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ANIMAL FEEDS OF THE FEDERATION

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FOREWORD

In 1960 the gross value of the livestock industry of the Federation was £21.5 million, of which £11.5 million was obtained from the slaughter of 416 thousand head of cattle excluding stock slaughtered by the African population for their own subsistence. The turnover of the national herd is about 10 per cent. in marked contrast to more than double this figure today in certain other countries. The main reason for this low productivity is the long dry winter, during which cattle lose weight and condition and cows fail to reproduce regularly owing to gross malnutrition. Indeed, some three-quarters of our cattle population suffers from hunger and starvation every winter. The remedy lies in providing them with more to eat during this period and in particular raising the level of protein intake. The same state of affairs applies to the flocks of sheep and goats.

In the case of pigs, poultry and dairy stock, whose produce exceeds £7.3 million, the price squeeze necessitates a wise selection and careful feeding of rations because feeds are the largest costs in each of these enterprises. Furthermore, the country imports over £1 million of animal feeding stuffs which are largely consumed by these classes of stock.

Our knowledge of the nutritive value of the available feeds is limited and, in addition, the information is widely scattered in numerous publications. Dr. Topps, Lecturer in Animal Nutrition, has gathered the relevant material together in the following pages, which we venture to hope will be of service to livestock owners, managers and extension officers in the Federation.

The University College is currently publishing a series of "Occasional Papers" on a wide range of subjects and this is the first such paper from its Department of Agriculture.

A. G. DAVIS,

Professor of Agriculture.

24th July, 1961.

ANIMAL FEEDS OF THE FEDERATION

A Review by J. H. Topps, Ph.D., Department of Agriculture, University College of Rhodesia and Nyasaland.

INTRODUCTION

A knowledge of the nutritive value of feeds is essential for correct and economical feeding of farm stock. In countries where the science of agriculture has been practised for a century or more a vast amount of data has accumulated and from this reliable values have been obtained for the animal feeds in use. In the tropics the study of animal nutrition is a relatively new subject and most of the information available about local feeding stuffs is based on chemical analysis. This is true in the Federation, although a few digestibility trials with animals have been carried out. It is well known that without digestibility data chemical analysis can only provide approximate values.

Many Rhodesian animal feeds are also used in other countries. Data obtained from these countries, in particular the United States of America and to a lesser extent Great Britain and Commonwealth countries, may be used in the Federation, but some discretion is needed in their application. The chemical composition of any plant species, and so its nutritive value, may vary considerably with the country of production. This is due to differences in climate, soil, agronomic practices and the variety grown. For many feeding stuffs there may be also a difference in processing or method of conservation. The difference in nutritive value is well illustrated by maize silage produced in the Federation compared with the United States. The available data indicate an appreciable difference in feed value between the two silages which is due mainly to differences in the variety grown and the method of conservation.

In this publication the values given have been taken from Rhodesian sources or have been interpolated from these by means of correlations and relationships such as digestibility coefficients. For the calculations, F. B. Morrison's authoritative work, *Feeds and Feeding*, has been widely used but the feed values tabulated in Morrison's book have not been and should not be accepted.

A great deal of information on Rhodesian feeding stuffs still requires elucidation and it will probably be several years before our knowledge approaches completion. This paper will be revised as information becomes available.

The author is indebted to numerous chemists in the Federation for their help in supplying analytical data.

GENERAL INFORMATION

Feeding stuffs are composed of the following:—

Water.

Proteins and other nitrogenous compounds.

Ether extract, which includes fat and oils with varying amounts of other compounds dissolved by the ether in the process of extraction

Carbohydrates, such as starch or sugars, which are called the nitrogen-free extractives (N.F.E.).

Crude fibre, which may be valuable cellulose or useless lignified-cellulose.

Mineral substances or ash.

Vitamins.

Proteins are the tissue or muscle-building components of the diet, so growing stock and lactating animals have a particular need for dietary protein. Protein which is fed to animals in excess of this requirement is used as a source of energy.

Fats and carbohydrates are the main sources of energy, and one pound of fat provides 2.25 times the energy of a pound of carbohydrates.

Crude fibre is important as a source of energy and also for its physical effect on aiding mastication and rumination.

Minerals include calcium and phosphorus, which are the principal constituents of the skeleton, but there are eleven other essential minerals with equally vital functions to perform.

Vitamins are essential dietary constituents which are necessary for the functioning of the body cells and to maintain health.

An animal's ration must provide the following:—

(1) Enough energy for movement, for the muscular activity of grazing, for maintenance of thermal equilibrium in the body and for milk or egg production.

(2) Enough protein to repair the wear and tear of body tissues in maintenance, with a surplus to produce new flesh in growing stock or as a source of milk proteins or egg proteins.

(3) Minerals for the maintenance of body functions and a surplus for skeletal growth and or the minerals in milk or eggs.

(4) Adequate levels of vitamins for the correct functioning of the body cells and the vitamin content of milk or eggs.

Energy Value of Feeding Stuffs

The main function of food is to furnish energy for body processes and to form the non-nitrogenous, organic tissues and secretions. The value of food for this function, in which carbohydrates, fats and proteins can take part, is denoted by the expression food energy. There are several different measures of food energy; in the Federation total digestible nutrients (T.D.N.) is the measure commonly used.

The T.D.N. content of a food is obtained in the following way. The crude protein, crude fibre, ether extract and nitrogen free extract content is determined by chemical analysis. A digestion trial, with at least three animals, is carried out, and in this the nutrients consumed and the amounts voided in the faeces are recorded. By subtraction, the amount of each nutrient digested is obtained. From this data digestion coefficients are calculated.

Digestion coefficient (expressed as a percentage) =

$$\frac{\text{Weight of digested nutrient}}{\text{Weight of consumed nutrient}} \times 100$$

Digestible nutrients are obtained by multiplying the amount of nutrient by its digestion coefficient. The digestible ether extract is multiplied by the factor 2.25, because it has that much more energy value than the other nutrients, and then added to digestible protein, digestible crude fibre and digestible nitrogen free extract to give total digestible nutrients.

Example: Dried veld grass cut in February (Elliott and Croft, 1958).

Nutrient.	Total nutrient in 100 lb.	Digestion coefficient percentage.	Digestible nutrient. lb.
Crude protein	5.6 lb.	29.0	1.62
Crude fibre	34.8 lb.	68.6	23.87
Nitrogen free extract	48.1 lb.	59.4	28.57
Ether extract	1.5 lb.	31.9	0.48
Total digestible nutrients			54.54 lbs.

In the Federation, T.D.N. is used to express the energy requirements of farm stock, except those of pigs and poultry. The latters' requirements are commonly expressed in terms of pounds of feed.

Total digestible nutrients must not be considered as the final measure of the useful, productive energy. It does not take account of the loss in the urine, the rumen gases and, most important, the heat loss. A considerable fraction, 25 to 40 per cent., of a food's total energy is converted to heat by the animal. Some of this heat is used to maintain body temperature, but in a warm climate much of it serves no useful purpose and is allowed to escape from the body. These urinary, gaseous and heat losses of energy are relatively larger for roughages than for concentrates, e.g., a pound of T.D.N. in roughage has considerably less productive value than a pound in concentrates. This limitation of the T.D.N. measure should be recognised, especially when animals are fed an all-roughage ration.

T.D.N. values are relatively easy to determine and have been determined for many Rhodesian feeds by Elliott (1956), Elliott and Croft (1958), Elliott and Fokkema (1960) and Topps (unpublished data).

Protein Value of Feeding Stuffs

The protein value of any food is the digestible protein content expressed as a percentage of the total food.

The protein requirement of ruminants and horses is expressed as digestible protein, but that of pigs and poultry is usually expressed as total protein.

Digestible protein, otherwise known as digestible crude protein (D.C.P.), is a more exact measure of useful protein than T.D.N. is of the useful energy, for the former disregards the urinary loss only. All proteins, however, are not of equal nutritional value. They are said to vary in quality or "biological value" and this is of considerable importance, especially for pigs and poultry. Proteins are composed of amino acids. Animals are able to synthesise some amino acids from other amino acids present in their food. They are unable to synthesise particular amino acids or cannot do so rapidly enough for normal growth. The latter are termed "essential" amino acids and include lysine, tryptophan, methionine and seven or eight others. An animal's protein supply must include these essential amino acids in adequate amounts. Some feeds, e.g., maize grain, are deficient in one or more essential amino acids and their protein is said to have a low biological value.

With ruminants the food protein need not contain all the essential amino-acids since the rumen bacteria can synthesise these. Protein utilisation is dependent to a large extent on the rate of rumen fermentation. With very rapid fermentation, the production of ammonia by bacterial breakdown of proteins may greatly exceed conversion of this ammonia to microbial protein. The excess ammonia is absorbed through the rumen wall into the blood and then passes to the urine as urea and is lost from the body. In this way the utilisation of proteins in different feeds may vary considerably.

Pigs and poultry must have all the essential amino acids in adequate amounts, and the feeding of animal protein is usually necessary to meet this requirement. Vegetable proteins are deficient in one or more essential amino acids. Over-heating of foods may spoil the quality of the protein by decomposing amino acids or making them unavailable in the form of a carbohydrate-amino acid complex. In a few instances, e.g., soyabeans, controlled heating improves the quality of the protein by the destruction of an anti-enzyme or other adverse factors.

Mineral and Vitamin Value of Feeding Stuffs

Both these values are expressed as the number of grams, milligrams or micrograms of the constituent per pound of feed, or as parts per million of the feed.

Certain vitamins are destroyed by heat, prolonged exposure to air or the action of light (bleaching).

Normally an animal's requirements for minerals and vitamins is met by feeding a mixed ration plus a simple mineral supplement. Vitamin supplements are usually needed for pigs and poultry. The likelihood of a mineral or vitamin deficiency in a feed is indicated in the text.

In general, Rhodesian roughages are low in protein and high in fibre and lignin. The legume forages are high in protein, but are also high in fibre. The high fibre and lignin contents limit digestibility and the T.D.N. values of roughages (expressed on a dry matter basis) rarely exceed 60 per cent. and may be as low as 40 per cent. The low protein may also have a very low digestibility.

The characteristics of Rhodesian concentrates are similar to those of concentrates of other countries. With regard to the mixed concentrates purchased from milling companies, these are required by statute to have this composition stated on their labels. From these figures some indication of their feed value is apparent. Normally they are adequately reinforced with minerals and vitamins. Details of these mixed concentrates are not discussed in this publication.

The animal feeds of the Federation may be classified into the following groups:

1. Cereal grains and their by-products.
2. Oil-seeds and products.
3. Grassland.
4. Legume seeds and forage.
5. Maize and sorghum forages.
6. Miscellaneous succulent and dry feeds.
7. Fodder trees and shrubs.
8. Animal products.

CEREAL GRAINS AND THEIR BY-PRODUCTS

All the cereal grains are rich in carbohydrates, which is present mainly in the form of starch. They are therefore rich in total digestible nutrients and energy. In addition, all the grains except rye are highly palatable to stock. Maize, wheat and the grain sorghums have the highest amount of total digestible nutrients, being closely followed by barley and rye. Oats with their thick hulls are higher in fibre and so lower in digestible nutrients. The oil content of wheat, barley and grain sorghums is low, but oats and maize contain a fair amount of this constituent.

Maize is decidedly low in protein and the other grains are relatively low, averaging 10 per cent. The proteins are also of poor quality, for they contain inadequate amounts of certain of the essential amino acids such as lysine and tryptophan.

The grains contain a satisfactory amount of phosphate, and certain of the by-products, especially wheat bran and wheat middlings, are rich in this mineral. They are all very low in calcium and maize is especially deficient in this respect.

With the exception of yellow maize, none of the grains contains significant amounts of carotene or vitamin A. All grains are fairly rich in thiamine, but are low in riboflavin. Wheat, barley and the grain sorghums contain considerable niacin, but maize, oats and rye have a much lower content of this vitamin. All the grains supply satisfactory amounts of vitamin E.

The dry matter content of cereals and by-products is usually in the range 85-90 per cent.; in Rhodesia and other countries with a dry climate the value is 90 per cent.

MAIZE, *Zea mays L.*

Percentage composition.

T.D.N. = 80; Protein = 8-10; Digestible protein = 6.5.

Maize is very rich in starch, very low in fibre and highly digestible. It is the most palatable of the cereals for farm stock. The great majority of the locally grown cereal is white maize with an average protein level of 8.0 per cent. Yellow maize has a higher protein content of 10.0 per cent. Maize protein is of poor quality, being deficient in tryptophan and lysine. Further, most of the hybrid varieties tend to produce grain of lower protein content than do the old open-pollinated varieties. High-protein hybrids have been developed that produce grain having 11 to 15 per cent. protein, but the yield of such hybrids is relatively low and their use has not become economic.

Maize is extremely low in calcium, having but 0.02 per cent. (i.e., 0.4 lb. Ca per ton of grain).

Maize grain is an excellent feed for dairy and beef cattle. It should be ground medium-fine (screen size ¼ inch), otherwise as much as 18-35 per cent. passes through the digestive tract as whole kernels. Because of its high energy value, maize is an excellent feed for pigs and poultry. The amount fed to bacon pigs should be limited

to about 40 per cent. of the ration to avoid an oily, soft carcass. Grain harvested before it is dry and with a moisture content of 20 to 30 per cent. may be ensiled in air-tight silos. The product when compared with normal maize on a dry matter basis has an 8 per cent. greater feed value for beef cattle and a slightly depressed value for pigs.

Flaked maize is made by cooking the grain to soften it and then passing it between hot rollers. It is finally dried in a current of hot air. The thin crisp yellow flakes are almost wholly digestible and are an especially valuable feed for young animals. Furthermore, they have a beneficial effect on the physical constituency of rations.

MAIZE COBS or Cob Meal.

Percentage composition.

T.D.N. = 45; Protein = 2.0; Digestible protein—negligible.

Ground maize cobs are a low-grade roughage which contain about 30 per cent. fibre and are very low in protein and minerals, e.g., 0.04 per cent. phosphorus. If amply supplemented with protein, or a mixture of protein and urea, and minerals and made palatable with molasses, they provide a very useful feed for wintering young stock or beef cows.

CORN-AND-COB MEAL or Ground Ear Corn.

Percentage composition.

T.D.N. = 72; Protein = 7.5; Digestible protein = 5.5.

The cobs usually form about 20 per cent. of the weight of corn-and-cob meal and the material is more bulky than ground corn. Corn-and-cob medium ground (screen size $\frac{1}{8}$ inch) is an economical form in which to feed maize to beef cattle and fattening lambs. The daily gain is apt to be a little less than on ground corn, but the cobs provide some of the roughage required in the ration. It is also a "safer feed" than maize with regard to digestive disturbances. The substitution of corn-and-cob meal for maize in a pig ration usually results in a slower rate of growth and a leaner carcass.

