Manganese Balance Studies With Lambs

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Previous reports from this Station (9) (7) indicated that differences in nutritive condition of beef cattle at the Range Cattle Minerals Station, near Wilburton, and those at the Lake Carl Blackwell Range, near Stillwater, were due to differences in the nutritive value of the range forage at these two areas. Cattle at Wilburton displayed symptoms typical of phosphorus deficiency but remained unthrifty even when this element was supplied. Chemical analysis showed that forage from the two areas contained similar amounts of the major nutrients but that the Wilburton forage was somewhat lower in phosphorus and was unusually high in manganese. It was suggested, therefore, that manganese, or factors associated with it in the Wilburton forage, interfered with the utilization of nutrients including phosphorus (5). Evidence of a low availability of phosphorus in the Wilburton forage has been obtained by Walters, Ross and Gallup (11) and further studies along this line are in progress.

Little is known about the effect of large intakes of manganese on animals, although small amounts representing less than 50 ppm of ration are known to be required for proper bone development in several species (4) (10). Nance *et al.* (6) recently reported that at high levels of intake, representing 1000 and 2000 ppm of ration, manganese interferes with growth and reproduction of rabbits. Studies with these animals and with cattle receiving manganese at dietary levels of 250 and 500 ppm are being continued.

The purpose of the present investigation was to determine the retention, path of excretion, and effect on nutrient digestibility of manganese added in increasing amounts to a ration of natural feeds for growing lambs.

Experimental Procedure

Balance trials were carried out with lambs weighing from 65 to 95 pounds. During 20-day collection periods lambs were kept in metabolism stalls with provisions made for the quantitative separation and collection of feces and urine. For 10 days preceding and during the collection periods all lambs in each trial received a basal ration of constant composition supplemented with different amounts of manganese. This ration was composed of prairie hay 46.9, corn 29.3, corn gluten meal 23.5 and calcium carbonate 0.3 per cent; it supplied 15.5 per cent protein, 0.32 per cent calcium and 0.25 per cent phosphorus. Manganese sulfate was added to the basal ration in amounts to provide rations which supplied manganese at levels of 30, 300, 600, 900, 1200 and 1500 ppm. In each trial six lambs

TABLE I.

Summary of Digestibility and Balance Data on a Daily Basis

TRIAL	TRIAD	APPROX. MN. CONTENT OF RATION	LAMB NO.	DRY MATTER INTAKE	NITROGEN INTAKE	MN. INTAKE	DIGESTIBILITY ORGANIC MATTER	DIGESTIBILITY PROTEIN (N×6.25)	MANGANESE RETAINED[1]	
		P.P.M.		GM.	GM.	MG.	%	%	MG.	%
		30	7	507	12.6	20	74.6	76.1	—4	0
	A	300	8	"	"	173	74.4	75.2	95	54.9
1		600	9	"	"	326	77.5	76.1	176	54.0
		30	10	380	9.4	15	76.3	75.3	—2	0
	B	300	11	"	"	130	71.8	71.3	75	57.7
		600	12	"	"	244	72.8	69.8	141	57.8
		30	1	422	10.5	16	72.0	72.7	—8	0
	C	300	2	"	"	144	70.8	72.1	35	24.3
		600	3	"	"	271	74.1	71.3	57	21.0
2		30	4	394	9.8	15	76.6	77.2	—5	0
	D	300	5	"	"	134	72.5	71.1	27	20.1
		600	6	"	"	253	73.8	73.0	71	28.1
		900	7	539	13.4	511	75.2	76.0	167	33.7
	A	1200	8	"	"	674	72.7	75.6	158	23.3
3		1500	9	"	"	837	77.2	78.7	244	29.2
		900	10	"	"	511	72.3	73.5	134	26.2
	B	1200	11	"	"	674	71.8	74.7	223	33.1
		1500	12	"	"	837	69.5	68.0	110	13.1
		900	1	394	9.8	373	73.9	76.9	—4	0
	C	1200	2	"	"	493	75.2	73.5	45	9.1
		1500	3	"	"	611	74.5	69.9	50	8.2
4		900	4	367	9.1	347	78.1	75.6	40	11.5
	D	1200	5	"	"	458	76.2	75.7	29	6.2
		1500	6	"	"	568	76.3	74.7	19	3.3

[1] Values expressed in milligrams and as a percentage of the intake.

were fed in triads, each member within a triad receiving the same total amount of feed but a different level of manganese. Due to feed refusals, the amount of ration consumed was not constant from day to day. Low feed consumption, however, was not associated with the manganese content of the ration.

Methods of chemical analysis were those recommended by the A. O. A. C. (1) with slight modification. All manganese determinations were made in duplicate and checked for repeatability with proper attention given to blanks and recovery of added manganese.

Results and Discussion

Table I shows the digestibility of organic matter and protein, and the amounts of manganese retained by individual lambs, in relation to manganese intake. Comparison of individual values obtained in the same trial or different trials shown in Table I fails to reveal any effect of ingested manganese on the digestibility of nutrients in the ration or on the amounts of nitrogen retained by the lambs. The digestibility of both organic matter and protein varied only slightly from 75 percent in all rations. Wide differences in urinary nitrogen excretion by lambs on similar rations in the same trial and in different trials produced variations in percentage of nitrogen retained.

There were conspicuous trial differences in the amounts and percentage of manganese retained. These differences are brought out in a comparison of the results obtained in trials 1 and 2 with lambs receiving rations containing approximately 30, 300 and 600 ppm of manganese. In trial 1 lambs retained from 54 to 58 per cent of the manganese in rations which supplied 300 and 600 ppm; in trial 2 they retained from 20 to 28 per cent. Likewise in trial 3 with lambs receiving manganese at levels of 900, 1200 and 1500 ppm, manganese retention ranged from 13 to 34 per cent of the intake, while in trial 4 less than 12 per cent was retained. Within the same trial these retention values when expressed as mg per day were roughly proportional to manganese intake. In contrast to these results, Reid and Ward (8) found that lactating cows receiving daily from 622.4 to 1325.6 mg of manganese retained a constant amount of approximately 154.4±9.8 mg. In the latter studies, however, the range of manganese intakes was narrow and the amounts of manganese fed were small in proportion to body weight and total feed intake.

Although manganese determinations were made separately on aliquoted samples of both feces and urine, manganese could not be detected even in large samples of urine. Dry ashing of samples of feces in combination with urine resulted in appreciable amounts of manganese being combined with silica; consequently, for complete recovery of manganese in these combined samples, volatilization of silica with hydrofluoric acid was necessary. The results indicate that, although ingested manganese is not excreted by way of the urine, the variability of excretion by way of the feces precludes its use with lambs as a suitable reference substance in calculating the digestibility of ration nutrients by a ratio technic (3) (2).

There is nothing in the results to suggest that manganese, at the levels used in these trials, impairs digestion in lambs or interferes with nitrogen utilization. Although it may interfere with normal mineral metabolism, preliminary results to be reported later have failed to show that it has an adverse effect on the retention of calcium and phosphorus.

Summary

In a series of balance trials with lambs, manganese in amounts representing approximately 30, 300, 600, 900, 1200 and 1500 ppm of ration

was found to be without effect on protein digestion, nitrogen retention or the digestibility of total ration nutrients.

The lambs retained appreciable amounts of manganese at all levels of intake above 30 ppm of ration. In different trials the percentage of dietary manganese retained was neither constant nor related to intake. Large amounts of manganese were excreted through the feces and none was excreted by way of the urine.

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