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Analysing feeds for cattle, sheep and goats

By David Barker, Senior Cattle Research Officer, Bunbury Regional Office

The Department of Agriculture's Feed Evaluation Unit at Bunbury provides a service for farmers and allied industries on a fee-for-service basis, and conducts analyses for research officers, advisers and organisations such as the University of Western Australia. It also analyses feedstuffs for Departments of Agriculture in other States.

These analyses are important because feedstuffs vary widely in their nutritive value according to the plant species, the various parts of the plant and the particular conditions under which plants are grown, harvested, stored and processed. The analyses considerably reduce the uncertainty which would otherwise be associated with feeding such materials. They are especially important for the intensive systems of finishing beef cattle, producing milk and feeding sheep, but they can also provide useful information about grazed fodders such as dried-off pasture residues.

The Unit analyses about 5,000 samples each year. The workload is high because no other laboratory in Western Australia provides the same service. Results are recorded on a computer which makes it easy to retrieve results of analyses of particular types of feedstuffs or from a particular owner or district.

Feed quality

Although feedstuffs may be classed as high-protein feeds (for example lupins, meat-meal and lucerne), highly digestible feeds (lupins and cereals), good-quality roughages (hay and silage) or low quality roughages (pasture residues and straw), there is considerable variation within these groups.

Many agricultural reference books give average nutritive values for many plants and other feedstuffs, but these are based on growing and processing techniques overseas. Such values do not always correspond to their feed value under local Australian, regional, or district conditions. The CSIRO is also building up a data base of results of analyses of Australian feedstuffs. However Table 1 shows the range in metabolisable...
energy content between samples of apparently similar feedstuffs found in Western Australia. Variation in protein content of common feedstuffs is equally high.

To provide a common basis for defining the required concentrations of nutrients in the diet, nutrient level is always expressed as the content of the nutrient in the dry matter of the diet. When formulating diets, the appropriate mixtures of feed are first estimated on a dry matter basis and subsequently converted back to wet (as is) weights of the raw materials.

Most "dry" feeds in Western Australia consist of about 90 per cent dry matter, and mixing them in the appropriate proportions on an "as is" (that is, 90 per cent dry matter) basis gives the same nutrient concentrations as mixing them on a dry matter basis. Once the nutrient characteristics of available feeds are known, standard textbooks on nutrition can be consulted for the feed requirements for the animals and production required, and appropriate feed mixtures provided.

### Nutrient characteristics of ruminant feeds

The major characteristics affecting the nutritional value of feedstuffs for ruminants are metabolisable energy content, protein content and mineral and trace element content.

### Metabolisable energy content

Many different systems of expressing the energy value of feeds have been used in the past 100 years, including hay equivalents, starch equivalents, total digestible nutrients and Scandinavian feed units. The most commonly used today are the net energy system in the U.S.A. and the metabolisable energy system in the United Kingdom and Australia.

The useful energy content of feeds was, until recently, usually expressed in terms of the disappearance of feedstuffs from the intestines, that is, their digestibility. However the estimation of their metabolisable energy content more accurately reflects the useful energy value of feeds, though it does not account for all the variation in energy value of all feedstuffs for all metabolic activities.

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Table 1. Range in metabolisable energy (MJ/kg DM) content of common Western Australian feedstuffs

<table>
<thead>
<tr>
<th>Feedstuff</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oat hay</td>
<td>4.9</td>
<td>10.7</td>
</tr>
<tr>
<td>Barley hay</td>
<td>6.1</td>
<td>10.2</td>
</tr>
<tr>
<td>Pasture hay</td>
<td>5.9</td>
<td>11.2</td>
</tr>
<tr>
<td>Oat grain</td>
<td>8.0</td>
<td>12.6</td>
</tr>
<tr>
<td>Barley grain</td>
<td>11.2</td>
<td>13.3</td>
</tr>
</tbody>
</table>

Source: Feed Evaluation Unit analyses for 1986.

Cows need a highly nutritious ration for best production.

TOP LEFT: Several core samples are needed from large hay rolls to improve the accuracy of the feed analysis.

