and cellulose digesting bacteria and so indirectly decrease the digestibility of roughage. Feeding trials with adult ruminants have given conflicting results (RUSOFF *et al.* 1952, CHANCE *et al.* 1963, JUKES 1955, KLOPPENSTEIN *et al.* 1969, MITCHELL *et al.* 1969). In general, the addition of antibiotics to feeds for adult ruminants is not recommended (McDONALD *et al.* 1966).

The purpose of this study is to study the effect of large oral antibiotic doses on the voluntary intake, mastication and digestibility of hay in adult cows. The word mastication means in this work the mincing of the feed in the whole alimentary tract. Zinc bacitracin was chosen because it is not absorbable from the alimentary tract (A-L., Zinc Bacitracin 1962).

Experimental procedure

Two dry Ayrshire cows were used in this experiment. The cows, Ilmu and Nopea, were of different ages and sizes. Ilmu was 7 years old and weighed 674 kg at the beginning of the experiment, while Nopea was 3 years and weighed 417 kg.

The cows were fed solely on chopped timothy hay. It was given *ad libitum*, but the amount consumed at each feeding time was noted. The animals were fed twice a day. They had free access to water.

The preparation used in this experiment was Norwegian A-L Zinc Bacitracin containing 54 % zinc bacitracin. The amounts given here represent pure Zn-bacitracin. Bacitracin powder in a capsule was pushed directly down the throat of the cow. It was found more practical to give the antibiotic in this way than to mix it with water and give it from a bottle, as had been done in the preliminary trials.

The preliminary trials indicated that 20 g/day of zinc bacitracin would be suitable for the first experimental period of the cow Nopea. The antibiotic ration of the cow Ilmu in the corresponding period was 25 g/day. So the relation of zinc bacitracin to the amount of hay consumed in Period 0 (only hay given) was about the same for both cows, and averaged 2.5 g of zinc bacitracin per kg hay.

The amounts of pure zinc bacitracin (g/day) given in the different experimental periods were as follows:

period	cow Nopea	cow Ilmu
1	20	25
2	28	35
3	40	50

Results and discussion

Voluntary intake. Tables 1 and 2 show that zinc bacitracin has an individual effect on the consumption of hay. As from Period 0 (no Zn-bacitracin) to Period 1 (smallest amounts of Zn-bacitracin), the average daily hay consumption by the cow Nopea diminished 2.7 kg whereas by cow Ilmu it diminished only 0.5 kg. Table 1 shows that the average daily hay consumption of the cow Nopea was about the same in Periods 1 and 2, but that the consumption dropped sharply when the antibiotic dose was increased to 40 g/day (Period 3). Table 2 shows that the daily hay consumption of the cow Ilmu diminished later in Period 3. This cow tolerated 50 g of antibiotic for 8 days and was then taken ill with diarrhoea. The return of appetite in the cows was investigated by giving them only hay *ad libitum* after the antibiotic treatment. This test was made after Period 3. It took one week before Ilmu's hay consumption was back to normal, while Nopea's recovered within 2—3 days.

Efficiency of mastication. The efficiency of the mastication of the hay with different doses of zinc bacitracin was studied by taking sieve analyses of the faeces (PALOHEIMO, SYRJÄLÄ and VAINIO 1968). The results are shown in Table 3.

The fractions remaining on the sieves consist of the exogenous part of the faeces (PALOHEIMO 1962, PALOHEIMO 1966), and contain mainly plant cell wall substances derived from the food. The fraction passing through all the sieves consists to a great degree of

Table 1. Daily hay consumption (kg) of the cow Nopea in different experimental periods.

Experi- mental day	Period 0 (no Zn- bacitracin)	Period 1 (20 g/day Zn- bacitracin)	Period 2 (28 g/day Zn- bacitracin)	Period 3 (40 g/day Zn- bacitracin)
1	7.7	5.2	5.4	6.2
2	7.4	3.0	7.4	0.4
3	7.5	3.3	6.0	
4	8.1	4.6	5.8	
5	9.4	7.1	5.8	
6	9.7	5.2	6.3	
7	7.1	6.6		
8	7.6	7.1		
9	7.6	6.6		
10	9.0	5.8		
11	9.1			
12	8.7			
13	8.0			
Average	8.2	5.5	6.1	

Table 2. Daily hay consumption (kg) of the cow Ilmu in different experimental periods.

