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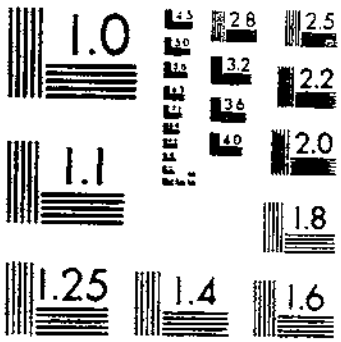


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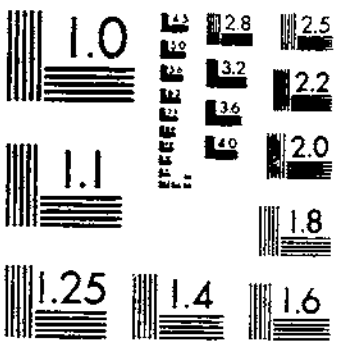


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# Comparison of Chromic Oxide and Conventional Methods in Digestion Trials Using Steers Fed Pelleted Rations



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# Comparison of Chromic Oxide and Conventional Methods in Digestion Trials Using Steers Fed Pelleted Rations

By P. A. PUTNAM, *research animal husbandman, Animal Husbandry Research Division;* C. J. ELAM, formerly *research animal husbandman, Animal Husbandry Research Division;* and D. EVERSON, formerly *analytical statistician, Biometric Services, Agricultural Research Service*

Little information is available concerning the variability and reliability of digestion coefficients determined by use of the chromic oxide ($Cr_2O_3$) method when cattle are fed pelleted, complete rations containing $Cr_2O_3$.

Reports by Bradley and others (*3*)[1] and by Elam and others (*5*) indicate that a time-concentration variation can be expected in the fecal pattern of $Cr_2O_3$ excretion even though the indicator was mixed with the entire ration. Although variations have been noted in the recovery of $Cr_2O_3$ from feces (*7*) most of the reports indicate nearly 100 percent recovery of this indicator. Difficulties in obtaining complete recovery would be reflected in the digestion coefficients calculated by use of the indicator.

The purpose of this report is to compare the variation in digestion coefficients determined by the $Cr_2O_3$ "grab" sampling method, the $Cr_2O_3$ total-collection aliquots method, and the conventional total-collection method using beef cattle fed widely differing types of pelleted rations containing $Cr_2O_3$.

## EXPERIMENTAL PROCEDURE

When possible, about 0.5 percent of chromic oxide was incorporated in all rations during routine digestion studies with steers during the period of 1957 through 1961. During these studies the plane of nutrition varied from less than maintenance to nearly two times maintenance. Rations contained 22 to 89 percent roughage and zero to 30 percent molasses. One ration contained 34 percent sugarcane bagasse pith (table 1). This feed was pelleted in sizes ranging from three-eighths to five-eighths of an inch in diameter. Sixty-four digestion trials were conducted on 24 animals, and results of the total-collection and the chromic oxide methods were directly compared.

Because of the variety of rations fed and number of animals studied, it was felt that a useful estimate of the variation in digestion coefficients determined by use of the chromic oxide method could be obtained. Fecal "grab" samples weighing 250 grams were taken about 9 a.m. and 3 p.m. The samples were composited on an equal wet-

[1] Italic numbers in parentheses refer to Literature Cited, p. 7.

TABLE 1.—*Composition of rations and approximate plane of nutrition*

| Feedstuff | Ration number | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1[1] | 2[1] | 11 | 41 | 48 | 49 | 50 | 51 | 62 | 74[1] | 83 |
| Linseed meal.....percent | 14.8 | 8.9 | ------ | 4.5 | ------ | ------ | ------ | ------ | ------ | 10.0 | ------ |
| Cottonseed meal.....do | ------ | ------ | 14.7 | 4.5 | 16.1 | 15.9 | 15.6 | 15.0 | ------ | ------ | ------ |
| Soybean meal.....do | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 19.0 | ------ | 16.0 |
| Alfalfa hay.....do | 81.5 | 48.8 | ------ | 44.5 | ------ | ------ | ------ | ------ | ------ | ------ | 22.0 |
| Orchardgrass hay.....do | ------ | ------ | 24.5 | 44.5 | ------ | ------ | ------ | ------ | ------ | 60.0 | ------ |
| Timothy hay.....do | ------ | ------ | ------ | ------ | 60.3 | 59.7 | 58.5 | 56.0 | ------ | ------ | ------ |
| Bagasse pith.....do | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 33.9 | ------ | ------ |
| Cornmeal and cobmeal.....do | ------ | ------ | 49.0 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| Corn.....do | ------ | 40.1 | ------ | ------ | 22.1 | 21.9 | 21.4 | 20.5 | 30.9 | ------ | ------ |
| Barley.....do | 3.7 | 2.2 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 57.0 |
| Molasses.....do | ------ | ------ | 9.8 | ------ | ------ | ------ | ------ | ------ | 14.2 | 30.0 | ------ |
| Salt.....do | ------ | ------ | 1.0 | 1.0 | 1.0 | 2.0 | 4.0 | 8.0 | 1.0 | ------ | 1.0 |
| Bonemeal.....do | ------ | ------ | 1.0 | 1.0 | .5 | .5 | .5 | .5 | 1.0 | ------ | ------ |
| Soybean oil.....do | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 4.0 |
| Approximate plane of nutrition (x maintenance) | 1 | 1¼–2 | 1¼ | 1 | 1¼ | 1¼ | 1¼ | 1¼ | ⅞ | 1¼ | 1¼ |