Electrically-driven core sampling devices are best used to take multiple samples from a bulk feed supply.
Metabolisable energy (ME) is the amount of energy that an animal can extract from the feedstuff and use for its metabolic processes, such as growth of muscle tissue, storage of fat, production of milk, repairs and maintenance and exercise. It is measured in megajoules of metabolisable energy per kilogram of dry matter (MJME/kg DM). Other methods of feed evaluation are more accurate, but they are much more complex and costly to carry out.

At the Feed Evaluation Unit, metabolisable energy is estimated by first measuring the solubility of the dry matter of the feed sample in a series of enzyme solutions which are similar to those produced in the digestive system of ruminants. Our technique is based upon research into the feeding value of roughages conducted overseas and elsewhere in Australia (McLeod and Minson 1978). It has been developed further by Western Australian research workers (Dunlop, unpublished) to include an evaluation of grains.

The solubility values are then adjusted according to the dry matter digestibilities of 15 to 20 samples of different standard feedstuffs (cereals, hay, straw, legumes and green fodder) as actually recorded in sheep at the Unit, and whose solubilities were also measured alongside the test samples. This adjustment gives an estimate of the dry matter digestibility of the test samples.

The metabolisable energy content of the feed is then estimated from the dry matter digestibility using equations developed from analyses and feeding trials (MAFF, 1984). The result is reasonably accurate for forages and cereals, but is under-estimated for silages because some digestible volatile compounds in silage are lost during drying of the sample. It is also under-estimated in high protein feeds and feeds containing fats or oils because these nutrients have a much higher energy value than the carbohydrates which mainly make up forages and cereals.

The enzymes of the ruminant digestive system include a much broader range than those in the digestive systems of pigs, poultry and other non-ruminant animals, and estimates of metabolisable energy as made at Bunbury cannot be applied to pigs and poultry. Their feed must be evaluated using different techniques.

Quality control

Quality control is an important part of the feed evaluation process. Checks are included in the analyses at various stages.

Samples must be representative of the material being tested, or the results will be meaningless. It is often difficult for farmers to get a representative 0.5 to 1 kg sample of a bulk farm supply of feedstuff, and the assistance of Department of Agriculture advisers for sampling is recommended, especially for bulk forages. The Department uses electrically-driven core sampling devices to take multiple samples from a bulk supply.

In the laboratory the samples are dried, chopped and milled and two 0.5 g sub-samples are taken for testing. If the solubility of the two analyses differs by more than 5 per cent, the data entered into the computer are checked. If they are correct, the analysis is rejected and another pair of samples is analysed. This procedure is repeated until the results are consistent.

Other checks are included. Each weekly batch of samples for testing includes 15 to 20 samples or standards of known dry matter digestibility in sheep. When the analyses for the batch are complete, all the results are entered into the computer, which first estimates the relationship between the solubility of the 15 to 20 standards and their dry matter digestibilities. If the consistency of the relationship is not good, either the whole batch (or, more commonly, the part of it consisting of particular types of feedstuffs which are giving aberrant results) is discarded, and the process is repeated until the results are consistent, that is, more than 90 per cent of the values fall within ± 6 per cent of the predicted dry matter digestibilities.

The final check is a comparison of the results against book values and previous analyses of similar types of material. If the values obtained are outside the normal range, the analysis is repeated. If the same result is obtained a comment is added to the report of the results. The provision of background information on the plant species and parts sampled, stage of growth and method of processing is thus important to the quality control procedure.

The turn-around time for analysis of dry matter digestibility is about three weeks. Of this, about one week is spent sub-sampling and waiting in the queue to get started, one week for the analytical procedure and one week for data processing and postage. One batch of as many as 150 samples is analysed each week.

Protein content

Protein content also varies widely amongst different feedstuffs, and strongly influences an animal's feed intake, digestion, growth, lactation, body condition and production efficiency.

The simplest measure of protein content is crude protein (CP), which is estimated by multiplying the nitrogen content of the feed by 6.25 (because most proteins contain about 16 per cent nitrogen).

Crude protein does not precisely describe the value of the feed as a source of nitrogen, because nitrogen in the diet may be either:

- Undigested, that is passed out in the faeces. The proportion digested is the digestible nitrogen (DN) content.
- Digested by the rumen micro-organisms and used for their growth. This fraction is known as rumen-degradable nitrogen (RDN). It helps the organisms digest roughages and other components of the diet, and thus release energy for the animal. The organisms are subsequently digested by the animal, thus contributing high-quality protein to the animal's diet.
- Undigested by the rumen organisms but digested by the animal itself, contributing directly to its protein supply. This fraction is the undegradable nitrogen (UDN).

