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INDIGESTION IN YOUNG CALVES

II. THE INFLUENCE OF GROUND BARLEY, COARSE AND FINE HAY

By

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LAKSESVELA, B., P. SLAGSVOLD, N. KROGH, Å. OMMUNDSEN and T. LANDSVERK: *Indigestion in young calves. II. The influence of ground barley, coarse and fine hay.* Acta vet. scand. 1977, *18*, 416—425. — Four experiments comprising 86 calves have been carried out in order to examine the influence of ground barley, coarse and fine hay, when raising young calves on a high lactose milk replacer causing diarrhoea. The frequency of diarrhoea decreased when feeding barley ($P < 0.01$) or fine hay ($P < 0.001$), but increased when feeding coarse hay ($P < 0.01$). Barley increased ($P < 0.01$) live weight gain and carcass weight, reduced ($P < 0.001$) rumen pH, favoured gram-positive cocci and rods in the rumen, caused hyperkeratosis and gave increased ($P < 0.01$) empty reticulo-rumen weights, the latter being supposed to be enhanced by hyperkeratosis. The calves ate more ($P < 0.001$) fine than coarse hay, fine hay being superior ($P < 0.01$) in promoting growth of the rumen. All hay maintained a predominantly gram-negative rumen flora, but somewhat different from that on the milk replacer, and counteracted ($P < 0.01$) low pH in the rumen and apparently also hyperkeratosis due to barley. The results with barley indicated no relationship between diarrhoea and hyperkeratosis.

barley; hay; indigestion; calves.

In a previous paper *Slagsvold et al.* (1977) briefly described the occurrence of indigestion in young calves in Norway, and reported experiments showing that high dietary levels of lactose significantly increased the frequency of diarrhoea. But lactose did not consistently influence intake of hay and barley, growth rate and a number of clinical measurements or anomalies in the digestive tract. In all experiments, the calves received ground barley, chopped hay and tepid water, when they were approx. 3 weeks old.

According to literature, much barley, and carbohydrates on the whole, may have some undesirable effects in young calves. Thus pH of the rumen fell on a 90 % barley diet (*Fell et al.* 1968) and on a 87.5 % barley diet (*Mullen* 1973), but the latter author found that the fall in pH was partly counteracted by hay. *Fell et al.* and *Kay et al.* (1969) also observed that much barley in the diet and low pH in the rumen content were accompanied by lesions in the rumen wall. It seems, however, that the effect of barley on diarrhoea is open to question.

It is commonly said that young calves should receive fine hay, but it seems difficult to find data from experiments in which coarse and fine hay have been compared.

The present paper describes 4 experiments regarding the influence of ground barley, coarse and fine hay, when raising young calves on a high lactose milk replacer causing diarrhoea.

MATERIALS AND METHODS

Exps. 1 and 2 were 2×2 factorial tests of ground barley (GB) and coarse hay (CH 1 and CH 2) as supplements to the milk replacer. Exp. 3, carried out simultaneously with Exp. 2, was a comparison between fine hay (FH 1) and no supplement (NS), while Exp. 4 compared coarse hay (CH 3) and fine hay (FH 2) as single supplements.

The present experiments were conducted in the same manner as those described earlier (*Slagsvold et al.* 1977), except that specimens for histologic examination were only taken from the central part of atrium ruminis. The recording of the width of the papillae in Exp. 4 was performed by measuring the papillae under the stereomicroscope. The high lactose milk replacer given to all groups was the one denominated I in the previous publication, consisting of 41.4 % skim milk powder, 14 % sweet whey powder, 30 % lactose, 13.3 % butter plus minerals and vitamins. The barley was of normal quality, with 12—13 % total protein and 5—5.5 % crude fibres in the dry matter.

Age and weight of the calves varied from 2 to 13 days and from 29 to 54 kg, respectively, averages being 6—7 days and approx. 40 kg at the start of the experiments. The number of calves and duration of the tests are set out in Table 2. In Exp. 1, the calves were kept on a concrete floor covered with sawdust, in Exps. 2—4 on raised metal grates with no litter.

Table 1. Chemical composition of hay used. (CH 1, CH 2 and CH 3 denominate 3 coarse and FH 1 and FH 2 denominate 2 fine samples).

	Coarse			Fine	
	CH 1	CH 2	CH 3	FH 1	FH 2
Crude protein, %	8.0	6.4	6.5	10.5	12.5
Fat „	2.1	2.1	2.0	2.6	3.0
N-free extract. „	52.7	54.6	55.7	52.1	50.2
Crude fibres „	31.9	32.5	31.5	28.6	26.6
Ash „	5.3	4.4	4.3	6.2	7.7
Total „	100.0	100.0	100.0	100.0	100.0

Hay quality

All hay samples consisted mainly of timothy, but came from different batches. Their chemical composition is listed in Table 1. CH 3 and FH 2 were also characterized by sorting them meticulously by hand in stem, ears and leaves. FH 2 was grown in a mountain valley, cut at a very early stage and dried artificially; it consisted of 26.7 % stem, 7.3 % ears and 66.0 % leaves. CH 3 was grown on low land, cut at a late stage and dried on wire fences; it consisted of 57.7 % stem, 11.8 % ears and 30.5 % leaves.