The wet entire ear from early harvesting, when the moisture content is around 30 per cent., may be ground and ensiled. The product compares favourably in feed value with normal corn-and-cob meal.

When the entire corn ears in the husks are ground, the product is called ground snapped corn. It has a feed value slightly inferior to that of corn-and-cob meal (T.D.N. = 69 per cent.; Digestible protein = 5.0 per cent.).

HOMINY CHOP, also called Hominy Feed or Hominy Meal.

Percentage composition.

T.D.N. = 82; Protein = 9-12; Digestible protein = 7.2.

Hominy chop is the by-product obtained in the manufacture of maize meal for human use. It consists of a mixture of the maize bran, the maize germs and some of the starchy portion of the kernels. Hominy chop resembles ground maize in composition and is about equal to it in feeding value. It is usually slightly higher than maize in protein and it contains more fibre than maize and is therefore more bulky. It is a popular ingredient of dairy feeds. Only small amounts are available in Rhodesia and many of the feeds named "hominy chop" are in fact maize bran.

MAIZE BRAN, or Madeva.

Percentage composition.

T.D.N. = 68; Protein = 7; Digestible protein = 4.

Maize bran consists of the outer coating of the maize kernels, including the hull and the tip cap. It contains 15.0 per cent. fibre and is used as a "filler" in concentrates for ruminants.

OTHER MAIZE BY-PRODUCTS

In the manufacture of starch and glucose from maize the following feeds are obtained: maize gluten feed, maize gluten meal, maize oil meal and maize germ meal. These feeds are not normally available in the Federation; information on them may be found in Morrison's *Feeds and Feeding* pp. 423-426.

OATS. *Avena sativa L.*

Percentage composition.

T.D.N. = 70; Protein = 9-12; Digestible protein = 7.5

Of all the cereals, oats can be fed liberally with safety to all classes of stock, with the exception of pigs. They have the same general nutritional deficiencies as the other cereals and contain approximately 11 per cent. fibre. There is a great variation in the proportion of hulls in oats and consequently in their feeding value. The feeding value is inversely related to the hull content. On the average, they contain about 30 per cent. of hulls.

Oats should preferably be crushed or rolled before being fed to stock. Crushed oats are excellent for ruminants, and for dairy cows are worth fully 90 per cent. as much as ground maize. They are the standard cereal for horse feeds, but are too high in fibre to be the chief concentrate in pig rations. For growing and fattening pigs, oats should form not more than a quarter of the ration. Oats are excellent for poultry feeding and their comparative richness in manganese is a preventative of perosis.

WHEAT. *Triticum aestivum L.*

Percentage composition.

T.D.N. = 80; Protein = 10-16; Digestible protein = 8.5-13.

Wheat is used mainly for human consumption and only small quantities of damaged and broken grain are available for stock-feed. It resembles the other cereals in general nutritive characteristics. The protein content of wheat varies widely depending on the climate, the variety and the soil fertility. Hard wheat has an average content of 13 to 15 per cent. protein, whilst soft wheat is much lower in protein, averaging 10 per cent. Small quantities of the latter are included in Rhodesian poultry feeds.

Wheat meal should always be mixed with other feeds which are relatively high in fibre. In itself it is too glutinous and can cause dangerous digestive disturbances to pigs and horses. Cattle and sheep go "off feed" or have indigestion when heavily fed on wheat. It is best fed in the crushed or coarsely ground state. Wheat is well liked by poultry and it is slightly superior to maize in value for them.

WHEAT BRAN.

Percentage composition.

T.D.N. = 66; Protein = 12-16; Digestible protein = 11.

Wheat bran, which consists almost entirely of the coarse outer coatings of the wheat kernel, is one of the most important and valuable stock feeds. It is highly

palatable to stock and it has a mild laxative effect if fed wet, but is costive when fed dry. It usually contains about 10 per cent. fibre, and if of good quality it must consist of clearly visible flakes. The protein of bran is of better quality than that of maize or wheat. In phosphorus content bran is one of the richest of all common feeds, but it is low in calcium.

Wheat bran is a popular dairy feed and its value for milk production seems to be greater than would be indicated from its nutritive value. If the ingredients of a meal ration have been put through a hammer-mill, the inclusion of wheat bran improves its physical constituency, especially where large quantities are fed. It frequently forms 10 per cent. of the diet of farrowing sows, but is rather fibrous for use in the ration of fattening pigs.

POLLARD or MIDDLINGS.

Percentage composition.

T.D.N. = 72; Protein = 14-16; Digestible protein = 11.

This is fine wheat bran mixed in varying proportions with wheatmeal. A good quality pollard would consist of 50 per cent. bran and 50 per cent. meal. It is appreciably more digestible than wheat bran and it has a lower fibre content. For these reasons it is a popular feed for young animals and for pigs. In pig production it produces excellent results when fed with grain (e.g., maize or barley) and a protein supplement (e.g., soyabean oil meal or fishmeal). Fed in this way, middlings are worth as much or slightly more than maize.

BARLEY. *Hordeum vulgare L.*

Percentage composition.

T.D.N. = 76; Protein = 9-11; Digestible protein = 7.5.

At present no barley is available as stock feed in the Federation. The imported grain is used in the brewing industry.

The protein and energy values of barley are between those of oats and of maize. Because of the hulls, which form about 15 per cent. of the grain, barley has 5 per cent. of fibre. It has the same nutritive deficiencies as the other cereals.

Barley should be ground, rolled or crushed, except for sheep or when fed with whole grain to poultry. Barley is widely used in Europe as stock-feed and is particularly popular for pigs. The best bacon in the world is said to be produced on barley!

GRAIN SORGHUM or Kaffir Corn. *Sorghum vulgare Pers.*

Percentage composition.

T.D.N. = 78; Protein = 9-11; Digestible protein = 7.5.

The sorghums are grown for grain and also for forage in areas of the world where the rainfall is inadequate for satisfactory maize cropping. The sorghums are of two general types—the *sweet sorghums*, or sorghos, which have stems filled with sweet juice, and the *grain sorghums*, which usually have pithy stems. The sweet sorghums are grown for forage rather than grain. They are usually five to seven feet tall or more and give large yields per acre. The two types of sorghum cross freely, whereby certain hybrid varieties have been developed which combine some of the more valuable characteristics of both. Many of the dwarf varieties, now so popular in the United States of America, were developed by crossing milo with Kaffir or other sorghums. They grow only two to four feet tall, have erect heads and usually have dry, pithy stalks.

BUCKWHEAT, *Fagopyrum esculentum*, Moench.

Percentage composition.

T.D.N. = 62; Protein = 10-10.5; Digestible protein = 7.4.

Buckwheat is not really a cereal, but is discussed here because the seed has much the same nutritive characteristics as the cereal grains. The woody hulls of buckwheat form 18 to 20 per cent. or more of the seed and the grain has between 11 and 14 per cent. fibre. It has less protein than oats and only about one-half as much fat, while it furnishes appreciably less total digestible nutrients. It is not so palatable as most of the grains and therefore should be mixed with palatable feeds.

Buckwheat should be ground for all classes of stock except poultry. If fed to pigs it tends to produce soft fat. The protein of buckwheat appears to have a much higher biological value than that in other plant products. Occasionally buckwheat grain and also the green fodder or straw cause peculiar eruptions and intense itching of the skin. This affects only white or light-coloured portions of the hide, and animals are injured only when exposed to light.

BREWING BY-PRODUCTS

The by-products obtainable in Rhodesia are brewers' wet grains and brewers' dried grain from barley and kaffir corn brewing, and malt culms. In the process of brewing, the carbohydrates are utilised to produce alcohol so that the residue when dry is richer in protein and fibre than the original grain.

The wet grains readily turn sour and mouldy if left exposed to the air. To preserve them in a wholesome condition they should be stored under air-tight conditions or by adding common salt (14 lb. per ton), followed by hard trampling. These methods of preservation should have no adverse effect on the feed value of the product. The grains are "balanced" for milk production, but their odour may taint the milk, either through feeding before milking or by direct absorption of the odour.

BREWERS' DRIED GRAINS.

Percentage composition.

T.D.N. = 60; Protein = 20-23; Digestible protein = 16.

The dried grains from kaffir corn and those from barley have very similar compositions and nutritive values. The protein content is 20 per cent. or a little more, the fat content is approximately 6 per cent. and the fibre about 14 per cent. The nitrogen-free extract largely comprises pentosans, for most of the starch is removed during the malting. The dried grains are fed chiefly to cattle and are very palatable. They are too fibrous to be a suitable feed for pigs.

WET BREWERS' GRAINS.

Percentage composition.

T.D.N. = 20-25; Protein = 7-9; Digestible protein = 6.

The average moisture content of the wet grain is from 60 to 70 per cent. Wet brewers' grains may be fed to dairy cows at the rate of 20 to 30 lbs. per head daily to replace an equal weight of silage or as a substitute for part of the concentrate (4 lbs. of wet grains for 1 lbs. of concentrates)

The grain sorghums resemble maize in composition and in feeding value. Like maize, they contain about 70 per cent. nitrogen-free extract, which is nearly all starch, and they are low in fibre and rich in digestible nutrients. Most of the grain sorghums have considerably more protein than maize, but they have less fat. The grain sorghums have the same nutritive deficiencies as the other grains. They are reasonably well liked by stock, but they are less palatable than maize. The seeds are so small that the grain should be ground for cattle and horses, otherwise a considerable amount will escape mastication. It has the disadvantage of tending to cause constipation. For beef cattle and for fattening and breeding pigs, ground grain sorghum is worth about 90 to 95 per cent. as much as maize.

RICE BRAN.

Percentage composition.

T.D.N. = 65; Protein = 12; Digestible protein = 8.0.

Rice bran consists of the bran and germs removed in milling rice (*Oryza sativa L.*) for human food. It has an average content of protein and a relatively high oil content (12 per cent.). The quality of its protein is better than that of maize. Rice bran varies considerably in fibre content (average 11 per cent.) because of the variable amounts of hulls present. It is rich in the B vitamins, thiamine and niacin. Unfortunately it often turns rancid in storage because of the high oil content.

Rice bran is fed chiefly to dairy cattle as part of a concentrate mixture. Its fibrous and oily nature make it an unsuitable feed for pigs.

MUNGA or MILLET, *Pennisetum typhoides* (Burm.), Stapf and Hubbard.

Percentage composition.

T.D.N. = 80; Protein = 10-11.5; Digestible protein = 8.0.

Munga is a millet which is widely grown in parts of the Federation, particularly by the African farmer. The small seed resembles maize in composition and feeding value, but is appreciably higher in protein. It has a low fibre content (1.5-2.0 per cent.) and is also low in calcium. As with grain sorghums, the seeds should be ground for feeding to livestock. Munga is a valuable ingredient of pig feeds since it has the same qualities as barley in promoting firmness and whiteness of fat (Calder, 1955). An excellent simple ration for self-feeding can be based on the following grain mixtures: 40 per cent. maize, 40 per cent. munga and 20 per cent. pollard. Care should be taken in feeding munga to breeding sows, for in a wet season the ergot content of munga may be dangerously high and this may cause a type of agalactia (lack of milk) in sows.

RUPOKO or FINGER MILLET, *Eleusine coracana,* Gaertn.

Percentage composition.

T.D.N. = 72; Protein = 6.5-7.5; Digestible protein = 5.5.

Rupoko is another millet widely grown by Africans for making beer. It has a lower protein content and nutritive value than munga, but a slightly greater fibre content (3 per cent.). Before being fed to livestock the small seeds should be ground. Recent investigations (Calder, 1960) have shown that rupoko has the same effect as munga when incorporated into pig rations, for it counteracts the softening effects of maize. However, compared with munga the pigs fed on rupoko have a less economical feed conversion and a slower growth rate. It is best fed to pigs during the finishing stage (above 120 lb. liveweight) and it is advisable not to use rupoko in excess of 50 per cent. of the grain content of the ration, because of its inferior feed efficiency.

MALT CULMS.

Percentage composition.

T.D.N. = 20; Protein = 24-25; Digestible protein = 20.

Malt culms consist of the dried sprouts and rootlets of the malt. They are similar in composition to brewers' dried grains, except that they have much less fat. One-third of the protein is present as asparagine. Malt sprouts are somewhat bitter and are unpalatable if fed alone.

DRIED BREWERS' YEAST.

Protein = 40-45 per cent.

Dried brewers' yeast results from drying waste yeast from breweries. It contains practically no fibre and no oil, but 10 per cent. of ash which is very rich in phosphate and low in calcium. Dried yeast is particularly rich in the vitamin B complex, and 2-3 per cent. included in poultry feeds safeguards the supply of vitamin B_1 and riboflavin. It is deficient in vitamin B_{12}. The proteins of dried yeast have a high biological value.

OIL SEEDS AND PRODUCTS

The oil seeds are grown mainly in tropical countries for the edible oil they contain. Oil cakes and extracted meals are the residues remaining after the removal of the greater proportion of the oil from these seeds and fruits. The residues are rich in protein and are used as protein supplements or protein-rich concentrates.

The old method of removing the oil by hydraulic pressure is now obsolete. The modern method is to use the expeller screw-press or to extract the oil by means of an organic solvent. In the expeller process the prepared seed is forced by a powerful screw along a constricting tube so that the oil is squeezed out. The residue is in the form of broken flakes and usually has an oil content of 5-6 per cent. Some charring may take place owing to the heat produced in the expeller. In the extraction process a non-inflammable volatile solvent such as trichlorethylene is allowed to percolate through the coarsely ground prepared seed, so that it dissolves most of the oil; the residue contains no more than 1-2 per cent. Considerable care is taken to recover as much as possible of the volatile solvent and to ensure its complete removal from the extracted meal.

Sometimes the process is more complex in that the husk or hulls of the seed have to be removed before extracting the oil; this gives a residue termed decorticated cake or meal. Hence it is important to distinguish between expeller nuts or meal, extracted meal, undecorticated cake or meal, decorticated cake or meal and extracted-decorticated cake or meal. The method of preparation may influence the feeding value considerably.

GROUNDNUTS (Peanuts, Earthnuts or Monkey nuts), *Arachis hypogaea* L.

Whole ground nuts, including the shells, have an average content of 25 per cent. protein, which is of good quality. Though they are high in fibre, they are very rich in total digestible nutrients because of their fat content of 36 per cent. They are deficient in carotene, low in calcium and not very rich in phosphorus.

GROUNDNUT OIL MEAL OR CAKE (Decorticated and Undecorticated).