The more digestible the nitrogen, the more it is available to the animal either directly or via its rumen organisms. Sufficient rumen degradable nitrogen in the diet is important to maximise the rate of activity of the organisms and thus the rate of feed intake and its digestibility in the rumen. The organisms can also use a certain amount of non-protein-nitrogen (NPN) such as urea in the diet, but not more than about 40 per cent of the total dietary nitrogen should be replaced by non-protein nitrogen if high performance is to be attained. A sulphur supplement is often necessary if non-protein-nitrogen is provided because some of the high quality essential dietary proteins provide sulphur as well as nitrogen.

Although the analysis of total nitrogen content of feedstuffs is relatively simple, measurement of digestible nitrogen, rumen degradable nitrogen and undegradable nitrogen contents is much more difficult.

Rumen degradable nitrogen in most unprocessed feedstuffs corresponds fairly well with digestible nitrogen, but heat or other treatment (for example with formaldehyde)
"protects" proteins from degradation in the rumen and thus decreases the amount of rumen degradable nitrogen. Excessive treatment prevents proteins from being digested and thus reduces the amount of digestible nitrogen. There are also many different proteins, each with a different value to animals for different purposes. While a certain amount of all the essential proteins can be synthesised by the rumen organisms, they do not work to their greatest efficiency unless some of the essential protein is included in the diet.

Crude protein and digestible nitrogen are only first approximations of the value of feedstuffs as sources of protein. However their measurement is easy and inexpensive, using current technology.

The technique used to estimate the nitrogen (crude protein) content of feedstuffs at Bunbury is a modification of that of Isaac and Johnson (1976). Because we want a quick turn-around time for analysis, the size of the sample analysed has been reduced, but it is analysed in quadruplicate to provide a check on the consistency of the result. Other built-in checks, such as known standards, are included.

Other tests

The Feed Evaluation Unit conducts other tests if required. These are:

- Dry matter content, which is important when diets are prepared from feedstuffs of different dry matter content.

- Amylase solubility. This is a measure of the water-soluble fraction plus starch in the feedstuff. It is the first stage of the dry matter digestibility (metabolisable energy) estimation technique used for cereals.

- Neutral detergent and modified acid detergent fibre content. These analyses were used as indicators of digestibility, but they have largely been superseded by the enzyme technique.

- Ash content. This is an index of the organic matter content of the feed, which in combination with digestibility can be used to more accurately estimate metabolisable energy content.

Minerals and trace elements

Commercial laboratories will analyse these components. The Government Chemical Laboratories and other Departments of Agriculture, CSIRO and university laboratories carry out these analyses as part of their research activities but they are not carried out at the Feed Evaluation Unit.

In future, we hope to expand the work of the Unit to provide estimates of other important nutrient characteristics of feedstuffs for research and for use by farmers and industry. These include specific amino-acids (which are particularly important in the nutrition of high-yielding dairy cows, calves, lambs, pigs and poultry), minerals and trace elements (which are particularly significant for animals grazing in the high-rainfall zone), and other important compounds for nutritional research in the high-rainfall areas.

Uses of feedstuffs analyses

In research

The major use of the analyses in research is to provide a measure of the effect of different treatments upon the nutritional value of feedstuffs. The range of treatments includes different plant species and varieties, stages of growth, fertilisers, sowing times and rates, stages of maturity and methods of conservation. Eventually this knowledge becomes part of the stock-in-trade of the farmer who can use it to help management of the nutrition of his livestock.

Analyses of feeds are also used in specific research projects to formulate diets (for example to ensure that animals fed different sources of feed all receive sufficient nitrogen to use the feed to their best potential) and to define the diets fed in experiments in a way that will enable the results to be used and reproduced by industry.

In the industry

The analyses can be used by farmers to estimate the most economical diets (for example using the Department of Agriculture's Dairy Feed Management Service and Beef Cattle Finishing Models), and to indicate the potential values of particular feeds, their suitability for different classes of stock, and the need for supplementation with urea or other nitrogen sources.

Nearly all feedstuffs are costly; to be profitable, feeding systems must use them efficiently and this is much more likely if the formulation of the diet is based on analyses rather than guesses.