the field, such as at a hay auction, it can provide valuable information quickly. As the instrumentation continues to improve, new applications, such as amino acid analysis and the detection of molds and mycotoxins, may become possible.

E. Determination of Vitamins
Because of the diversity of compounds in this class, there is no routine analysis for vitamins. However, methods are available for assaying individual vitamins. Biological assays are used for some vitamins, whereas others are determined strictly on the basis of chemical analysis.

F. Determination of Energy
The bomb calorimeter is an instrument used for determining the gross energy content of a material (solid, liquid or gas). The energy value of a given sample is determined by burning it in an atmosphere of oxygen. When the sample is burned, the heat liberated raises the temperature of water surrounding the container in which the sample is enclosed, and the temperature increase provides the basis for calculating the energy value.

The energy value is expressed in units called calories where 1 calorie is the amount of heat required to raise the temperature of 1 g water from 14.5° to 15.5° C.

G. The nutrient or energy content of a feed may be expressed as a percentage or quantity per unit of weight (mg/kg, g/lb, etc.) on one of the following bases:
1. Dry matter basis—amount contained in only the dry matter fraction, without water.
2. As-fed basis—amount contained in the feed as it would be fed to the animal, including water.
3. Air-dry basis—generally assumed to be approximately 90% dry matter. Most feeds will equilibrate to about 90% dry matter after prolonged storage (aerobic). Air-dry and as-fed basis may be the same for many common feeds.
4. Since feeds contain varying amounts of dry matter, it would be much simpler, and more accurate, if both feed composition and nutrient requirement values were on a dry matter basis.
5. Conversion of feed nutrients from an as-fed to a dry matter basis.
   a. Assume alfalfa silage analyzed 7% crude protein on an as-fed basis and contained 40% dry matter. What percent crude protein would the alfalfa silage contain when expressed on a dry matter basis?
      The solution for this example can be obtained by the following equation:
      \[
      \frac{\text{% nutrient as fed basis}}{\text{% feed dry matter}} = \frac{\text{% nutrient dry matter basis}}{100 \text{ % dry matter}}
      \]
      Thus:
      \[
      \frac{7}{40} = \frac{x}{100}
      \]
      \[
      20x = 700 \text{ (values obtained by cross-multiplying)}
      \]
      \[
      x = \frac{700}{40} = 17.5\% \text{ dry matter}
      \]
      (4) The alfalfa silage contains 17.5% crude protein on a dry matter basis.
   b. Two samples of shelled corn were sent to a laboratory for analysis of crude protein. One sample was “dry” corn and the other “high-moisture” corn. The laboratory sent back the following analysis:
"Dry" corn % dry matter 75.0
89.0 8.8 % crude protein 7.4
(as-fed basis)

To compare crude protein content to the two samples, calculate the composition on a dry matter basis.

(1) "Dry" corn:

(a) \( \frac{8.8}{89} = \frac{X}{100} \)
(b) \( 89X = 880 \)
(c) \( X = \frac{880}{89} = 9.89 \)

(2) "High-moisture" corn

(a) \( \frac{7.4}{75} = \frac{X}{100} \)
(b) \( 75X = 740 \)
(c) \( X = \frac{740}{75} = 9.87 \)

(3) Thus, the two samples of corn contain the same percent crude protein when expressed on a dry matter basis.

6. Conversion of feed nutrients from a dry matter to an as-fed basis.

a. Assume a feed nutrient composition table lists linseed meal as containing 10% crude fiber on a dry matter basis. If the linseed meal contains 91% dry matter, what is the percent crude fiber expressed on an as-fed basis? The solution for this problem can be obtained by the same equation given in the previous example.

(1) \( \frac{X}{91} = \frac{10}{100} \)
(2) \( 100X = 910 \)
(3) \( X = \frac{910}{100} = 9.1 \)

(4) The linseed meal contains 9.1% crude fiber on an as-fed basis.

b. Three samples of corn silage contain the following digestible energy (dry matter basis) and % dry matter levels:

<table>
<thead>
<tr>
<th>Sample</th>
<th>DE, kcal/kg</th>
<th>% dry matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1230</td>
<td>40</td>
</tr>
<tr>
<td>B</td>
<td>1225</td>
<td>36</td>
</tr>
<tr>
<td>C</td>
<td>1237</td>
<td>33</td>
</tr>
</tbody>
</table>

Calculate digestible energy (DE) kcal/kg, on an as-fed basis. The same equation is followed with nutrient concentration per weight unit (kcal/kg) used rather than percent. (See Section IV for a definition of DE.)
(1) Sample A:
(a) \( \frac{X}{40} = \frac{1230}{100} \)
(b) \( 100X = 49,200 \)
(c) \( X = \frac{49,200}{100} = 492 \)