Percentage composition.

Decorticated: T.D.N. 75; Protein = 40-48; Digestible protein = 36-42.
Undecorticated: T.D.N. = 67; Protein = 30; Digestible protein = 26.

The decorticated product has a fibre content of 6-10 per cent., while the undecorticated feed may be high in fibre up to 25 per cent. Hence the difference in nutritive values. The corresponding extracted meals are lower in total digestible nutrients due to their very low oil content.

The quality of the protein of groundnut oil meal is good, ranking close to that of soyabean oil meal, but it usually has less lysine. Groundnut oil meal is one of the best protein supplements for livestock feeding. It is well liked by stock. It is most commonly fed to dairy cattle and is very suitable for milk production. When fed to pigs it tends to produce soft bacon, but this can be partly overcome by the use of the extracted decorticated meal.

COTTON SEED MEAL OR CAKE from cotton, *Gossypium L.*

Percentage composition.

Decorticated: T.D.N. = 73; Protein = 40-45; Digestible protein = 32-36.
With shells: T.D.N. = 50; Protein = 21-25; Digestible protein = 18.

The better quality cottonseed meal consists of the cake after the oil has been extracted and from which the lint has been removed. The quality will vary according

to the amount of lint left in the seed. A good quality meal is light yellow and has a sharp nutty smell. A dark colour indicates that it contains a high percentage of shells and fibre.

Most of the cottonseed meal, including the local product, has 5 per cent. of fat or more. It supplies protein of satisfactory quality for cattle, sheep or horses, but as a protein source for pigs and poultry it is too low in lysine. Cottonseed meal is one of the richest feeds in phosphorus, containing 1.0 per cent. or more of that important mineral. In contrast, it has only about 0.2 per cent. calcium. Cottonseed meal tends to produce milk fat of a high melting point and hard body fat.

For pigs and poultry the ordinary kind of cottonseed meal should be fed in strictly limited amounts because of the danger of injury from a substance called gossypol which cottonseed meal contains. Raw cottonseed contains appreciable amounts of gossypol, the amount varying considerably with the climate and the soil. Gossypol is poisonous to pigs, poultry and calves if consumed in sufficient amounts. Fortunately, in the process of oil manufacture the heat changes much of the gossypol into "bound gossypol," which is much less poisonous. Nevertheless, it is not safe to include more than 10 per cent. cottonseed meal in the ration of pigs, poultry and calves. The symptoms of gossypol poisoning are: anaemia, diarrhoea and eventually paralysis. If the ration of laying hens has more than about 5 per cent. of ordinary cottonseed meal, the yolks of the eggs are apt to develop an olive green or brown colour and the white a pinkish colour on storage.

COTTONSEED HULLS.

Percentage composition.

T.D.N. = 43; Protein = 4; Digestible protein = nil.

The hulls are low in calcium, very low in phosphorus and are lacking in carotene. They should be fed with protein-rich feeds or a source of nitrogen, in which case they are about equal in value to fair quality grass hay.

SUNFLOWER SEED. *Helianthus annus L.*

Percentage composition.

Without hulls: T.D.N. = 110; Protein = 30; Digestible protein = 24.
With hulls: T.D.N. = 75; Protein = 15-17; Digestible protein = 14.

The seed contains 25 to 26 per cent. of oil and so its use as a stock feed is limited. The oil content accounts for its exceptionally high T.D.N. value. It has a great tendency to produce soft bacon and soft butter and, further, its protein is low in lysine.

SUNFLOWER OIL MEAL OR CAKE.

Percentage composition.

Decorticated: T.D.N. = 75-80; Protein = 40; Digestible protein = 35.
Undecorticated: T.D.N. = 55; Protein = 20; Digestible protein = 17.

The decorticated meal has a fibre content of approximately 14 per cent. and the undecorticated product about 30 per cent. fibre. Sunflower seed oil meal is very palatable and keeps well in storage. When it has been over-heated it is very deficient in lysine, due to the destruction of this amino acid.

SUNFLOWER HEADS.

Percentage composition.

T.D.N. = 60-65; Protein = 12-14; Digestible protein = 11.

The entire sunflower head is frequently used as a feed for stock. As soon as the seeds are formed the flower, plus about a foot of stem, is cut and passed through a hammermill. The resultant meal contains up to 14 per cent. protein and about 25 per cent. fibre. The T.D.N. value is considerably influenced by the amount of seed, which has a high oil content. It may be mixed with maize and used as a cattle feed.

SOYABEANS, *Glycine max.* Merr.

Percentage composition.

T.D.N. = 88; Protein = 38; Digestible protein = 34.

Soyabeans are the richest in protein of all the common seeds used for feed. They are also high in fat, having 18 per cent., but low in fibre with 5 per cent. In total digestible nutrients they rank even above maize because of their high fat content. Most black-seeded varieties of soyabeans are somewhat lower in fat than the yellow-seeded varieties. Soyabeans are rather low in calcium, with only 0.25 per cent. They contain 0.60 per cent. phosphorus.

For some unknown reason, feeding a large proportion of soyabeans to cattle decreases the utilisation of carotene or vitamin A and consequently increases the vitamin A requirement in the ration.

The nutritive value of soyabeans and of soyabean oil meal for non-ruminants, such as pigs and poultry, is increased by proper cooking. Such cooking greatly increases the availability and value of the protein for these animals and also destroys the trypsin inhibitor. This substance depresses the growth of non-ruminants and prevents the action of the protein digestive enzymes, trypsin and erepsin.

Raw soyabean protein therefore has a low value for pigs and poultry. Fortunately properly cooked soyabean oil meal or soyabeans furnish protein which is nearly equal in value to the protein of milk or fish meal. Too high a temperature or prolonged cooking reduces the value, because it destroys or makes unavailable lysine or certain other amino-acids.

The protein of soyabeans is rather low in total amount of the sulphur containing amino-acids—methionine and cystine. However, this may be partly corrected by the relative amounts of amino-acids contained in the cereal grains if they are included in the ration. Soyabeans should be ground for dairy cattle, but this is unnecessary for other stock. Ground soyabeans are apt to turn rancid if stored long in warm weather.

The ground pods and seeds, which contain about 24 per cent. protein and 10 per cent. oil, are occasionally mixed with a cereal and fed as a concentrate to cattle.

SOYABEAN OIL MEAL OR CAKE.

Percentage composition.

T.D.N. = 78; Protein = 41-45; Digestible protein = 37.

The use of trichlorethylene instead of hexane in the solvent process produces a meal which is poisonous to cattle and certain other animals. Hence this solvent should not be used to extract the oil from soyabeans.

Soyabean oil meal is low in fibre—6 per cent.—and contains 5 per cent. oil. The solvent process oil meal has only about 1.5 per cent. oil. For pigs, calves and poultry the properly cooked meal ranks ahead of all other plant protein supplements because of the high quality of its protein. Further, it is one of the best protein supplements for dairy cattle. The low oil product is recommended for pigs to avoid the tendency of soyabeans to produce soft bacon. When fed with a source of vitamin B_{12} its value as a protein supplement is only slightly less than that of animal protein. For feeding to poultry, soyabean proteins are deficient in methionine.

LINSEED MEAL OR CAKE from flax. *Linum usitatissimum L.*

Percentage composition.

T.D.N. = 75; Protein = 34-37; Digestible protein = 30.

Linseed meal is rarely fed in the Federation, whereas it is one of the most popular protein supplements in other countries. Its popularity is due to its palatability and richness in protein and to its slightly laxative effect, which aids in keeping stock healthy. Also it has a conditioning effect on stock, imparting "bloom" to the animal's coat.

Linseed is excellent as a sole protein supplement for dairy cattle, sheep and horses. The protein of linseed meal does not effectively supplement the protein of maize or other grains for non-ruminants. Further, in pig feeding it is apt to produce an oily soft carcass. It is not satisfactory when forming an appreciable part of the rations for poultry. Linseed meal has a fair calcium content, averaging 0.37 per cent., and is rich in phosphorus with an average of 0.86 per cent.

GRASSLAND

Natural grasses (the veld) and cultivated grasses play an extremely important role in the feeding of livestock in the Federation, providing most of the fodder for cattle. While differing to some extent in palatability and growth pattern, many of the grasses resemble each other in composition and feed value. In general, cultivated grasses have a better nutritive value than natural herbage because of higher protein and phosphorus contents, which are principally a reflection of improved soil fertility. The great differences in nutritive value are between young, immature grasses and the same plants when they are mature or even at the hay stage of growth. This applies to all species. The following notes serve to illustrate these characteristics. For further information on grassland in general the reader is referred to Meredith (1955) and Whyte *et al.* (1959).

SEASONAL CHANGES IN THE COMPOSITION OF DIGESTIBILITY OF VELD (Elliott, 1960)

Percentage composition on a dry matter basis

Date of Cutting	Crude protein	Ether extract	Crude fibre	N.F.E.	Ash	T.D.N.	Digestible protein.
24.11 and 7.12.58	8.4	1.7	35.8	42.8	11.3	61.7	4.47
8.12 and 22.12.58	6.2	1.6	36.3	44.6	11.3	50.8	2.19
22.12.58 and 5.1.59	10.6	2.9	34.7	40.5	11.3	62.5	6.03
5.1 and 19.1.59	10.2	2.3	34.5	40.8	12.2	53.8	4.79
19.1 and 2.2.59	8.0	1.4	34.2	41.8	14.6	50.2	3.91
2.2 and 16.2.59	7.5	1.4	36.0	41.9	13.2	49.2	2.86
16.2 and 2.3.59	7.2	1.0	35.2	42.6	14.0	45.3	2.63
2.3 and 16.3.59	5.7	0.7	38.1	44.1	10.4	44.5	0.91
16.3 and 30.3.59	4.9	1.1	36.7	46.8	10.5	47.2	0.58
30.3 and 13.4.59	3.6	1.3	42.0	44.8	8.3	45.4	0.15
14.4 and 28.4.59	3.8	0.7	42.8	43.2	9.5	49.2	Negligible

General Characteristics

(Unless otherwise stated, the values reported are percentages of the dry matter)

PROTEIN.

Young plants are richer in protein than the same plants at later stages of growth. Young pasture grass that is growing actively usually contains 12-16 per cent. or more protein. Young legumes, such as lucerne and clover, are even richer than young grass in protein. On the other hand, when pasture plants become mature and weathered, the protein content may fall to a very low level of 1-2 per cent.

The percentage of protein in grasses falls rapidly when they run to seed, largely because of an accumulation of carbohydrates. Also at this stage there is a much smaller proportion of leaves in the plants. Grass hay, cut at the usual stages of maturity, will generally have only 6 to 9 per cent. of protein, and this value will be lower the later it is cut.

In warm climates, as in the Federation, indigenous grasses at the pasture stage seem generally to have a much lower percentage of protein and a higher percentage of fibre and lignin than do grasses at the same stage in a cooler climate (Plowes, 1957). This may not be so where heavy applications of nitrogen fertiliser have been applied (Brockington, 1961; Barnes, 1960) or on soils of very high fertility.

DIGESTIBLE NUTRIENTS.

The second great difference between young plants and those that are more mature is that the young plants have much less fibre and less lignin than at later stages of growth. They are, therefore, more digestible than hay cut at the usual time (Louw, 1938). When dried to a hay basis, young grass from a fertile pasture supplies about 70 per cent. total digestible nutrients in comparison with 50 per cent. for grass hay of good quality. There is probably an even greater difference in productive energy value between young grass and hay made from the same crop at the usual stage of growth. Furthermore, an animal's intake of dry matter decreases as the grass becomes more fibrous.

When grass becomes mature the digestibility and nutritive value are further decreased. If it is then weathered by exposure it will resemble a rather poor grade of straw in composition and value. The more digestible and valuable nutrients will have been largely lost by leaching or by the shattering of leaves and other finer parts.

The decrease in digestibility as plants become more mature is, to a considerable extent, due to the increase in lignin. The digestibility of lignin by ruminants and horses is very low. Other classes of animals cannot digest it. Its nutritive value is therefore much less than that of cellulose, although both are carbohydrates. The digestibility of older plants is also reduced because the cell walls, especially of the stems, become lignified or encrusted with lignin. This decreases the digestibility of the nutrients which are enclosed within the cell walls.

PHOSPHORUS AND CALCIUM.

Young grasses or legumes on land well supplied with phosphorus usually contain 0.25 per cent. or more of that element. The percentage of phosphorus decreases as the plants become older, but until they are nearly mature the amount will generally be sufficient for livestock. When the forage becomes mature and weathered the phosphorus content falls greatly, and even where the soil phosphorus is adequate, such forage may not supply enough to meet the requirements of animals pastured on it. Where the soil is deficient in phosphorus, pasture plants may furnish enough phosphorus during active growth, but there is a serious deficiency when the plants are mature and weathered. For example, the veld *Hyparrhenia* species have a phosphorus content of 0.10-0.15 per cent. during the wet season and this declines to 0.02 per cent. in the winter months.

The percentage of calcium in grasses and other forage plants decreases somewhat as growth advances and carbohydrates are accumulated in the plants. However, the change is much less than is the case with the phosphorus content.

VITAMIN CONTENT.

One of the most important factors in livestock feeding is that all actively growing green parts of plants have a very high vitamin A value because of their richness in carotene. Such forage is also rich in most of the B complex vitamins, in vitamin E, in ascorbic acid and in certain unknown factors that may be beneficial to animals. The content of vitamins, especially of carotene, decreases as plant growth advances. When pasture plants mature and dry, the carotene is lost rapidly. Practically all the carotene disappears from most grasses and other pasture plants when they become mature and weathered.

SELECTIVE GRAZING.

In grazing, livestock tend to select the leaves and finer parts of the stems, which are more tender and more nutritious, and eat less of the coarser stemmy parts. The composition of the forage actually eaten may therefore differ appreciably from that of the entire plants. This applies especially to protein and phosphorus content, for in the case of both nutrients the percentage in the leaf is generally 1.5-2.0 times that in the stem. In the case of very young and palatable pasturage, there is much less selectivity in grazing.

MATURE WEATHERED PASTURE.

Range stock obtain most of their feed during the dry season by grazing on forage which has matured and dried. As we have seen, mature grass is always low in protein and phosphorus and has practically no carotene. If it is weathered by exposure to rains the value will be lessened still further by leaching. It is also lacking in palatability and is low in digestibility. If stock receive no other feed they suffer severely from nutritive deficiencies, viz., protein deficiency, phosphorus deficiency and vitamin A deficiency.

VELD

There are two main veld types in Southern Africa designated by the terms "sourveld" and "sweetveld" (Rattray, 1957). A great deal of confusion appears to exist with regard to the meaning of these terms. From the strictly scientific point of view they are words which should probably be avoided, but they have entered into such general use that an explanation is necessary.