[1] Salt and bonemeal offered ad libitum.

weight basis during the 10-day total-collection periods. During four digestion trials, chromic oxide values were determined from daily total-collection and "grab" samples as well as from composite total-collection samples. Chromic oxide values for 5-day and 10-day total-collection composites were determined in nearly all trials. The 5-day, 9 a.m. and 3 p.m. "grab" sampling method was selected because it was not only convenient but also because previous observations showed a significant time-concentration variation of $Cr_2O_3$ excretion when animals were fed chromic oxide in a mixed and pelleted ration (*5*).

Most of the trials were conducted at or slightly above maintenance feeding levels, but in the studies involving plane of nutrition, the animals were essentially on an ad libitum regimen. The latter condition might be considered as being nearly comparable to that existing in a feedlot. With the exception of studies with the bagasse ration, all total collections were for 10-day periods following a 1-week period in which animals became adjusted to the crates. Because of a limited supply of feed, the bagasse ration was offered during a preliminary period of 5 days before a standard 10-day collection period.

All fecal samples were placed on aluminum pans and dried in a force-draft oven for 24 hours at 70° C. The dried samples were then ground in a Wiley [2] mill. Moisture analyses were made by use of a vacuum oven according to the recommended A.O.A.C. method. The method of Christian and Coup (*4*) was used for the $Cr_2O_3$ analyses.

## RESULTS AND DISCUSSION

Since these studies were conducted on different animals, in different years and seasons, and with grossly different types and amounts of feed, the data are not altogether suitable for a routine statistical analysis. These experimental divergencies, however, tend to give the data wider application than they normally would. For these reasons the raw data obtained in the study are in the appendix tables.

Digestion coefficients determined by the 10-day total-collection method, first 5-day "grab" and second 5-day "grab" methods and total-collection $Cr_2O_3$ (recovery) techniques are available for 60 trials. Several interpretations may be applied to the data. Differences in the digestion coefficients obtained by use of the standard total-collection method and the $Cr_2O_3$ method using the total-collection aliquot represent incomplete recovery of $Cr_2O_3$ or of fecal dry matter, or possibly an inaccurate estimate of $Cr_2O_3$ intake per unit of material consumed. Agreement among digestion coefficients suggests either accurate values or balancing errors.

The two 5-day "grab" $Cr_2O_3$ values may be evaluated according to the total-collection values, to the total-collection $Cr_2O_3$ values, and with each other. If in agreement with the total-collection values, the 5-day "grab" values may be considered adequate. If they agree with the total-collection $Cr_2O_3$ values, it may be assumed the grabbing procedure accurately estimated mean fecal $Cr_2O_3$ concentration. Com-

[2] Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement by the Department over other products not mentioned.

pared with each other, the values may indicate the presence or absence of 5-day trends in digestibility.

Correlation coefficients for digestion values determined by use of the chromic oxide and the standard total-collection methods are shown in the tabulation that follows. The digestion coefficients from which these correlations were calculated are in appendix table 4.

| Method comparison: [1] | $r$ value one animal |
|---|---|
| $x_1x_2$ | [2] 0.35 |
| $x_1x_3$ | [3] .69 |
| $x_1x_4$ | [3] .40 |
| $x_2x_3$ | [3] .67 |
| $x_2x_4$ | [3] .53 |
| $x_3x_4$ | [3] .44 |

[1] $x_1$=First 5-day $Cr_2O_3$ "grab" sampling method;
$x_2$= Second 5-day $Cr_2O_3$ "grab" sampling method;
$x_3$=10-day total-collection $Cr_2O_3$ method;
$x_4$=Standard 10-day total-collection method.
[2] Indicates statistical significance at $P<0.05$.
[3] Indicates statistical significance at $P<0.01$.

There were significant ($P<0.05$) correlations among all methods compared. However, the $r$ values were lower than had been anticipated. The rather narrow range in digestion coefficients is probably the reason for the low $r$ values. This suggests that the $Cr_2O_3$ method would not be sensitive enough for detecting small differences in digestion coefficients. The analysis of variance indicated differences in mean digestion coefficients between methods. Duncan's test indicated that the total-collection value was significantly higher ($P<0.01$) than either of the 5-day $Cr_2O_3$ "grab" values and significantly higher ($P<0.05$) than the total-collection $Cr_2O_3$ value. The mean digestion coefficients determined by chromic oxide and total-collection techniques follow.

| Method: | *Mean digestion coefficients* [1] |
|---|---|
| First 5-day $Cr_2O_3$ "grab" | 60.9[a] |
| Second 5-day $Cr_2O_3$ "grab" | 61.0[a] |
| 10-day total-collection—$Cr_2O_3$ | 61.5[b] |
| 10-day total-collection | 62.3[c] |

[1] Values with unlike superscripts are significantly different at the 5-percent level and values with unlike subscripts are significantly different at the 1-percent level of probability. Each value represents an average for 60 observations.

