CHROMIC OXIDE AS AN INDEX OF DIGESTIBILITY OF ALL-CONCENTRATE RATIONS FOR SHEEP

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Increased interest in all-concentrate rations for ruminant feeding (Guerin et al., 1959; Lassiter et al., 1960; Nicholson et al., 1962; Preston et al., 1962) has resulted in the need to determine whether many of the concepts that are accepted for conventional rations also apply to all-concentrate rations. One of these concepts involves the value of the indicator method for determining digestibility. Compared with conventional methods for determining digestibility, indicator methods such as chromic oxide (Cr₂O₃) offer many advantages in rations for simple-stomached animals (Clawson et al., 1955). Its use in conventional rations for ruminants, however, involves the difficulty of obtaining representative fecal samples (Barnicoat, 1945). Crampton and Lloyd (1951) have suggested that accuracy could be improved in such rations by mixing the Cr₂O₃ into the concentrate portion of the ration.

Elam et al. (1962) studied the value of Cr₂O₃ in complete pelleted rations containing hay, but reports of its value in mixed all-concentrate rations have not been found in the literature.

The studies reported here compared the indicator method with the total collection method for determining digestion coefficients in mixed all-concentrate rations fed to sheep.

Materials and Methods

In each trial Cr₂O₃ was incorporated at the rate of 0.5% into all-concentrate rations. The objective of the experiments was to compare the two methods with all-concentrate rations fed ad libitum or hand-fed, utilizing three fecal sampling procedures.

During the experiments the sheep were kept in wooden metabolism crates similar to those described by Hansard et al. (1951). Water was available ad libitum. The rations were sampled as fed, and composite samples of the rations were ground through a 20-mesh screen before analysis. The daily fecal excretions and the grab samples for Cr₂O₃ analysis were refrigerated until the end of each trial, when they were dried in a forced-air oven at 41°C until below air moisture. They were then allowed to equilibrate with the air and were weighed before being ground in a Wiley mill through a 20-mesh screen, mixed and sampled for the analyses. Dry matter and ash were determined by the methods of the A.O.A.C. (1955). Chromic oxide was determined by the method described by Brisson (1956).

Experiment I. Eight Hampshire x western crossbred wether lambs averaging 32 kg. were used in four groups of two in each of a series of four digestion trials to measure digestibility of the organic matter in all-concentrate rations fed ad libitum. The four trials were run consecutively with no break between the trials. Four rations were used in each trial; one ration was fed to each group of lambs. No group of lambs received the same ration more than once in the four trials. Also, assignment of the rations was arranged so that no ration would follow any other more than once. Ingredients of the rations are shown in table 1.

The lambs were allowed to eat from self feeders. Seven-day preliminary periods preceded 7-day total collection periods in each trial. During the last 4 days of each collection period, the rations fed during the preliminary period and the first 3 days of the collection period were replaced with rations of the same composition modified by the inclusion of 0.5% Cr₂O₃. At 3 p.m. on the last day of each collection period, single rectal grab samples (10 to 15 gm.) were obtained for the digestibility determinations by the Cr₂O₃ indicator method.

Experiment II. Eight crossbred wether lambs averaging 33.5 kg. in weight were used in four groups of two in each of a series of four digestion trials to measure digestibility of the organic matter in all-concentrate rations fed ad libitum. The four trials were run consecutively with no break between the trials. Four rations were used in each trial; one ration was fed to each group of lambs. No group of lambs received the same ration more than once in the four trials. Also, assignment of the rations was arranged so that no ration would follow any other more than once. Ingredients of the rations are shown in table 1.

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INDEX OF DIGESTIBILITY FOR SHEEP

TABLE 1. COMPOSITION OF RATIONS (EXPERIMENT 1)

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground shelled corn</td>
<td>70.4</td>
<td>69.1</td>
<td>70.4</td>
<td>69.1</td>
</tr>
<tr>
<td>Soybean oil meal, 50%</td>
<td>24.0</td>
<td>24.0</td>
<td>24.0</td>
<td>24.0</td>
</tr>
<tr>
<td>Stabilized animal tallow</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Poultry fat</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Salt</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>Ground limestone</td>
<td>0.5</td>
<td>1.8</td>
<td>0.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Mineral supplement a</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Vitamin supplement b</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Antibiotic c</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>

a Furnished the following in ppm of ration: Co, 0.3; Cu, 4.4; Mn, 47; I, 0.75; Zn, 36; and Mg, 300.
b Furnished 11,000 I. U. vitamin A and 1760 I. U. vitamin D/kg. ration.
c Dicyclomycin, 88 mg./kg. ration.

The mean organic matter digestion coefficients with their standard errors, as determined by the total collection and the Cr2O3 methods, are listed in table 3. Each mean is based on data from the four groups of two lambs each. Digestion coefficients in all cases were quite high and reflected the greater digestibility of all-concentrate rations. The value of 90% for organic matter, as measured by total collection, may be compared with 56% for dry matter, as determined by Crampton and Lloyd (1951) with grain and hay, and with 65% by Elam et al. (1962) in studies with pelleted conventional feeds.

