

# 10

## Supplements for milking cows

### **This chapter:**

Explains how to select a supplement based on its nutrient composition.

### **The main points in this chapter:**

- factors to consider when deciding on which supplements to use:
  - what is the limiting nutrient in the diet?
  - which supplements are available and what is their nutrient composition?
  - what are the practical considerations of feeding?
  - how will a supplement affect the balance of the diet?
- feeds can be classified as energy supplements, protein supplements, basal forages and forage supplements
- tables of feed composition show the wide variation in energy and protein content in feeds
- chemical treatment of low quality roughages can improve their nutritive value but unsupplemented, they will not support high milk yields.

It is unlikely that the entire diet of milking cows will consist of just one forage. These other feeds are called supplements to the major forage source. If there is no major forage source, all feeds could be considered as supplements. This chapter addresses some practical and nutritional considerations involved in the use of different supplements.

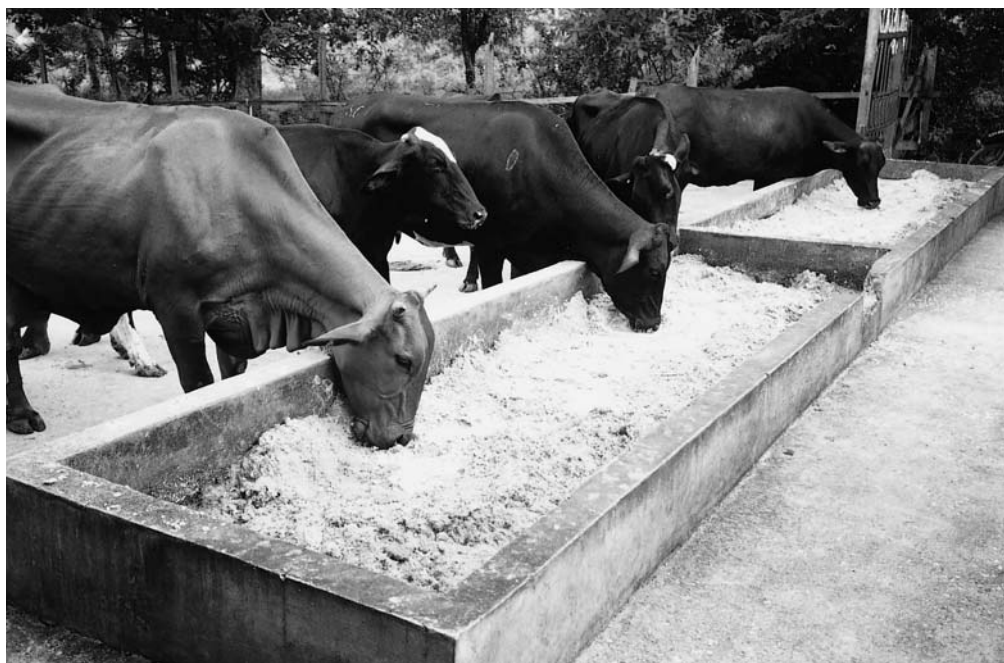
### **10.1 Choice of supplement**

Several supplement types are fed to dairy cattle. The decision on which supplement is determined by a combination of factors, such as:

- What is the limiting nutrient: energy, protein, fibre or a combination of all three?
- What supplements are available?

- What is their nutritive composition?
- What are the relative costs?
- What are the practical implications (eg facilities for storage and feeding, labour requirements, reliability of supply?)
- What are the nutritional implications: how will the supplement affect the ration balance, and could problems such as acidosis arise?

In forage-based dairy systems, energy is normally the first limiting nutrient. Therefore, supplements should be compared on the basis of their cost per unit energy, such as Thai baht per kg of Total Digestible Nutrients (TDN) (as in Table 8.1) or Vietnam dong per MJ of Metabolisable Energy (ME) (as in Table 8.2). The lower the cost of energy supplied, the cheaper the supplement. Supplements can also be compared on the basis of cost per kilogram of Crude Protein (CP) supplied.



Malaysian milking cows in Malacca eating fresh citrus pulp.

### 10.1.1 Defining the nutritive value of supplements

Supplements are classified by their ability to supply additional energy, protein, fibre or vitamins and minerals to dairy cows. They come in the form of concentrates, fresh forages, conserved fodder, roughage by-products and concentrate by-products.

Most tables of feed composition report only the average energy and protein contents. Yet, there can be large variations within any type. For example, plant-derived feeds may vary with season of growth, soil type and crop management.

