Acta vet. scand. 1978, *19*, 159—165.

From the Department of Animal Husbandry and Genetics and the Department of Pathology, Veterinary College of Norway, Oslo.

INDIGESTION IN YOUNG CALVES

III. THE INFLUENCE OF POWDERS FROM HEAT-TREATED SKIM MILK AND WHEY

By

B. Laksesvela, P. Slagsvold and *T. Landsverk*

LAKSESVELA, B., P. SLAGSVOLD and T. LANDSVERK: *Indigestion in young calves. III. The influence of powders from heat-treated skim milk and whey.* Acta vet. scand. 1978, *19*, 159—165. — Two experiments comprising 24 calves, lasting 44—46 days, have been carried out in order to examine the influence of powders from heat-treated skim milk and whey on indigestion in young calves. The frequency of diarrhoea increased much ($P < 0.01$) in the first experiment when feeding the heat-treated products, but little in the other. Possible reasons for this difference are discussed. Calves fed heat-treated products in the first experiment consumed 13.8 l of electrolyte fluid per head per day 14—22 days after commencing the test, when both diarrhoea and fluid consumption reached peak values. It is postulated that some of the calves might have succumbed without electrolyte fluid.

heat-treatment; skim milk; whey; indigestion; diarrhoea; calves.

The first paper in this series reported that the frequency of diarrhoea increased over the first 10—12 days when young calves were fed various high lactose diets along with hay and barley. On the other hand, lactose did not consistently influence the growth rate or a number of clinical observations or anomalies in the digestive tract (*Slagsvold et al.* 1977). Further experiments showed that ground barley or fine hay counteracted, while coarse hay promoted diarrhoea in calves fed a high lactose milk replacer (*Laksesvela et al.* 1977).

Roy stated in a review on calf nutrition (1974) that problems arise when milk is heat-treated in the production of milk powders, if the time-temperature relationship is such that the whey proteins including immunoglobulins are denaturated and the products are fed to calves which have received only a marginal passive immunity or are exposed to an adverse microflora.

Skim milk and whey powders are not known to be heat-damaged in this country nowadays. But damage of a similar kind may take place during storage if products sufficiently high in moisture are stored for some time (*Herrman* 1966). In order to test the influence of heat damage on skim milk and whey powders on indigestion in young calves, 2 experiments were carried out with experimentally heat-treated products.

MATERIALS AND METHODS

In both experiments, groups of 6 calves averaging approx. 7 days and 39 kg were fed milk replacers containing either 1) Normal, commercial skim milk and whey powders, these products and the respective diet being denominated N, or 2) Powders from experimentally heat-treated skim milk and whey, these products and the respective diet being denominated HT.

Exp. 1 was conducted in Feb.-March, the calf pens having been washed and contained no cattle for 100 days, while Exp. 2 was conducted in the same pens in Sept.-Oct. after they had been washed and contained no cattle for 215 days.

The diets were made up like Diet B in the earlier experiments (*Slagsvold et al.* 1977), containing 39.7 % skim milk powder and 40 % whey powder. After 12 days on experiment, the calves were offered ground barley, hay and tepid water with 3 g NaCl, 4.3 g $NaHCO_3$ and 2 g KCl per l (electrolyte fluid). After slaughtering, attempts were made to measure the diameter of the curds in abomasum. Other examinations dealt with in the present paper were conducted as described earlier (*Slagsvold et al., Laksesvela et al.* 1977).

Skim milk and whey powders

The commercial products used in Diet N were vacuum-condensed, low temperature spray dried.

The heat-treated products used in Diet HT were made up separately for Exps. 1 and 2, but all were subjected to 80°C for 30 min. in a condensed state, and subsequently dried to powder with rotation drying in a "tower" with 180—200°C at the inlet and 95—100°C at the outlet.

The whey powders were made of sweet whey with pH 6.2—6.3. Analytically, the effect of the heat treatment was characterized by the content of available lysine.

The content of available lysine is recorded in Table 1. Products used in Exp. 1 were analysed in one laboratory (Lab. 1) according to the method of *Carpenter* (1960) as modified by *Booth* (1971); 2 of the same products and those used in Exp. 2 were analysed in another laboratory (Lab. 2) according to the version of *Rexen & Christensen* (1966).

Table 1. Available lysine in skim milk and whey powders, g/16 g N.

	Prod. used in Exp. 1		Prod. used in Exp. 2
	Lab. 1	Lab. 2	Lab. 2
Skim milk powder N[1]	7.53		6.3
Skim milk powder HT[2]	6.39	5.2	4.2
Whey powder N[1]	6.82		5.2
Whey powder HT[2]	4.26	3.7	4.3

[1] Normal, commercial products.
[2] Heat-treated products.