Experi- mental day	Period 0 (no Zn- bacitracin)	Period 1 (25 g/day Zn- bacitracin)	Period 2 (35 g/day Zn- bacitracin)	Period 3 (50 g/day Zn- bacitracin)
1	9.6	11.0	9.2	7.5
2	5.8	8.3	7.7	6.8
3	8.9	8.6	7.7	4.8
4	10.3	8.5	8.5	4.7
5	10.2	6.1	9.6	6.5
6	10.5	8.0	7.8	3.7
7	9.1	9.4	6.0	3.2
8	9.3	9.8		1.0
9	8.5	10.3		
10	9.6	8.7		
11	9.0	7.1		
12	9.4			
13	9.5			
14	8.4			
Average	9.2	8.7	8.1	4.8

endogenous and bacterial material and probably of cell wall particles small enough to pass through the 0.1 mm sieve. Table 3 indicates that Zn-bacitracin tended to depress slightly the mincing of the hay.

Table 3. Percentages of dry matter of faeces remaining on different sieves.

Cow	Zinc bacitracin g/day	Experimental period and day	Remaining on 1.0 mm sieve	Remaining on 0.5 mm sieve	Remaining on 0.1 mm sieve	Total	Passing through 0.1 mm sieve
Nopea	—	0-period, day 14	5.6	12.9	30.7	49.2	50.8
»	20	1-period, day 11	8.7	18.9	26.3	53.9	46.1
»	28	2-period, day 7	6.1	13.6	32.4	52.1	47.9
»	40	3-period, day 3	13.3	16.0	21.7	51.0	49.0
Ilmu	—	0-period, day 14	5.0	12.0	30.6	47.6	52.4
»	25	1-period, day 11	5.9	16.0	27.8	49.7	50.3
»	35	2-period, day 7	5.9	12.9	31.6	50.4	49.6
»	50	3-period, day 8	8.8	12.4	30.5	51.7	48.3

The depressing effect of zinc bacitracin on the mincing of hay may actually be somewhat stronger than is suggested by Table 3. It was seen in the preceding section that large doses of the antibiotic decreased the consumption of feed. This makes it possible for the feed to be more thoroughly ground since it has been shown that smaller amounts of food stay a proportionally longer time in the rumen and the mouth than larger ones (PALOHEIMO and MÄKELÄ 1952, 1959). In spite of this, the antibiotic depressed mastication.

Digestibility. For the investigations of the digestibility of the feed, faeces samples were taken from both cows in Period 0, from Nopea in Period 2 (Zn-bacitracin 28 g/day) and from Ilmu in Period 3 (Zn-bacitracin 50 g/day). Tables 4 and 5 show the results of the analysis, the digestibility percentages and the amounts of digestible nutrients in the different experimental periods.

From the hay and faeces samples determinations were made of dry matter, ash, crude protein and cell wall substances, the last mentioned being determined as the sum of their chemical fractions (SALO 1965). The cell wall substances were also determined as a complex from hay by the method of PALOHEIMO and VAINIO (1965) and from the faeces by the method of PALOHEIMO and SYRJÄLÄ (unpublished, see also PULLIAINEN, PALOHEIMO and SYRJÄLÄ 1968, p. 8). In the latter method the exogenous material of the faeces is separated from the endogenous and bacterial material by ultrasonic treatment and filtration through glass sinter. The cell wall complex is obtained from a certain crude fraction (F-fraction) by extraction with 80 % (v/v) ethanol and by using ash and crude protein corrections. 0.05 N acid fibre was determined by the method of PALOHEIMO (1945) with a small modification. In the case of the faeces samples it was determined from the F-fraction after ethanol extraction. From the hay samples also crude fibre determinations were made, using the Weende method as modified by Puranen and Tomula (ref. PALOHEIMO 1969), as well as water soluble sugars (SALO 1965).

Crude lignin was determined by the method of SALO (1965) and corrected for protein to obtain the value for pure lignin. This substance, referred to simply as lignin, was supposed to be completely indigestible and was selected as the indicator in the digestibility trial. Although digestibility values calculated in this way are not very exact, they show the effect of the antibiotic supplement on the digestibility of the food.