The term "sour" appears to have been used in South Africa for many years to denote "unpalatability." Thus a "sour" veld was one which cattle or sheep found unpalatable at some stage of its growth. Certain vleis and other localised areas often carry a type of vegetation with harsh unpalatable leaves or containing acrid, aromatic plants which animals do not relish at any time during the growing season, and such a veld has always been described as being very "sour." Other types of veld were eaten and relished during the spring and summer months, but as the grass matured cattle began to find them unpalatable and only grazed them because there was no alternative. This was also described as a "sour" veld and was generally situated in the high country or "highveld," as it was called. For this reason the older generations of farmers in Southern Africa, in the days when large tracts of land were still unoccupied, used to trek with their cattle in search of so-called "sweet" grazing for winter. These farmers had discovered that in the lower-lying parts of the country, or "lowveld," the grasses were both palatable and nutritious during the winter months and they described this type of veld as "sweet." Generally speaking, annual grasses are more palatable than perennials; and because the grass cover in the lowveld often consists largely of annual species, due to the low rainfall, which does not favour the growth of perennials, it is greatly relished by stock throughout the year. Thus the terms "sourveld" and "sweetveld" became almost synonymous with "highveld"—above 4,000 feet—and "lowveld"—below 2,000 feet, and any veld at the medium altitudes between these two extremes became known as "middleveld" or "mixed veld" and contained both "sour" and "sweet" elements.

The following is a summary of the principal characteristics of the veld types (Groenewald, 1959).

SOUR VELD.

The cover consists mainly of perennial species which provide palatable grazing only whilst growing. The rainfall, which varies from 25 to 70 inches, encourages rapid plant growth and infertile, leached, acid soils, which in turn may result in a low mineral content of the grasses. The grass cover is relatively dense and so has a potentially high carrying capacity and is suitable for making veld hay. Spring and early grazing is usually of high quality and palatable, but late summer and autumn grazing is fibrous, relatively unappetising and of low nutritive value; during the winter the grass is of very poor quality. Experimental evidence has shown that cattle weights begin to drop from the beginning of June due to a deficiency of protein. The veld grasses contain a negligible amount of digestible protein from June to October.

SWEET VELD.

The grasses are principally annuals which remain palatable for most of the year and retain their nutritive value to a certain extent during the dry season. The rainfall is low, averaging 15 inches per annum, and so the grass cover is sparse and the carrying capacity is low. Furthermore, the low rainfall means little or no leaching and so the soils are reasonably well supplied with calcium and other minerals. Because of this the mineral composition of "sweet veld" grasses is probably higher than that of the "sour veld" forage. This is likely to improve their palatability. Sweet veld does not provide good spring grazing and the sparse cover does not warrant the making of veld hay. Cattle weights are maintained and occasionally show small gains until about the end of September in "sweet veld." The forage eaten by the cattle has a digestible protein content of approximately 3 per cent.

MIXED VELD.

This type possesses the characteristics of both sour and sweet veld. Its management and properties will, therefore, depend on the relative percentage of annuals and perennials in the veld.

The characteristics of some of the more common grasses grown in the Federation are discussed below. The protein, digestible protein, fibre and T.D.N. percentages, which are given on a dry matter basis, are *average* values derived from several reports.

RHODES GRASS, *Chloris gayana* Kunth.

Stage	Percentage composition		
	Dry matter	Protein	Fibre
Young, leafy condition (up to 3 feet)	30	9	30
Early flowering	32	6	32
Full to late flowering	35	4	34

Rhodes grass is a leafy, turf-forming perennial which spreads rapidly by stolons. Two varieties, which differ considerably, are widely used in Rhodesia: Giant Rhodes, which is vigorous but very frost-tender, and Katambora Rhodes, which is moderately frost-resistant, exceptionally leafy and, more important, is resistant to root knot eelworm. Rhodes grass is adapted to tropical and sub-tropical summer rainfall areas and a moderately long dry season. It grows best on fertile soils of medium texture with a pH 6.0 to 8.0. It does not thrive at high altitudes and under natural conditions it is usually found in the sweet (low) veld.

In the Federation it is one of the most useful species for rotational grasslands and is undoubtedly the best hay grass, provided the hay is cut at the early flowering stage. It gives palatable, warm-season pasture which withstands grazing and trampling well, but rotational grazing is desirable, for continuous use permits rapid invasion by weeds. Rhodes grass is one of the few indigenous palatable grasses which seeds profusely and, furthermore, it is relatively easy to establish from seed and forms a rapid cover. It does well under irrigation and is considered valuable for rebuilding soil structure. It is a heavy yielder and several cuts a year can be taken from a well-established sward. Unfortunately it tends to die out after three years, but with good mangement it will persist. It makes most growth fairly late in season and seeds late. At maturity it possesses a low leaf:high stem ratio (1:2.5) and is therefore of low quality.

STAR GRASS. *Cynodon plectostachys* Pilg.

Stage	Percentage composition		
	Dry matter	Protein	Fibre
Very young growth (6 inches)	25	15	25
Early flowering (12-18 inches)	30	6	32
Mature (2 feet)	40	4	32

Star grass is a spreading perennial with stout, rapidly-growing stolons. It may grow two to three feet high when fully mature. There are many known varieties, of which Star Grass No. 2 is the most popular in Rhodesia (Weinmann, 1950). Once established, Star grass covers the ground, grows luxuriantly and is very persistent, withstanding hard grazing. It is not easy to eradicate. It is adapted to a tropical climate with dry conditions of 20-30 inches annual rainfall. It is usually propagated by means of stolons and supplies good grazing and hay if it is not too mature. Grazing is the most suitable use for Star Grass No. 2. Early reports suggested that Star grass was likely to cause cyanide poisoning in stock. Varieties have been tested in different areas and no reports of stock losses have been published.

Star is a relatively high protein grass and is a fairly good source of minerals. The initial high protein content drops sharply during the period of rapid growth.

The stolons, especially when old, are considerably lower in protein than shoots.

NAPIER FODDER or ELEPHANT GRASS, *Pennisetum purpureum,* Schumach.

Stage	Percentage composition				
	Dry matter	T.D.N.	Fibre	Digestible protein	Protein
Up to 8 feet	30	51	37	3.5	7.5
5 feet	18	56	33	4.5	8.5
2½-3 feet	15	57	30	10.0	15

Napier fodder is a tall, vigorous, erect, deep-rooted perennial which resembles sugar cane in growth habit. It spreads by short stout rhizomes to form large clumps which are up to three feet across. Many varieties are known and there is considerable variation among them. In Rhodesia the Gold Coast type is popular because of its leafiness and vigour, and also the Cameroons variety, which is more bushy and yields better under good conditions and high rainfall.

Napier fodder grows best in deep, retentive soils of moderate to fairly heavy texture and responds well to fertiliser (Addison, 1958). It is remarkably drought-resistant for a grass of this type and is moderately frost-resistant. Its chief use is for green soiling or silage (after chopping), and annual yields of over 120 tons green fodder per acre have been obtained with irrigation. It is not very suitable for grazing, but *rotational* grazing is possible and practical. It should be grazed at an early stage (2½ to 3 feet high), at which time it is palatable and leafy and has a high nutritive value. For silage it is best cut when approximately five feet high to ensure a good yield, a fair protein content and not too much fibre. Mature Napier fodder, which has reached a height of 8 to 10 feet, has a large proportion of stem that is hard and fibrous. At that height its digestibility and feed value are considerably decreased.

Napier fodder holds the soil together efficiently and so it is used to prevent erosion. It also makes an effective windbreak.

NAPIER FODDER SILAGE.

Percentage composition				
Dry matter	T.D.N.	Protein	Fibre	Digestible protein
25	53	7.0	35	4.0

(Dividing the above figures by four will give the nutritive value of the silage as fed.)

Napier fodder cut when 4 to 5 feet high, chopped and ensiled makes an average quality silage. Molasses at the rate of 60 lbs. per ton of green fodder should be added to ensure initial rapid fermentation.

Silage made from more mature Napier fodder which is 6 to 8 feet high will have a very similar T.D.N. value, but a considerably lower digestible protein of 1.00 per cent. on a dry matter basis or 0.25 per cent. as fed.

Napier fodder silage is best fed to fattening stock. It compares unfavourably with maize silage for milk production.

WEEPING LOVE GRASS. *Eragrostis curvula* Nees.

	Percentage composition				
Stage	Dry matter	T.D.N.	Protein	Fibre	Digestible Protein
Before flowering	44	60	10	35	6
Mature	55	45	7	40	4

Weeping Love grass is a variable, strongly-tufted, deep-rooted bunch grass which forms large clumps with abundant, drooping basal leaves. The flowering stems are 3 to 4 feet in height. There are a great many varieties, which occur over a wide range of conditions from 20 to 40 inches annual rainfall, either in disturbed or trampled veld or on old lands. They are very drought-resistant and grow well in a wide range of well-drained soils, especially sandy loams. Ermelo variety is widely grown in Rhodesia, particularly in tobacco rotations, for the reason that it is resistant to eelworm.

Weeping Love grass is fairly high in protein, but this is offset from an early growth stage by the high fibre content. Stock graze it only very early in spring, for it quickly becomes tough and unpalatable when it starts to mature. A fair quality hay or silage may be made from Love grass if cut at the early flowering stage. Hay yields of three tons per acre have been obtained with a protein content of 6 to 8 per cent. It tends to be low in minerals, especially phosphorus.

KIKUYU GRASS, *Pennisetum clandestinum*, Hochst.

Stage	Dry matter	Percentage composition Protein	Fibre	Phosphate
About 4 inches high	16	24	20	1.00
12 to 20 inches long	25	12	32	0.40

Kikuyu grass is a low-growing, deep-rooted perennial that forms a dense turf and spreads by numerous creeping rhizomes and stolons, which root at nodes throwing up clustered, short, stout branches. It is a valuable grass in moderately humid sub-tropics with a rainfall of 35 inches or more. The foliage is killed by moderate frosts, but re-growth is rapid if frosts are not too severe. Kikuyu requires deep well-drained *fertile* soils and it grows best on loams or sandy loams. With declining soil fertility it is replaced by less demanding grasses. It has deep roots and will remain green during considerable periods of drought provided the roots can reach available soil moisture, but it will not endure periods of complete desiccation.

Kikuyu is a nutritious palatable grass which produces a good quality pasture with a relatively high protein content (Coetzee, 1948). It is mainly used for permanent pastures which withstand close grazing and trampling. It is unsuitable for temporary leys, since it is very difficult to eradicate. Furthermore, it is unsuitable for hay or silage, since it is difficult to cut and rake, but its high value probably justifies the use of a forage harvester. Kikuyu pasture, either with or without wild white clover, is an excellent sward for pig grazing during the wet months when other leys would be severely damaged by trampling. If it is allowed to become rank it is rather unpalatable due to a musty condition developing.

COMMON PASPALUM, *Paspalum dilatatum*, Poir.

Stage	Dry matter	Percentage composition T.D.N.	Protein	Fibre	Digestible protein
Pasture (9 to 12 inches)	25	60	12	30	8
In flower	30	55	7	37	4

Paspalum dilatatum is a tufted, rather coarse, leafy, deep-rooted perennial which grows to a height of 2 to 4 feet. It is a typical bunch grass, but spreads by short rhizomes and forms open turf when grazed. It is best adapted to humid sub-tropical climate with not less than 35 inches of rain, but it also gives promising results under drier tropical conditions. Its strong root development helps it to withstand drought, but it grows best on moist heavy soils. It is resistant to moderate frost.

Paspalum dilatatum is an excellent pasture grass which gives high yields of palatable, nutritious forage and persists under grazing and trampling (Norval, 1942). It has a high proportion of leafy growth. The flowering stalks are rather heavy and succulent, which makes hay-making difficult, and it is more conveniently conserved as silage. Molasses should be added to the ensiled material at the rate of 3 gallons per ton of grass. The quality of silage is relatively high, with an average protein content of 2.5 per cent. It is a warm-season grass which has a long growing period from early spring until the first winter frosts. *Paspalum dilatatum* is well adapted to irrigation, but it requires a high fertility. It combines well with legumes, especially red or white clovers or lucerne. In the absence of legumes it responds well to nitrogen. If it becomes mature it is coarse and unpalatable and the seed heads may be infected by ergot, which can cause poisoning. Hence the growth should be kept short.

Unfortunately it is sometimes difficult to establish because of poor germination of the seed and so it is often sown mixed with Rhodes grass.

UPRIGHT PASPALUM, *Paspalum urvillei*, Steud.

This paspalum is a densely tufted, erect-growing perennial which attains a height of 4 to 6 feet. It is similar to, but taller and coarser than, *Paspalum dilatatum*. It is specially well adapted to cool, damp localities and gives good results in "vleis." It does not require any specific type of soil. Upright paspalum is rapidly eliminated by close grazing and it is grown mostly for hay and silage, with the aftermath providing excellent grazing. With adequate fertiliser a leafy growth is obtained which provides a good hay crop up to 3 tons per acre.

BAHIA GRASS, *Paspalum notatum*, Flügge.

Paspalum notatum is a low-growing, deep-rooted perennial which spreads by short rhizomes and forms a dense turf. Its deep-rooting habit helps it to withstand considerable drought and, unlike *Paspalum dilatatum*, it is best suited to sandy soils. Many geographical races and breed strains are known and recognised. It is essentially a pasture grass and persists well under grazing and trampling. It is palatable and gives good late season grazing.

MANNA GRASS, *Setaria sphacelata*, Schumach Stapf and Hubbard.

Setaria sphacelata is a vigorous, tufted perennial which sometimes has creeping rhizomes. It is a variable species with several ecotypes in Southern Africa. The Kazungula ecotype is the most common variety in Rhodesia.

Kazungula setaria.

Stage	Percentage composition		
	Dry matter	Protein	Fibre
18 inches	20	16	29
2 feet to 2 feet 6 inches	20	11	30
Full flower	25	6	45

Kazungula setaria grows up to 8 feet in height with broad, blueish-green leaves and thick stems. It is best suited to summer rainfall areas where the precipitation is 25 inches or more. Provided there is adequate fertility, it may be grown successfully on all soil types. The grass may be established by means of seed or roots, but unfortunately the harvesting of the seed is a difficult operation.

