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RECOVERY OF CHROMIC OXIDE ADMINISTERED IN PAPER TO GRAZING STEERS [1]

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CHROMIC oxide has been used as an external indicator to determine fecal output under a wide range of conditions with diverse results. The most common method of administering Cr_2O_3 has been as powder in gelatin capsules or mixed with the ration. One of the main problems in its use in powder form is the diurnal variation pattern of excretion (Kane, Jacobson and Moore, 1952; Linnerrud and Donker, 1961; Smith and Reid, 1955). An effort was made by Corbett, Greenhalgh and McDonald (1958) to reduce diurnal variation by using paper as a carrier for the indicator. The paper, containing 20 to 30% chromic oxide, seemed to approximate more nearly the physical characteristics of roughage rations. Corbett *et al.* (1960a, b) reported reduced variation when chromic oxide was administered as a component of shredded paper. Streeter and Clanton (1964) and Nelson, Kromann and Green (1966) have also found chromic oxide-impregnated paper to be a reliable external indicator.

The purpose of this study was to determine chromic oxide recovery by steers grazing tobosa (*Hilaria mutica*) at two stages of maturity (immature to prebloom and dormant), when chromic oxide was administered once daily as a component of shredded paper.

Experimental Procedure

Trial 1. Five grade Hereford steers grazing dormant tobosa (November, 1966) were each given three boluses of chromic oxide-impregnated shredded paper (13.60 gm. of chromic oxide) with a balling gun daily at 7 a.m. for 8 days. Each steer was fitted with a fecal collection bag and harness of the type described by Gorski *et al.* (1957); however, the urine separator was not used. The bags were emptied twice daily (7 a.m. and 5 p.m.) and the total quantity of feces excreted was weighed and sampled daily. On the seventh and eighth days fecal "grab" samples were also taken every 2 hr. to determine the diurnal variation in chromic oxide excretion. All samples were analyzed for dry matter and for chromic oxide concentration (Kimura and Miller, 1957).

Trial 2. Five grade Hereford steers were allowed to graze green tobosa (immature to prebloom stage of maturity) in July, 1967. Three boluses of chromic oxide paper (12.94 gm. of chromic oxide) were administered with a balling gun to each steer at 7 a.m. daily for 10 days. Each steer was fitted with a fecal collection bag and harness of the type described by Garrigus and Rusk (1939). The bags were emptied twice daily (7 a.m. and 7 p.m.) and the feces excreted during each day were weighed and sampled once daily. Samples for day one were discarded because previous studies in dry lot (Nelson *et al.*, 1966) indicated very low concentrations of chromic oxide in the feces collected during the first day after administration. All other samples were analyzed for dry matter and chromic oxide concentration.

Trial 3. Shredded paper containing chromic oxide (13.02 gm. of chromic oxide) was packed into three gelatin capsules per steer for administering at 7 a.m. daily for 9 days in November, 1967, to each of four grade Hereford steers grazing dormant tobosa. At the beginning of the second day, each steer was fitted with a fecal collection bag and harness of the same type used in trial 2. The bags were emptied twice daily (7 a.m. and 6 p.m.) and the feces for each day were weighed, sampled and analyzed for dry matter and chromic oxide concentration.

Statistical Analysis. Sources of variation in the analysis of variance in the first part of trial 1 and in trials 2 and 3 were days and steers with days x steers used as the error term. For days 7 and 8 of trial 1, days, hours, steers and the two-way interactions were the sources of variation. Significance among or

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TABLE 1. CHROMIC OXIDE RECOVERY (%) BY STEERS GRAZING DORMANT TOBOSA, TRIAL 1

Day of collection	Steer					Av.
	A	B	C	D	E	
1	0	0	0	0	0	0
2	47.1	39.4	33.9	48.3	62.1	46.2
3	79.6	66.7	64.4	71.1	83.1	73.0
4	63.1	78.1	82.0	60.5	70.6	70.8
5	32.5	98.8	66.8	67.1	84.3	69.9
6	54.3	88.6	59.3	91.5	51.0	68.9
7	45.7	68.1	55.7	61.9	89.2	64.1
8	51.1	112.9	78.0	71.7	96.2	82.0
(Av. of days 3 to 8)	54.4[b]	85.5[a]	67.7[ab]	70.6[ab]	79.1[a]	71.5

[a, b] Steer means with different letter superscripts are significantly different ($P<.05$).

between means was determined by Duncan's multiple range tests (Steel and Torrie, 1960).