In compiling the right-hand parts of Tables 4 and 5 it was supposed that the exogenous organic matter of the faeces equals the organic matter of the F-fraction. This being so, the exogenous crude protein of the faeces equals the crude protein of the F-fraction. Further the exogenous N-free organic cell enclosure substances equal the exogenous N-free organic matter minus the cell wall complex. The digestibility values in the left-hand part of the tables show the apparent digestibility of hay, with the exception of the values of the cell wall complex, which are true. The values in the right-hand part show the true digestibility.

Table 4 shows that the cows digested a relatively small proportion of the dry matter of the hay: Nopea 51.9 % and Ilmu 49.0 %. This was at least partly due to the fact that the hay was not of very good quality although it was blooming timothy hay (crude fibre 34.8 % of dry matter). Its sugar content was only 5.8 % of the dry matter.

In the cow Nopea 28 g of zinc bacitracin per day decreased the digestibility of the organic matter by about 10 %-units, although it had no effect on the hay consumption (Table 1). The decrease in the digestibility of the cell wall complex and the hemicellulose was also about 10 %-units, while that of the cellulose was 7.8.

Table 4. The dry matter and chemical components of hay and faeces as percentages of dry weight and the digestibility percentages in different experimental periods.

	Dry matter	Cr ₂ O ₃ free ash	Org. matter	Crude protein	N-free org. matter	Cell wall complex	N-free org. cell enclosure subst.	0.05 N acid fibre	Cell wall subst. (SALO's meth.) Hemicellulose					Exogenous ²			
									Neutral sugar anhydrides	Uronic anhydrides	Cellulose	Lignin ¹	Total	Org. matter	Crude protein	N-free org. matter	N-free org. cell. enclosure subst.
Hay	88.3	7.3	92.7	10.9	81.8	65.6	16.2	54.4	21.3	4.2	26.8	9.6	61.9	92.7	10.9	81.8	16.2
Faeces:																	
Cow Nopea																	
0-period	17.4	11.6	88.4	11.3	77.1	54.5	22.6	47.3	18.2	4.7	20.4	19.9	63.2	58.2	1.8	56.4	1.9
2- »	17.2	9.3	90.7	11.5	79.2	57.2	22.0	51.5	19.3	4.8	21.0	17.0	62.1	61.3	1.9	59.4	2.2
Cow Ilmu																	
0-period	15.5	10.3	89.7	13.8	75.9	51.9	24.0	45.3	18.2	4.3	18.4	19.0	59.9	55.8	1.9	53.9	2.0
3- »	19.7	10.6	89.4	13.0	76.4	56.2	20.2	48.9	18.3	4.5	19.7	17.4	59.9	60.4	2.3	58.1	1.9
Digestibility %:																	
Cow Nopea																	
0-period	51.9	23.3	54.2	50.5	54.6	60.1	32.7	58.1	58.7	45.2	63.4	0.0	50.9	69.8	91.7	66.9	94.4
2- »	43.3	27.4	44.6	40.4	45.1	50.6	22.8	46.3	48.8	35.7	55.6	0.0	43.1	62.5	89.9	58.8	92.6
Cow Ilmu																	
0-period	49.0	27.4	50.7	35.8	52.7	59.6	24.7	57.5	56.3	47.6	64.9	0.0	50.7	69.3	90.8	66.4	93.8
3- »	45.2	20.5	47.1	34.9	48.8	53.0	31.5	50.7	53.1	40.5	59.7	0.0	47.0	64.3	88.1	61.1	93.8

¹) Crude lignin obtained by Salo's method and corrected for protein.

²) Derived from food.

Table 5. Digestible nutrients, expressed as g per 100 g of dry matter of hay, in different experimental periods.

	Dry matter	Ash	Org. matter	Crude protein	N-free org. matter	Cell wall complex	N-free org. cell enclosure subst.	0.05 N acid fibre	Cell wall subst. (SALO's method)					Exogenous			
									Hemicellulose					Org. matter	Crude protein	N-free org. matter	N-free org. cell. enclosure subst.
									Neutral sugar anhydrides	Uronic anhydrides	Cellulose	Lignin	Total				
Cow Nopea																	
Period 0	51.9	1.7	50.2	5.5	44.7	39.4	5.3	31.6	12.5	1.9	17.0	0.0	31.5	64.7	10.0	54.7	15.3
Period 2	43.3	2.0	41.3	4.4	36.9	33.2	3.7	25.2	10.4	1.5	14.9	0.0	26.7	57.9	9.8	48.1	15.0
Cow Ilmu																	
Period 0	49.0	2.0	47.0	3.9	43.1	39.1	4.0	31.3	12.0	2.0	17.4	0.0	31.4	64.2	9.9	54.3	15.2
Period 3	45.2	1.5	43.7	3.8	39.9	34.8	5.1	27.6	11.3	1.7	16.0	0.0	29.1	59.6	9.6	50.0	15.2

