Tropical Feeds: Feeds Information Summaries and Nutritive Values

by: Bo Gohl

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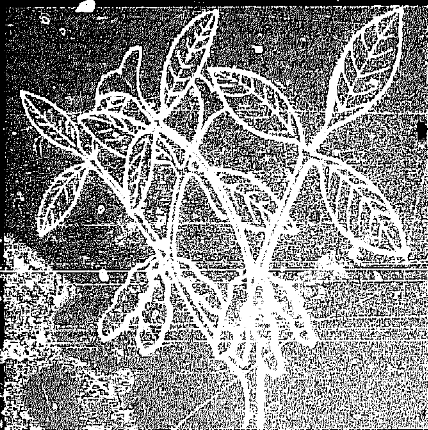
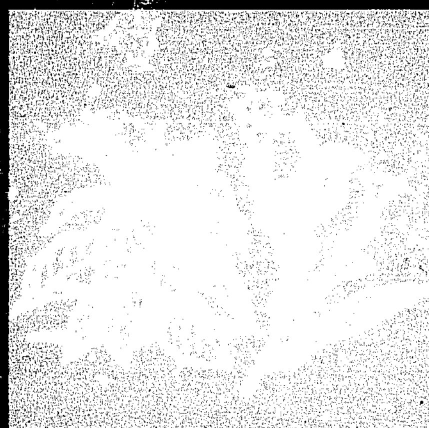
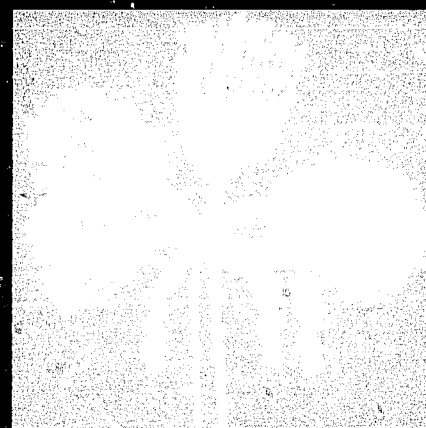
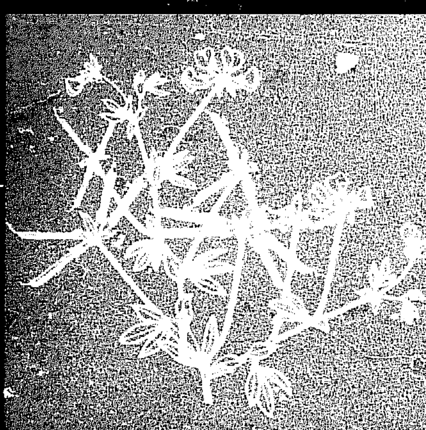
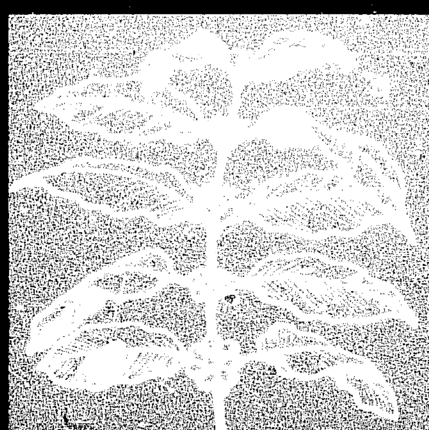


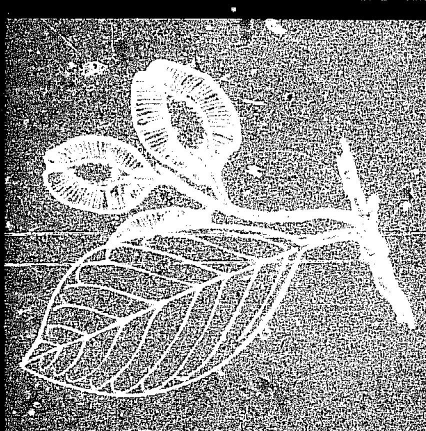
tropical feeds











Future expansion of the livestock industry in the tropical developing countries will depend on fuller and more efficient use of local feedstuffs. Published information on the nutritive values of tropical feeds has hitherto been almost unavailable.

The 554 feed information summaries in the present updated edition of this manual are accompanied by analyses of the major components and their digestibility for livestock.

The many drawings, as well as the indexes of botanical and vernacular names of feed sources, make this an invaluable reference work.

FAO Animal Production and Health Series No. 12

tropical feeds

feed information summaries and nutritive values

by

BO GÖHL
International Foundation for Science
Stockholm, Sweden

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FOREWORD TO THE FIRST EDITION

Published information on the nutritive value of feeds in general is scanty, and for tropical feeds it is almost nonexistent. Correct data on the nutritive value of local feedstuffs are essential for the expansion of the livestock industry in the developing countries. The third meeting of the Expert Panel on Animal Nutrition, held in Göttingen, recommended that the Animal Production and Health Division of FAO collect and publish information appertaining to feedstuffs typical of developing countries throughout the world. The present monograph has been prepared as a first step toward meeting the need for information and data on feeds in those countries. The panel also encouraged the Animal Production and Health Division to create a Feeds Information Centre to collect and disseminate data.

At a late stage in the preparation of this monograph it was agreed that FAO would participate through its Feeds Information Centre in an International Network of Feed Information Centres, designed to provide a means of collecting and disseminating data on the composition and the nutritive values of feeds and information on their use. The International Network uses the nomenclature and coding system described by L.E. Harris, J.M. Asplund and E.W. Crampton in *An international feed nomenclature and methods for summarizing and using feed data to calculate diets* (Utah Experiment Station Bulletin 479, 1968). It is recommended that they be followed by authors reporting new data on the composition and the nutritive values of feeds. To obtain the full international code number (Harris *et al.*, 1968), certain additional terms are required — for example, all feeds must be specified as aerial parts, browse, roots, etc.

The continuous support to the author and the many constructive ideas of Dr C.C. Balch, former Animal Nutrition Officer at FAO and now at the National Institute of Research in Dairying, Reading (United Kingdom), are gratefully acknowledged, as is also the assistance of the following: Mr F.E. Alder (FAO), Dr M.H. French (FAO), Dr L.E. Harris (Utah State University), Dr G.R. Pearce (Australia), Dr H.J. van Rensburg (FAO), Dr C.A. Walker (United Kingdom) and Dr H. Neumark (Volcani Institute, Israel). The Swedish International Development Authority is thanked for its financial support.