These comparisons among methods involve differences of around one digestion unit and, though some of the differences were statistically significant, in practice such variations would be acceptable. Furthermore, the total-collection method employed in these studies involved the use of metabolism crates equipped with grates through which urine was collected. In some of the earlier trials, an observable but unmeasured amount of feces was washed into the urine containers. Under such conditions, total-collection digestion coefficients would be biased upwards an unknown amount. Thus, the correct digestion coefficient is nearer the coefficient determined by the $Cr_2O_3$ "grab" method than the raw data indicate. It is the contention of the

authors that in these studies the $Cr_2O_3$ total-collection digestion coefficients are as nearly accurate as the conventional total-collection coefficients. There would, however, be no advantage to conducting 10-day total collections and using the $Cr_2O_3$ ratio for estimating the digestion coefficients. The 5-day "grab" sampling method would appear to be a suitable alternative because the digestion coefficients are comparable, and the method requires less work and equipment.

Some general observations concerning appendix table 4 merit attention. Note the digestion coefficients for animal No. 1 when fed ration No. 62. The $Cr_2O_3$ "grab" and $Cr_2O_3$ total-collection values agree with each other for this animal and ration, but the total-collection value is nearly 6 units higher. The feces from this animal was very liquid (9.2 percent air-dry matter), and fecal dry-matter losses occurred as a result of extensive spattering during each defecation. The coefficients calculated by the $Cr_2O_3$ method are believed to be more accurate than those calculated by the conventional method. Conversely, the coefficients for ration 1–1 [3] are consistently higher when the $Cr_2O_3$ methods are used. This was one of the earlier (chronologically) trials, and it illustrates the importance of an accurate feed-$Cr_2O_3$ value. The feed-$Cr_2O_3$ value is suspected of being inaccurate because the $Cr_2O_3$ results were uniform and the $Cr_2O_3$ concentration in the feed was the common value used in calculations. These two observations illustrate the importance of accurate sampling techniques for determining the $Cr_2O_3$ value of the feed and the adaptability of the $Cr_2O_3$ method to conditions that are unfavorable for total-collection procedures.

Daily estimates of dry-matter digestibility, using the $Cr_2O_3$ "grab" sampling and total-collection methods, were available from 28 digestion trials. Twenty different animals were used in these studies. Variances were calculated for one group of eight animals and three groups of four animals (the group of eight animals was used in two experiments). The variances and the efficiency values of the estimates are expressed as ratios of the variances in table 2.

Methods were also compared by calculating the number of collection days required to have a standard error of 1.0 for the estimated digestion coefficients (table 3). Both comparisons indicate that daily estimates of digestibility are less variable when the $Cr_2O_3$ "grab" method is used (tables 2 and 3). The average variance for the daily total-collection method was 6.95 times the average variance for values determined by the chromic oxide ratio method (table 2). When expressed as the number of collection days necessary for a $S\bar{x}$ of 1.0, 4.9 collection days were necessary with the $Cr_2O_3$ "grab" method and 25.4 days with the total-collection method (table 3).

The statistical results and observation of individual coefficients lead to the conclusion that there is less day-to-day variation in digestion coefficients when the $Cr_2O_3$ method is used than when the conventional-collection method is used (appendix table 5). This appears to be true whether the $Cr_2O_3$ "grab" or $Cr_2O_3$ total-collection methods are used (appendix table 5, rations 62 and 74). Therefore, if the

[3] For numerals separated by a dash, the numeral on left is the ration number; the one on right is the trial number.

variations from total-collection values described above and in appendix table 5 are acceptable, a 2- to 5-day $Cr_2O_3$ "grab" sampling method would appear to be equal to a 10-day total-collection method.

TABLE 2.—*Variances for dry-matter digestion coefficients determined by the chromic oxide "grab" and total-collection methods for steers on various rations*

| Variance | Method | Rations | | | |
|---|---|---|---|---|---|
| | | 62 and 74 | 2–2 [1] | 2–3 [1] | 41 |
| $s^2$ | $Cr_2O_3$ "grab" [a] | 2. 52 | 5. 71 | 9. 23 | 2. 23 |
| | Total collection [b] | 14. 95 | 34. 54 | 21. 86 | 30. 05 |
| | Degrees of freedom | 54 | 54 | 54 | 21 |
| | $s^{2(b)}/s^{2(a)}$ | 5. 92 | 6. 04 | 2. 37 | 13. 48 |

[1] For numerals that are separated by a dash, the numeral on left is the ration number; the one on right is the trial number.

TABLE 3.—*Estimated number of days fecal collections are necessary to obtain a standard error of 1.0*

| Method | Rations | | | | Average |
|---|---|---|---|---|---|
| | 62 and 74 | 2–2 [1] | 2–3 [1] | 41 | |
| | *Days* | *Days* | *Days* | *Days* | *Days* |
| $Cr_2O_3$ "grab" | 2. 5 | 5. 7 | 9. 2 | 2. 0 | 4. 9 |
| Total collection | 15. 0 | 34. 6 | 21. 9 | 30. 0 | 25. 4 |

[1] For numerals separated by a dash, the numeral on left is the ration number; the one on right is the trial number.