In the cow Ilmu the digestibility values of the hay and its constituents decreased when 50 g of zinc bacitracin were given per day, but not as much as those of Nopea. It should, however, be noted that Ilmu's hay consumption in Period 3, when the faeces sample was taken for the digestibility investigations, was much lower than in Period 0. It is thus possible that the hay remained in the rumen for a longer time than in the case of Nopea and so was relatively more effectively digested (PALOHEIMO and MÄKELÄ 1952, 1959, van SOEST 1965). Thus the depressive effect of the antibiotic on the digestibility of the hay is not so evident with Ilmu as with Nopea.

An examination of Table 4 reveals rather large differences between the values for true digestibility and those for apparent digestibility. As regards crude protein, the former values are as much as 55 %-units higher in the case of Ilmu in Period 0. In Period 3 the corresponding figure is 53.2. In the case of Nopea the true digestibility of the crude protein is about 50 %-units higher than the apparent digestibility. The digestibility percentages of the N-free organic cell enclosure substances are of interest. Their apparent digestibility values are very low, 22.8—32.7 %, being only about half of the values of the cell wall complexes, while the corresponding true digestibility values are much higher varying from 92.6 % to 94.4 % in the different periods. This shows how deceptive the digestibility figures can be, if the exogenous material of the faeces is not separated from the endogenous and bacterial material.

On the whole Ilmu tolerated zinc bacitracin better than Nopea. During the experiment the cows were in good condition, but both decreased in weight by 5.8 %.

A c k n o w l e d g e m e n t s . I wish to record my thanks to Professor emeritus Lauri Paloheimo for all his valuable advice during the work, and to Mr. Aimo Vasara, B. Agr., for technical assistance. My thanks are also due to A/S Apothekernes Laboratorium, Norway, which presented the zinc bacitracin used in the experiments.