RESULTS

Growth data, feed intake, diarrhoea and general health

Data on the above-mentioned parameters are collected in Table 2, significant differences mainly being pointed out below.

The live weight gain was greater ($P < 0.001$) on GB + CH than on NS in both Exp. 1 and 2, and also when comparing GB + CH to CH and GB to CH ($P < 0.05$ in Exp. 1 and $P < 0.01$ in Exp. 2 in both comparisons). In Exp. 3, the weight gain was greater on FH ($P < 0.01$) than on NS.

The dressing-out % was lower ($P < 0.001$), when relating both types of CH and FH to NS, while the differences between CH and GB did not reach significance ($P < 0.1$).

The carcass weights were heavier on GB + CH, and on GB than on NS or CH (P values ranging between 0.001 and 0.05).

The intake of hay was higher ($P < 0.01$) in Exps. 1 and 2 when no GB was offered. For the intake of GB, there was no

Table 2. Duration of the experiments, growth data, average daily intake of ground barley (GB), coarse hay (CH), fine hay (FH) and electrolyte fluid (EF) and days with diarrhoea.

Exp. no.	Diet	Number of calves per group	Days on exp.	Wt. gain kg	Dress. %	Carcass wt. kg	Daily intake GB g	Daily intake hay g	Daily intake EF l	Diarrhoea days
1	GB + CH 1	6	49	22.3	49.5	31.2	454	119		14.3
	GB	6	49	18.6	50.2	29.8	402	—		5.8
	CH 1	6	49	16.4	47.9	27.5	—	320		19.7
	NS	6	49	12.8	51.3	27.5	—	—		10.8
2	GB + CH 2	8	44	19.8	53.7	33.2	170	179	3.4	4.9
	GB	8	44	19.4	52.8	32.4	319	—	3.7	7.5
	CH 2	8	44	13.8	51.4	28.7	—	312	4.6	21.1
	NS	8	44	11.4	54.0	29.0	—	—	4.2	16.1
3	FH 1	6	48	19.2	50.5	28.8	—	196	3.4	7.7
	NS	6	48	12.3	55.4	27.7	—	—	4.4	19.8
4	FH 2	9	49	22.6	50.8	31.7	—	493	3.1	3.7
	CH 3	9	49	20.6	51.7	31.5	—	277	3.8	10.0

clear trend. In Exp. 4, the calves ate 78 % more of FH than CH ($P < 0.001$).

Electrolyte fluid was drunk in somewhat greater quantities when diarrhoea was frequent, but the difference appeared to be insignificant ($P > 0.2$).

Diarrhoea was less frequent ($P < 0.01$) on GB than on NS when treating Exps. 1 and 2 statistically together ($P < 0.1$ in Exp. 1 and $P < 0.02$ in Exp. 2). Further, GB gave much less diarrhoea ($P < 0.001$) than CH.

CH gave more ($P < 0.01$) and FH much less diarrhoea ($P < 0.001$) than NS.

Other differences shown by Table 2 in the various respects were not statistically significant.

No calves died or appeared clinically ill, apart from the occurrence of diarrhoea.

Findings in the rumen fluid

During the first 2—3 weeks on experiment, the rumen pH ranged between 6 and 7 in most cases. Values below 6 or above 7 were occasionally recorded in single samples from some calves.

As a rule, the pH kept this level the rest of the time in groups on NS or hay.

On the contrary, the rumen pH showed a marked ($P < 0.001$) drop in calves fed GB or GB + CH. In groups on these regimens, the average pH might fall to nearly 5 with single samples as low as 4.6. In calves on GB + CH, the pH rose ($P < 0.01$) to normal values in the 6th week, whereas it remained low throughout the experimental period on GB.

Direct microscopy of rumen samples revealed great variation in the bacterial picture. On NS the flora consisted of a heterogeneous population of mainly gram-negative bacteria. When hay was fed, the flora was still dominated by gram-negative organisms, although morphologically somewhat different from that on milk feeding. In contrast to these findings, a gram-positive flora of cocci and rods appeared in abundance on GB.

Ciliates were never observed in any of the samples during the experiments, whereas flagellates were regularly found as long as the rumen pH kept a level of about 6 or higher. Irrespective of the diet, living flagellates were not seen at lower pH.