Results and Discussion

Trial 1. Percentage recovery of chromic oxide is given in table 1. No chromic oxide was recovered during the first day after initial administration and recovery was very low (46.2%) for the second day. The average recovery for days 3 through 8 was 71.5%, and varied from 64.1% on day 7 to 82.0% on day 8. None of these differences was significant ($P<.05$). These low recoveries are in agreement with most other results with grazing steers (Harris *et al.*, 1967). Nelson *et al.* (1966) reported recovery of slightly over 100% in drylot by the third day and near 100% for days 3 through 9. Other researchers, including Deinum, Immink and Deijs (1963) and Cowlishaw and Alder (1963) have also reported recovery of near 100%. The low recovery obtained in this grazing trial may have been due to loss of some boluses by regurgitation, incomplete collection of feces or improper sampling. Neither loss was noted.

Differences among steers were significant ($P<.05$) and are shown in table 1. Recovery ranged from 54.4% for steer A to 85.5% for steer B.

The diurnal variation in excretion of chromic oxide by grazing steers on days 7 and 8 is shown in table 2. The highest average recovery (79.5%) was obtained at 5 p.m., which is a practical sampling time. This recovery was significantly higher than the recoveries for 5 a.m. through 3 p.m. Average recovery was significantly lower ($P<.01$) the first 24 hr. (65.5%) than for the second 24 hr. (73.5%). Recovery was significantly higher ($P<.05$) for steer E (88.8%) and lower for steer A (48.4%) than the other steers. Average recovery for steers B, C and D was 70.4%, with no significant difference among them ($P>.05$).

The day x steer interaction was significant ($P<.05$) with recovery being higher during the second 24 hr. for steers C and D, while there were no significant differences between 24-hr. periods for the other three steers. The day x hour interaction was also significant ($P<.05$) with recovery being higher during the second 24 hr. at 5 and 7 p.m. than during the first 24 hours. There was no significant dif-

TABLE 2. DIURNAL VARIATION IN EXCRETION OF CHROMIC OXIDE BY STEERS GRAZING DORMANT TOBOSA, TRIAL 1

Item	First 24 hr.	Second 24 hr.	Difference	Av.
Hour				
7 a.m.	71.1	65.3[d]	5.8	68.2[g]
9 a.m.	63.4	65.3[d]	1.9	64.4[g]
11 a.m.	62.8	68.2[b, c, d]	5.4	65.5[g]
1 p.m.	70.0	66.2[c, d]	3.8	68.1[g]
3 p.m.	65.5	73.6[b, c, d]	8.1	69.5[g]
5 p.m.	69.2	89.8[a]	20.6*	79.5[f]
7 p.m.	61.9	79.8[a, b]	17.9*	70.9[f, g]
9 p.m.	64.4	79.0[a, b, c]	14.6	71.7[f, g]
1 a.m.	61.6	72.1[b, c, d]	10.5	66.8[g]
3 a.m.	66.0	77.6[a, b, c, d]	11.6	71.8[f, g]
5 a.m.	65.1	71.2[b, c, d]	6.1	68.1[g]
Steer				
A	48.6[k]	48.3[l]	0.3	48.4[z]
B	65.6[j]	70.0[k]	4.4	67.8[y]
C	62.5[j]	78.7[j]	16.2*	70.6[y]
D	64.3[j]	79.3[j]	15.0*	71.8[y]
E	86.7[i]	90.9[i]	4.2	88.8[x]
$\bar{X}$	65.5	73.5	8.0*	69.5

[a, b, c, d] Hour means within the same 24-hr. period with different letter superscripts are significantly different ($P<.05$).
[f, g] Average hour means with different letter superscripts are significantly different ($P<.05$).
[i, j, k, l] Steer means within the same 24-hr. period with different letter superscripts are significantly different ($P<.05$).
[x, y, z] Average steer means with different letter superscripts are significantly different ($P<.05$).
* $P<.05$ for differences between 24-hr. periods.

ference among hours during the first 24 hr., but considerable differences existed during the second 24 hours.