Heat-treated products used in Exp. 1 looked more brownish, contained more brown lumps and tasted more like caramel than those used in Exp. 2. All were manufactured just before the experiments started or while they were running.

RESULTS

Growth data, intake of feed and electrolyte fluid, diarrhoea, general health

Data on the above-mentioned parameters and the duration of the experiments are set out in Table 2.

Table 2. Duration of the experiments, growth data, average daily intake of ground barley (GB), hay (H) 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	Hay g	EF l	Diarrhoea, days
1	N[1]	6	44	17.8	51.7	29.6	250	73	5.1	8.0
	HT[2]	6	44	14.6	52.5	27.6	187	70	8.9	19.5
2	N[1]	6	46	21,5	51.9	32.1	278	67	3.9	7.0
	HT[2]	6	46	20.8	51.7	31.6	319	90	4.3	8.7

[1] Normal, commercial products.
[2] Heat-treated products.

Exp. 1. The live weight gain appeared to be greater on N than on HT, though not significantly ($P > 0.1$). The same applies to carcass weights ($P > 0.3$). Calves on diet N ate somewhat more ground barley, but those on HT drank much more ($P < 0.02$) electrolyte fluid. Diarrhoea occurred more frequently ($P < 0.01$) on HT than on N. Both diarrhoea and consumption of electrolyte fluid reached peak values 14 to 22 days after commencement of the experiment, when calves on diet HT drank 13.8 l per day on the average. The highest consumption of electrolyte fluid recorded for 1 calf in a single day was 22 l, i.e. 48 % of its live weight at the time. It is postulated that some of the calves might have succumbed without electrolyte fluid. One calf on diet N died suddenly after 5 weeks on experiment. On necropsy a 15 cm long rupture in abomasum was found, the reason being unknown. No other health problems than those mentioned were noticed.

Exp. 2. No marked differences occurred, incidences of diarrhoea and electrolyte fluid consumption being only slightly higher on diet HT than on N. Apart from some diarrhoea, all calves appeared healthy.

Post slaughter findings in the digestive tract

The post slaughter findings are recorded in Table 3. Abomasum with content and the diameter of the curds were slightly larger on diet N than on HT in Exp. 1.

Ulcers in the rumen and hyperkeratosis in its epithelium occurred most frequently on diet N in Exp. 1. For the rest, there were no tendencies to differences between diets or experiments as to lesions in the stomach compartments. The appearance of the lesions did not differ from those described in the first experiments (*Slagsvold et al.* 1977).

DISCUSSION

Lister & Emmons (1976) reported higher incidence of diarrhoea and slower rate of gain of calves fed skim milk powder prepared after heating the milk for 30 min. at 85°C as compared to heating at 60 or 73.9°C. *Shillam et al.* (1962) experienced mortality rates up to 60 % when feeding a so-called synthetic milk containing heat-damaged skim milk, as compared to 27 % on whole milk diets.

Table 3. Post slaughter findings in the digestive tract.

Exp.	1		2	
Diet	N[1]	HT[2]	N[1]	HT[2]
Weight in kg				
Abomasum with content	1.14	0.90	1.03	0.89
Abomasum without content	0.31	0.28	0.34	0.33
Diameter of curds in abomasum[3]				
<1 cm	1/5	3/6	1/6	1/6
1—3—4 cm	2/5	3/6	5/6	5/6
>3—3 cm	2/5	0/6	0/6	0/6
Lesions in the stomach compartments[3]				
Ulcers in the rumen	5/5	1/6	2/6	1/6
Scars in the rumen	0/6	2/6	1/6	4/6
Hyperkeratosis in the rumen epithelium	4/5	2/6	1/6	1/6
Necroses in the omasum	3/5	3/6	1/6	1/6

[1] Normal, commercial products.
[2] Heat-treated products.
[3] Number of calves out of all calves in the group.

In the 2 experiments reported here, the 2 sets of heat-treated products were subject to the same procedure. Still, they gave different results. There is no obvious explanation for this. If the subjective judgement of colour and taste was valid, the reason might have been that the products used in Exp. 1 gave much higher incidence of diarrhoea because they were more heat-damaged. The manufacture data do not support this assumption. But available lysine appeared to be particularly much reduced by the heat treatment in the whey powder used in Exp. 1 (Table 1).

Browning of heated milk products results from the so-called Maillard reaction, which is a formation of amino acid—sugar complexes. Since milk and whey powders are hygroscopic this reaction can, according to *Hermann* (1966), also take place during prolonged storage. But it seems unlikely that the 2 sets of heat-treated products used in the experiments reported here should have deteriorated even to a significantly different degree during the short time they were stored.