H.A. Jasiorowski, Director
Animal Production and Health Division
Rome, December 1971

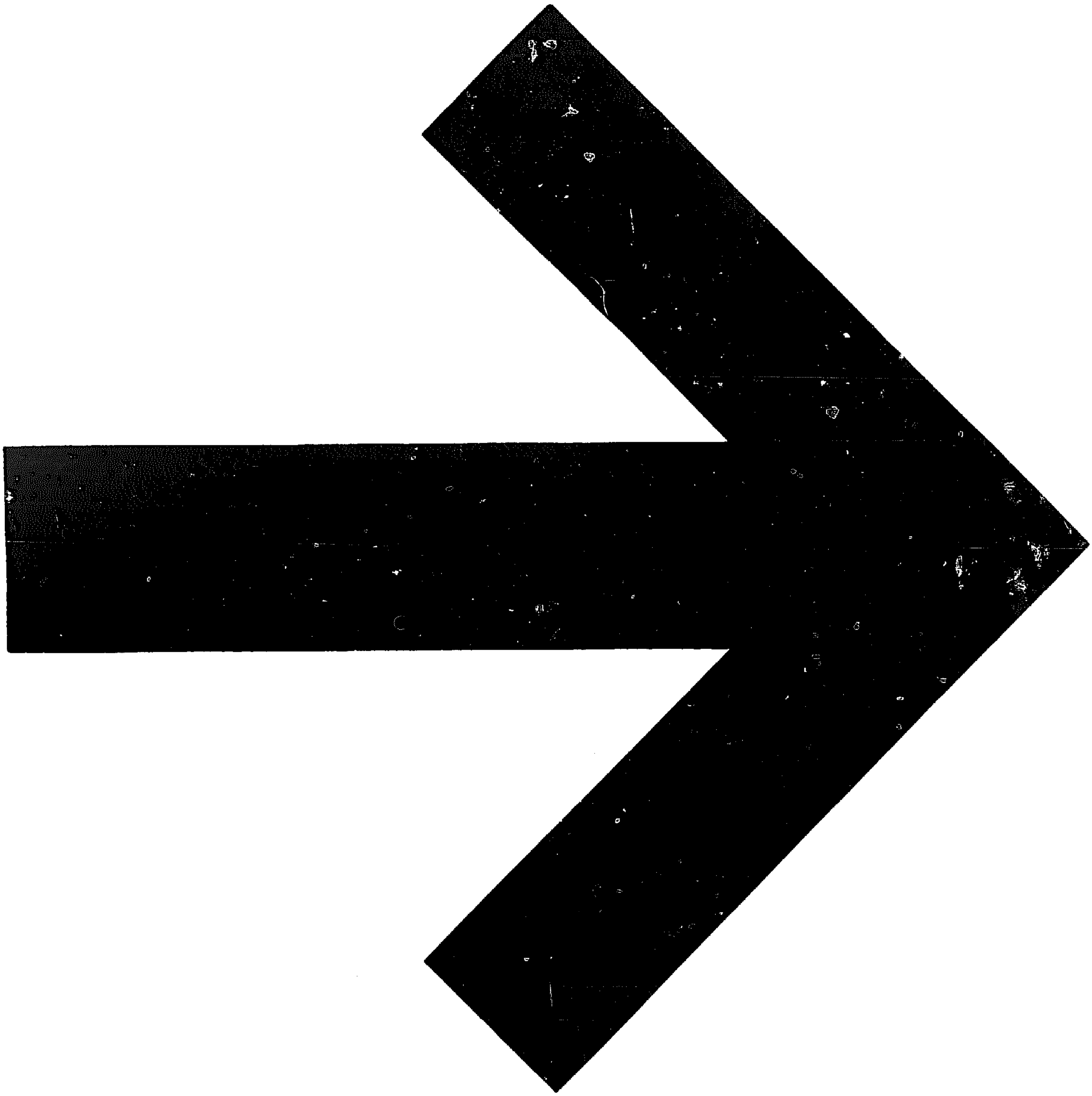
NOTE ON NOMENCLATURE

The plant specialist has to live with frequent changes and variations in nomenclature. With new species being identified and old species reassessed in the light of continuing research, name changes inevitably occur. The vernacular names, of course, vary from country to country and often from region to region within a country. It has been attempted, as far as possible, to take this into account in the preparation of this work by using the most up-to-date materials available, among which the following handbook proved to be particularly valuable: *A checklist of names for 3 000 vascular plants*, by E.E. Terrell. Agriculture Handbook No. 505. Agricultural Research Service, United States Department of Agriculture, Washington, D.C. 1977.

FOREWORD TO THIS EDITION

Growing interest in better utilization of the feed resources of the tropics has become very evident in recent years. This interest encouraged FAO to call a conference to review the results of current research (see *New feed resources*, Proceedings of a technical consultation held in Rome, 22-24 November 1976, FAO Animal Production and Health Paper No. 4). The conference emphasized the important role of FAO in spreading this information in nonindustrialized countries. Consequently, this publication, first issued in 1971, has been updated with new information on the use and values of tropical feeds. Drs J. Rendel and M. Chenost of FAO have assisted the author in preparing the new edition.

H.C. MUSSMAN, Director
Animal Production and Health Division
Rome, March 1978



CONTENTS

INTRODUCTION: EXPLANATIONS AND CONVERSIONS

Digestibility and energy value of feeds

Different units are used to measure the energy content of feedstuffs in the various countries. The diversity of units often causes confusion. The most common units are:

(i) Starch equivalent (SE), which measures the amount of pure starch that, when fed, produces as much fat as 100 kg of the feed.

(ii) Russian oat unit (OU), which is similar to the unit above but based on oats.

(iii) Scandinavian feed unit (FE, from *Foderenhet*), which is based on barley and refers to milking rather than fattening.

(iv) Modified feed unit (FEc, UF or French feed unit).

(v) Metabolizable energy (ME), which is usually expressed in megacalories per kilogram of feed, but can also be expressed in joules or megajoules per kilogram of feed. To convert calories to joules the value should be multiplied by 4.18.

(vi) Total digestible nutrients (TDN), a unit which is almost identical to the German *Gesamtnährstoff* (GNS).

The table on page XII will enable the reader to calculate the desired energy unit from the proximate composition and the digestibility data.

The "availability" *(Wertigkeit)* factor needed for the calculation of SE, FE and OU can be obtained from references 183 and 512.

If digestibility data are not available, the energy content may be approximated with the following regression equations (ref. 86):

Fresh grasses: $\text{TDN} = 54.6 + 3.66 \text{ Log}_e \text{ CP} - 0.26 \text{ CF} + 6.85 \text{ Log}_e \text{ EE}$

Hay: $\text{TDN} = 51.78 + 6.44 \text{ Log}_e \text{ CP}$

The following is an example of how to calculate the metabolizable energy in barley for pigs:

	Dry matter (%)	Dry matter (g/kg)	Digestibility (coefficient)	Digestible nutrient (g/kg)	Digestible nutrient (kcal/g)	Total (kcal)
CP	10.0	100	79	79	5.01	395.8
CF	3.9	39	20	7.8	3.44	26.8
EE	1.7	17	50	8.5	8.93	75.9
NFE	68.7	687	90	618.3	4.08	2 523.5
					Sum	3 022.0

Therefore, the barley contains 3 022 kilocalories (3.02 megacalories) of energy per kg of dry matter.

DETERMINATION OF THE NUTRITIVE VALUE OF FEEDSTUFFS IN DIFFERENT FEED UNITS AND ENERGY UNITS

Feed unit	Unit of the digestible nutrient[1]	Multiply digestible nutrient by				Further procedure
		Crude protein	Ether extract[1]	Crude fibre	N-free extract	
TDN or GNS (weight units or %)	Weight units or %	1	2.25 (TDN) 2.30 (GNS)	1	1	Sum up
SE (weight units or %)	Weight units or %	0.94	2.41 2.12 or 1.91	1	1	Sum up and multiply by the availability *(Wertigkeit)*
FEc (per kg)	g/kg	0.94	2.41 2.12 or 1.91	1	1	Sum up, multiply by the availability *(Wertigkeit)* and divide by 700
OU (per kg)	g/kg	0.94	2.41 2.12 or 1.91	1	1	Sum up, multiply by the availability *(Wertigkeit)* and divide by 600
FE (per kg)	g/kg	1.43	2.41 2.12 or 1.91	1	1	Sum up, multiply by the availability *(Wertigkeit)* and divide by 750
DE ruminants (kcal/kg)	g/kg	5.79	8.15	4.42	4.06	Sum up
DE pigs (kcal/kg)	g/kg	5.78	9.42	4.40	4.07	Sum up
ME ruminants (kcal/kg)	g/kg	4.32	7.73	3.59	3.63	Sum up
ME pigs (kcal/kg)	g/kg	5.01	8.93	3.44	4.08	Sum up

[1] The digestible ether extract of oily seeds, cakes and feeds of animal origin should be multiplied by 2.41; that of leguminous seeds, cereal grains and their by-products by 2.12; that of hays, straws, chaffs, green fodders, silages, roots and tubers by 1.19.