REFERENCES

- A-L. (Apothekernes Laboratorium A/S) 1962. Zinc bacitracin as a feed supplement in animal nutrition. A/S Apothekernes Laboratorium for specialpraeparater, Oslo 62 p.
- CHANCE, C. M., HUFFMAN, C. F. & DUNCAN, C. W. 1953. Antibiotics in rumen digestion and synthesis. I. The effect of aureomycin on rumen digestion and the passage of nutrients from the rumen during specific intervals after feeding. *J. Dairy Sci.* 36: 253—259.
- CUNHA, T. J. 1955. Antibiotics for swine, beef cattle, sheep, and dairy cattle. First international conference on antibiotics in agriculture, 9—17.
- FULGHUM, R. S., BALDWIN, B. B. & WILLIAMS, P. P. 1968. Antibiotic susceptibility of anaerobic ruminal bacteria. *Appl. Microbiol.* 16: 301—37.
- HUNGATE, R. E. *The rumen and its microbes.* Academic Press, Inc., 533 p. New York.
- JUKES, T. H. 1955. Antibiotics in nutrition. 128 p. New York.
- KLOPFENSTEIN, T. J., PURSER, D. B. & TYZNIK, W. J. 1964. Influence of aureomycin on rumen metabolism. *J. Animal Sci.* 23: 490—495.
- MCDONALD, P., EDWARDS, R. A. & GREENHALG, J. F. D. 1966. *Animal nutrition.* 407 p. London.
- MITCHELL, G. E. JR., LITTLE, C. O., KENNEDY, L. G. & KARR, M. R. 1969. Ruminal volatile fatty acid concentrations in steers fed antibiotics. *J. Animal Sci.* 29: 509—511.
- MUNCH-PETERSEN, E. & ARMSTRONG, J. 1958. The influence of orally administered oxytetracycline on the rumen bacteria of sheep. *Australian J. Exp. Biol.* 36: 77.
- PALOHEIMO, L. 1945. Determination of total quantity of cell wall constituents in foods and feeds (Preliminary report). *J. Scient. Agric. Soc. Finn.* 17: 19—21.
- »— 1961. Quantitative measurements of the effect of antibiotics upon the digestion and physical fractions of the faeces. Paper presented at the European Symposium: Antibiotics in animal nutrition. Oslo 8th — 11th June 1961.
- PALOHEIMO, L. 1962. Food analysis and the evaluation of foods. *Nordisk jordbr.forsk.* 44: 78—86.
- »— 1966. Some remarks on the digestion trials. *World Review of Animal Production* 2: 86—91.
- »— 1969. *Weender Analyse. Handbuch der Tierernährung* 1: 164—171.
- »— & MÄKELÄ, A. 1952. The rate of passage of food in the digestive tract of ruminants. Preliminary report. *J. Scient. Agric. Soc. Finn.* 24: 165—169.
- »— & MÄKELÄ, A. 1959. Further studies on the retention time of food in the digestive tract of cows. *Acta Agr. Fenn.* 94.2: 1—25.
- »— & VAINIO, K. A. 1965. Determination of the complex of cell wall substances in plant products. *J. Scient. Agric. Soc. Finn.* 37: 305—312.
- »— SYRJÄLÄ, Liisa & VAINIO, K. A. 1968. Studies on the faeces. *J. Scient. Agric. Soc. Finn.* 40: 237—246.
- PRINS, R. A. 1969. Effect of some antibiotics and sulphonamides on cellulose breakdown by mixed rumen microorganisms *in vitro*. *Br. vet. J.* 125, 5: 18—20.
- PULLIAINEN, E., PALOHEIMO, L. & SYRJÄLÄ, Liisa. 1968. Digestibility of blueberry stems (*Vaccinium myrtillus*) and cowberries (*Vaccinium vitis-idaea*) in the willow grouse (*Lagopus lagopus*) *Ann. Acad. Sci. Fenn. Series A. IV. Biologica* 126: 1—14.
- PURSER, D. B., KLOPFENSTEIN, T. J. & CLINE, J. H. 1965. Influence of tylosin and aureomycin upon rumen metabolism and the microbial population. *J. Animal Sci.* 24: 1039—1044.
- RUSOFF, L. L., HAQ, M. O., BRANTON, Cecil, PATRIC, T. E. & D'ARENSBOURGH, G. 1952. Report on feeding aureomycin supplement to mature dairy bulls and lactating dairy cows. *J. Animal Sci.* 11: 774.
- SALO, M-L. 1965. Determination of carbohydrate fractions in animal foods and faeces. *Acta Agr. Fenn.* 105: 1—102.
- VAN SOEST, P. J. 1965. Symposium on factors influencing the voluntary intake of herbage by ruminants: voluntary intake in relation to chemical composition and digestibility. *J. Animal Sci.* 24: 834—843.

SELOSTUS

RUNSAAN SINKKIBASITRASIINIANNOSTUKSEN VAIKUTUS HEINÄN SYÖNTIMÄÄRÄÄN,
HIENONTUMISEEN JA SULAVUUTEEN TÄYSIKASVUISELLA MÄREHTIJÄLLÄ

LIISA SYRJÄLÄ

Helsingin yliopiston kotieläintieteen laitos

Märehtijäin rehut sisältävät paljon kettoaineita, joiden hajoitus tapahtuu pääasiassa pötsin mikrobien avulla. Näiden toiminnan tehokkuudesta riippuu siten koko rehun sulavuus ja ravinnollinen arvo. Tässä tutkimuksessa muutettiin pötsin mikrobiston kokoonpanoa syöttämällä koelehmille sinkkibasitrasiniä eri suurina annoksina.

Kokeessa käytettiin kahta lehmää. Ne saivat ainoana rehunaan silputtua timoteiheinää. Antibioottiannosta suurennettiin kokeen aikana, kunnes koelehmät lopettivat heinän syönnin. Koelehmille syötetyt sinkkibasitrasiniinimäärät olivat tällöin 80—100 mg elopainokiloa kohti.

Seulontakokeilla seurattiin rehun hienontumista ruoansulatuskanavassa. Karkeiden fraktioiden osuus suureni, kun sinkkibasitrasiniannostusta lisättiin. Tämä osoittaa rehun hienontumisen heikentyneen.

Rehun sulavuuden tutkimisessa käytettiin johtoaineena ligniiniä. Kokeen tulokset osoittavat sinkkibasitrasiniin heikentäneen selvästi kettoaineiden sulavuutta. Myös heinän muiden aineosien sulavuus aleni sinkkibasitrasiniä lehmille syötettäessä.