However, it should be emphasized that these data apply to restricted experimental conditions in which all the animals were fed chromic oxide in a complete, ground, mixed, and pelleted ration. Furthermore, and in regard to appendix table 5, the steers fed rations 2–2, 2–3, and 41 were offered all the feed they would consume. A greater daily variation in fecal production would be expected under these conditions than when the animals were fed at nearly maintenance levels, as is frequently done in metabolism crates. In addition, indicator methods minimize the large end-period error associated with short-term total-fecal collections (*1*, *2*).

The small variation between daily coefficients obtained through use of the $Cr_2O_3$ "grab" method in these trials is similar to the variation reported by Axelsson and Kivimae (*1*) and Elam and others (*6*) who used the $Cr_2O_3$ total-collection method with sheep. The use of short-term total collections and of $Cr_2O_3$ ratios to calculate digestion coefficients as suggested by these workers would also appear to be a suitable method with cattle.

The use of the 5-day $Cr_2O_3$ "grab" sampling method as described in this report is satisfactory in feeding trials and experiments in which the determination of digestion coefficients supplements other measurement criteria. Under feedlot conditions, animals should not be allowed to consume bedding material. Digestion coefficients can be expressed on an ash-free basis to circumvent errors that are attributable to consumption of soil in unpaved lots.

## SUMMARY

Sixty-four digestion trials, involving 24 steers fed 11 pelleted rations at various planes of nutrition, were conducted by the direct (total-collection) and the indirect ($Cr_2O_3$) methods.

The digestion coefficients determined by use of the 5-day $Cr_2O_3$ "grab" sampling, 10-day $Cr_2O_3$ total-collection, and 10-day conventional total-collection methods were significantly correlated. However, small but significant differences in digestion coefficients were observed in the use of these methods. Variances calculated for daily digestion coefficients were greater for values determined by the conventional total-collection procedure than by the $Cr_2O_3$ method. This fact indicates that to have a standard error of 1.0, fewer collection days are needed when the indirect ($Cr_2O_3$) method is used than when the direct method is used.

Incorporating $Cr_2O_3$ in a pelleted, complete ration and taking fecal "grab" samples at 9 a.m. and 3 p.m. for 5 days proved to be a satisfactory technique for estimating dry-matter digestion coefficients using steers and the indicator method.

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# APPENDIX

TABLE 4.—*Digestion coefficients of stated rations determined by the chromic oxide and total-collection methods*

| Ration No.[1] | Animal No. | First 5-day $Cr_2O_3$ "grab" | Second 5-day $Cr_2O_3$ "grab" | 10-day total collection $Cr_2O_3$ | 10-day total collection |
|---|---|---|---|---|---|
| | | *Percent* | *Percent* | *Percent* | *Percent* |
| 1–1 | 151 | 62.0 | 63.0 | 60.9 | 55.8 |
| | 152 | 60.8 | 61.9 | 61.4 | 57.3 |
| | 147 | 62.8 | 61.1 | 63.5 | 56.4 |
| | 157 | 62.4 | 61.2 | 63.4 | 60.9 |
| Mean | | 62.0 | 61.8 | 62.3 | 57.6 |
| 2–1 | 159 | 65.6 | 60.7 | 60.8 | 65.9 |
| | 160 | 65.1 | 54.8 | 63.0 | 64.2 |
| | 148 | 64.5 | 68.6 | 67.0 | 68.9 |
| | 158 | 67.9 | 67.5 | 69.0 | 68.1 |
| Mean | | 65.8 | 62.9 | 65.0 | 66.8 |
| 1–2 | 151 | 59.3 | 61.1 | 60.3 | 62.2 |
| | 152 | 60.6 | 61.4 | 62.2 | 62.1 |
| | 147 | 58.8 | 65.0 | 60.0 | 62.3 |
| | 157 | 64.7 | 62.8 | 63.7 | 66.3 |
| Mean | | 60.9 | 62.6 | 61.6 | 63.2 |
| 2–2 | 159 | 66.0 | 63.9 | 65.9 | 69.6 |
| | 160 | 66.2 | 66.3 | 67.0 | 68.9 |
| | 148 | 68.7 | 69.7 | 69.3 | 71.5 |
| | 158 | 67.3 | 67.5 | 69.1 | 67.1 |
| Mean | | 67.1 | 66.9 | 67.8 | 69.3 |
| 2–3 | 151 | 54.7 | 60.5 | 59.7 | 60.1 |
| | 152 | 58.5 | 59.9 | 62.4 | 65.3 |
| | 147 | 63.7 | 62.6 | 65.0 | 64.6 |
| | 157 | 62.0 | 61.8 | 64.7 | 68.5 |
| Mean | | 59.7 | 61.2 | 63.0 | 64.6 |
| 2–3 | 159 | 64.3 | 65.7 | 67.1 | 70.4 |
| | 160 | 62.6 | 66.7 | 66.9 | 71.1 |
| | 148 | 63.6 | 67.0 | 66.5 | 69.4 |
| | 158 | 67.2 | 67.9 | 68.4 | 68.9 |
| Mean | | 64.4 | 66.8 | 67.2 | 70.0 |
| 11 | 1 | 65.6 | 68.0 | 67.8 | 68.4 |
| | 10 | 67.3 | 65.7 | 66.7 | 68.4 |
| | 15 | 70.4 | 69.1 | 70.4 | 71.5 |
| | 29 | 68.9 | 65.5 | 67.4 | 67.6 |
| Mean | | 68.1 | 67.1 | 68.1 | 69.0 |

See footnote at end of table.