Conversion of energy units

SE, FE and OU. These three units may be reciprocally converted by multiplication, as FE_c and OU are fractions (0.7 and 0.6) of SE.

TDN and ME. The relationship between TDN and ME depends on the amount of crude protein and crude fibre in the feed. If the dry matter in a feed consists of 25% crude fibre containing 15% digestible crude protein, a kilogram of TDN corresponds to 0.274 megacalories of ME.

SE and TDN. The relationship between SE and TDN depends on the digestible CP content of the feed. The following approximation can be used:

SE (kg) = 0.995 TDN (kg) − 0.051 digestible CP (kg/kg feed).

Conversion of measurements

FROM METRIC TO BRITISH SYSTEM	FROM BRITISH TO METRIC SYSTEM
Length	
1 centimetre (cm) = 10 millimetres (mm) = 3/8 inch	1 inch = 2.5 centimetres
1 decimetre (dm) = 10 centimetres = 3 3/4 inches	
1 metre (m) = 100 centimetres = 1.1 yards	1 foot = 12 inches = 30.5 centimetres
	1 yard = 3 feet = 91.4 centimetres
Surface	
1 square centimetre (cm^2) = 0.15 square inch	1 square inch = 6.45 square centimetres
1 square metre (m^2) = 1.2 square yards = 11 square feet	1 square foot = 0.09 square metre
1 hectare (ha) = 2.5 acres	1 square yard = 0.84 square metre
	1 acre = 4 050 square metres

Weight

1 gram (g) = 15.4 grains

1 kilogram (kg) = 1 000 grams
= 2.2 pounds (lb)

1 ton = 1 000 kilograms
= 1.1. short tons
= 0.985 long ton

1 ounce (oz) = 28.4 grams

1 pound (lb) = 454 grams

1 short ton = 907 kilograms

1 long ton = 1 016 kilograms

Capacity

1 cubic centimetre (cm^3)
= 1 millilitre (ml)
= 0.06 cubic inch

1 cubic decimetre (dm^3)
= 1 litre
= 1 000 millilitres
= 2.1 US pints
= 1.8 Imperial pints

1 cubic inch = 16.4 millilitres

1 cubic foot = 0.03 cubic metre

1 US pint = 0.47 litre

1 US quart = 0.95 litre

1 US gallon = 3.8 litres

1 Imperial pint = 0.57 litre

1 Imperial quart = 1.14 litres

1 Imperial gallon = 4.6 litres

Temperature

$°C = \frac{5}{9} (°F - 32)$

$°F = \frac{9}{5}°C + 32$

Energy

1 calorie = 1 small calorie (cal) = 4.184 joules

1 kilocalorie (kcal) = 1 large calorie (Cal) = 1 000 calories

1 megacalorie (Mcal) = 1 000 kilocalories

Density of feeds

(collected values from various sources)

Number assigned to the feedstuff in this publication	*Name*	*(kg/dm³)*	*(lb/ft³)*
B41	Gram seeds	0.73	46
B79	Lentil seeds	0.75	47
B88	Lucerne (alfalfa) meal	0.30	19
B99	Peas	0.75	47
E2	Dried beet pulp	0.21	13
F1	Millets	0.65	41
F2	Ground oats	0.35	22
F2	Whole oats	0.46	29
F6	Barley	0.54	34
F7	Rice grains	0.72	45
F7	Rice bran	0.30	19
F7	Rice mill by-products	0.37	23
F9	Sorghum	0.79	50
F9	Ground sorghum	0.57	36
F10	Wheat	0.73	46
F10	Wheat bran	0.24	15
F10	Wheat shorts	0.41	26
F11	Maize	0.68	43
F11	Ground maize	0.62	39
F11	Flaked maize	0.21	13
F11	Hominy	0.65	41
F11	Maize gluten meal	0.60	38
F11	Maize gluten feed	0.48	30
G3	Groundnut (peanut) oilcake	0.60	38
G8	Hemp oilcake	0.44	28
G12	Coconut oilcake	0.46	29
G15	Palm-kernel oilcake	0.43	27
G16	Soybean oilcake	0.54	34
G17	Cottonseed oilcake, decorticated	0.60	38
G19	Sunflower seed oilcake, decorticated	0.54	34
G23	Linseed oilcake	0.56	35
G33	Sesame oilcake	0.46	29
H1	Meat meal	0.64	40
H1	Meat-and-bone meal	0.64	40
H1	Tankage	0.70	44
H2	Blood meal	0.43	27
H4	Bone meal	0.83	52

H16	Poultry by-product meal	0.60	38
H17	Fish meal	0.56	35
H28	Dried whey	0.60	38
I 7	Molasses	1.33	84
I 11	Malt culms	0.22	14
I 12	Dried brewer's grain	0.25	16
I 15	Maize distiller's dried grains	0.29	18
I 15	Maize distiller's dried solubles	0.41	26
I 20	Dried fodder yeast	0.64	40
I 29	Ground limestone	1.14	72
—	Water	1.00	63

How to use this book

In this publication the feeds are divided into groups (A through I), and each feed has been given an index letter and number (e.g., A43 for star grass), which is used for cross-references throughout the text and for easier identification of the feed in the tables at the end of the book. Most plants are listed alphabetically by their botanical names, but the index on page 523 can be consulted if only the vernacular name is known.

To take full advantage of this publication, the reader should use it together with a feeding standard, such as the ARC (*Nutrient requirements of farm livestock*, Agricultural Research Council, London) or the NRC (*Nutrient requirements of domestic animals*, a serial publication of the National Academy of Sciences, Washington, D.C.).

Feed information summaries

Many feeds are known by several names, both botanical and vernacular; the names given in the summaries are the more common ones. (Local names and outdated botanical names have in most cases been omitted.) The summaries include short descriptions of the feeds and the more important particulars of their use. If a feed has been reviewed in a published article, the article is given as a reference. The selected references themselves include extensive bibliographies which can serve as a guide to the literature on the feed.

Readers interested in exhaustive bibliographies are referred to organizations that publish abstracts, such as the Commonwealth Bureau of Pasture and Field Crops, Hurley, Maidenhead, Berks. SL6 5LR, England, or Dokumentationsstelle der Universität Hohenheim, Stuttgart-Hohenheim, Germany (F.R.). Husbandry data on grasses and legumes can be found in *Tropical pastures and fodder plants* by A.V. Bogdan (Longmans, 1977).