Carpenter et al. (1957) stated that heat damage to proteins, detectable as a reduction in available lysine and nutritive value,

cannot always be explained simply in terms of the formation of amino acid—sugar complexes. *Forsum & Hambraeus* (1977) concluded in a review of literature on the heat sensitivity of whey proteins that the results have conflicted as to which are least resistant. Moreover, it is not known which chemical compound in heat-damaged milk and whey powders may create indigestion. The direct relationship between heat-damage and indigestion in the experiments reported here thus remains obscure.

Seeking other explanations for the different results in the 2 experiments, one may point out the statement of *Roy* (1974) that problems due to heat-damaged milk proteins arise if the calves have received only a marginal passive immunity or are exposed to an adverse microflora. As to passive immunity, all calves in both experiments had received colostrum before they were brought to the experimental station 3 days old or more. It may, however, be questioned whether the calves used in Exp. 1 may have met with a more virulent microflora than those used in Exp. 2.

Microbiological examinations of the stable were not undertaken. But a comprehensive microbiological study was carried out in a later experiment of similar kind, which will be described separately.

ACKNOWLEDGEMENTS

We wish to thank the Agricultural Research Council of Norway for financial aid, Forsøkslaboratoriet, NMS, for making the heat-damaged products, Peter Møller A/S for providing most other dietary ingredients, the Department of Applied Biology, University of Cambridge, and Bioteknisk Institut, Kolding, for assessing available lysine.

REFERENCES

Booth, V. H.: Problems in the determination of FDNB-available lysine. J. Sci. Food Agric. 1971, *22*, 658—664.

Carpenter, K. J.: The estimation of the available lysine in animal protein foods. Bichem. J. 1960, *77*, 604—610.

Carpenter, K. J., G. M. Ellinger, M. I. Munro & E. J. Rolfe: Fish products as protein supplements to cereals. Brit. J. Nutr. 1957, *11*, 162—173.

Forsum, E. & L. Hambraeus: Nutritional and biochemical studies of whey products. J. Dairy Sci. 1977, *60*, 370—377.

Herrman, J.: III. Verarbeitung, Haltbarmachung und Zubereitung unserer Nährungs- und Futtermittel. (Manufacture, preservation and preparation of our foods and feeds). *In* A. Hock: Vergleichende Ernährungslehre des Menschen und seiner Haustiere. VEB. Gustav Fischer Verlag, Jena 1966.

Laksesvela, B., P. Slagsvold, N. Krogh, Å. Ommundsen & T. Landsverk: Indigestion in young calves. II. The influence of ground barley, coarse and fine hay. Acta vet. scand. 1977, *18*, 416—425.

Lister, E. E. & D. B. Emmons: Quality of protein in milk replacers for young calves. 2. Effects of heat treatment of skim milk powder and fat levels on calf growth, feed intake and nitrogen balance. Canad. J. Anim. Sci. 1976, *56*, 327—333.

Rexen, B. & B. Christensen: The determination of available lysine in feeding stuffs, automation in analytical chemistry. Technicon International Symposia 1966, 435—438.

Roy, J. H. B.: Problems in the nutrition of the preruminant calf. Proc. Nutr. Soc. 1974, *33*, 79—86.

Shillam, K. W. G., J. H. B. Roy & P. L. Ingram: The effect of heat treatment on the nutritive value of milk for the young calf. 2. The factor in a milk substitute associated with a high incidence of scouring and mortality. Brit. J. Nutr. 1962, *16*, 267—277.

Slagsvold, P., B. Laksesvela, K. Flatlandsmo, N. Krogh, T. L. Ulstein, N. Ek & T. Landsverk: Indigestion in young calves. I. Different lactose levels in milk diets and milk replacers. Acta vet. scand. 1977, *18*, 194—209.

SAMMENDRAG

Indigestion hos unge kalver. III. Virkningen av pulver fra varmebehandlet skummetmjølk og myse.

To forsøk over 44—46 dager med i alt 24 kalver har vært utført for å undersøke virkningen av pulver fra varmebehandlet skummetmjølk og myse på indigestion hos unge kalver. Hyppigheten av diaré økte mye ($P < 0,01$) i det første forsøket når det ble gitt varmebehandlete produkter, men lite i det andre. Mulige årsaker til denne forskjellen er diskutert.

Kalver gitt varmebehandlete produkter i det første forsøket drakk i gjennomsnitt 13,8 l elektrolyttvæske pr. dag 14—22 dager etter begynnelsen av forsøket. Både diaré og væskekonsum var da på det høgste. Det ble antatt enkelte kalver ville ha bukket under dersom de ikke hadde fått elektrolyttvæske.

(Received October 24, 1977).

Reprins may be requested from: P. Slagsvold, Veterinary College of Norway, P.O. Box 8146, Oslo Dep., Oslo 1, Norway.