TABLE 4.—*Digestion coefficients of stated rations determined by the chromic oxide and total-collection methods*—Continued

| Ration No.[1] | Animal No. | First 5-day $Cr_2O_3$ "grab" | Second 5-day $Cr_2O_3$ "grab" | 10-day total collection $Cr_2O_3$ | 10-day total collection |
|---|---|---|---|---|---|
| | | *Percent* | *Percent* | *Percent* | *Percent* |
| 48 | 1 | 59.5 | 56.8 | 56.9 | 58.2 |
| | 1 | 58.6 | 56.6 | 56.9 | 57.4 |
| | 10 | 53.1 | 51.9 | 53.8 | 54.0 |
| | 15 | 53.3 | 56.1 | 53.9 | 58.3 |
| | 29 | 55.9 | 56.0 | 56.6 | 56.9 |
| Mean | | 56.8 | 55.5 | 55.6 | 57.0 |
| 49 | 10 | 46.3 | 52.6 | 53.8 | 53.6 |
| | 10 | 53.0 | 55.4 | 54.4 | 54.3 |
| | 11 | 57.4 | 55.8 | 55.6 | 56.8 |
| | 15 | 57.4 | 59.0 | 57.7 | 58.9 |
| | 29 | 54.1 | 54.0 | 54.4 | 54.5 |
| Mean | | 53.6 | 55.4 | 55.2 | 55.6 |
| 50 | 15 | 60.8 | 62.5 | 60.5 | 60.8 |
| | 15 | 62.0 | 61.8 | 60.9 | 60.4 |
| | 1 | 61.4 | 58.9 | 59.8 | 61.2 |
| | 10 | 59.6 | 57.9 | 60.4 | 56.9 |
| | 29 | 60.3 | 59.1 | 59.3 | 58.0 |
| Mean | | 60.8 | 60.0 | 60.2 | 59.5 |
| 51 | 29 | 58.2 | 57.6 | 56.9 | 57.7 |
| | 29 | 58.8 | 57.7 | 56.5 | 56.4 |
| | 1 | 59.3 | 55.8 | 57.3 | 60.0 |
| | 10 | 56.6 | 54.8 | 56.6 | 56.3 |
| | 15 | 56.2 | 53.2 | 57.9 | 56.9 |
| Mean | | 57.8 | 55.8 | 57.0 | 57.5 |
| 62 | 10 | 65.9 | 67.8 | 66.5 | 66.9 |
| | 1 | 67.6 | 66.2 | 67.0 | 72.8 |
| | 29 | 66.8 | 67.2 | 67.1 | 67.9 |
| | 15 | 66.0 | 67.5 | 66.3 | 66.6 |
| Mean | | 66.6 | 67.2 | 66.7 | 68.5 |
| 74 | 53 | 53.7 | 53.5 | 55.0 | 57.2 |
| | 52 | 52.5 | 53.1 | 55.6 | 57.4 |
| | 45 | 54.9 | 53.6 | 55.8 | 60.0 |
| | 49 | 54.6 | 55.1 | 55.4 | 57.5 |
| Mean | | 53.9 | 53.8 | 55.4 | 57.1 |
| 83 | 63 | 56.2 | 59.3 | 60.8 | 59.8 |
| | 64 | 58.5 | 53.7 | 57.9 | 65.6 |
| | 52 | 65.0 | 55.6 | 59.7 | 59.3 |
| | 53 | 65.9 | 57.6 | 63.1 | 61.7 |
| Mean | | 61.4 | 56.6 | 60.4 | 61.6 |

[1] For numerals separated by a dash, the numeral on left is the ration number; the one on right is the trial number.

TABLE 5.—*Daily digestion coefficients calculated by use of chromic oxide and conventional methods*