To categorise South-East Asian feeds on their composition, data from analyses of local feeds in Thailand (Wanapat and Wachirapagoin 1990) and Indonesia (J Moran, unpublished 2003) are presented in Tables 10.2 to 10.5 and summarised in Table 10.6.

The tables list the actual values for Dry Matter (DM%), energy (Metabolisable Energy, and Total Digestible Nutrients), Crude Protein (CP%) and fibre, usually Crude Fibre (CF%) but occasionally Neutral Detergent Fibre (NDF%). Such values are necessary to calculate ration formulations (see Chapter 12) but also to represent ‘typical’ nutritive values of these particular feed types. Other chemical analyses of the same feed type can differ considerably to those in these tables. This highlights the importance of analyses of the actual feed ingredients used for the most accurate formulation of that ration.

### 10.1.2 Degradability of supplement protein

Tables 10.2 to 10.5 also present the supply of Undegradable Dietary Protein (UDP) and hence Rumen Degradable Protein (RDP) according to categories listed in Table 10.1. These data are collected from worldwide information by Target 10 (1999).

The more processed the supplement, the greater its degree of protection from rumen degradation of protein. Highly processed protein meals such as fish and blood meal are excellent sources of undegradable dietary protein, hence are in the high category. Most other protein meals are moderate sources of Undegradable Dietary Protein. Maize, sorghum and rice are also in the medium category, whereas other cereal grains fed in temperate countries, such as wheat, triticale and barley, are poor suppliers of Undegradable Dietary Protein. Formulated concentrates can be moderate when pelleted or poor when fed as meals. Forages conserved as hay are moderate sources but only poor suppliers of Undegradable Dietary Protein when fresh or ensiled.

**Table 10.1** Categories used to describe supplements on their ability to supply protein as Undegraded Dietary Protein (UDP) and Rumen Degradable Protein (RDP)

Rumen Degradable Protein (RDP); Undegradable Dietary Protein (UDP). (Source: Target 10 1999)

| Category     | UDP    | RDP    |
|--------------|--------|--------|
| High (H)     | > 69%  | < 31%  |
| Good (G)     | 50–69% | 31–50% |
| Moderate (M) | 30–49% | 51–70% |
| Poor (P)     | 10–29% | 71–90% |

The tables in the following sections in this chapter cover energy and protein supplements, fresh and conserved forages and forage by-products presenting the nutritive value of each feed type.

## 10.2 Energy supplements

### 10.2.1 Types of energy supplements

Feeds with large quantities of starches and sugars (eg cereal grains and some by-product feeds) are good energy supplements. Maize, sorghum and rice are cereal grains, while cassava and sweet potatoes are root crops. Many farmers feed commercially formulated concentrates and frequently high-energy by-products such as rice bran, cassava waste and brewer’s grain. Analyses of some energy-rich supplements are presented in Table 10.2. The formulated concentrates are from Thailand. The protein content of formulated concentrates varied considerably but there was little difference in the energy values of the three concentrates in Table 10.2.

Cassava roots and molasses are very low in protein (2–4%), while much of the energy in cassava can be extracted during processing. For example, the Metabolisable Energy content of Cassava waste 1 decreased from 12.9 (for cassava chips) to only 7.2 MJ/kg DM. However, with other cassava waste (Dried cassava waste 2) the Metabolisable Energy can still be relatively high (12.6 MJ/kg DM). As a result of contamination with rice hulls, the nutritive value of rice bran varies considerably with grade. These two examples from Table 10.2 highlight the problems of making generalities of the nutritive value of crop by-products. The nutritive value of a range of wet by-products has been presented in Table 9.3.

**Table 10.2** Nutritive value of some common energy-rich supplements available in South-East Asia

Crude Fibre (CF); Crude Protein (CP); dry matter (DM); Metabolisable Energy (ME); Neutral Detergent Fibre (NDF); Total Digestible Nutrients (TDN). See Table 10.1 for details of UDP supply: moderate (M); poor (P). (Sources: Wanapat and Wachirapagoin 1990 and J Moran, unpublished 2003).