Kazungula setaria is a high-yielding grass on fertile soils with adequate moisture and gives a large cut of silage or hay during the rainy season, followed by some dry season grazing. The best and most palatable hay is obtained when the grass is mown during the early stages of growth at a height of 2 to 2½ feet. It comes into flower early and this is accompanied by rapid maturity and coarseness. At this latter stage the yield and nutritive value are greatly reduced owing to a low leaf-stem ratio. The growing grass is very palatable and is readily eaten by all grazing stock. It provides good grazing for dairy cows at a height of 18 inches. It will not tolerate continuous and severe grazing and so rotational grazing should be practised. *Kazungula setaria* is of further value during the autumn after it has been mown for the last time. It rapidly sprouts again and provides good pasturage. As a silage crop, yields of up to 20 tons of green material per acre have been obtained.

RHODESIAN FOXTAIL, *Cenchrus ciliaris* L.

Rhodesian foxtail is a tufted, tussock-forming perennial which is sometimes rhizomatous. It is variable in habit, from spreading types for pasture to erect types

for hay. It is extremely resistant to drought and grows in a wide range of soils, especially the lighter and more sandy types. A popular local variety is Chipinga foxtail, which is a fine, leafy grass and a reliable seeder (West, 1952).

The grass is an excellent, protein-rich, palatable fodder at the early stage of growth. The protein content varies from 15 per cent. when relatively immature to 10 per cent. at the late flowering stage, when it becomes less palatable. It persists well under fairly close grazing and is used for permanent pastures and leys.

SABI PANICUM, *Panicum maximum*, Jacq.

Stage	Dry matter	Percentage consumption		Digestible protein
		Protein	Fibre	
9 to 12 inches	25	14	26	10
2 to 3 feet	30	8.5	33	3.5
9 feet	40	5.5	42	2.5

Sabi panicum is a tall, vigorous, rather coarse, tufted perennial which spreads slowly by short root stocks to form large stools. It shows considerable variations in growth habits.

It is suited to a rainfall of 35 to 70 inches and occurs naturally in such areas with a dry season not exceeding four months. Although it is drought-resistant, it will not stand long periods of complete desiccation. The grass grows well in a wide variety of well-drained soils. It is not resistant to more than occasional light frosts, but it is shade-tolerant. *Panicum maximum* is found in the sweet veld and is known to be one of the most palatable of our indigenous grasses.

Sabi panicum is a valuable grass for grazing, green-soiling, hay and silage. It has given yields of 50 to 60 tons of green fodder per acre under favourable conditions. It is about equal to Napier fodder as a soiling crop for dairy cows. The nutritive value and palatability are high when the grass is leafy and young, but both decline rapidly with increasing maturity. During the growing season the grass may be mown every six weeks when it is at a height of 6 to 9 inches. If grazed, rotational grazing is essential, for it rapidly dies under close continuous grazing. The grass has a high mineral content and a high leaf-stem ratio even when mature.

PANICUMS, *Panicum coloratum* L. var. Makarikariense, Goossens.

This grass is a spreading, rather coarse, leafy perennial. Two types are cultivated, one more or less erect, the other with creeping stems rooting at nodes. In Rhodesia selection and improvement of natural strains have produced Bambatsi panicum, which is a useful and promising grass (West, 1952). It is erect in habit and produces large yields of seed which germinate readily. It is very resistant to drought and is found in alluvial flood plains with as little as 15 inches of rainfall. It grows best in deep alluvial soils and on lighter soils. It provides good pasture, hay or silage in the 20 to 35 inch rainfall areas and is used increasingly for leys in rotation with arable crops. It is highly palatable even when dry in the winter.

ROMPHA GRASS, *Phalaris tuberosa* L. x *Phalaris arundinacea* L.

Rompha grass is a robust, long-lived, drought-resistant, coarse, tufted perennial. It is a sterile hybrid. It is usually grown under irrigation, but is also used as a dry-land pasture (West, 1956).

It provides good pasture, but it becomes unpalatable to stock when it grows tall. Of greater importance is the tendency of stock to suffer from a cobalt deficiency known as Phalaris staggers when grazing this grass. This unfortunate characteristic applies to some extent to other Phalaris species and appropriate preventive treatment should be given to stock on these pastures.

TANNER GRASS, *Brachyaria neupica* species.

This grass originated in Tanganyika, but is now fairly widely used in the Federation, being planted on dam walls and in waterways. It is palatable with a relatively high nutritive value.

GRASS HAYS.

Stage	Percentage composition as fed				
	Dry matter	T.D.N.	Protein	Fibre	Digestible protein
Early flowering (good quality)	90	50	7-8	30	3.5-4.0
Mature	90	45	4	32	1.0
Very mature (poor quality)	90	40	3	34	0.2

The nutritive value of hay is dependent on three main factors. Of these, the stage of growth at which the hay is cut is of the foremost importance. Very young herbage has the highest feed value on a dry matter basis, but the yield of nutrients per acre should also be taken into account. In most instances the yield of digestible protein per acre rises to a maximum at early flowering, whilst the yield of T.D.N. per acre is at the maximum at seed-setting. To obtain a good product, without sacrificing too much quantity, cutting at the early flowering stage is advocated. At this stage very little lignification has occurred and so the hay constituents, including the fibre, are normally highly digestible. Following this, the protein content, its digestibility and the digestibility of other constituents rapidly decline.

The nutritive value is affected to a small extent by the botanical composition of the herbage, e.g., improved pasture hay is usually superior to veld hay. However, the presence of a clover or legume in the mixture markedly improves the feed value, especially with respect to protein.

The third factor which affects hay quality is the losses incurred during making and storage. For a considerable time after cutting, the living cells respire, oxidising carbohydrates to carbon dioxide and water. This loss has been estimated at between 5 and 10 per cent. of the original dry matter. If drying is rapid, death of the cells is hastened and so in the Federation the lower figure is more applicable. Mechanical losses have been estimated at 5 to 10 per cent., but they may be considerably higher if the leaf becomes brittle and easily shatters. Hence, unless some care is taken, this loss in the Federation may be as high as 30 per cent. Further, it involves a loss of the more nutritious part of the plant. Leaching losses are variable and entirely dependent on the amount of rain falling on the crop during the hay-making. If subjected to heavy rain, almost all the soluble carbohydrate, protein and soluble minerals are lost. The other "climatic loss," that due to bleaching, may cause an appreciable loss of carotene; 66 per cent. losses have been reported and they may be higher if excessive bleaching occurs. Finally, losses occur in the stack or bale. These have been estimated to be 5 to 10 per cent., but where moulding or overheating occurs this loss is greater due to a decrease in digestibility.

VELD HAY.

	Percentage composition as fed	
	Range	Average
Protein	2.0-7.0	5.0
T.D.N.	40-50	44
Digestible protein	0.0-3.0	1.5
Fibre	35-44	39
Calcium	0.16-0.41	0.25
Phosphorus	0.05-0.21	0.10

As mentioned under "Grass hay," veld hay is usually a poor quality hay. Generally it is low in protein, high in fibre and low in phosphorus, calcium and other minerals other than silica. The average yield is about half a ton per acre. Its poor quality makes it an unsuitable feed for high-producing animals, particularly dairy cows. A common practice is to treat it with urea and molasses, which greatly increases its feed value and palatability. When so treated it is very useful for over-wintering cattle and sheep on the veld.

GRASS SILAGE.

	Percentage composition	
	Range	Average
Dry matter	10-30	20-25
Protein on a dry matter basis	5-10	7
Digestible protein on a dry matter basis	2-6	4
T.D.N. on a dry matter basis	45-60	50

The nutritive value of grass silage is dependent upon the composition of the original material and the losses incurred during the process of ensiling. They consist of the initial respiration loss, those which result from the fermentation and the loss caused by wastage at the side and top and through seepage from the silo. All of these may be considerable unless the silage is well made. For a well-made grass silage the loss of original dry matter and T.D.N. is approximately 25 per cent. A poor quality silage frequently results from either under-consolidation or, when very young, wet, high protein grass, with a low content of fermentable carbohydrate, is ensiled. With under-consolidation, over-heating of the silage mass occurs leading to excessive destruction of carbohydrates and a marked reduction in the digestibility of the protein. Hence overheated silages have a low nutritive value, but are very palatable.

The other type of poor quality silage, which is often made from young high-moisture grass, is the result of a slow rate of fermentation and acidification due to insufficient fermentable carbohydrate in the ensiled material. Butyric acid-forming organisms predominate, very little heat is produced and considerable hydrolysis of proteins to ammonia occurs. The resultant under-heated, butyric-type silage has an unpleasant odour, it is very unpalatable and has a lowered feed value because of protein losses.

DRIED GRASS.

Artificial drying of grass, causing its rapid dehydration, almost completely eliminates the losses of dry matter which occur during ensiling and hay-making. Thus dried grass made from fertilised swards and cut at the appropriate time compares

favourably in nutritive value with many concentrates. Since the cost of drying is high, the aim should always be to use good quality grass. By so doing the product obtained will be rich in digestible protein, minerals and carotene, unless overheating has occurred during the process. On an average, one-third of the carotene is destroyed.

Dried grass has a dry matter content of 90 per cent., with an average T.D.N. value of 70 per cent., and the digestibility of its protein is 70 per cent.

IRRIGATED PASTURES.

Irrigated pastures comprising a mixture of exotic species of grasses and clovers which have received applications of lime, phosphate and nitrogen and are under rotational grazing provide herbage of high quality. The protein content is of the order of 15 to 26 per cent. (Barnes, 1961), usually only over a short period.

CHICORY LEYS, *Chicorum intypus*, etc.

Chicory ley, which consists of French agricultural chicory, meadow fescue and clovers, provides excellent, palatable grazing for pigs (Calder, 1957). In Rhodesia it has the valuable characteristic of being continuously productive throughout the year. Chicory is a highly nutritious plant with a rich protein content and a good supply of trace elements, especially iron. A good chicory pasture has 10 tons per acre of root matter down to a depth of 12 inches, most of which consists of thick, fleshy roots. These roots have a 20 per cent. dry matter content, of which about 4 per cent. is protein and 13 per cent. carbohydrate. Recently a method has been devised to allow all-the-year-round grazing of chicory leys. During the rainy season a part of the ley is heavily stocked and the pigs allowed to eat the roots as well as the herbage. This is followed by ploughing, a final gleaning of the roots by the pigs and re-sowing as soon as the rains finish.

LEGUME SEEDS AND FORAGE

BEAN SEEDS.

Velvet beans, cowpeas and jack beans are frequently grown for stock feed. They all have approximately the same general composition and feed value. Their protein content ranges from 23 to 33 per cent., with a digestible protein value of 20 per cent. They are relatively low in oil and fibre contents.

Beans are not very palatable to stock; their digestibility is not particularly high when they are fed raw, especially to pigs, and their protein is of fair quality. Bean meals have the disadvantage of developing a rancid, bitter taste after a few weeks' storage.

VELVET BEANS, *Stizolobium* spp.

Percentage composition

T.D.N. = 82; Protein = 23; Digestible protein = 19.

Velvet beans belong to several species of the genus *Stizolobium* and to hybrids between them. They are grown chiefly for forage (see page 36). When they are gathered for feeding to stock they are generally fed whole in the pod or else the beans and pods are ground. Pods are two to six inches long and contain three to six seeds.

GROUND VELVET BEANS (with pods).

Percentage composition

T.D.N. = 74; Protein = 18; Digestible protein = 13; Fibre = 13.

Velvet beans in the pod and even when ground are unpalatable, but they may be fed to dairy cows, beef cattle or sheep as a small part of the ration (e.g., 4 lbs. daily for cattle). If too much is fed they may be unduly laxative. Dry beans and pods are satisfactory for fattening cattle. However, for dairy cows the value is increased considerably by grinding. If this cannot be done the beans and pods should be soaked for 24 hours.

Velvet beans are most unsuitable for pigs. This has been shown no matter whether the beans have been fed shelled, ground or as ground velvet beans and pods. They even cause severe vomiting and diarrhoea. The poor results are caused largely by dinydroxyphenylalanine, which is poisonous to pigs, and also by the poor quality of the protein in the beans. Cooking merely reduces the toxicity and makes the beans more digestible.

JACK BEANS, *Canavalia ensiformis* D.C.

Percentage composition

T.D.N. = 78; Protein = 34; Digestible protein = 20.

Jack beans are one of the well-known species of the genus *Canavalia* which is distributed throughout the tropics. It is a bushy, annual legume which grows to a height of approximately 2 feet. It has the advantages of being hardy and drought-resistant and immune to most pests. The pods are from 8 to 10 inches long and contain 10 to 12 white seeds. The Jack bean is a high-yielding legume and 2,000 to 2,400 lbs. of clean seed per acre may be obtained. The young pods and immature seeds (without pods) are eaten as a vegetable. The Jack bean plant is considered a valuable green manure species for the tropics and sub-tropics. Trials have indicated that it is easier to mill and feed the complete pod and obviate the necessity for threshing.

Great care is needed in the feeding of Jack bean seed. Early work by Steyn (1934) suggested that Jack bean is not poisonous, but recent investigations by Shone (1961) have established the toxicity of the seeds for cattle. One ounce of the seed per 1.62 lbs. bodyweight administered over three days was lethal. The chief symptoms are a very severe diarrhoea, weakness, inability to eat or drink and stiffness of the hindquarters. Jack bean seed is a quantitative poison, i.e., it is very dangerous when a certain level is exceeded. Therefore it should be mixed with other feeds and the amount incorporated should not exceed 30 per cent. of the total. Alternatively, the seeds may be cooked, since the injurious substance is destroyed by heat.

Jack beans are unpalatable to livestock and so must be gradually introduced into the ration or made acceptable by the addition of molasses. On no account must they be mixed with urea, since they contain appreciable quantities of the enzyme urease, which rapidly releases ammonia from urea.

JACK BEAN MEAL (WITH PODS).

Percentage composition

T.D.N. = 72; Protein = 19; Digestible protein = 13.

The ratio of pod to seed is approximately 1:1 by weight.

Addison (1957), in a feeding trial with steers, found 2.5 lbs. pod and bean meal per head daily equivalent as a protein supplement to 1.5 lbs. cottonseed cake. In an experiment with three cows, 5.2 lbs. per head daily of the pod and bean meal caused no ill effects, but the quantity fed was probably below the toxic level. A probable case of poisoning has been reported in cattle fed with pod and bean meal, so it should be treated with the same care as the seed. The pod and bean meal is similar to the bean meal in being unpalatable to stock and causing a rapid release of ammonia from urea.

COWPEAS, *Vigna sinensis*, Savi.

Percentage composition

T.D.N. = 76; Protein = 23; Digestible protein = 19.

The cowpea (*Vigna sinensis*) is the most common species of the genus *Vigna*. It is an annual legume which is deep-rooted, vigorous and herbaceous. Cowpea seeds are used for human food and as concentrates for farm animals.