| Ration,[1] method, and animal No. | Coefficients according to test day | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Ration 1–2: | | | | | | | | | | |
| Chromic oxide "grab": | | | | | | | | | | |
| Animal No. 151 | 56. 1 | 55. 4 | 60. 7 | 62. 4 | 61. 8 | 57. 7 | 64. 4 | 58. 5 | 60. 9 | 63. 9 |
| Animal No. 152 | 58. 1 | 59. 4 | 61. 7 | 62. 3 | 61. 7 | 64. 1 | 61. 3 | 60. 8 | 59. 4 | 61. 5 |
| Animal No. 147 | 52. 0 | 57. 9 | 57. 3 | 62. 2 | 64. 4 | 62. 1 | 65. 3 | 65. 3 | 67. 3 | 64. 8 |
| Animal No. 157 | 62. 9 | 64. 7 | 66. 4 | 65. 2 | 64. 5 | 62. 9 | 60. 9 | 63. 6 | 64. 0 | 62. 5 |
| Mean | 57. 3 | 59. 4 | 61. 5 | 63. 0 | 63. 1 | 61. 7 | 63. 0 | 62. 1 | 62. 9 | 63. 2 |
| Total collection: | | | | | | | | | | |
| Animal No. 151 | 60. 4 | 61. 4 | 63. 8 | 67. 1 | 61. 9 | 65 9 | 48. 7 | 59. 4 | 59. 9 | 73. 8 |
| Animal No. 152 | 52. 9 | 55. 4 | 63. 5 | 63. 8 | 58. 4 | 59. 3 | 65. 8 | 67. 9 | 63. 2 | 70. 5 |
| Animal No. 147 | 45. 5 | 56. 4 | 67. 2 | 52. 9 | 68. 4 | 66. 9 | 62. 9 | 68. 8 | 69. 8 | 64. 5 |
| Animal No. 157 | 52. 4 | 65. 2 | 69. 3 | 65. 0 | 66. 6 | 68. 0 | 66. 8 | 70. 8 | 69. 5 | 69. 6 |
| Mean | 52. 8 | 59. 6 | 66. 0 | 62. 2 | 63. 8 | 65. 0 | 61. 1 | 66. 7 | 65. 6 | 69. 6 |
| Ration 2–2: | | | | | | | | | | |
| Chromic oxide "grab": | | | | | | | | | | |
| Animal No. 159 | 70. 1 | 64. 3 | 65. 2 | 65. 8 | 64. 8 | 65. 8 | 60. 2 | 64. 2 | 65. 3 | 63. 9 |
| Animal No. 160 | 69. 5 | 66. 2 | 65. 2 | 66. 6 | 63. 5 | 65. 7 | 66. 1 | 66. 4 | 69. 1 | 64. 3 |
| Animal No. 148 | 69. 6 | 72. 3 | 70. 1 | 66. 9 | 64. 7 | 67. 5 | 69. 5 | 69. 4 | 74. 0 | 68. 1 |
| Animal No. 158 | 66. 7 | 69. 9 | 67. 0 | 65. 4 | 67. 4 | 67. 0 | 67. 2 | 67. 7 | 66. 1 | 69. 3 |
| Mean | 69. 0 | 68. 2 | 66. 9 | 66. 2 | 65. 1 | 66. 5 | 65. 8 | 66. 9 | 68. 6 | 66. 4 |
| Total collection: | | | | | | | | | | |
| Animal No. 159 | 72. 4 | 66. 8 | 73. 3 | 72. 9 | 69. 4 | 57. 7 | 74. 0 | 72. 0 | 76. 9 | 62. 9 |
| Animal No. 160 | 72. 9 | 74. 2 | 84. 1 | 53. 9 | 75. 5 | 67. 5 | 55. 2 | 55. 6 | 75. 4 | 76. 7 |
| Animal No. 148 | 72. 4 | 74. 9 | 71. 1 | 65. 2 | 65. 6 | 70. 5 | 75. 7 | 69. 3 | 75. 1 | 76. 2 |
| Animal No. 158 | 63. 1 | 79. 5 | 65. 2 | 60. 9 | 67. 6 | 64. 1 | 67. 6 | 68. 8 | 71. 5 | 71. 6 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 70.2 | 73.9 | 73.4 | 63.2 | 69.5 | 65.0 | 68.1 | 66.4 | 74.7 | 71.9 |
| Ration 2–3: | | | | | | | | | | |
| Chromic oxide "grab": | | | | | | | | | | |
| Animal No. 151 | 56.3 | 55.9 | 48.0 | 54.0 | 59.4 | 61.6 | 56.0 | 56.8 | 62.2 | 65.9 |
| Animal No. 152 | 64.0 | 57.9 | 51.2 | 62.5 | 56.8 | 59.8 | 64.3 | 59.0 | 57.7 | 58.9 |
| Animal No. 147 | 70.8 | 68.1 | 56.8 | 58.7 | 64.3 | 63.7 | 61.7 | 62.0 | 60.0 | 65.8 |
| Animal No. 157 | 61.6 | 59.6 | 61.0 | 65.4 | 62.6 | 63.1 | 61.5 | 65.2 | 62.3 | 56.8 |
| Mean | 63.2 | 60.4 | 54.3 | 60.2 | 60.8 | 62.1 | 60.9 | 60.8 | 60.6 | 61.9 |
| Total collection: | | | | | | | | | | |
| Animal No. 151 | 69.1 | 67.1 | 64.6 | 68.3 | 72.4 | 63.8 | 67.8 | 59.6 | 62.0 | 58.7 |
| Animal No. 152 | 62.1 | 65.4 | 57.2 | 60.9 | 59.3 | 53.6 | 64.0 | 61.9 | 58.7 | 58.8 |
| Animal No. 147 | 68.3 | 66.1 | 68.8 | 61.7 | 66.3 | 68.8 | 64.5 | 67.7 | 65.4 | 58.1 |
| Animal No. 157 | 75.1 | 65.2 | 68.6 | 78.2 | 76.9 | 69.9 | 66.5 | 64.7 | 58.2 | 61.9 |
| Mean | 68.7 | 66.0 | 64.8 | 67.3 | 68.7 | 64.0 | 65.7 | 63.5 | 61.1 | 59.4 |
| Ration 2–3: | | | | | | | | | | |
| Chromic oxide "grab": | | | | | | | | | | |
| Animal No. 159 | 67.6 | 58.1 | 64.0 | 67.4 | 64.3 | 67.6 | 64.7 | 64.4 | 65.1 | 66.9 |
| Animal No. 160 | 59.3 | 63.7 | 61.9 | 63.7 | 64.3 | 68.2 | 64.7 | 67.3 | 66.1 | 67.1 |
| Animal No. 148 | 61.5 | 64.6 | 60.6 | 67.2 | 64.1 | 65.5 | 67.1 | 69.8 | 67.1 | 65.7 |
| Animal No. 158 | 67.3 | 66.0 | 67.7 | 66.4 | 68.6 | 68.5 | 67.6 | 67.6 | 67.7 | 68.0 |
| Mean | 63.9 | 63.1 | 63.6 | 66.2 | 65.3 | 67.5 | 66.0 | 67.3 | 66.5 | 66.9 |
| Total collection: | | | | | | | | | | |
| Animal No. 159 | 65.2 | 80.4 | 66.5 | 77.3 | 73.9 | 68.5 | 73.4 | 75.3 | 69.6 | 53.2 |
| Animal No. 160 | 72.5 | 65.6 | 72.4 | 75.9 | 76.4 | 70.8 | 80.8 | 71.9 | 64.5 | 61.5 |
| Animal No. 148 | 63.2 | 74.3 | 63.7 | 77.3 | 60.6 | 72.5 | 77.1 | 75.2 | 67.6 | 70.3 |
| Animal No. 158 | 66.5 | 69.5 | 70.2 | 78.2 | 75.8 | 66.1 | 68.1 | 63.0 | 66.2 | 65.8 |
| Mean | 66.9 | 72.5 | 68.2 | 77.2 | 71.7 | 69.5 | 74.9 | 71.4 | 67.0 | 62.7 |