Proximate analysis

The type of analysis given with each feed information summary was originally devised by the Weende Experiment Station in the Federal Republic of Germany and has become universally accepted. It consists in determining the major classes of components: water, crude protein (CP), crude fat (CF), crude fibre, ash and nitrogen-free extract. It should be noted that these groups of components are more or less artificial and do not necessarily describe the actual chemical composition of the feed; nevertheless, this type of analysis serves as a good index to nutritive value. Other analytical determinations now coming into use (P.J. Van Soest, *Journal of Animal Science*, 26:119, 1967) are said to reflect more closely the structural constituents of plant materials; however, these data are available only in few cases. For details of the laboratory procedures used in the proximate analysis, the reader is referred to *Official Methods of Analysis of the Association of Official Agricultural Chemists*, published by the Association of Official Agricultural Chemists, P.O. Box 540, Benjamin Franklin Station, Washington, D.C. The general principles are given below.

CRUDE PROTEIN (CP). This is approximated by multiplying the Kjeldahl nitrogen analysis by the factor 6.25. Depending on the type of feed, a greater or lesser part of the crude protein is true protein, while the remainder consists of inorganic nitrogen salts, amides, etc. In the feed information summary (I 30) on nonprotein nitrogen this is discussed more fully.

ETHER EXTRACT (EE). The crude fat content is measured as diethyl ether or petroleum ether extracted material, including not only oils and fats but fatty acids, resins, chlorophyll, etc.

CRUDE FIBRE (CF). This refers to organic matter insoluble in a hot diluted sulphuric acid and diluted sodium hydroxide solution. It should be noted that crude fibre is in many cases a misleading indicator of the digestibility and nutritive value of a feed. Fibre is of special value for lactating ruminants, which should receive a minimum of 15% fibre in their diet to maintain good health. Digestible fibre is also necessary in the diet of dairy cows to produce milk that is rich in butterfat. Fibre is essential for rumination, and with low-fibre diets (for instance, feedlot beef) it is necessary to provide artificial roughage (plastic pellets, oyster shells, etc.). As pigs digest crude fibre more poorly, pig starter feed usually contains only about 3% crude fibre, while grower feed contains 7-8% and sow feed 9-12%. The optimum crude fibre content of chick grower feed is about 3%, while for layers about 4% is common.

ASH. This is determined by igniting samples until they are free of carbon. A high level of ash in plant material often indicates contamination with soil.

NITROGEN-FREE EXTRACT (NFE). This is the difference between the sum of the other constituents and the original dry weight — in other words, what remains (sugars, starches, etc.) after the other groups of components have been detected by analysis.

DRY MATTER (DM). All analyses are based on dry matter. To convert the value given on a dry-matter basis to a fresh-matter basis for the formulation of feeds, the percentage is multiplied by that of the dry-matter content. For instance, fresh milk is 15% dry-matter, of which 24% is crude protein; thus the crude protein content on a fresh-matter basis is $15/100 \times 24 = 3.6\%$. As the dry-matter values in the tables apply only to those specific examples, the reader should try to ascertain the dry-matter content of his particular sample and use only in exceptional cases the dry-matter figure given in the table.

The criteria for the selection of the analyses used herein were optimum reliability of the source, adequate definition of the feed wherever possible and the condition that the analyses be fairly typical for the specific feed.

FEED INFORMATION SUMMARIES

A. Grasses

Useful reference: 521

It is estimated that there are about ten thousand species of grasses in the world. Only about forty are commonly used in artificial pastures, however, and less than half of those are cultivated in the tropics because of the heavy reliance on natural grasslands and savannahs.

The chemical composition of grasses varies widely, not only by species, but also with maturity, climate and soil. This is especially true of mineral content, which to a great extent reflects the composition of the soil; therefore, no figures on minerals or vitamins are given for individual species of grass. The following table serves as a general guide to the change in composition with maturity. The values are averages based on dry matter for six cultivated grasses in Suriname (ref. 26).

	3 weeks	4 weeks	5 weeks	6 weeks	7 weeks	8 weeks
	Percent					
Crude protein	12.9	10.7	9.4	7.5	7.3	6.7
Crude protein digestibility	57.0	58.0	55.0	54.0	53.0	56.0
Crude fibre	31.0	33.4	32.8	33.7	34.4	34.4
Ether extract	2.6	1.8	1.7	1.9	2.1	1.7
Ash	10.9	11.0	9.7	8.3	7.8	7.7
Phosphorus	0.36	0.35	0.32	0.30	0.27	0.26
Potassium	3.25	2.97	3.08	2.19	2.06	2.05
Calcium	0.18	0.23	0.20	0.16	0.19	0.21
Magnesium	0.26	0.30	0.28	0.30	0.28	0.28
Sodium	0.16	0.23	0.16	0.17	0.19	0.17
Chloride	1.19	1.16	0.96	0.86	0.85	0.88
Sulphur	0.47	0.46	0.35	0.30	0.30	0.29
	Parts per million					
Cobalt	0.35	0.53	0.42	0.29	0.22	0.29
Copper	8.2	9.3	7.1	6.1	6.4	6.8
Manganese	130	168	128	132	146	193
Iron	1 022	885	720	345	289	267
Molybdenum	0.81	0.79	0.77	0.69	0.68	0.91

Another consideration in judging the nutritive value of grasses is selective grazing of animals, especially sheep and horses. The difference between the chemical composition of the pasture and that which is actually eaten can be considerable, in some cases 25% for crude protein and crude fibre. Despite their limitations, chemical analyses are useful for comparing the nutritive value of grasses.

The value of a specific grass depends largely on the amount an animal is willing to consume. Voluntary intake is affected not only by the stage of growth but also by the fertilization and by the physical form in which the grass is presented to the animal. [For further information on these important questions, see D.J. Minson, *Australian Journal of Experimental Agriculture and Animal Husbandry, 11:*18 (1971), *12:*21 (1972), *13:*153 (1973); D.J. Minson and R. Milford, *ibid., 8:*270 (1968); and R. Milford and D.J. Minson, *ibid., 8:*409 (1968), *8:*413 (1968).]

Grasslands

Natural grasslands. It is estimated that half of the world's cattle graze on natural pasture. These pastures can be greatly improved by easing the grazing pressure during the dry season. Their botanical composition can be changed by controlled grazing, fertilizing, mowing, seasonal burning and other means. The provision of drinking water at close intervals and of feed supplements during the dry season will help increase productivity on natural pastures. This type of grassland, usually grazed continually, is found mainly in the tropics where rainfall is inadequate and soils are deficient for arable crops. These grasslands normally contain trees and shrubs which provide needed shade and valuable browse, especially during the dry season. To avoid the risk of deterioration, grazing should be deferred each year on one third of the grassland until after seed maturity.

Artificial grasslands. The grasses in these pastures have been planted or sown, very often together with legumes. The pasture is generally used intensively by either rotational or strip grazing. When grazed rotationally, the grassland is typically subdivided into paddocks, and the animals are moved systematically from one paddock to another at intervals of perhaps four to six days. The aim of this system is to use the pasture at its most productive stage. Strip grazing is more intensive. An electric fence is moved progressively along the paddock. As the area on which the animals can graze is changed once or twice a day, trampling losses are minimized. With the zero-grazing or soiling method, high-producing grasses sensitive to trampling can be used and the land utilized to its maximum capacity. The herbage is cut each day and brought to the confined animals.

When perennial forage crops are harvested in small quantities for daily feeding, the harvesting schedule is set in accordance with the number of cuttings that can be taken from the crop in one year. For example, a Guinea grass field gives ten cuttings a year at intervals of 35-40 days; thus it is convenient to divide the field into 36 plots and harvest one plot each day in a regular sequence.