Unfortunately most varieties of cowpeas ripen unevenly, and therefore, when the crop is grown for seed, it is necessary to pick the pods by hand as they ripen, otherwise the plants are cut when about three-quarters of the pods are ripe and before the first ones are shattered or damaged. For this reason cowpeas are used mostly for forage. Cowpeas furnish protein of fair quality to supplement the cereal grains and may be used satisfactorily as a protein supplement in feeding cattle, sheep and horses. For pig feeding, cowpeas are best fed in combination with a better-quality protein supplement.

LEGUME FORAGE.

The great value of legume forages in stock feeding is related to their high content of protein, minerals and vitamins. Of foremost importance in this respect is their richness in protein. Thus a mixture of legume hay and maize grain makes a well-balanced ration for many classes of stock. Furthermore, legume protein has an average biological value and it helps to correct amino-acid deficiencies of cereals. Legumes have a very high content of calcium, but they are not particularly rich in

phosphorus. When fed green they are very palatable, whilst legume hays are almost equally palatable, and if the crop is well managed the majority give high yields of roughage per acre. Legume forages are rich in vitamins, especially carotene, while field-cured hays are rich in vitamin D. Legumes have the two additional benefits of improving the yield and protein content of grasses in a mixed sward and of maintaining or improving soil fertility.

In Rhodesia a very large proportion of legumes grown for forage are made into hay. The remainder is made into legume silage or fed green.

LEGUME HAYS.

Legume hays are excellent roughages provided they are cut at the appropriate stage and made without appreciable rain spoilage and loss of leaf. The optimum stage of cutting is the early pod stage or when the crop is one-third in flower. However, it appears that changes in composition of many legumes, once they have reached a hay-cutting stage, are relatively small. Hay made at the late stage will have a slightly lower protein content and a higher fibre and lignin content, both of which will decrease its digestibility. On the other hand, certain legume hays, e.g., Jack bean and soyabean, increase in digestible nutrient content as they mature because of the accumulation of oil in the seed. As mentioned earlier under "Grass hays," rain spoilage causes loss of soluble carbohydrate, protein and soluble minerals. Unfortunately the loss of leaf from legume hay tends to be high in Rhodesia. The rapid drying conditions causes the leaf to lose water quickly and become brittle before the stem is sufficiently dry for the hay to be stacked or baled. Hence on collection of the hay, and later while feeding, the leaf shatters and a considerable amount is lost. The protein content of the leaf is approximately twice that of the stem and so the loss of protein may be considerable. A rough estimate indicates that it may be as high as 50 per cent. Furthermore, the hay leaf is generally more nutritious and digestible than the stem.

To summarise, legume hays, if well made, are rich in protein, calcium, carotene and vitamin D. They also have a high fibre content. The following table gives their composition:—

	Percentage composition	
	Range	Average
Protein	9-16	13
Fibre	25-45	30
Digestible protein	5-10	8
T.D.N.	45-54	50

LUCERNE, *Medicago sativa* L.

	Percentage composition			
	Dry matter	T.D.N.	Protein	Digestible protein
Young, before flower	20	12.5	4.6	3.5
Early flower	25	14	4.6	3.5
Mature	35	14.5	3.5	2.5

Lucerne is the highest quality legume and it possesses to a marked degree the nutritive properties mentioned earlier. It provides excellent grazing or green fodder for all classes of farm livestock, but it has the one great disadvantage of frequently causing cattle and sheep to bloat when they eat the green material in any appreciable quantity. The danger of bloat is most acute when stock eat the young, leafy fodder. Some prevention is possible by spraying the lucerne with oil, e.g., peanut oil, but this

measure is impractical for other than small quantities. Treatment of the animal with an antibiotic, e.g., penicillin, again affords some control, and recent research findings have indicated that dosage with a mixture of antibiotics may prevent the incidence of bloat for several weeks.

LUCERNE HAY.

Stage	Percentage composition		
	T.D.N.	Protein	Digestible protein
Cut early (before flower)	52	18	12
Good, average quality	50	15	11
Mature and stemmy	46	12	8

Lucerne hay possesses to a high degree the nutritive characteristics of legume forages. It is exceptionally rich in calcium, with an average content of 1.50 per cent. The average phosphorus content is 0.25 per cent. Good lucerne hay is unexcelled as a roughage for dairy cattle, and for pigs not on pasture it is especially valuable as a vitamin supplement.

LUCERNE SILAGE.

Percentage composition

Dry matter = 25; T.D.N. = 15; Protein = 4.0; Digestible protein = 2.5

In Rhodesia a small quantity of lucerne is ensiled. For this method of conservation the crop should not be cut too young (optimum the early flowering stage); it should be wilted a little and/or molasses added to the material whilst ensiling (60 lbs. molasses per ton of lucerne). If none or only some of these measures are undertaken there is a tendency to produce the butyric-acid, unpalatable type of silage. When it is well made, lucerne silage is an excellent high-protein forage which is especially suited to dairy cows.

DRIED LUCERNE.

Dried lucerne is very similar to dried grass in nutritive value, but it invariably has a higher protein and fibre content. It is a common constituent of pig and poultry feeds, where it supplies appreciable amounts of carotene and also tends to give a "good colour" to poultry products.

SUNN HEMP, *Crotalaria juncea* L.

Sunn hemp may be grown for fibre, soil cover, green manure and forage (du Toit, 1948). It is a branched, erect annual 6 to 10 feet high. The pods are small and have stiff hairs. It grows rapidly and is used extensively in Rhodesia as a green manure crop. It has lost favour in recent years due to the increased prevalence of the stem-branch disease caused by the fungus *Colletotrichum curvatum*.

Sunn hemp is known to be poisonous, but Stark (1947) records that sheep readily eat both the hay and herbage and suffered no ill effects. Investigations in Rhodesia by Romyn and Fitt (1938) and Lawrence (1941) have also shown that sunn hemp hay is not poisonous to cattle and pigs.

Sunn hemp provides a large yield of bulky green material which is high in protein, being approximately 20.0 per cent. on a dry matter basis. It may be grazed, but stock tend to eat the leaves and leave the fibrous stalks. If used as a forage it is generally cut for a hay or silage crop.

SUNN HEMP HAY.

Percentage composition

T.D.N. = 50; Protein = 14; Digestible protein = 8; Fibre = 44.

For hay, sunn hemp is best cut at the budding stage just before the crop comes into flower. At this stage it has the highest feeding value, but the yield of hay is appreciably lower than the maximum. Hence it may be worth obtaining a higher yield of an average quality product by harvesting at the full flower stage. The average hay yield is 1.6 tons per acre. Unfortunately the stems of sunn hemp are very coarse and fibrous, especially if it is cut late, and there is often considerable wastage in feeding the hay. This may be overcome by feeding the hay coarsely ground.

Provided it is cut at the bud or flowering stage and well made, the hay is fairly palatable. The feeding value of sunn hemp hay compares favourably with that of lucerne. Experiments have shown that sunn hemp hay is not poisonous to pigs and cattle, but it is considered toxic to horses and it is generally advisable not to feed it by itself to any stock over a long period.

SUNN HEMP SILAGE.

Percentage composition

Dry matter = 27; T.D.N. = 13.0; Protein = 3.0; Digestible protein = 2.0.

For silage, sunn hemp should be cut at the budding stage just before the crop flowers. If cut at a later date the ensiled material tends to be fibrous and inadequately compressed in the silo. When ensiled by itself about three gallons of molasses should be applied to every ton of sunn hemp. A very suitable silage mixture is two or three parts of green maize with one part of sunn hemp, and in this case the addition of molasses is unnecessary.

DOLICHOS BEAN HAY, *Dolichos lablab* L.

Percentage composition

T.D.N. = 56; Protein = 13; Digestible protein = 8.5; Fibre = 26.

Dolichos lablab is a widely cultivated perennial, but in Rhodesia it is usually grown as an annual. The seeds are edible, but it is invariably grown for hay or for green manure. The hay is palatable with a fairly high nutritive value if it is cut and made at the optimum time without a large loss of leaf. The average yield per acre is 1.2 tons. The Dolichos bean plant tends to have a remarkably constant composition for several weeks once it has reached the hay cutting stage.

JACK BEAN HAY, *Canavalia ensiformis*, D.C.

	Percentage composition		
Stage	T.D.N.	Protein	Digestible protein	Fibre
Cut early	49	14.5	8	24
Cut late	57	12.5	7	32

Jack bean hay is most conveniently made from plants cut at the flowering stage, but it should be noted that the total digestible nutrient content of the hay markedly increases with maturity. Unfortunately the late cut hay has a low palatability due to the large pods and a relatively high proportion of seed. Jack bean hay is sometimes ground and fed as a "concentrate."

The work of Shone (1961) suggests that Jack bean herbage is not toxic, but Affleck (1961) reports two cases of poisoning of cattle which grazed Jack bean aftermath. Hence some caution should be observed in feeding Jack bean hay.

JACK BEAN SILAGE.

Percentage composition

Dry matter = 28; T.D.N. = 14.0; Protein = 3.5; Digestible protein = 2.3.

For silage, Jack beans should be cut at the full flowering stage. During the ensiling process three gallons of molasses should be applied to every ton of green material. Alternatively a mixture of green maize and Jack bean (without molasses) makes a good silage material. As with the hay, some care is needed in feeding the silage.

VELVET BEAN HAY, *Stizolobium* spp.

Percentage composition

T.D.N. = 47; Protein = 14.5; Digestible protein = 9; Fibre = 28.

The velvet bean is an annual which produces a tangled mass of vines up to 10 feet or more in length. Velvet beans are difficult to cure into hay and so are not a popular forage for that purpose. They are usually grown in combination with maize, which supports the vines, and the mixture is cut for a silage crop. The average yield of velvet bean hay is 1.45 tons per acre.

COWPEA HAY, *Vigna sinensis* Savi.

Percentage composition

T.D.N. = 51; Protein = 18; Digestible protein = 12; Fibre = 27.

Cowpeas are a hot-weather, viny, annual legume which thrive fairly well in all types of soil. They mature and continue to grow and bear pods over a long period. The crop is best cut for hay when the first pods ripen. It is rather difficult to cure and for these reasons it is not a popular hay crop. The average yield of cowpea hay is low, 1.1 tons per acre. It is rich in protein and when of good quality it is equal to lucerne hay in feed value.

If cowpea seed is harvested for human or animal feed the remaining straw is an average quality forage with the following approximate percentage composition:

T.D.N. = 40; Protein = 7; Digestible protein = 2; Fibre = 45.

SOYABEAN HAY, *Glycine max* L.

Percentage composition

T.D.N. = 58; Protein = 15-18; Digestible protein = 10; Fibre = 28.

Soyabean hay is a palatable forage, rich in protein, which gives an average annual yield of 1.7 tons per acre. Well-made soyabean hay compares in feeding value with lucerne hay. However, there is often a wastage of 20 per cent. or more when feeding, owing to the coarse stems being left uneaten. The crop will make good hay at any stage from pod formation until the beans are almost fully developed. This is because the late-cut hay, although coarse and less leafy, has a considerable proportion of seed which is rich in protein and oil.

Good quality soyabean hay is excellent for dairy cows and may be used as a vitamin supplement for pigs.

SOYABEAN STRAW.

Percentage composition

T.D.N. = 40; Protein = 4.0; Digestible protein = 1.0; Fibre = 42.

Soyabean straw consists mainly of the fibrous stems with a very small amount of leaves. It has a low feeding value and is not a suitable feed for high-producing stock.

GROUNDNUT HAY. *Arachis hypogaea* L.

Percentage composition

T.D.N. = 60; Protein = 9; Digestible protein = 5; Fibre = 27.

Groundnut hay is the forage remaining after the groundnuts have been shelled. If well-made, leafy and not mouldy, groundnut hay is a good quality forage which is very palatable to stock, but it is not rich in protein (Verbeek, 1949). It always contains some dirt and so it should be shaken before being fed or fed from a rack. The average yield is about half a ton per acre. Groundnut hay is a suitable feed for dairy cows, especially in the chaffed state.

DAHL BEAN OR PIGEON PEA. *Cajanus indicus* Spreng.

Dahl bean is a common legume of the sub-tropics and tropics. It is a short-lived, perennial, legume shrub which is sometimes grown as an annual. It is deep-rooted, resistant to drought and grows to a height of 4 to 8 feet. Under favourable conditions it may last for three to five years. It is, however, very susceptible to frost damage. Dahl bean is an excellent soil renovator. It may be used for hay, as a browse plant, for silage (with molasses) and for green manure. In Rhodesia the first two uses are the most popular. The part of the shrub which is grazed consists almost entirely of leaves which are rich in protein, palatable and relatively low in fibre (Sellschop and Muller, 1953). In frost-free areas it is a useful legume in dry land pasture.

DAHL HAY.

Dahl hay has a high protein content and is best fed coarsely ground to ensure maximum utilisation of the fibrous stem. Yields of 5 tons per acre have been obtained.

MAIZE AND SORGHUM FORAGES

MAIZE.

Maize is an excellent forage crop, and when cut at the appropriate stage it gives a high yield of digestible nutrients. If the entire plant is used for forage, as in maize silage, it exceeds all other crops in average yield of dry matter and of digestible nutrients per acre. The stage of growth at which the maize is cut for forage is very critical. If the crop is harvested too early a large loss of nutrients occur. At the milk stage the maize plant has the greatest green weight, but only about two-thirds as much dry matter as when the kernels have ripened. There is even a greater difference in the amount of total digestible nutrients owing to the accumulation of starch in the maize kernels. The main storage of fat also occurs after the milk stage. The rate of increase in protein, fibre and mineral content is greatest in the early stages when the leaves and stalks are rapidly growing.

Maize forage is high in carbohydrates but low in protein. Its calcium content is about 0.25 per cent. on a dry matter basis and it is low in phosphorus. The green forage is high in carotene and may supply considerable vitamin D.

MAIZE SILAGE.

	Percentage composition			
	Dry matter	T.D.N.	Protein	Digestible protein
Good quality	30	20	2.3	1.3
Average quality	27	17	2.0	1.0
Poor quality	25	15	1.7	0.8

Maize is an ideal silage crop. If the green forage is cut at the appropriate stage of growth, chopped into small pieces and packed well into a suitable silo, it almost always makes good silage. The material contains sufficient sugar for quick and active fermentation, which produces enough acid to keep the silage from spoiling. The yield of silage per acre varies widely with the soil and season, but is usually in the range 8 to 10 tons per acre.

The best silage is made from maize cut when the kernels have reached the dough stage of growth and most of the leaves are still green. If the process is delayed longer the silage is less palatable and there is a risk it may mould unless water is added whilst ensiling. On the other hand, if the crop is cut earlier there is a loss of potential nutrients and a tendency to produce sour silage.