See footnote at end of table.

TABLE 5.—*Daily digestion coefficients calculated by use of chromic oxide and conventional methods*—Continued

| Ration,[1] method, and animal No. | Coefficients according to test day | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Ration 41: | | | | | | | | | | |
| Chromic oxide "grab": | | | | | | | | | | |
| Animal No. 107 | 52. 0 | 50. 2 | 52. 5 | 49. 7 | 52. 8 | 55. 6 | 53. 9 | 53. 9 | ---- | ---- |
| Animal No. 108 | 54. 3 | 52. 0 | 55. 9 | 50. 4 | 50. 9 | 53. 7 | 53. 9 | 52. 2 | ---- | ---- |
| Animal No. 109 | 54. 1 | 53. 9 | 51. 6 | 49. 5 | 54. 1 | 50. 7 | 54. 0 | 52. 4 | ---- | ---- |
| Animal No. 110 | 51. 8 | 51. 5 | 51. 8 | 50. 9 | 50. 6 | 51. 7 | 50. 9 | 51. 1 | ---- | ---- |
| Mean | 53. 1 | 51. 9 | 53. 0 | 50. 1 | 52. 1 | 53. 1 | 53. 2 | 52. 4 | ---- | ---- |
| Total collection: | | | | | | | | | | |
| Animal No. 107 | 55. 5 | 57. 0 | 50. 5 | 57. 3 | 52. 5 | 53. 0 | 51. 1 | 49. 9 | ---- | ---- |
| Animal No. 108 | 62. 7 | 55. 5 | 48. 3 | 54. 3 | 52. 0 | 42. 1 | 49. 5 | 51. 2 | ---- | ---- |
| Animal No. 109 | 52. 8 | 54. 0 | 58. 2 | 55. 3 | 59. 4 | 48. 6 | 44. 5 | 48. 9 | ---- | ---- |
| Animal No. 110 | 58. 6 | 51. 0 | 54. 5 | 58. 0 | 53. 6 | 58. 2 | 67. 2 | 40. 8 | ---- | ---- |
| Mean | 57. 4 | 54. 4 | 52. 9 | 56. 2 | 54. 4 | 50. 5 | 53. 2 | 47. 7 | ---- | ---- |
| Ration 62: | | | | | | | | | | |
| Chromic oxide "grab": | | | | | | | | | | |
| Animal No. 10 | 64. 1 | 65. 7 | 66. 5 | 66. 2 | 67. 2 | 67. 6 | 67. 8 | 67. 9 | 68. 0 | 67. 5 |
| Animal No. 1 | 66. 4 | 68. 6 | 67. 8 | 68. 2 | 67. 1 | 66. 6 | 66. 0 | 67. 0 | 65. 9 | 65. 6 |
| Animal No. 29 | 66. 0 | 66. 4 | 67. 3 | 67. 4 | 67. 1 | 67. 9 | 66. 0 | 67. 5 | 68. 2 | 66. 5 |
| Animal No. 15 | 62. 9 | 66. 0 | 66. 7 | 67. 1 | 67. 1 | 68. 9 | 68. 3 | 66. 9 | 67. 3 | 66. 2 |
| Mean | 64. 9 | 66. 7 | 67. 1 | 67. 3 | 67. 1 | 67. 8 | 67. 0 | 67. 3 | 67. 4 | 66. 5 |
| Chromic oxide total-collection: | | | | | | | | | | |
| Animal No. 10 | 63. 3 | 65. 1 | 66. 6 | 66. 4 | 67. 4 | 67. 4 | 66. 2 | 67. 9 | 67. 4 | 67. 2 |
| Animal No. 1 | 63. 4 | 67. 9 | 67. 6 | 69. 0 | 67. 8 | 66. 6 | 66. 4 | 67. 1 | 67. 4 | 66. 5 |
| Animal No. 29 | 64. 9 | 66. 5 | 67. 4 | 68. 1 | 67. 8 | 67. 4 | 66. 7 | 67. 5 | 67. 3 | 67. 2 |
| Animal No. 15 | 60. 9 | 65. 1 | 66. 7 | 67. 1 | 67. 5 | 67. 5 | 68. 6 | 66. 6 | 66. 2 | 66. 3 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 63. 2 | 66. 2 | 67. 1 | 67. 6 | 67. 6 | 67. 2 | 67. 0 | 67. 3 | 66. 9 | 66. 8 |