| Feed                  | DM (%) | CP (%) | CF (or NDF) (%) | ME (MJ/kg DM) | TDN (%) | UDP supply |
|-----------------------|--------|--------|-----------------|---------------|---------|------------|
| Cassava chips         | 88     | 2.1    | 3.4             | 12.9          | 80      | M          |
| Maize grain           | 85     | 11.0   | (9.0)           | 13.5          | 83      | M          |
| Sorghum grain         | 90     | 12.0   | 2.5             | 14.6          | 89      | M          |
| Paddy rice            | 89     | 8.9    | 10.1            | 12.7          | 79      | M          |
| Brown rice            | 88     | 10.3   | 1.2             | 15.1          | 92      | M          |
| Molasses              | 79     | 2.8    | -               | 14.0          | 86      | P          |
| Rice bran 1           | 91     | 14.1   | 12.8            | 11.1          | 70      | M          |
| Rice bran 2           | 89     | 7.7    | 26.1            | 7.9           | 53      | M          |
| Sweet potatoes        | 32     | 5.0    | 5.9             | 12.9          | 80      | P          |
| Dried pineapple waste | 85     | 4.6    | 22.7            | 11.1          | 70      | M          |
| Cassava waste 1       | 20     | 2.5    | 1.5             | 7.2           | 49      | P          |
| Dried cassava waste 2 | 88     | 1.9    | (22.2)          | 12.6          | 78      | M          |
| Sweet corn waste      | 18     | 12.6   | 21              | 11.0          | 70      | P          |
| Wheat pollard         | 89     | 15.0   | (36.6)          | 12.5          | 78      | P          |
| Brewer's grain        | 26     | 28.8   | (57.0)          | 10.2          | 65      | M          |
| Concentrate 1         | 90     | 17.2   | (26.5)          | 11.2          | 71      | P/M        |
| Concentrate 2         | 90     | 19.3   | (25.8)          | 11.4          | 72      | P/M        |
| Concentrate 3         | 90     | 19.9   | (25.1)          | 11.2          | 71      | P/M        |

### 10.2.2 Milk responses to energy supplements

Milk responses should be expressed as the extra milk produced per additional kg DM of the supplement fed (L milk/kg supplement DM), that is the marginal response to supplement feeding. Milk responses to supplementary feeding vary widely, depending on stage of lactation, quality of supplement and amount of forage consumed (see Chapter 11 for detail).

#### Stage of lactation

With energy supplements, responses can be over 1 L milk/kg DM of supplement fed in early lactation while this decreases in late lactation. This is because cows partition more dietary energy into regaining body condition during late lactation, hence less is expressed as extra milk.

### **Forage and supplement quality**

Trials with grazing cows have shown consistently that milk responses vary with forage quality, with better milk yields being on lower quality pastures. This would also occur with cut and carry systems, when forage supplies are adequate. However, in most cases, small holder farmers do not fully feed their cows on fresh forage so the quality of that forage is less likely to influence the milk response to the energy supplement. Milk response per kg DM of energy supplement generally increases with supplement quality.

Formulated concentrates would be expected to yield better milk responses than high energy cereal grains and by-products, because they would be formulated to supply extra protein, minerals and vitamins. However, research has consistently shown that milk responses in cows fed cereal grains are equivalent to those of formulated concentrates, up to 5 kg/cow per day.

Farmers in developed countries often feed fat supplements to provide additional energy. These can take the form of either cooking oils or tallow (from slaughter houses), while some fats have been specially processed to bypass rumen digestion. Fats that are present in the rumen may coat fibre in the diet, and can reduce fibre digestion if dietary levels are too high. The upper limit for dietary fat concentration is about 5% of total DM. Many countries have banned the feeding of ruminant-based feeds, such as tallow, because of concerns with 'mad cow disease' (bovine spongiform encephalopathy), which originated from this practice.

Bypass fats are digested in the small intestine and can be fed at higher levels without these side effects. However, they are very expensive, up to A\$950/t. They should only be fed during early lactation to high yielding cows (producing greater than 30 L/day).

Feeding high levels of high starch feeds or suddenly increasing their amount in the diet can lead to acidosis. This is caused by a build-up of lactic acid in the rumen. Increased acidity reduces the activity of the microbes that break down fibre, which results in slower digestion and reduced appetite (see Chapter 13 for further details).

## **10.3 Protein supplements**

The nutritive values of some common protein-rich supplements available in South-East Asia are presented in Table 10.3. Many of these are derived from by-products of leguminous grains, such as peanuts, soybean and sunflowers, while others are whole grains, such as mung beans and cottonseed.

Urea is a common source of nitrogen, but being a form of non-protein nitrogen, it is not a true protein. It has no energy value and is all degradable in the rumen. It is sometimes used as a substitute for true protein sources in feed mixtures and pellets, but is only effective when fed in combination with an energy source such as cereal grains or maize silage. It is recommended that urea only be fed to animals that have a fully functioning rumen and at a maximum rate of 1% of total DM intake.