Maize silage is an excellent forage for cattle and sheep. Care should be exercised in feeding it to sheep, for they will only consume silage of good quality. It is too bulky and fibrous to be a suitable food for pigs and poultry, but it has given satisfactory results when fed to breeding sows. For ruminants it is generally fed in combination with hay or dry food and in this respect it gives the best results when fed with legume hay. If maize silage is the only roughage in a fattening ration, care should be taken to balance the ration with an adequate amount of protein supplement.

Well-eared maize silage is a combination of roughage and concentrate. It contains one pound of dry maize grain in approximately 8 lbs. of silage and this maize grain has the same feeding value as ordinary shelled maize.

MAIZE and VELVET BEAN SILAGE.

Percentage composition

Dry matter = 30; T.D.N. = 20; Protein = 3.0; Digestible protein = 1.5

A mixture of maize and velvet beans is frequently grown for silage in Rhodesia. The beans increase the protein content of the silage, which is dark in colour and very

palatable. The average yield per acre, 10 tons, is slightly higher than that for maize. Maize and velvet bean silage is a very suitable forage for dairy cattle and for other high-producing animals.

SCOTCH or MAIZE TOP SILAGE.

Percentage composition

Dry matter = 25; T.D.N. = 8; Protein = 1.0; Digestible protein negligible.

The top of the maize plant may be removed and ensiled when the crop has ceased to grow and the kernels start to mature. The resultant silage is a poor quality product which is not a suitable forage for high-producing animals.

MAIZE STOVER.

	Percentage composition		
	T.D.N.	Protein	Digestible protein
Stooked	45	3.0	1.0
Late-cut	40	2.0	0.2

Maize stover is the forage which remains after the ears have been harvested. It is a low-grade roughage, but it has considerable value when properly used. Good quality stover has nearly one-half of the dry matter and about a quarter of the digestible protein of the entire crop. Hence if maize stover is not used or is poorly utilised, there is a considerable waste of nutrients. The above figures show the considerable difference between the stover from the maize which is allowed to mature in the stook and the late cut material. On many farms the stover is fed by allowing the stock into the lands after harvesting the grain. This results in the leaf being eaten and the majority of the stalk left on the ground.

Stover is a very palatable roughage which is most suited to the feeding of beef cattle during the winter. For this purpose it is frequently treated with urea and molasses, which greatly increases its protein content, digestibility, nutritive value and palatability. It should form only a small part of the ration for high-producing stock. Stover is very low in phosphorus, as most of the phosphorus of the maize plant is in the grain.

GREEN MAIZE.

Green maize is an excellent fodder to cut and feed (zero grazing). It remains in a suitable condition for feeding over a comparatively long period and is high in digestible nutrients and very palatable. It is unwise to graze green maize, since cattle tend to over-eat and have serious digestive upsets.

SORGHUM.

The sorghums grown for forage are the sweet sorghums or sorghos, certain hybrid varieties, e.g., Atlas, and the tall grain sorghums such as Kaffir. Their relative nutritive values are dependent on the proportion of grain that each type is able to produce. Sorghum forage resembles maize forage in composition, but it has invariably less total digestible nutrients because of a lower proportion of grain. With cattle its actual T.D.N. value is even lower, since the grain is much smaller than maize grain and a considerable amount escapes mastication and digestion.

Green sorghum plants of most varieties may contain sufficient prussic acid (hydrogen cyanide) to cause the death of cattle or sheep. The cyanide content is apt to be dangerously high in young plants and when the growth is checked by drought. Fortunately, sorghum which is harvested when approaching maturity is not dangerous.

SORGHUM SILAGE.

Percentage composition

Dry matter = 38; T.D.N. = 16; Protein = 2.8; Digestible protein = 0.8.

The sorghums make good, palatable silage if ensiled when the seeds are hard and ripe. If harvested at an earlier stage the silage will be sour and relatively low in feeding value. Sorghum silage is suitable for dairy cattle, beef cattle and sheep, but its value per ton is considerably less than good quality maize silage. As stated earlier, this is because of the lower proportion of grain, a considerable percentage of which passes through cattle undigested. The average yield of green sorghum per acre is usually higher than that of maize and 17 tons per acre or more of cut material may be expected from a good crop.

MISCELLANEOUS SUCCULENT AND DRY FEEDS

GREEN OATS and GREEN BARLEY.

The nutritive value of green cereals is very dependent on the stage of growth, and so the following average figures are only an indication of the actual feeding value:

	Percentage composition			
	Dry matter	T.D.N.	Protein	Digestible protein
Oat pasture before heading	20	12.0	3.0	2.3
Oats headed out	25	14.0	2.0	1.5
Barley pasture before heading	20	12.0	5.0	3.5
Barley headed out	25	16	3.0	2.0

Oats, barley and occasionally a mixture of the two cereals are grown in Rhodesia under irrigation to provide green fodder during the winter for farm livestock, in particular dairy stock. A mixture of oats and hairy vetch serve the same purpose. Green oats are also grazed or fed to dairy cows during the summer in order to supplement veld grazing. Both cereals, when fed green, are palatable nutritious feeds with high protein and carotene contents. Their average yields per acre of green material are considerably less than those obtained from many other forages, e.g., maize and sorghum.

KALE, *Brassica oleracea*, var. acephala, D.C.

Percentage composition

Dry matter = 15; T.D.N. = 10; Protein = 2.0; Digestible protein = 1.6.

A small acreage of kale is grown in the eastern district of Southern Rhodesia, where the climate is suited to the growing of this crop. It is used as a green forage for dairy cows. Kale is a palatable feed with a high moisture content and a relatively high protein and mineral content. It is especially rich in calcium. If fed in large amounts, cattle tend not to eat the stem of the plant and so the resultant feed is richer in protein and lower in carbohydrates than the complete plant.

RAPE, *Brassica napus* L.

Rape is occasionally grown in Rhodesia as a temporary winter pasture crop. It has a high nutritive value and the leaf is very rich in protein. It is most suited to sheep grazing, but it is also satisfactory for cattle. There is a slight risk of bloat in ruminants when grazed on rape.

PUMPKINS, *Cucurbita pepo* L. and MAJODA MELONS, *Citrallus vulgaris* Schrad.

	Percentage composition			
	Dry matter	T.D.N.	Protein	Digestible protein
Pumpkins	13.0	9.0	1.7	1.3
Majorda melons	6.0	4.8	0.7	0.5

Pumpkins and Majorda melons are useful succulent feeds which are low in nutritive value, but nevertheless are popular feeds in the dry winter months. During this period their high moisture content, succulence and palatability make them very acceptable to livestock. They are easily cultivated and give good yields per acre

(pumpkins average 9 tons and melons between 15 and 20 tons). Pumpkins are generally grown in the high-rainfall area and thrive under irrigation. They are best adapted to fertile loams and sandy loams. Majorda melons are grown more in the low-rainfall areas and thrive on less fertile soils. It is a common practice to plant pumpkins and melons between maize.

Pumpkins and majorda melons should be stored in a cool, airy place, e.g., under trees, and if they have to be stored for a long time it is essential that only sound fruit be selected. The nutritive value of the pumpkin is approximately twice that of majorda melons, but both are low in protein and minerals and should be considered as "carbohydrate succulents."

SWEET POTATOES, *Ipomoea batatas* Lam.

	Percentage composition			
	Dry matter	T.D.N.	Protein	Digestible protein.
Tubers	28	25	1.4	1.2
Young leaves	15	6	3.0	1.5
Vines as dry forage	90	50	13.0	8.0

Sweet potatoes are grown in Rhodesia as a home-produced feed for pigs (Calder, 1960). The tubers are also suitable for human consumption, whilst the young leaves and vines are valuable forages for other types of livestock.

Sweet potato tubers are similar to Irish potatoes in composition and nutritive value. They are very low in protein, minerals and fibre, but are very rich sources of highly digestible soluble carbohydrate, which consists predominantly of starch with approximately 5 per cent. sugar. The characteristic sweetness makes them very palatable to livestock. The protein has a high biological value. When fed to pigs, the very low protein content should be adequately compensated by feeding a high protein meal. Sweet potatoes are high in carotene and have the valuable quality of producing a hard carcass fat.

The young leaves of sweet potatoes are a valuable nutritious fodder. They are rich in protein and calcium and are well liked by livestock. However, frequent grazing or cutting of the foliage will tend to reduce the yield of tubers.

Sweet potato vines are also a nutritious forage. They are difficult to cure into good hay, but they usually make a satisfactory silage.

CASSAVA, *Manihot utilissima* Pohl.

Cassava is a bushy tropical plant with fleshy roots. It yields between 4 and 12 tons roots per acre and is one of the most productive tropical crops in terms of yields of dry matter. In many parts of tropical Africa it is used as a cheap carbohydrate food for man and for livestock. The roots have a very low content of protein, minerals and crude fibre.

The juice of cassava meal contains the cyanogenetic glycoside, linamarin. The glycoside may be hydrolysed by the enzyme linase (also present in the juice), which liberates hydrogen cyanide and renders the cassava poisonous. Fortunately, in many varieties the glycoside is concentrated in the skin and so the inside edible portion is comparatively harmless. Furthermore, heating or drying the product before feeding will reduce the hydrogen cyanide content.

DRIED, GROUND CASSAVA ROOTS.

Percentage composition
T.D.N. = 75; Protein = 1.0; Digestible protein = 0.5.

This is the form of cassava which is available in Rhodesia. It is a valuable source of carbohydrates, but is very low in protein, oil (1.0 per cent.), crude fibre (2.0 per cent.) and minerals (2.0 per cent.). It may be included in concentrates for cattle and in pig feeds, but the level should not exceed approximately 10 per cent. of the food because of the danger of cyanide poisoning.

DRIED ORANGE PULP.

Percentage composition
T.D.N. = 67; Protein = 5.0; Digestible protein = 2.0.

Orange pulp is a by-product of orange-processing factories which make orange juice and other products. It consists of the peel, the inner residue of pith and cull fruits which are dried, ground and sold as dried pulp.

Dried orange pulp is a palatable, highly digestible feed with an average fibre content of 14.0 per cent. It is fed chiefly to dairy cattle as part of a concentrate ration. It may also be used in rations for fattening cattle, but it is too fibrous to be a suitable feed for pigs and poultry.

RUSSIAN COMFREY, *Symphytum asperum*, Lepech.

Percentage composition on a dry matter basis.
T.D.N. = 50; Protein = 15-18; Digestible protein = 11; Fibre = 12; Ash = 20.

Russian comfrey is a leafy perennial which grows to a height of 2½ to 5 feet. The leaves are high in protein, palatable and are excellent feed for cattle and sheep. Also they are a suitable green feed for poultry. The ash content is very high and this accounts for a relatively low T.D.N. value.

RUSSIAN COMFREY HAY.

Russian comfrey hay is a good quality roughage with a high protein content (13 per cent.) and a correspondingly low fibre content (13 per cent.).

MOLASSES.

Percentage composition
Dry matter = 75; T.D.N. = 60; Protein = 2.0; Digestible protein negligible.

Molasses is a by-product in the manufacture of sugar from sugar cane or from sugar beet. In Rhodesia cane molasses is the product available. Molasses is relished by stock and it has a mild laxative effect. It contains about 55 per cent. sugar, which provides most of the feeding value. When any considerable amount of molasses is added to a ration for ruminants the digestibility of the protein and other nutrients of the ration is likely to be decreased. Thus molasses usually has a negative protein digestibility.

Molasses is most useful when a small amount is used to induce stock to eat poor quality roughage, e.g., veld hay or winter veld grazing. For this purpose it is often mixed with urea and water and sprinkled over the roughage. It is also used in many nitrogen (protein) supplements with urea and in commercial concentrates, especially those for cattle. It adds to the palatability of the feed, prevents dustiness and is frequently a cheap source of carbohydrate.

UREA.

Percentage composition

Nitrogen content = 46; Equivalent protein content = 287 (per cent. N x 6.25).

Urea is a simple organic compound not unlike sugar in appearance. It has a high nitrogen content and is invariably fed with molasses. It is widely used in Rhodesia to *partially* replace the protein in a ration for ruminants. It has little or no value as a protein substitute for pigs or poultry or for calves before the rumen is developed. When urea is added to a suitable ration for ruminants the micro-organisms in the rumen convert it rapidly into ammonia. Some of this ammonia is absorbed through the rumen wall and metabolised into other nitrogenous compounds, most of which are excreted by the animal. The other portion of ammonia, together with other products of rumen fermentation, is converted to microbial protein, which is digested further on in the digestive tract and made available to the animal.

The utilisation of urea is poor when the ration has little or no supplies of available energy or when it is added to a mixture that is already fairly high in protein (12-13 per cent.). Hence for good utilisation of urea the ration should contain a certain amount of grain, the starch of which furnishes plenty of energy for the bacteria. It is well to remember that urea itself supplies no energy to an animal. The amount of urea incorporated into a concentrate should be restricted to 3 per cent. or less, otherwise the animals may be poisoned by eating too much or the concentrate tends to be unpalatable. Urea is very toxic in excessive amounts and it must be thoroughly mixed in a ration to prevent any animal from receiving a dangerous amount. In general practice 4 ozs. per day should not be exceeded for mature cattle, 2½ ozs. per day for young stock and 1 oz. per day for sheep. The symptoms of urea poisoning are increased respiration, bloating and salivation.

In Rhodesia urea is widely used in various ways in maintenance and fattening rations for beef cattle. For maintenance, urea can replace most of the protein in the ration, e.g., 3 to 4 ounces of urea per day will supply the protein maintenance requirements of steers and cows. For growth and fattening, urea can supply up to 50 per cent. of the protein requirements.

The following mixtures, which incorporate urea, are recommended by the Federal Department of Conservation and Extension, from whom details of amounts to be fed for each class of stock may be obtained:

(1) 1 lb. urea in 1 gallon of water, 10 lb. molasses. Sprayed on 100 lbs. silage, hay or maize stover.

(2) 5 lbs. urea, 60 lbs. molasses, 100 lbs. cobmeal. Maintenance ration for over-wintering cattle on the veld.
4 lbs. urea, 25 lbs. molasses, 46 lbs. cobmeal, 25 lbs. cottonseed meal. Concentrate for kraaled fattening steers.

(3) 30 lbs. urea, 10 gallons molasses, 34 gallons water. Sprayed on the veld at 40 gallons of mixture per acre.

(4) 10 lbs. urea, 1 gallon water, 4 gallons molasses. A liquid urea feed to be used as a protein supplement.