| Total collection: | | | | | | | | | | |
| Animal No. 10 | 60. 8 | 67. 1 | 65. 4 | 66. 9 | 69. 2 | 67. 4 | 68. 6 | 67. 7 | 68. 6 | 67. 5 |
| Animal No. 1 | 75. 8 | 76. 9 | 74. 2 | 70. 7 | 69. 7 | 73. 4 | 70. 9 | 73. 0 | 68. 3 | 74. 7 |
| Animal No. 29 | 65. 1 | 61. 9 | 68. 6 | 67. 6 | 69. 0 | 76. 2 | 69. 2 | 64. 8 | 69. 7 | 66. 4 |
| Animal No. 15 | 65. 7 | 62. 7 | 64. 7 | 68. 8 | 66. 7 | 71. 1 | 66. 4 | 66. 2 | 63. 9 | 70. 0 |
| Mean | 66. 9 | 67. 1 | 68. 2 | 68. 5 | 68. 6 | 72. 0 | 68. 8 | 67. 9 | 67. 6 | 69. 7 |
| Ration 74: | | | | | | | | | | |
| Chromic oxide "grab": | | | | | | | | | | |
| Animal No. 53 | 53. 6 | 52. 2 | 52. 0 | 55. 7 | 54. 4 | 51. 2 | 51. 3 | 53. 1 | 58. 1 | 53. 9 |
| Animal No. 52 | 52. 1 | 51. 5 | 53. 8 | 51. 0 | 54. 0 | 55. 9 | 52. 2 | 54. 0 | 50. 3 | 52. 9 |
| Animal No. 45 | 53. 2 | 55. 7 | 55. 1 | 56. 3 | 54. 4 | 57. 0 | 55. 0 | 53. 9 | 52. 4 | 49. 6 |
| Animal No. 49 | 52. 8 | 56. 1 | 56. 1 | 54. 0 | 53. 5 | 56. 1 | 53. 2 | 55. 5 | 57. 1 | 53. 6 |
| Mean | 52. 9 | 53. 9 | 54. 4 | 54. 3 | 54. 2 | 55. 1 | 52. 9 | 54. 1 | 54. 5 | 52. 5 |
| Chromic oxide total-collection: | | | | | | | | | | |
| Animal No. 53 | 56. 4 | 55. 3 | 56. 2 | 56. 3 | 57. 5 | 55. 5 | 54. 2 | 54. 3 | 51. 7 | 51. 7 |
| Animal No. 52 | 53. 7 | 55. 1 | 55. 9 | 55. 9 | 56. 0 | 56. 5 | 55. 7 | 56. 3 | 55. 6 | 54. 6 |
| Animal No. 45 | 55. 2 | 57. 5 | 56. 9 | 56. 8 | 56. 4 | 57. 4 | 55. 7 | 54. 8 | 53. 7 | 53. 1 |
| Animal No. 49 | 54. 1 | 53. 9 | 55. 3 | 55. 2 | 53. 6 | 56. 3 | 55. 3 | 57. 2 | 55. 7 | 57. 4 |
| Mean | 54. 9 | 55. 5 | 56. 1 | 56. 1 | 55. 8 | 56. 4 | 55. 2 | 55. 7 | 54. 2 | 54. 2 |
| Total collection: | | | | | | | | | | |
| Animal No. 53 | 62. 5 | 56. 7 | 60. 7 | 54. 9 | 56. 7 | 51. 7 | 61. 2 | 52. 9 | 56. 5 | 57. 7 |
| Animal No. 52 | 57. 3 | 60. 3 | 48. 2 | 60. 1 | 54. 4 | 55. 0 | 62. 3 | 62. 4 | 62. 7 | 51. 1 |
| Animal No. 45 | 63. 4 | 55. 9 | 65. 3 | 59. 7 | 58. 8 | 60. 4 | 66. 0 | 59. 3 | 52. 1 | 58. 7 |
| Animal No. 49 | 48. 1 | 51. 4 | 56. 9 | 60. 1 | 60. 4 | 57. 5 | 63. 4 | 63. 1 | 53. 6 | 60. 6 |
| Mean | 57. 8 | 56. 1 | 57. 8 | 58. 7 | 57. 6 | 56. 1 | 63. 2 | 59. 4 | 56. 2 | 57. 0 |

[1] For numerals separated by a dash, the numeral on left is the ration number; the one on right is the trial number.

END