Similar to the earlier experiments, the gross appearance of the rumen fluid varied considerably. Many samples contained more or less milk products and sometimes also clots of these. Samples with low pH might be identified by a slightly sourish odour, otherwise the smell varied from aromatic to unpleasant.

Post-slaughter findings in the digestive tract

Data from the post-slaughter examinations are recorded in Table 3.

Rumen content varied with the diets used. On GB and NS a marked admixture of hairs was noticed. Bezoars were frequent in the rumen of calves on NS; in Exp. 1 their stomachs also contained sawdust. Calves fed FH 2 had a green coloured, fine textured roughage in the rumen, while those fed CH 3 had a coarser, yellow coloured roughage.

Weight of the stomach compartments. The following, significant differences may be worth mentioning: The empty reticulo-rumens were heavier ($P < 0.05$) on CH 1 than on NS in Exp. 1, and heavier ($P < 0.01$) on GB + CH 2 and on GB than on CH 2, and also on CH 2 than on NS in Exp. 2, and heavier on FH 2 than on CH 3 in Exp. 4 ($P < 0.01$). When the empty reti-

Table 3. Weights of the stomach compartments, development of the rumen papillae, and lesions in the stomach compartments.

Exp.	1				2				3		4	
Diet	GB+CH 1	GB	CH 1	NS	GB+CH 2	GB	CH 2	NS	FH 1	NS	FH 2	CH 3
Age at slaughter, days	55.2	55.2	55.3	55.4	51.1	51.0	51.1	51.2	53.7	53.8	56.1	56.0
Stomach weights in kg												
Rumen/retic with cont.	7.28	5.57	8.00	5.65	4.49	4.15	4.20	1.54	6.33	1.43	5.94	6.37
„ „ without cont.	0.90	0.93	0.87	0.48	0.66	0.81	0.54	0.29	0.71	0.35	0.79	0.66
Omasum without cont.					0.16	0.19	0.10	0.07	0.18	0.07	0.20	0.18
Abomasum with cont.	1.15	1.13	1.3	0.9	0.76	0.82	0.72	0.73	1.33	0.85	0.91	1.08
Abomasum without cont.	0.33	0.35	0.31	0.22	0.28	0.31	0.24	0.23	0.31	0.25	0.34	0.28
Development of the rumen papillae												
Average length in mm of papillae in atrium ruminis[1]	3.75	3.66	4.33	<0.5	1.31	2.19	1.19	<0.5	1.5	<0.5	3.67	2.11
Lesions in the stomach compartments[2]												
Ulcers in the rumen	4/6	3/6	1/6	0/6	6/8	7/8	0/8	0/8	0/6	0/6	2/9	2/9
Scars in the rumen	0/6	0/6	1/6	0/6	1/8	0/8	0/8	0/8	0/6	0/6	4/9	8/9
Hyperkeratosis in the rumen epithelium	2/6	3/6	0/6	0/6	0/8	5/8	0/8	0/8	1/6	0/6	0/9	1/9
Necrosis in the omasum	1/6	0/6	0/6	1/6	1/8	0/8	0/8	0/8	0/6	0/6	2/9	3/9
Ulcers in the abomasum	0/6	0/6	0/6	0/6	0/8	1/8	0/8	0/8	1/6	2/6	0/9	1/9

[1] When ridges were present they were measured from the bottom to the top.

[2] Calves with lesions out of all the calves in the group.

culo-rumen weights in Exp. 2 were corrected for differences in live weights for each calf, the above-mentioned difference between GB + CH 2 and CH 2 was almost abolished, while the other differences retained their significance. But with this correction the weights on GB appeared significantly higher ($P < 0.01$) than on GB + CH 2.

The rumen papillae development. NS gave under-developed papillae, whereas the feeding of hay and barley resulted in papillary proliferation. Extensive hyperkeratosis was noted on barley diets. FH 2 gave longer papillae than CH 3 ($P < 0.01$). The papillae on FH 2 seemed to be more foliated than on CH 3, the greatest width of the papillae averaging 1.4 mm on FH 2 versus 1.0 mm on CH 3. However, the difference was not significant ($P > 0.05$). Detailed morphological descriptions of the ruminal papillae in selected parts of these experiments will be given in a separate paper.

Ruminal ulcers and scars were more frequent on barley diets and mainly confined to the anterior and posterior rumen pilae. The ulcers were relatively deep and had raised edges. They were elongated with sizes mostly varying from 1 to 10 cm in length. The omasal necroses in Exps. 1 and 2 were round, up to 2 cm in diameter, and usually situated in the middle of the laminae. Their colour was dark brown and they were always perforating laminae. In Exp. 4 the omasal necroses were elongated, never more than 3 mm in length and situated at the border of the laminae. The ulcers of abomasum were usually shallow and round, never more than 15 mm in diameter, and situated mostly in the pyloric region. Occasionally, petechial haemorrhages were found in the mucosa of different parts of the abomasum.