Fresh-cut young grass is an excellent source of vitamins and protein of great value also for poultry, especially when they are housed intensively. In some tropical areas, grass plots are planted near poultry houses and cut in rotation to supply clippings for the birds.

Conservation methods

Hay. Grass harvested for hay should be cut early in the flowering stage. If cut sooner, the nutritive value is greater, but the yield is low and the moisture content is too high for easy curing. If cut after flowering, the increased yield tends not to compensate for the decreased palatability and nutritive value. To make good hay, it is imperative that the grass be dried quickly without undue exposure to the sun. The loss of nutrients in curing is above 25% under normal conditions. In many tropical countries the growing season of grass coincides with heavy rains, so haymaking is not possible. In the arid tropics standing hay, or stem-cured grass, left in the field for dry season grazing has a lower nutritive value than hay made from the same grass. This method should only be used when there are no other means of conservation. Hay can be expected to have less than 5% of the vitamin A activity of the grass from which it is made.

Silage. The manufacture of silage is suited to many parts of the tropics as it is practically independent of weather conditions. A good silage loses very little of the nutrients in the grass. Many simple types of silos have been devised, but trench silo is probably the best for the tropics. Fresh fodder is compressed by tractor or roller in the trench, which should be well drained and preferably located on a hillside.

The top surface should be protected from the air by a thick layer of molasses or a plastic sheet. Under the anaerobic conditions in silage the carbohydrate is fermented into acids. The acidity prevents spoilage of the ensiled material. Coarse material should be chopped and moist material wilted before ensilage. If legumes and young grass are to be ensiled, molasses or ground maize must be added to initiate fermentation. Good silage has a pH of less than 4.2. It should not be mouldy or smell bad. Ensiling preserves vitamin A activity of grass rather well, so that silage usually has about one third that of fresh grass. The press liquor from many ensiled grasses can be fed to pigs.

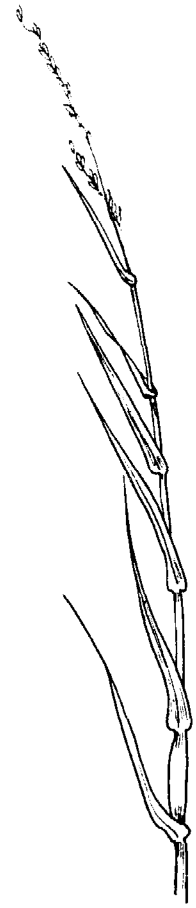
Haylage. Low-moisture hay crop silage, called "haylage," is one of the best ways of preserving forage as it offers the advantages of mechanized handling and more efficient utilization of silos. This method reduces the moisture in the grass to 55-60% by curing in the field before it is chopped and ensiled in an airtight silo. This type of silo is so expensive that this method of conservation is rarely used in the tropics.

Dried grass. Artificial drying eliminates nutrient losses in the grass and makes it suitable for transport and incorporation in mixed feeds as a source of protein, vitamin A and vitamins of the B complex. The process is expensive and justifiable only for high-quality grasses. *Pennisetum purpureum* and *Eragrostis curvula* have been artificially dried with good results and have replaced imported lucerne meal in compound rations.

A1 *Acroceras macrum* Stapf

Nile grass

Perennial with stems up to 1 m high. The rhizomes and stolons form a dense sward. Common on floodplains, river banks and swamp edges in eastern and southern Africa, where it provides very palatable and nutritious dry-season grazing. Gives large yields of hay. Withstands waterlogging but not drought. Used to improve moist natural pastures by planting splits or rhizome cuttings.



Acroceras macrum

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, early bloom, Kenya		8.7	30.8	9.9	5.9	44.7	133
Fresh, whole aerial part, Suriname		14.0	34.6	8.7	2.6	40.1	126
Fresh stems, Suriname		7.9	38.5	9.0	1.5	43.1	126
Fresh leaves, Suriname		21.3	30.0	8.4	3.8	36.5	126
Hay, South Africa		8.5	31.8	6.1	1.8	51.8	489

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME[1]	Ref.
Hay	Sheep	57.5	66.2	47.3	69.9	2.35	489

[1] ME (metabolizable energy) is always given in megacalories per kilogram of dry matter.

A2 *Agropyron intermedium* (Host) Beauv. × *Triticum turgidum* L.

A cross resulting in a perennial grass which can be propagated either from seed or vegetatively. Aerial portion closely resembling that of wheat except for the rather velvety leaves. Drought-resistant and grows during the cold season; therefore valuable as a pasture crop during early spring.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, 40 cm, South Africa	24.6	22.8	21.0	13.5	5.7	37.0	489
Fresh, 50 cm, South Africa	24.5	22.9	23.4	13.3	5.4	35.0	489
Fresh, 60 cm, South Africa	24.0	21.7	25.3	12.2	5.4	35.4	489
Fresh, regrowth, 35 cm, South Africa	24.4	19.3	26.6	12.5	5.9	35.7	489

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, 40 cm	Sheep	84.5	70.6	59.4	81.1	2.72	489
Fresh, 50 cm	Sheep	83.5	78.5	50.6	77.6	2.68	489
Fresh, 60 cm	Sheep	83.7	79.8	53.1	78.1	2.73	489
Regrowth, 35 cm	Sheep	83.5	83.7	61.5	82.4	2.84	489

A3 *Agrostis schimperana* Steud.

Tufted perennial 30-75 cm high that occurs in swamps, usually as low growth between larger tufts of coarse grasses and sedges. Well grazed and high in feed value. Competes poorly with other grasses.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		17.9	28.2	10.7	2.1	41.1	130

A4 *Alloteropsis semialata* (R. Br.) Hitchc.

Tufted perennial 25-55 cm high with shoot bases coated with densely hairy scales. An early grass which flowers at the very beginning of the rains. Good grazing and can withstand some waterlogging.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		15.6	14.7	9.0	1.1	59.6	130

A5 *Andropogon canaliculatus* Schum.

Tufted perennial 15-90 cm high that grows in seasonal swamps. Produces little bulk, only occasionally forming a noticeable portion of sward.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		13.3	31.9	9.8	2.0	43.0	131
Fresh, 8 weeks, Ghana	25.3	11.0	25.9	11.4			437
Fresh, 12 weeks, Ghana	29.0	8.2	28.1	10.2			437
Fresh, 16 weeks, Ghana	33.3	6.1	30.3	8.0			437
Fresh, 24 weeks, Ghana	67.0	5.7	27.3	7.5			437

A6 *Andropogon gayanus* Kunth

Gamba grass

Tall perennial tussock grass with stems up to 2 m high that grows on a variety of soils in areas with 600-1 100 mm of rain and a 5- to 6-month dry season. Tolerates low fertility, but not water-logging or overgrazing. Palatable and nutritious when young, but produces numerous hard and unpalatable flowering stems which should be removed by burning or mowing. Frequent burning tends to suppress this grass, and it is replaced by less useful species. Can stay green long into the dry season. Propagated vegetatively through splitting tillers or through seeding. Can be grown with *Centrosema pubescens* or *Stylosanthes gracilis*. One of the high-yielding grasses in West Africa.