The highest quality protein supplements originate from animals (eg fish, shrimp, blood). This is because much of their protein escapes rumen degradation and is more efficiently digested in the intestines. These supplements, originating from animals, have amino acid profiles more closely related to those in milking cows, hence are more efficiently utilised following digestion. The feeding of meat and bone meal, once

considered an excellent protein supplement, has been banned because of mad cow disease. Energy levels of these protein meals, with the exception of shrimp waste, are comparable to those of cereal grains.

**Table 10.3** Nutritive value of some common protein-rich supplements available in South-East Asia

Crude Fibre (CF); Crude Protein (CP); dry matter (DM); Metabolisable Energy (ME); Neutral Detergent Fibre (NDF); Total Digestible Nutrients (TDN). See Table 10.1 for details of UDP supply: high (H); good (G); moderate (M); poor (P) (Sources: Wanapat and Wachirapagoin 1990 and J Moran, unpublished 2003)

| Feed             | DM (%) | CP (%) | CF (or NDF) (%) | ME (MJ/kg DM) | TDN (%) | UDP supply |
|------------------|--------|--------|-----------------|---------------|---------|------------|
| Soybean meal     | 91     | 48.7   | 6.2             | 14.0          | 86      | M          |
| Coconut meal     | 92     | 19.2   | (49.3)          | 12.0          | 75      | M          |
| Peanut meal      | 93     | 50.6   | 16.0            | 13.6          | 84      | M          |
| Mung beans       | 91     | 28.3   | 5.7             | 14.0          | 86      | P          |
| Sunflower meal   | 94     | 52.4   | 5.7             | 12.0          | 75      | M          |
| Cottonseed meal  | 93     | 44.3   | 12.8            | 12.5          | 78      | M          |
| Whole cottonseed | 92     | 30.3   | 23.1            | 9.8           | 63      | M          |
| Palm kernel cake | 91     | 15.1   | 66.4            | 12.1          | 76      | M          |
| Kapok seed       | 86     | 27.4   | 28.0            | 10.3          | 66      | M          |
| Fish meal A      | 90     | 64.7   | 0.7             | 10.5          | 67      | H          |
| Fish meal B      | 94     | 59.8   | 2.2             | 11.6          | 73      | H          |
| Blood meal       | 92     | 89.7   | 0.9             | 10.3          | 66      | H          |
| Shrimp waste     | 90     | 52.0   | 12.3            | 7.0           | 48      | G          |
| Soybean curd     | 15     | 22.2   | (30.2)          | 13.3          | 82      | M          |
| Urea             | 100    | 280    | –               | –             | –       | –          |

Good milk responses to protein supplements can only be obtained if they are used to overcome an actual protein deficiency. Otherwise, they are broken down and used inefficiently as an expensive energy supplement.

## 10.4 Basal forages and forage supplements

The nutritive values of common forages and forage supplements found in South-East Asia are presented in Tables 10.4 and 10.5. The supplements are generally the poorer quality forages, those that are fed as a last resort when better quality forages are in short supply.

There are many species of grasses sown for small holder dairy systems (see Chapter 8), and Table 10.4 lists 'typical' values for well-managed grass swards. Forage quality varies with many factors that include:

- grass species
- stage of plant maturity
- environment (rainfall, temperature, sunlight)
- soil fertility
- fertiliser regime
- mixed swards (eg growing grasses in combination with legumes).

The high growth rates of tropical grasses are associated with greater stem development and hence lower leaf to stem ratios than in temperate grass species. Stems

contain more fibre and less energy and protein than leaves, hence tropical grasses have the lower nutritive values.

As such forages approach the end of the vegetative stage of maturity, and become reproductive, flowers and seeds develop in the grass heads and their nutritive values decline. Plant fibre levels increase and energy decreases. Therefore, it is essential to maintain the vegetative stage of maturity in grasses to ensure quality forage, particularly for milking cows.

Fertilisers not only promote rapid growth but also improve forage quality, both protein and energy levels (see Chapter 8). Cow manure does not provide sufficient nutrients to promote maximum growth and optimum forage quality.

Energy and protein levels in well-managed tropical grasses are only moderate, ranging from 7 to 9 MJ/kg DM of ME and 6% to 12% protein (Table 10.4). Legumes have higher protein, and often higher energy values than grasses. The best quality, and often highest yielding, grass species is maize, with whole crop maize usually fed fresh or conserved as silage. Maize silage should be harvested at the correct stage of maturity to achieve maximum dry matter yield and quality. This is because the grain that develops in the cob compensates for increasing fibre levels in the stalk and leaves. The low protein content of maize silage means additional protein supplements are needed when fed in large quantities.