The digestion coefficients for organic matter by the total collection method were both higher (P<.01) and less variable (P<.05) than those obtained by the Cr2O3 method. Agreement between the total collection and Cr2O3 methods was not as close as the values obtained by Elam et al. (1962) or Crampton and Lloyd (1951). In the study by Elam et al. (1962) the digestion coefficients by the Cr2O3 method were based on the total collection of feces after 10-day preliminary and 10-day collection periods. In the study by Crampton and Lloyd (1951) 1% Cr2O3 was mixed with ground oats, dampened with water and dried in an air oven at 90°C. before it was fed with hay. Their coefficients of digestibility were calculated from random fecal samples taken daily for 4 days after 6 days on Cr2O3.

Some of the variability in each of the trials on the total collection, as well as on the Cr2O3 methods, was due to the four rations employed. The coefficients by the total collection method were significantly higher than those by the Cr2O3 method in trials 3 and 4. The greater (P<.05) variability by the Cr2O3 method were treated statistically by calculation of the lamb-to-lamb variance.

Results and Discussion

Experiment I. The mean organic matter digestion coefficients with their standard errors.
method than by the total collection method, however, was undoubtedly due to the single sample at the end of each trial's not representing the true fecal excretion of that trial. This could have resulted not only because of a single sample, but also because the sample was taken after the wethers had been fed the Cr$_2$O$_3$ for only 4 days. Experiment II thus was designed to compare the coefficients obtained by the total collection method with those obtained by different sampling procedures and length of time on Cr$_2$O$_3$.

**Experiment II.** Mean coefficients with their standard errors for the dry matter digestibility, as determined by the total collection and Cr$_2$O$_3$ methods, are listed in table 4. One of the lambs was quite erratic in feed consumption over the entire experiment, and his total consumption was little more than half as much as that of the other lambs. Although the cause for this was not known, the performance of this lamb was considered to be abnormal, and the data were not included in the comparisons. Another lamb did not consume the ration at the last feeding, and these data also were not included.

As in experiment I, higher average digestion coefficients resulted from the total collection method than from the Cr$_2$O$_3$ indicator methods. This difference approached significance. The dry matter digestion coefficients calculated from the Cr$_2$O$_3$ content in the total fecal collection were no higher than those calculated from the Cr$_2$O$_3$ content in the fecal samples obtained on the fifth through the eighth days and in the samples from the eighth days and in the samples from the eighth through the 11th days were significantly (P<.05) more variable than those based on the four fecal samples obtained on the eighth day. This may have resulted from daily variation in the fecal chromic oxide concentration. The individual daily samples were not analyzed. With the Cr$_2$O$_3$ method end-period errors should not have been involved. Diurnal variation in Cr$_2$O$_3$ excretion may have been a factor, however. Four different samples representing excretion during different times of the day were picked up on the eighth day, whereas the samples for the fifth through the eighth and the eighth through the 11th days were taken at the same time (4 p.m.) each day.

Chromic oxide recovery was calculated using the weight and percent Cr$_2$O$_3$ of the dry feed intake and of the total dry fecal excretions of each lamb during the 7-day collection period. Recovery averaged 78%, which was low and may be due to the fact that total collection began 4 days after the beginning of the Cr$_2$O$_3$ feeding. That this was a factor in the recovery is indicated by figures showing the mean Cr$_2$O$_3$ concentration in the feces of the samples collected on the eighth day was 6% greater than for either the 7-day total collection or for samples from the fifth through the eighth days.

These data indicate that the Cr$_2$O$_3$ indicator method does not result in digestion coefficients quite as high nor as consistent as does the total collection method, when all-concentrate rations are fed ad libitum or hand-fed, and the methods of sampling used in this study are employed. However, the small variation between coefficients determined from data on the eighth day by the Cr$_2$O$_3$ method suggests that this method would be appropriate for digestibility comparisons between rations.

**Summary**

The Cr$_2$O$_3$ method was compared with the total collection method for determining digestibility of organic matter or dry matter in all-concentrate rations fed in two experiments to sheep. In the four trials of the first experiment, single samples after 4 days of Cr$_2$O$_3$ feeding were employed to compare the organic matter digestibility. In the second experiment dry matter digestibility calculated from total collection was compared with that obtained
for the \( \text{Cr}_2\text{O}_3 \) content of fecal samples taken on the fifth through the eighth days, the eighth day, and the eighth through the 11th days after beginning \( \text{Cr}_2\text{O}_3 \) feeding.

Digestion coefficients for dry and organic matter were quite high for sheep. In experiment I digestion coefficients for organic matter by the total collection method were significantly \((P < 0.01)\) higher than those by the \( \text{Cr}_2\text{O}_3 \) method. The standard errors were lower by the total collection method in three of the four trials, but these were not significant.

In experiment II higher average coefficients also resulted from the total collection method than from the \( \text{Cr}_2\text{O}_3 \) indicator methods, but the differences were not significant. Coefficients calculated from the \( \text{Cr}_2\text{O}_3 \) content in the total fecal samples, in the samples obtained on the fifth through the eighth days and in the samples from the eighth through the 11th days were significantly \((P < 0.05)\) more variable than those based on the four fecal samples obtained on the eighth day. Coefficients calculated from a composite of four samples obtained the eighth day after beginning \( \text{Cr}_2\text{O}_3 \) feeding were slightly but significantly lower than those obtained by total collection. The comparable standard errors, however, suggest that the method would be appropriate for digestibility comparisons between rations.

Literature Cited