Andropogon gayanus

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, early vegetative, Nigeria	27.8	6.5	29.6	9.9	3.1	50.9	58
Fresh, mature, Nigeria	27.5	4.1	30.3	8.3	0.6	56.7	58
Fresh, 4 weeks, Ghana	21.0	7.7	21.5	9.3			437
Fresh, 8 weeks, Ghana	19.9	12.9	25.6	8.5			437
Fresh, 12 weeks, Ghana	19.1	12.1	26.5	8.5			437
Fresh, 16 weeks, Ghana	30.9	8.4	29.2	6.6			437
Fresh, 24 weeks, Ghana	59.4	5.4	29.9	5.5			437
Hay, Nigeria	88.5	6.1	35.1	7.9	1.7	49.2	58
Silage, Nigeria	25.0	5.8	37.4	7.4	1.9	47.5	58

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Early vegetative	Cattle	52.3	74.0	64.5	67.4	2.33	58
Mature	Cattle	41.5	59.4	0.0	63.1	2.02	58
Hay	Cattle	11.5	54.1	35.3	50.0	1.65	58
Silage	Cattle	20.7	63.9	42.1	42.9	1.71	58

A7 *Anthephora nigritana* Stapf *et* C.E. Hubb.

Perennial grass up to 1.5 m tall that is quite common in the Sahel, where it is found on heavy soils and along watercourses. It produces a leafy herbage and is palatable.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, mid-bloom, Niger		14.1	38.0	8.4	1.8	41.4	45


Aristida adscensionis

A8 *Aristida adscensionis* L.

Common needle grass

Annual grass up to 75 cm high with narrow leaves and sharp seeds that make it almost unpalatable from the full flowering stage until the sharp seeds are shed after ripening. Sheep should not be allowed to graze mature needle grass as the sharp seeds may penetrate their skin and remain deposited on the inner side, causing considerable pain. In the early stages of growth it can be well grazed by cattle or cut for hay.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		8.9	36.8	11.4	1.7	41.2	133
Fresh, early vegetative, Kenya	25.8	10.5	33.6	9.5	1.6	44.8	537
Fresh, mature, Kenya		5.2	39.1	9.6	1.5	44.6	537
Standing hay, Kenya	91.0	2.0	45.7	7.9	0.9	43.5	537

A9 *Arundinaria cannavieira* Alv. Silv.

Bamboo

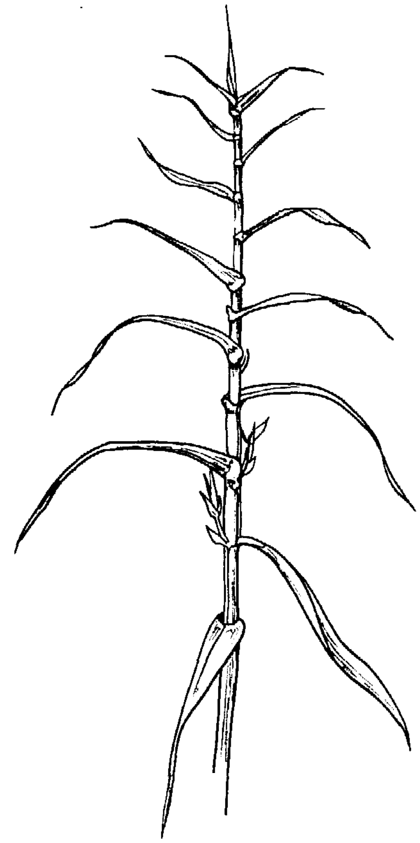
Tall shrub forming more or less extensive colonies in dry areas, often at high altitudes, where it is frequently an important source of forage.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Dried leaves, Brazil	88.3	7.8	45.0	3.3	2.4	41.5	112

A10 *Arundo donax* L.

Nal grass or giant reed

Quick-growing perennial and prolific yielder up to 3 m high. The stems are woody, and the grass is unpalatable in later stages. Difficult to eradicate. Only the young leaves are browsed.



Arundo donax

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh aerial part, Chile	84.6	6.6	31.8	13.9	2.0	45.7	315
Fresh, early vegetative, 90 cm, India		13.2	28.5	15.0	1.9	41.4	476
Hay, India		8.8	33.0	12.4	1.1	44.7	476

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Early vegetative	Oxen	74.0	69.0	56.0	67.0	2.22	476
Hay	Oxen	43.0	48.0	27.0	38.0	1.37	476

A11 *Avena byzantina* K. Koch

Red oat or Algerian oat

Annual grass cultivated for grain and fodder. Adapts to warmer weather than common oat and is more resistant to drought. Palatable grazing.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh aerial part, Chile	16.9	9.7	20.9	9.6	3.8	56.0	315
Fresh, 7 weeks after sowing, South Africa	17.7	26.1	18.1	11.7	5.3	38.8	489
Fresh, 8 weeks after sowing, South Africa	18.0	22.7	18.9	11.1	5.1	42.2	489
Fresh, 9 weeks after sowing, South Africa	18.6	18.4	19.2	10.5	5.1	46.8	489
Fresh, 10 weeks after sowing, South Africa	20.0	16.6	20.3	10.2	5.1	47.8	489
Fresh, 11 weeks after sowing, South Africa	21.1	14.0	20.9	9.1	4.5	51.5	489
Fresh, 12 weeks after sowing, South Africa	21.4	11.8	20.3	10.4	4.0	53.5	489
Fresh, 13 weeks after sowing, South Africa	21.1	10.0	19.6	8.5	3.6	58.3	489
Fresh, 14 weeks after sowing, South Africa	23.3	9.8	18.3	6.9	3.1	61.9	489
Fresh, 15 weeks after sowing, South Africa	28.3	8.5	18.4	6.8	3.0	63.3	489

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, 7 weeks	Sheep	86.6	80.6	47.9	87.7	2.93	489
Fresh, 8 weeks	Sheep	84.9	87.6	43.9	88.9	2.96	489
Fresh, 9 weeks	Sheep	81.9	85.7	49.7	89.2	2.95	489
Fresh, 10 weeks	Sheep	82.6	88.2	50.8	91.0	3.01	489
Fresh, 11 weeks	Sheep	79.2	97.7	46.2	90.9	3.07	489
Fresh, 12 weeks	Sheep	57.7	86.1	39.0	91.2	2.81	489
Fresh, 13 weeks	Sheep	68.6	84.2	33.3	90.7	2.90	489
Fresh, 14 weeks	Sheep	62.1	80.2	26.1	90.2	2.88	489
Fresh, 15 weeks	Sheep	56.3	80.3	29.5	89.3	2.86	489

A12 *Avena sativa* L.