Many of the by-product forages in Table 10.4 have reasonable energy and protein levels but they are not readily available throughout the year and are only found in certain regions. Therefore, they may be the major source (hence basal forage) for only short periods of the year.

The forage supplements included in Table 10.5 are all low in nutritive value. They should not be used as a major feed source for milking cows because high fibre levels limit feed intakes. Milk responses to these feeds would be very poor and in most cases, uneconomical.

The term 'rice straw' covers an enormous range of types of straw. Modern breeding programs for rice have generally produced 'dwarf' varieties with short stems, to maximise the plant nutrients deposited in the seed head as rice grain. Consequently rice straws can vary from more than 50 cm in length down to 20 cm or less. With different stages of maturity at harvest, they can also vary widely in energy, protein and fibre contents. In reporting the feeds offered to livestock, many researchers fail to report the variety of rice straw, or even its physical characteristics, such as straw length or stage of maturity of the crop at harvest. This makes it very difficult for readers to fully comprehend their data on nutritive value, hence usefulness in dairy feeding systems.

**Table 10.4** Nutritive value of some common South-East Asian forages

Crude Fibre (CF); Crude Protein (CP); dry matter (DM); Metabolisable Energy (ME); Neutral Detergent Fibre (NDF); Total Digestible Nutrients (TDN). See Table 10.1 for details of UDP supply: high (H); good (G); moderate (M); poor (P). (Sources: Wanapat and Wachirapagoin 1990 and J Moran unpublished 2003)

| Forage                   | DM (%) | CP (%) | CF (or NDF) (%) | ME (MJ/kg DM) | TDN (%) | UDP supply |
|--------------------------|--------|--------|-----------------|---------------|---------|------------|
| <b>Grasses</b>           |        |        |                 |               |         |            |
| Napier grass (immature)  | 13     | 11.3   | (74.5)          | 7.6           | 51      | P          |
| Napier grass             | 22     | 9.5    | 30.8            | 8.3           | 55      | P          |
| Rhodes grass             | 29     | 7.9    | 36.8            | 8.8           | 58      | P          |
| Guinea gras              | 25     | 10.3   | 32.7            | 7.7           | 52      | P          |
| Para grass               | 26     | 11.8   | 31.6            | 8.5           | 56      | P          |
| Star grass               | 32     | 7.6    | 34.2            | 7.0           | 48      | P          |
| Pangola grass            | 21     | 10.6   | 28.0            | 8.3           | 55      | P          |
| Forage sorghum           | 16     | 16.3   | (72.1)          | 7.7           | 52      | P          |
| Native pasture           | 31     | 7.6    | (58.2)          | 7.9           | 52      | P          |
| Sudan grass              | 28     | 5.9    | 33.6            | 10.1          | 65      | P          |
| Maize silage             | 28     | 8.3    | 24.2            | 10.3          | 66      | P          |
| <b>Legumes</b>           |        |        |                 |               |         |            |
| Centro                   | 19     | 23.5   | 31.7            | 7.4           | 50      | P          |
| Peuro                    | 31     | 17.9   | 27.1            | 10.1          | 65      | P          |
| Leucaena                 | 32     | 18.7   | 37.8            | 7.9           | 53      | P          |
| Leucaena leaf hay        | 91     | 26.7   | 16.3            | 11.6          | 73      | M          |
| Stylo                    | 25     | 17.3   | 24.5            | -             | -       | P          |
| <b>By-products</b>       |        |        |                 |               |         |            |
| Maize stover hay         | 91     | 6.5    | 34.0            | 8.7           | 57      | M          |
| Maize stover 1           | 23     | 5.7    | 26.4            | 8.7           | 57      | P          |
| Maize stover 2           | 18     | 7.3    | (69.3)          | 7.2           | 49      | P          |
| Sorghum stover           | 25     | 6.0    | 28.1            | 10.9          | 69      | P          |
| Sweet corn cobs          | 23     | 9.1    | 30.0            | 9.2           | 60      | P          |
| Cassava hay              | 90     | 24.7   | 17.3            | 8.5           | 56      | M          |
| Soybean                  | 26     | 15.0   | 26.3            | 9.9           | 64      | P          |
| Field bean leaf and stem | 11     | 17.1   | 23.2            | 9.8           | 63      | P          |
| Peanut leaf and stem     | 26     | 18.5   | 26.3            | 9.6           | 62      | P          |
| Soybean leaf             | 28     | 23.0   | 20.8            | 11.1          | 70      | P          |