Trial 2. One of the fistulated steers was observed to regurgitate several of the paper boluses which dropped to the ground after leaving the corral. This resulted in an extremely low recovery of chromic oxide and the data for this steer were excluded from the results. Losses due to regurgitation were reduced by keeping the steers confined in the corral for about 30 min. after administration of the boluses. Recovery was low on days 2 and 3 but increased to an average of 75.1% by day 4 (table 3). Recovery for steer C was very low until day 9, and it is likely that he regurgitated some of the boluses.

There was no significant difference in percentage recovery of chromic oxide for days 4 through 10. Average recovery for these 7 days was 88.0%, which was higher than in trial 1, but still lower than those reported by Deinum *et al.* (1963), Cowlishaw and Alder (1963) and Nelson *et al.* (1966). For days 7 through 10, average recovery was 93.4%. There was a significant ($P<.01$) difference between steers with a high of 105.4% recovery for steer B and a low of 64.7% for steer C.

Trial 3. Recovery of chromic oxide (table 4) steadily increased until the fourth day and remained fairly constant (82.4% av.) for days 4 through 9. This recovery was higher than with dormant tobosa in trial 1, but lower than with green tobosa in tral 2. This is in agreement with the report by Corbett *et al.* (1960b) which indicated that recovery of chromic oxide declined with increasing maturity of the forage being grazed. There was no significant difference in percentage recovery among steers and among days 4 through 9.

TABLE 3. CHROMIC OXIDE RECOVERY (%) BY STEERS GRAZING GREEN TOBOSA, TRIAL 2

Day of collection	Steer A	B	C	D	Av.
2	43.7	4.2	40.3	47.6	33.9
3	63.1	23.1	58.4	81.9	56.6
4	87.2	90.7	39.3	83.3	75.1
5	96.8	108.2	21.6	82.2	77.2
6	105.9	127.6	50.4	78.4	90.6
7	91.6	114.9	70.5	104.7	95.4
8	103.7	92.3	79.5	90.7	91.4
9	82.7	93.0	97.1	96.1	92.2
10	85.7	110.4	94.4	87.2	94.5
(Av. of days 4 to 10)	93.3[a, b]	105.4[a]	64.7[c]	88.8[b]	88.0

[a, b, c] Steer means with different letter superscripts are significantly different ($P<.05$).

TABLE 4. CHROMIC OXIDE RECOVERY (%) BY STEERS GRAZING DORMANT TOBOSA, TRIAL 3

Day of collection	Steer A	B	C	D	Av.
2	24.9	43.0	41.7	44.7	38.6
3	54.6	65.5	75.3	69.1	66.1
4	80.0	90.6	77.4	82.2	82.5
5	78.3	73.2	79.0	76.6	76.8
6	82.7	77.7	79.6	77.5	79.4
7	83.3	85.5	92.2	84.2	86.3
8	78.3	96.0	99.1	81.3	88.6
9	82.3	88.6	71.4	82.2	81.1
(Av. of days 4 to 9)	80.8	85.3	83.1	80.6	82.4

Summary

Average recovery of chromic oxide was 71.5% for days 3 through 8 when the indicator was administered as a component of shredded paper in boluses to five steers grazing dormant tobosa. Steer differences were significant ($P<.05$) with recovery ranging from 54.4 to 85.5%, but differences among days (3 through 8) were not significant ($P>.05$). When the shredded paper was packed in gelatin capsules and administered to four steers grazing dormant tobosa, average recovery for days 4 through 9 was 82.4%. Steer and day differences were not significant. With four steers grazing green tobosa, average recovery of chromic oxide was 88.0% for days 4 through 10, and 93.4% for days 7 through 10 when the indicator was administered in paper boluses. Differences among days (4 through 10) were not significant, but steer differences were significant ($P<.05$). Concentration of chromic oxide in the feces varied throughout the day. The highest average recovery (79.5%) was obtained at 5 p.m., and this recovery was significantly higher ($P<.05$) than the recoveries for 5 a.m. through 3 p.m.

Recovery of chromic oxide was considerably less than 100% and was highly variable among steers. Apparently, administering this indicator impregnated in shredded paper is no better than other methods of administration and results in wide variation among animals within a trial and between trials.

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