Oat

Stout, erect annual cereal up to 1 m high, widely distributed in temperate and subtropical climates. Used for grazing, hay and silage. Two cuttings possible from a well-grown field of oats. The first cutting often used for fodder and the crop then left for seed, resulting in delayed maturity and a lower grain yield. Can be grown with berseem or peas.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, 2 months, Israel	11.0	18.2	28.2	14.5	3.6	35.5	365
Fresh, 3-4 months, Israel	14.1	12.8	27.0	12.1	4.3	43.8	365
Fresh, early bloom, Israel	22.8	7.9	35.1	10.1	1.8	45.1	365
Fresh, regrowth, 10 cm, Kenya		34.1	21.4	10.0	6.5	28.0	128
Fresh, regrowth, 25 cm, Kenya		30.2	17.2	9.1	5.8	37.7	128
Fresh, var. *orientalis*, Chile	16.9	22.6	23.8	16.3	4.7	32.6	315
Hay, milk stage, Zimbabwe	82.6	10.8	30.6	6.4	3.9	48.3	499
Hay, Chile	87.1	7.1	30.9	4.9	1.9	55.2	315
Silage, United Kingdom	23.7	8.0	35.9	7.6	3.4	45.1	512
Straw, Kenya		5.3	38.0	10.2	1.4	45.1	416

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Fresh, 2 months	Sheep	74.0	58.0	70.0	63.0	2.18	365
Fresh, 3-4 months	Sheep	73.0	55.0	67.0	63.0	2.16	365
Fresh, early bloom	Sheep	67.0	58.0	67.0	63.0	2.08	365
Hay	Cattle	51.5	49.0	64.0	59.3	2.01	499
Silage	Sheep	57.9	60.0	50.0	55.1	2.01	512
Straw	Sheep	23.8	43.5	54.1	41.9	1.39	46

3

A13 *Axonopus affinis* A. Chase

Tall carpet grass, narrowleaf carpet grass, mat grass

Creeping perennial spread by short stolons and forming low growth, with stems up to 50 cm high and narrow smooth blunt leaves. Grows on well-drained sandy soils in humid areas. Persistent on poor soils but not very palatable. Responds well to manuring. A popular pasture grass in areas to which it is adapted; also grown for soil conservation. The seeds are easy to harvest, and good stands can be established with a minimum of seedbed preparation.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, cut at 4-week intervals, Malaysia	28.9	8.3	30.4	5.9	1.7	53.7	292
Fresh, cut at 6-week intervals, Malaysia	30.7	7.5	30.9	5.9	1.3	54.4	292
Fresh, mid-bloom, Colombia	34.2	6.2	37.2	5.1	1.4	50.1	537

A14 *Axonopus compressus* (Sw.) Beauv.

Savannah grass, flat joint grass or tropical carpet grass

Shallow-rooted perennial with stems up to 80 cm high and with broader and shorter leaves than *A. affinis*. A pasture grass in wet areas. Withstands poor conditions and is dormant in the dry season. Survives seasonal flooding, but is susceptible to insects. May be heavily grazed, although it is outyielded by some other grasses, especially on better soils.

Axonopus compressus

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, dry season, 4 weeks, Trinidad	28.6	9.0	29.2	10.5	1.5	49.8	117
Fresh, dry season, 8 weeks, Trinidad	35.6	7.6	28.8	8.1	1.1	54.4	117
Fresh, wet season, 4 weeks, Trinidad	23.8	10.5	43.1	12.4	1.2	32.8	117
Fresh, wet season, 8 weeks, Trinidad	24.9	11.4	42.4	10.4	1.8	34.0	117
Fresh, wet season, 6 weeks, 20 cm, Thailand	25.6	8.2	30.5	10.2	2.0	49.1	219

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, 6 weeks	Sheep	48.0	31.0	37.0	30.0	1.10	219

A15 *Axonopus scoparius* (Flügge) Hitchc.

Imperial grass

Densely tufted perennial forming large tussocks, 1-1.5 m high, with big blunt-ended hairy leaves. Grows best in areas of high rainfall, but tolerates drought on deep soils. Prefers well-drained soils. Tolerant of high and low temperatures (down to 0°C). Used mainly as silage grass or for zero-grazing, as it gives high yields and is persistent only when cut. The succulent stems readily eaten by cattle at practically all stages of growth. Clones available that are resistant to the bacterial disease caused by *Xanthomonas.* Planted by rooting stem cuttings or pieces of stolons.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, 4 weeks, Costa Rica	14.6	11.4	28.6	12.2	3.4	44.4	537
Fresh, 6 weeks, Costa Rica	15.0	7.1	30.0	9.5	2.7	50.8	537
Fresh, 8 weeks, Costa Rica	15.3	6.2	29.7	14.2	1.4	48.5	47
Fresh, late bloom, Brazil	18.3	7.3	30.5	7.8	1.9	52.5	88

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Fresh, 8 weeks	Zebu	48.6	75.7	53.5	58.4	2.02	47

A16 *Bambusa arundinacea* Retz. (*Bambusa spinosa* Roxb.)

Bamboo

Thorny shrub of several varieties, native to India. New small shoots contain lethal amounts of hydrocyanic acid, but the leaves are an important fodder.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh leaves, India	57.1	18.6	24.1	11.8	4.1	41.4	443

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Leaves	Sheep	72.4	49.1	10.8	48.8	1.77	443

A17 ***Bambusa vulgaris* Schrad. *ex* Wendl.**

Bamboo or feathery bamboo

Native to the Pacific islands, but very widely cultivated. Grows up to 15 m high. Both green-stemmed and green-striped yellow forms exist. Readily browsed by cattle, and the leaves relished by goats.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh leaves, Jamaica		19.0	28.8	16.9	0.5	34.8	43

A18 *Bothriochloa insculpta* (Hochst.) A. Camus (*Amphilopsis insculpta* Stapf)

Sweet-pitted grass or pinhole grass

Perennial with stems up to 110 cm high. Develops stolons when well-grazed, forming a dense sward. Has a sweet smell, but is palatable to stock. Well adapted to tropical black-earth soils in Asia and Africa. Often found on rocky sites. Valuable in natural pastures. Withstands heavy grazing, and its proportion in the pasture increases with grazing density.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, early vegetative, 20 cm, Kenya	25.0	9.7	32.5	12.7	2.6	42.5	480
Fresh, early bloom, 30 cm, Kenya	20.0	9.2	34.9	12.0	2.7	41.2	480
Fresh, mid-bloom, 30 cm, Kenya	40.0	8.4	32.4	14.2	2.3	42.7	480
Hay, mature, Kenya	92.5	5.5	37.2	11.2	1.7	44.4	481
Standing hay, Kenya	91.0	4.6	35.2	9.9	1.8	48.5	481

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Early vegetative	Sheep	62.7	73.3	55.6	64.3	2.22	480
Early bloom	Sheep	63.5	74.9	46.1	61.1	2.20	480
Mid-bloom	Sheep	54.3	69.5	54.8	57.3	1.99	480
Hay, mature	Sheep	39.6	60.6	48.0	47.4	1.73	481
Standing hay	Sheep	33.6	56.8	45.6	55.3	1.82	481

A19 *Bothriochloa intermedia* (R. Br.) A. Camus (*Andropogon intermedius* R. Br.)

Australian bluestem grass

A widespread grass in semiarid tropical and subtropical areas with summer rainfall. Useful for both grazing and haymaking.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, 4 weeks, Ghana	30.0	13.6	25.0	13.4			437
Fresh, 8 weeks, Ghana	21.8	9.2	26.2	8.1			437
Fresh, 12 weeks, Ghana	23.4	8.3	29.9	9.0			437
Fresh, 16 weeks, Ghana	30.5	5.6	31.6	6.6			437
Fresh, 36 weeks, Ghana	59.7	9.3	28.7	5.7			437
Fresh, first cutting, India		3.9	38.9	9.5	1.3	46.4	436
Fresh, second cutting, India		3.7	37.7	9.2	1.1	48.3	436
Fresh, third cutting, India		2.1	37.8	8.5	1.3	50.3	436
Hay, flowering stage, India		4.2	43.2	9.2	1.5	41.9	436

A20 *Bothriochloa pertusa* (L.) A. Camus [*Amphilopsis pertusa* (L.) Nash *ex* Stapf; *Andropogon pertusus* (L.) Willd.]