**Table 10.5** Nutritive value of some common South-East Asian forage supplements.

Crude Fibre (CF); Crude Protein (CP); dry matter (DM); Metabolisable Energy (ME); Neutral Detergent Fibre (NDF); Total Digestible Nutrients (TDN). See Table 10.1 for details of UDP supply: high (H); good (G); moderate (M); poor (P). (Source: Wanapat and Wachirapagoin 1990)

| Feed                    | DM (%) | CP (%) | CF (%) | ME (MJ/kg DM) | TDN (%) | UDP supply |
|-------------------------|--------|--------|--------|---------------|---------|------------|
| Rice straw              | 92     | 4.2    | 42.3   | 6.4           | 45      | P          |
| Urea-treated rice straw | 93     | 7.4    | -      | 8.1           | 54      | P          |
| Banana stem             | 5      | 3.2    | 19.1   | 9.6           | 62      | P          |
| Sugar cane tops         | 26     | 5.0    | 32.6   | 7.2           | 49      | P          |
| Bagasse                 | 95     | 3.0    | 43.1   | 7.4           | 50      | M          |

## 10.5 Categorising supplements on energy and protein contents

To simplify the selection of forages and supplements for milking cow diets, those in the above four tables have been categorised into poor, moderate and good suppliers of dietary energy and protein in Table 10.6. Energy levels have been categorised as poor (<8 MJ/kg DM of ME), moderate (8–10 MJ/kg DM of ME) or good (>10 MJ/kg DM of ME) while protein levels have been categorised as poor (<10% CP), moderate (10–16% CP) or good (>16% CP).

**Table 10.6** Classification of supplements and basal forages in Tables 10.2, 10.3, 10.4 and 10.5 according to their energy and protein contents

Crude Protein (CP); dry matter (DM); Metabolisable Energy (ME).

| Energy/protein classification       | Poor energy (<8 MJ/kg DM of ME)  | Moderate energy (8-10 MJ/kg DM of ME)   | Good energy (>10 MJ/kg DM of ME)  |
|-------------------------------------|--|---|---|
| <b>Poor protein (&lt;10% CP)</b>    | Rice straw<br>Urea rice straw<br>Maize stover 2<br>Sugar cane tops<br>Cassava waste 1<br>Bagasse | Rice bran 2<br>Most grasses<br>Maize stover 2<br>Sweet corn cobs<br>Banana stem | Cassava chips<br>Dried cassava waste 2<br>Paddy rice<br>Molasses<br>Sweet potatoes<br>Pineapple waste<br>Corn silage    |
| <b>Moderate protein (10–16% CP)</b> | –  | Brown rice<br>Well-managed grasses<br>Soybean                                   | Maize<br>Sorghum<br>Rice bran 1<br>Wheat pollard<br>Palm kernel cake<br>Sweet corn waste                                |
| <b>Good protein (&gt;16% CP)</b>    | Urea   | Whole cottonseed<br>Shrimp waste<br>Cassava hay<br>Most legumes<br>Legume hays  | Brewers grain<br>Coconut meal<br>Soybean curd<br>Kapok seed<br>Commercial concentrate<br>Protein meals<br>Legume leaves |

## 10.6 Agro-industrial by-products

Many of the supplements included in the above tables are agro-industrial by-products. The storage of wet by-products has been discussed in Chapter 9. Some of the important dry by-products are described below.

**Paddy rice:** There are many forms of rice by-product concentrates resulting from processing paddy rice for human consumption, with nutritive value varying with the degree of contamination by rice hulls. Rice pollard contains minimal hulls but is generally used by pig and poultry farmers. Table 10.1 presents data for two grades of rice bran (1 and 2), varying in rice hull contamination. Rice bran quality can be subjectively assessed by gently blowing the bran as it drops from one hand to another. The more hulls that can be blown away, the lower the nutritive value. Chemical treatment of rice straw is discussed below.

**Maize:** There are many by-products from processing maize grain in western countries, some of which may be available to small holder dairy farmers in the humid

tropics. The most important is maize gluten, the residue after extraction of maize starch and maize syrup. It is sold either as maize gluten meal or maize gluten fed, the latter including the bran. Wet maize gluten meal is produced as a by-product of the wet milling of maize grain. Other by-products, often used as feeds for pig and poultry, are first, maize steep liquor or distilled solubles, a condensed fermented maize soluble with maize meal and bran, and second, maize distillers grains. These by-product all have ME levels of 13 to 14 MJ/kg DM and CP levels of 11% to 30%, with gluten meal having 47% CP. Other by-products include mill mix (mixture of bran and pollard), hominy (or grits) and maize cobs.