Other organs. No lesions were found outside the digestive tract.

DISCUSSION

Influence of barley

The experiments reported here showed that ground barley, apart from promoting the growth, counteracted diarrhoea occurring on a high lactose diet. Available publications on the feeding of barley to young calves lack information regarding its influence on diarrhoea.

Regarding reduction in pH, occurrence of hyperkeratosis and ulcers in the rumen following the feeding of much barley, the

experiments recorded here confirmed the findings of other authors, quoted introductory. The results with barley indicated no relationship between diarrhoea and hyperkeratosis.

Also the findings of hair-admixture in the rumen contents and heavier rumens of calves fed barley in addition to the milk replacer, are in accordance with other reports (*Fell et al.* 1968, *Kay et al.* 1969). It is also documented earlier that giving no dry feed leads to under-developed rumen and that supply of hay initiates rumen development, including growth of papillae (*Brownlee* 1956, *Warner et al.* 1956, *Sandler et al.* 1959, *Tamate et al.* 1962).

Influence of coarse versus fine hay

The texture of the hay, and qualities that go with it, seemed to be of paramount importance. Fine hay reduced the frequency of diarrhoea and increased the growth of the rumen, including its papillae, compared with coarse hay. *Brownlee* comparing grass to hay (quality not mentioned), found best development of the rumen papillae with grass.

The fact that the daily intake of fine hay was nearly double the intake of coarse hay may partially explain the better papillae development noted in the calves fed fine hay. Also the nutritive value of the fine hay was assumed to be greater than that of coarse hay. These 2 factors may have increased the amount of available end products of rumen fermentation from fine hay. Volatile fatty acids constituting such end products are known to initiate rumen mucosal development (*Warner et al., Flatt et al.* 1958, *Tamate et al.*).

Roy (1970) states that once the rumen begins to function the incidence of diarrhoea is negligible in calves fed a balanced, dry diet. According to the findings reported in this paper, the effect of hay depends on its texture and quality.

Hay — barley interactions

When correcting the empty reticulo-rumen weights for differences in the live weights of the calves, it emerged that barley gave heavier reticulo-rumens than barley plus hay. This may partly be due to the fact that the feeding of barley was accompanied by hyperkeratosis, while hay was not. These results seem to coincide with the finding of *Kay et al.* that calves on a barley

diet had a reduced ratio of rumen muscular to mucosal weight.

It is of interest that hay maintained a predominantly gram-negative rumen flora, similar to that on the milk replacer, and counteracted low pH in the rumen after a few weeks, and apparently also hyperkeratosis due to barley. The rise in pH when feeding hay is in conformance with the finding of *Mullen* (1973), and it is supposed to have prevented hyperkeratosis in the present experiments. *Kay et al.* showed that raising rumen pH by the aid of neutralizing salts prevented hyperkeratosis.

CONCLUCIONS

Ground barley increased the live and carcass weights and counteracted diarrhoea, but reduced rumen pH, favoured gram-positive cocci and rods in the rumen, caused hyperkeratosis and increased the empty reticulo-rumen weights.

Fine hay counteracted diarrhoea, maintained a normal pH and a predominantly gram-negative flora in the rumen, and was superior in promoting growth of the rumen.

Coarse hay aggravated diarrhoea, but counteracted low pH in the rumen after a few weeks when fed along with barley.

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SAMMENDRAG

Indigestion hos unge kalver. II. Virkningen av byggrøpp, grovt og fint høy.

Fire forsøk med i alt 86 kalver har vært utført for å undersøke virkningen av byggrøpp, grovt og fint høy når unge kalver ble gitt en laktoserik mjølkeerstatning som forårsaker diaré.

Hyppigheten av diaré minket når det ble gitt byggrøpp ($P < 0,01$) eller fint høy ($P < 0,001$), men økte når det ble gitt grovt høy ($P < 0,01$). Byggrøpp økte ($P < 0,01$) levendevekt og slaktevekt, reduserte ($P < 0,001$) pH i vomma og fremmet oppvekst av gram-positive kokker og staver i vomma, ga hyperkeratose og økt ($P < 0,01$) vekt av nettmage og vom renset for innhold. Denne vektøkningen antas å delvis skyldes hyperkeratose.

Kalvene spiste mer ($P < 0,001$) fint enn grovt høy, og det fine ga overlegent best vomvekst. Alt høy opprettholdt en overveiende gram-negativ vomflora, som avvek noe fra vomfloraen hos kalver som fikk bare mjølkeerstatning. Høy motvirket etter noen uker den låge pH i vomma, og tilsynelatende også hyperkeratose grunnet byggrøppet.

Resultatene med byggrøpp tyder ikke på noen sammenheng mellom diaré og hyperkeratose.

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