(2) Sample B:
(a) \( \frac{X}{36} = \frac{1225}{100} \)
(b) \( 100X = 44,100 \)
(c) \( X = \frac{44,100}{100} = 441 \)

(3) Sample C:
(a) \( \frac{X}{33} = \frac{1237}{100} \)
(b) \( 100X = 40,821 \)
(c) \( X = \frac{40,821}{100} = 408 \)

(4) Digestible energy levels for the three samples on an as-fed basis:
A = 492 kcal/kg
B = 441 kcal/kg
C = 408 kcal/kg

7. Convert the weight of ration ingredients from an as-fed to a dry matter basis.

**Problem:** How many kilograms of ration dry matter are consumed daily if a steer is being fed the following amounts of as-fed feeds?

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight (as-fed)</th>
<th>Dry Matter (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn silage</td>
<td>10.0 kg</td>
<td>40%</td>
</tr>
<tr>
<td>Corn grain</td>
<td>4.0 kg</td>
<td>89%</td>
</tr>
<tr>
<td>Supplement</td>
<td>0.5 kg</td>
<td>92%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>14.5 kg</strong></td>
<td><strong>as-fed ration</strong></td>
</tr>
</tbody>
</table>

The solution is obtained with the following equation:
Parts dry matter feed = Parts as-fed feed \( \times \) % Dry matter in feed (kg, lb, g etc.)

Thus:

\[
\text{Feed kg, as-fed} \times \% \text{ dry matter} = \text{kg dry matter}
\]

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight (as-fed)</th>
<th>% Dry Matter</th>
<th>Dry Matter (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn silage</td>
<td>10.0</td>
<td>0.40</td>
<td>4.00</td>
</tr>
<tr>
<td>Corn grain</td>
<td>4.0</td>
<td>0.89</td>
<td>3.56</td>
</tr>
<tr>
<td>Supplement</td>
<td>0.5</td>
<td>0.92</td>
<td>0.46</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>14.5 kg</strong></td>
<td><strong>8.02 kg</strong></td>
<td></td>
</tr>
</tbody>
</table>
8. Convert the weight of ration ingredients from a dry matter basics to an as-fed basis.

*Problem:* The following concentrate mixture is being fed to yearling horses. Feeds are presented as pounds of dry matter. Calculate the pounds of asfed feeds in this diet.

- Rolled oats: 1045 lb
- Cracked corn: 425 lb
- Soybean meal: 182 lb
- Molasses (liquid): 80 lb
- Dicalcium phosphate: 23 lb
- Vitamin-mineral premix: 10 lb

Total: 1765 lb dry matter

The solution for the above example can be obtained with the following equation:

$$
\text{Parts (kg, lb, g etc.) as-fed feed} = \text{Parts dry matter feed} \div \% \text{ dry matter in feed}
$$

<table>
<thead>
<tr>
<th>Feed</th>
<th>lb, dry matter</th>
<th>% dry matter</th>
<th>=</th>
<th>lb, as-fed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rolled oats</td>
<td>1045</td>
<td>0.87</td>
<td>=</td>
<td>1201.1</td>
</tr>
<tr>
<td>Cracked corn</td>
<td>425</td>
<td>0.90</td>
<td>=</td>
<td>477.5</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>182</td>
<td>0.91</td>
<td>=</td>
<td>200.0</td>
</tr>
<tr>
<td>Molasses (liquid)</td>
<td>80</td>
<td>0.75</td>
<td>=</td>
<td>106.7</td>
</tr>
<tr>
<td>Dicalcium phosphate</td>
<td>23</td>
<td>0.96</td>
<td>=</td>
<td>24.0</td>
</tr>
<tr>
<td>Vitamin-mineral premix</td>
<td>10</td>
<td>1.00</td>
<td>=</td>
<td>10.0</td>
</tr>
<tr>
<td>1765</td>
<td></td>
<td></td>
<td>=</td>
<td>2019.3</td>
</tr>
</tbody>
</table>

9. "Thumb rules" for converting to and from dry matter and as-fed

a. When converting as-fed to dry matter
   (1) Nutrient concentration will increase.
   (2) Weight will decrease.

b. When converting dry matter to as-fed
   (1) Nutrient concentration will decrease.
   (2) Weight will increase.

_H. A chemical or proximate analysis fails to give adequate information regarding digestibility, palatability, toxicity or nutritional adequacy. Thus, further steps need to be taken to evaluate a feed._

**II. Feeding Trial**

A feeding trial simply gives an indication as to whether the animal will accept the feedstuff and the performance obtained from the feedstuff as compared to others. It tells nothing of why different results were obtained.