**Wheat pollard:** arises from milling wheat into flour. It is a major component of formulated dairy concentrates in countries such as Indonesia.

**Hulls:** from cottonseed, peanuts and soybeans are low in energy and protein and high in fibre. They are quite palatable.

**Palm kernel cake:** is the by-product residue following extraction of oil from oil palm fruit. The oil content can vary from 2% to 10% depending on the method of extraction (solvent or pressure). Other by-products from oil palm processing are palm oil sludge and palm pressed fibre.

**Oilseed meals:** such as cottonseed, sunflower and soybean meals, and palm kernel cake, are residues from oil extraction, and vary in oil (hence energy content) depending on the extraction method.

**Whole cottonseed** is the residue of ginning cotton. It is either white (containing some cotton lint) or black in colour (with all lint removed). The white cottonseed is high in digestible fibre while both types have high oil contents. Whole cottonseed contains gossypol, which can be toxic, particularly to young stock.

## 10.7 Chemical treatment of low quality roughages

With the abundant supply of rice straw throughout South-East Asia, considerable effort has been directed towards improving its nutritive value. This had led to a plethora of feeding systems utilising chemically treated rice straw developed for the wide variety of ruminants, ranging from breeding stock to growing stock to milking cows (Doyle *et al.* 1986). The high nutrient demands of lactating cows limits the proportion of their diet based on modified rice straw, particularly when fed to produce high milk yields.

Table 10.7 presents data from a metabolism study conducted with Zebu bulls in Indonesia (Moran *et al.* 1983) where rice straw was treated with alkali and supplemented with *Leucaena* and compared to freshly harvested Napier grass.

**Table 10.7** Nutritive value of rice straw-based diets in Zebu beef bulls fed to appetite

Diets are 100% rice straw (RS), alkali-treated rice straw (ARS), 70% RS plus 30% *Leucaena* (RS-L), 70% ARS plus 30% *Leucaena* (ARS-L) and 100% Napier grass (NG). (Source: Moran *et al.* 1983)

|                          | RS   | ARS   | RS-L | ARS-L | NG   |
|--------------------------|------|-------|------|-------|------|
| DM intake (kg/d)         | 5.1  | 3.6   | 6.6  | 5.9   | 5.4  |
| DM digestibility (%)     | 37.6 | 46.9  | 42.1 | 47.8  | 52.7 |
| Energy digestibility (%) | 41.6 | 54.7  | 47.7 | 50.6  | 55.3 |
| ME content (MJ/kg DM)    | 5.4  | 6.9   | 7.0  | 7.2   | 8.9  |
| Nitrogen balance (g/d)   | -3.1 | -10.0 | 20.5 | 20.3  | 14.1 |



Many dairy farmers in South-East Asia have constructed cement boxes to make urea-treated rice straw, which is supposedly a good forage source for milking cows.

Alkali treatment improved digestibility of the dry matter and of energy and Metabolisable Energy content, but reduced dry matter intake. Even when alkali treated and supplemented with 30% *Leucaena*, the Metabolisable Energy content only improved from 5.4 (untreated rice straw) to 7.2 MJ/kg DM (treated rice straw plus *Leucaena*), still lower than that of Napier grass (8.9 MJ/kg DM). The *Leucaena* supplement improved the nitrogen balance in the cattle above that of Napier grass (20 v 14 g/d).

The Metabolisable Energy content of rice straw, both untreated and alkali treated, are lower than those reported in Table 10.5, indicative of the large variability in nutritive value of forage by-products. The poorer Metabolisable Energy content of the best diet based on alkali-treated rice straw, compared to the Napier grass, which is only a moderate quality roughage, indicates its limited potential role as a basal ration for milking cows fed to produce 15 to 20 L/d of milk.

Urea treatment of rice straw provides additional nitrogen, some of which will be converted to microbial protein if sufficient dietary energy is provided, although improvements in Metabolisable Energy content are likely to be less than those in Table 10.6. However, if fed *ad libitum*, intakes of urea treated rice straw would be greater than the untreated straw.

Table 10.8 presents the results from a study conducted in South Vietnam, in which crossbred Friesian cows were fed *ad libitum* diets based on Napier grass and rice straw ensiled with 5% urea (Mann and Wiktorsson 2001). The diets consisted of varying proportions of Napier grass and urea-treated rice straw plus a fixed amount of concentrate (0.4 kg per L milk produced). The Napier grass contained 11.5% DM, 12.7% CP, 9.2 MJ/kg DM of ME, the urea treated rice straw had 37.8% DM, 14.6% CP and 8.7



Such cement boxes should be used to make silage, generally a better quality forage than urea-treated rice straw.