FODDER TREES AND SHRUBS

The trees and shrubs of the veld, especially those of the low veld (De La Hunt, 1954), are of great value to the stock farmer during the dry season because their leaves, shoots and fruits provide palatable, nutritious animal feed. Some of the indigenous species are found in many parts of the country and their feed value is well known to farmers, while a few exotic fodder trees such as carob and mesquite have also been grown in Rhodesia for many years. The following notes are a summary of the characteristics of the more common and important trees and shrubs.

PERCENTAGE COMPOSITION OF THE LEAVES AND PODS OF FODDER TREES

(after Bonsma, 1942, and Chem. Branch, 1949.)

	Protein	Fat	Fibre	Ash	N.F.E.
Giraffe thorn pods	11.5	2.0	31	3.5	43
Ana tree pods	11	1.5	27.5	3.5	49.5
Umbrella thorn pods	18.8	2.5	20.0	5.1	46.2
Flat-topped thorn pods	17.5	3.0	25	—	49
Monkeybread tree pods	6.5	3.0	24	4.0	57
Witgatboom leaves	14.5	—	32	1.5	—
Mopane leaves	12.5	—	25	1.5	—
Chinese lantern bush pods	18.0	2.0	21	5.0	46
Carob pods	6.5	2.5	9.5	2.5	73
Honey locust pods	12.0	5.0	10.5	3.5	60
Mesquite pods	14.0	2.0	28	4.0	53

INDIGENOUS SPECIES.

Indigenous trees are usually slow growing and hence exotic species are being introduced for new planting. The acacias make up a large number of the indigenous trees (West, 1950). The pods of all the acacias are useful feeds and the leaves are also eaten, especially when young and succulent. If possible the pods are best ground before feeding, otherwise the seed, which is rich in protein, may pass through the animal undigested.

GIRAFFE THORN, *Acacia giraffae*.

This is a large species which is valuable for its pods and shade. The shed dry pods, which cattle browse, are potentially dangerous due to their cyanide content. Fortunately cases of poisoning are extremely rare. It has been estimated that a mature giraffe thorn produces between a quarter and half ton of pods each winter.

ANA TREE, *Acacia albida*.

This species is found along rivers in the low veld. It may produce up to a ton a year of nutritious palatable pods which ripen and fall from August onwards.

UMBRELLA THORN, *Acacia sieberiana* var. Woodii.

The umbrella thorn produces pods which have a woody appearance, but are high in protein and very palatable to cattle. Annual yields of up to 500 lbs. per tree have been reported. The pods are loosely attached to the branches and many fall when twigs are touched by animals.

FLAT-TOPPED THORN, *Acacia heteracantha.*

The flat-topped thorn is very common in Matabeleland and is also found in many other parts of Rhodesia. The pod resembles a string of beads in appearance and is well-liked by animals. The tree yields large quantities of pods which fall during June and July.

MONKEYBREAD TREE, *Piliostigma thoningii.*

Monkeybread tree is found in the eastern district of Southern Rhodesia and it produces both edible pods and leaves. The seeds, which have the highest feed value, are not digested by cattle.

WITGATBOOM, *Boscia albitrunca.*

The witgatboom is an important evergreen fodder tree of the low veld (Bonsma, 1942). The leaves and young shoots of this tree are avidly consumed by livestock and during severe droughts are invaluable in keeping animals alive. The tree grows readily from seed, but very slowly. Unfortunately, when cattle extensively eat the leaves and shoots, the milk and meat acquire a very unpleasant taste.

MOPANE, *Copaifera mopane.*

The mopane is a deciduous tree which in Rhodesia seldom grows higher than 15 feet. The value of mopane leaves is well known, particularly by low veld farmers. They are rich in protein and phosphorus and during the dry season livestock may be very largely dependent on mopane for feed. Analyses have shown that mopane leaves have a high feeding value throughout the year. In early summer the young leaves have a mild laxative effect on animals.

MUKWA or MUMUNGU, *Pterocarpus rotundifolius.*

Mukwa is widespread in Southern Rhodesia and it provides leaves which are readily consumed by cattle.

Other trees and shrubs commonly browsed are the Chinese lantern bush, *Dichrostachys glomerata;* the Karreeboom, *Rhus lancea;* the buffalo thorn, *Ziziphus mucronata;* the indaba tree, *Pappea capensis;* donkey berries, *Grewia* spp.; wild pear, *Dombreya rotundifolia;* cabbage trees, *Cussonia* spp.; and bluebush, *Royena pullens.* Some of the wild fruits which are relished by animals are marula, *Sclerocarya caffra;* muhash, *Parinari mobola;* bitter plum, *Ximenia* spp.; and Muhobohobo, *Upaca Kirkiana.*

EXOTIC SPECIES.

Three such species were introduced into Southern Rhodesia many years ago. They are the carob (*Ceratonia seliqua*), the honey locust (*Gleditsihia triacanthos*) and the mesquite (*Prosopis juliflora*). With suitable cultivation they all grow well (Loock, 1947).

CAROB or LOCUST BEAN, *Ceratonia siliqua* L.

This tree is an evergreen with a dense foliage of glossy dark-green leaves. It prefers a Mediterranean climate, but it does thrive in frost-free inland regions where the summers are hot and the rainfall is 20 inches and less. The trees can be either

male, female or bisexual and so it is advisable to plant them in groups. The pods are short, wide and fairly thick. They contain a compound mass of sweet pulp rich in sugar which animals greatly relish. The protein content of the pods is relatively low. Trees are reputed to bear as much as 1,000 lbs. of pods per season, but the average yield is 500 lbs. The pods, when ground, are suitable feed for all farm livestock.

HONEY LOCUST, *Gleditsihia triacanthos* L.

This is a deciduous species indigenous to the U.S.A. It does well in sub-tropical climates, but it will grow in many areas where the rainfall exceeds 25 inches per annum. The honey locust is predominantly dioecious and unfortunately a large percentage of the trees yield poorly or not at all. The average yield of full-grown, good bearers is about 400 to 600 lbs. per tree. The pods are 15 to 18 inches long and should be well filled with a sweet pulp. They are very rich in protein and sugar and when ground they provide good yields of digestible nutrients. They are most suited to ruminants because of their relatively high fibre content.

MESQUITE, *Prosopis juliflora* L.

The mesquite is a deciduous tree indigenous to the Americas. It thrives best in warm, dry, sub-tropical climates. Mesquite is well known for its drought resistance, but it is sensitive to frost. The pods are rich in sugar and have a relatively high protein content. They are readily eaten by stock and provide a useful, energy-rich feed. Adult trees may yield up to 200 lbs. of pods per season.

ANIMAL PRODUCTS

Animal products include milk and its by-products and meat and fish by-products. They are characterised by a high protein content and are invariably rich sources of minerals. Their high cost restricts their use to growing young stock, and in this capacity they may be regarded as protein and mineral supplements. Unless overheating has occurred during drying, the protein has a high biological value.

WHOLE MILK.

Whole milk is a high quality food, marred only by a deficiency in certain trace minerals, notably iron and copper. It contains 3.5 per cent. high quality protein, 4.7 per cent. lactose (a highly digestible carbohydrate), 0.8 per cent. balanced minerals and a varying amount of fat—3 to 6 per cent. Milk is a good source of most vitamins, particularly vitamin A and riboflavin. The vitamin A value of milk is directly related to the amount of green feed consumed by the cow and its vitamin D content to the amount of sunshine received by the cow. The riboflavin is destroyed by prolonged exposure of milk to direct sunlight.

SEPARATED or SKIM MILK.

The removal of cream from whole milk reduces the fat content to approximately 0.10 per cent. and the content of vitamins A, D, E and K to negligible amounts. Other constituents are unaffected. Skim milk is very high in protein on a dry matter basis and it should be fed with cereal grain or other concentrates low in protein to obtain maximum value. It is used chiefly for dairy calves, pigs and poultry. In pig feeding, the proportion of skim milk that is needed to balance maize or other grain will depend on the age of the pigs (Calder, 1957). High quality fat and flesh of the pig is associated with the feeding of skim milk.

The dried product is a valuable human food, but is too costly to be used for stock feeding except in a few specialised instances, e.g., in a creep feed for very young pigs.

WHEY.

In cheese-making practically all the casein and most of the fat go into the cheese, leaving in the whey lactose, albumin and a large part of the minerals. Whey has approximately 5.0 per cent. lactose and 0.3 per cent. fat, with only 0.9 per cent. protein, 0.05 per cent. calcium and 0.04 per cent. phosphorus. It is necessary to remember that whey is not a protein-rich food. It is fed chiefly to pigs, for which purpose it has about one-half the value of skim milk on a weight basis.

The dried product has on average 12.5 per cent. protein and 70 per cent. lactose and is especially rich in the B vitamins.

FISH MEAL.

Several types of fish meal are made, differing both in the raw material and in the method of drying.

White fish meal is made solely from the flesh and bones of white fish such as cod, haddock, etc., which contain little oil. The heads and bones with a good proportion of adhering flesh are passed through vacuum sterilisers, cookers, drying tubes, grinders and riddles to give the final product. Drying is effected at a low temperature

to avoid damage to the nutritive value of the proteins. White fish meal should not contain more than 6 per cent. of oil and not more than 4 per cent. of common salt. It contains 60-62 per cent. protein, with 55 per cent. of digestible protein.

Oily fish meal or herring meal is made from oily fish such as herring and menhaden. The fish are partially cooked and then subjected to hydraulic pressure to squeeze out the edible oil. The residue is then treated in much the same way as in making white fish meal. Herring meal generally contains 8 to 10 per cent. of oil and is usually richer in protein than white fish meal. It contains 72 per cent. protein, of which 90 per cent. is digestible.

Fish meal is an ideal supplement for feeding with cereal grains. It contains all the essential amino-acids in roughly the same proportions as in milk proteins. Fish meal is also a rich source of calcium and phosphate and thus is able to rectify the deficiency of these minerals in cereal grain. It has an average of 4.0 per cent. calcium and 2.7 per cent. phosphorus, with a total mineral content of 12.0 per cent. It should also be noted that fish meal usually contains an appreciable amount of iodine.

Since fish meal is expensive, it is fed mainly to young animals. It is wasteful to feed fish meal to baconers after they attain 100 lbs. liveweight. It is also advisable not to feed fish meal to pork pigs for at least three weeks before slaughter to avoid tainting the meat. Fish meal is not a rich source of vitamins A or D, but supplies adequate amounts of vitamin B and some vitamin E.

Stockmen have hesitated to use fish meal for feeding, fearing that it might cause a fishy flavour in eggs, meat or milk. In numerous feeding experiments with fish meal no such effect has been produced when good fish meal, not unduly high in fat, has been fed in amounts needed to balance the ration. If a large allowance of fish meal is fed there is a danger of producing a fishy flavour.

MEAT and BONE MEALS.

The nutritive value of these by-products varies considerably, depending chiefly on the kind of raw material from which they are produced. If they consist largely of waste that is high in gristle, connective tissue or bone, the value will be much lower than in the case of a product containing more meat. This is because the protein in gristle and connective tissue, and also in bone, is of low value.

Pure meat meal is made from the material trimmed off the carcasses and is cooked in steam-jacketed melters until the moisture content has been reduced to 5 to 8 per cent., the mass being stirred continually. The surplus fat is then drained off. The residual material is then pressed in an expeller to remove a further substantial portion of fat. Pure meat meal contains 70-72 per cent. of crude protein (with 67 per cent. digestible protein) and only 3 to 4 per cent. of ash. The amount manufactured is small because of the difficulty of rendering the fat without the addition of bone.

There are two types of commercial meat meal known as meat meal and meat and bone meal. The former contains 55-60 per cent. protein (with 90 per cent. of this digestible), not more than 4 per cent. of salt and about 20 per cent. minerals. Meat and bone meal contains 40 to 50 per cent. protein (with 80 per cent. of this digestible), not more than 4 per cent. of salt and about 24 per cent. of minerals. The meat meals are used in much the same manner as white fish meal, though they are generally regarded as being slightly inferior in feeding value. They are high in lysine, but supply less methionine and tryptophan than does fish meal and have less tryptophan than soyabean oil meal.

BONE MEAL.

Steamed bone meal, often called merely "bone meal" is the most common phosphorus supplement for stock feeding. It contains an average of 30 per cent. calcium, 14.5 per cent. phosphorus, 7.5 per cent. protein and about 1 per cent. fat. It is produced by cooking fresh bones of suitable quality under steam pressure. This extracts most of the protein and fat, which are used for other purposes. The residue is pressed and dried and then ground. Only raw material of good quality should be used in making bone meal for stock feeding. For feeding, only bone meal should be bought that has definitely been made for this purpose and that has been so prepared that it is entirely free from any disease-producing organisms.

Cooked bone meal is cooked in open kettles instead of under steam pressure, the protein is removed less completely and cooked bone meal is lower in phosphorus and calcium. It has an average of 24.0 per cent. protein and 5.0 per cent. fat, 26 per cent. calcium and 9 per cent. phosphorus. Cooked bone meal is sometimes ground more coarsely than steamed bone meal and screened into various sizes for poultry of different ages.

BLOOD MEAL.

Blood meal, or dried blood, is made from the blood collected at abattoirs. It is first heated until it is thoroughly coagulated; the excess is then drained off, more moisture is removed in a press, and finally the solid residue is dried and ground. The temperature of drying has a distinct bearing on the nutritive value of blood meal.

Blood meal is highest in protein of all the animal by-products and contains over 80 per cent. However, the protein is less digestible (digestible protein 58 per cent.) and of much poorer quality than that in high-grade fish meal or meat meal, but it has a high lysine content. Blood meal is low in calcium and phosphorus. It is not very palatable and must be carefully introduced into the ration. The amount fed to pigs should not exceed 5 per cent. of the total ration. Only very small amounts are available in Rhodesia.

WHALE MEAT MEAL.

Whale meat meal can be a very rich source of protein, due to the modern method of removing the muscular tissue along the backbone of the whale unmixed with bone. However, commercial samples usually have bone or minerals added to them. The locally used product has an average content of 70 per cent. protein and 10 per cent. minerals, which includes 5.3 per cent. calcium and 2.9 per cent. phosphorus.

CHICKEN LITTER.

Because ruminants can use non-protein nitrogen as a partial substitute for protein, experiments have recently been conducted to find out whether or not chicken litter, including the manure, could be used as a substitute for ordinary protein supplements in feeding beef cattle and sheep. The dry chicken litter has an average of 4 per cent. nitrogen, equivalent to 25 per cent. crude protein. About one-fifth of the nitrogen is uric acid, which is the chief nitrogenous waste product in birds. The results were satisfactory when about 20 per cent. of dry chicken litter was included in the concentrate mixture. However, the performance of animals fed on chicken litter is usually inferior to those which receive a comparable amount of vegetable protein.

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