MJ/kg DM of ME, while the untreated rice straw contained 6.9% CP and 7.0 MJ/kg DM of ME.

When fed the 100% Napier grass diet, cows had significantly lower dry matter intakes than when fed the 75% Napier grass diet. This could be due to the lower dry matter percentage of the very succulent Napier grass. Dietary crude protein levels decreased with rice straw feeding but there was little difference in dietary Metabolisable Energy contents. Milk yields were similar on all four diets, although milk fat contents increased with feeding urea-treated rice straw.

**Table 10.8** Feed intake and milk production in Friesian crossbred cows fed various proportions of Napier grass (*Pennisetum purpureum*) and urea-treated rice straw

Crude Protein (CP); dry matter (DM); dry matter intake (DMI); Metabolisable Energy (ME). (Source: Mann and Wiktorsson 2001)

| Napier grass:urea rice straw ratio  | 100:0 | 75:25 | 50:50 | 25:75 |
|-------------------------------------|-------|-------|-------|-------|
| Roughage DM intake (kg/cow per day) | 7.3   | 8.6   | 8.0   | 8.0   |
| Total DMI (kg/cow per day)          | 11.0  | 12.3  | 11.9  | 11.6  |
| Total DMI (kg/100 kg LWT)           | 2.59  | 2.94  | 2.83  | 2.78  |
| Diet ME content (MJ/kg DM)          | 9.6   | 9.5   | 9.4   | 9.4   |
| Diet CP (%)                         | 13.8  | 12.6  | 12.1  | 11.4  |
| Diet DM (%)                         | 16.2  | 20.4  | 24.4  | 31.6  |
| Milk yield (L/cow perday)           | 10.2  | 10.0  | 10.1  | 9.8   |
| Milk fat (%)                        | 3.7   | 3.9   | 4.0   | 4.3   |
| Milk protein (%)                    | 3.1   | 3.1   | 3.1   | 3.2   |

An economic evaluation of the above study costed rice straw at 70 (Vietnam dong) VND/kg to purchase, its urea treatment at 182 VND/kg and purchased Napier grass at 196 VND/kg. Feed costs were then 670 VND/kg DM for urea-treated rice straw compared to 1700 VND/kg DM for Napier grass or 2.5 times less expensive.

Milk responses to chemical treatment of rice straw may vary with the type of rice straw. The rice straw used in Table 10.7 originated from an early maturing variety (7.0 MJ of ME/kg DM) whereas that used in Table 10.6 was a later maturing variety (5.4 MJ of ME/kg DM).

The fact that only a few farmers in Asia have adopted chemical treatment of rice straw raises many questions. In the first instance, has the technology been extended to farmers correctly and if so, why then has it not been more widely adopted? Is this due to conditions of pretreatment which may not lead to significant improvements in nutritive value when the process is carried out on farm, or is it, because the process is not economical?

## 10.8 Molasses urea blocks

With urea being considerably cheaper than most protein supplements, it can form a cost-effective supplement, provided there is a readily available carbohydrate source to allow the rumen bacteria to convert the urea into microbial protein. When urea and molasses were made into lick blocks and offered to milking cows together with formulated concentrates and rice straw, Preston and Leng (1987) observed reduced intakes of the formulated concentrates and/or increased rice straw intake. This led to small milk responses in low yielding cattle and buffaloes, producing only 4 to 6 L milk/d.

By incorporating molasses and urea into a solid block, additional nutrients such as specific minerals or veterinary drugs such as anthelmintics can be easily included in the blend. There is considerable interest in developing high quality feed blocks incorporating mixtures of protein sources, such as rice bran, cottonseed meal and fish meal, which may be useful in higher yielding stock.



A press for making feed blocks incorporating molasses, protein meal and minerals (West Java Indonesia).

Once adequate quality forage is available to provide the energy required, milk responses to manipulating the proportion of protein as undegradable dietary protein or even providing additional nitrogen in the form of urea, are more likely to be economical and sustainable. As with chemical treatment of rice straw, adoption of nutrient feed blocks by small holder farmers has been slow, presumably because of the extra effort required to present the feed to the cows. Farmers are driven by profit margins, and even though labour costs are often not included in any profit calculations, extra effort must lead to considerably higher milk sales or lower feed costs or else it is 'not worth it'.



The proud Indonesian dairy farmer who designed the press (shown in the photo on p. 111) with some of his feed blocks