Hurricane grass. Seymour grass. Barbados sourgrass, pitted bluestem

Tufted perennial, very similar to *B. insculpta* in form, rhizomes and stolons. Grows in dry areas. Valued by some for pasture, but considered by others a weed. Withstands heavy grazing and short dry spells, but is low yielding. Used for fodder, hay and mulch.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, mature, India		3.9	37.9	10.0	2.3	45.9	379
Hay, India	94.3	3.0	39.2	10.7	1.2	45.9	281
Fresh, early bloom, Venezuela	34.7	5.7	34.9	11.7	1.0	46.7	537

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Hay	Zebu	1.8	59.7	21.4	47.7	1.66	281

A21 *Bothriochloa radicans* (Lehm.) A. Camus

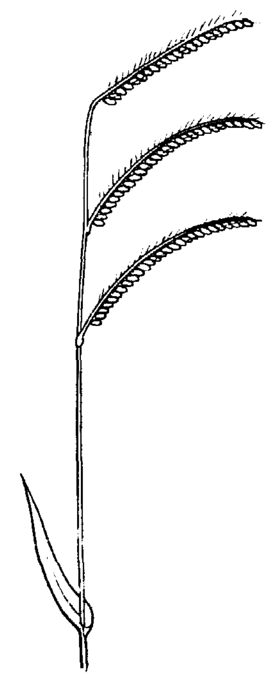
Tufted perennial 15-60 cm high which forms low cushions. Common in semiarid areas, mostly on rocky slopes in open grassland. Well liked by all grazing animals.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		10.2	28.8	8.6	3.7	48.7	130

A22 ***Brachiaria brizantha* (Hochst.) Stapf**

Signal, palisade, bread or Ceylon sheep grass

A coarse broad-leaved perennial grass up to 2 m high. Rhizomatous or stoloniferous. Very variable in habit, leafiness, hairiness and yield. Grows on most soils in sheltered places with over 750 mm of rainfall. Withstands moderate drought and binds loose soils. Prostrate types, which have high leaf stem and protein content, form valuable pastures. Under rainfed conditions only one or two cuttings possible owing to rather poor recovery. Propagated by seed. Can be grown together with *Centrosema pubescens* or *Pueraria phaseoloides*.



Brachiaria brizantha

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, mature, Nigeria	30.4	4.0	31.1	11.1	1.3	52.5	58
Hay, Kenya	91.4	8.6	31.3	10.6	1.9	47.6	499
Stem-cured, Kenya	90.6	8.7	28.0	10.8	1.6	50.9	481

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, mature	Cattle	20.0	56.6	15.4	61.0	1.84	58
Hay	Sheep	63.3	73.3	62.4	72.9	2.41	499
Stem-cured	Sheep	65.2	57.0	0.0	61.7	1.96	481

A23 ***Brachiaria decumbens* Stapf**

Suriname grass or Kenya sheep grass

Trailing perennial with up to 60-cm stems. Suitable for humid areas with well-drained sandy soils. Withstands drought but not waterlogging. Valuable constituent of East African savannahs. Readily grazed, but reported to cause scouring if eaten continually for a long time. Fairly high-yielding. Usually propagated by cuttings or tuft splits.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, early bloom, Kenya		11.2	28.0	9.9	2.8	48.1	130
Fresh, mid-bloom, Trinidad	19.5	8.2	33.4	8.4	2.5	47.5	82

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Fresh, mid-bloom	Sheep	46.9	72.9	16.9	66.1	2.21	82

A24 *Brachiaria distachya* (L.) Stapf (*Panicum distachyum* L.)

Herbaceous grass cultivated in Southeast Asia. A palatable fodder grass.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, wet season, 4 weeks, 15 cm, Thailand	21.4	8.9	27.1	12.1	3.3	48.6	219
Fresh, wet season, 8 weeks, 30 cm, Thailand	20.5	8.8	29.3	11.2	2.9	47.8	219
Fresh, wet season, 12 weeks, 55 cm, Thailand	21.6	6.9	30.6	10.2	2.8	49.5	219
Fresh, dry season, 4 weeks, 10 cm, Thailand	26.7	10.1	26.6	13.5	3.0	46.8	219
Fresh, dry season, 8 weeks, 20 cm, Thailand	25.3	9.1	26.5	14.2	3.2	47.0	219
Fresh, dry season, 12 weeks, 30 cm, Thailand	23.3	7.7	27.9	13.3	2.6	48.5	219

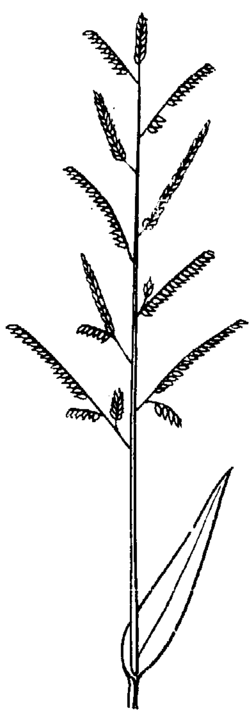
		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Fresh, 8 weeks	Sheep	58.0	65.0	61.0	65.0	2.17	219
Fresh, 12 weeks	Sheep	42.0	62.0	59.0	59.0	1.99	219

A25 *Brachiaria leersioides* (Hochst.) Stapf

Blue signal grass

An annual 20-60 cm high with narrow bluish leaves that grows in semiarid areas.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		11.8	31.5	13.5	1.9	41.3	133
Fresh, full bloom, Kenya		7.9	35.5	14.7	2.0	39.9	133



Brachiaria mutica

A26 *Brachiaria mutica* (Forsk.) Stapf (*Panicum barbinode* Trin.; *P. purpurascens* Raddi; *P. muticum* Forsk.)

Mauritius grass, Para grass, California grass, giant couch, water grass

A grass with very long trailing stems reaching 2.5 m and broad hairy leaves. Grows well only in poorly drained soils in high-rainfall areas or on seasonally wet land. Withstands waterlogging and is dormant in dry season. Should be grazed rotationally as it does not withstand heavy grazing. Often used as green chopped forage; not suitable for silage. Has proved a very satisfactory green manure crop in pineapple fields. Growers of this grass must prevent its invasion of irrigation ditches and ponds. In some areas, ponds have been completely covered with floating layers of vegetation thick enough to support the weight of grazing cattle. Easily established from cuttings or pieces of creeping shoots planted 1-2 m apart. Weeds are eventually suppressed because of the competitive vigour of this grass.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, 45 cm, Philippines	33.7	11.6	29.7	12.8	3.9	42.0	297
Fresh, 90 cm, Philippines	22.3	9.0	33.6	12.6	2.2	42.6	297
Fresh, 100 cm, Philippines	20.5	8.8	31.7	10.7	1.5	47.3	297
Fresh, mid-bloom, Trinidad	24.9	4.5	32.8	7.6	1.6	53.5	82
Fresh, dough stage, Hawaii	25.6	8.1	34.2	12.6	1.8	43.3	515
Fresh, whole aerial part, Suriname		8.8	37.5	6.9	1.3	45.5	126
Fresh leaves, Suriname		14.0	31.0	8.1	2.2	44.7	126
Fresh stems, Suriname		5.9	41.5	6.3	0.8	45.9	126
Fresh tops, Thailand	16.9	15.4	27.2	11.8	3.5	42.1	56
Hay, wet season, 6 weeks, 60 cm, Thailand	83.6	7.7	31.8	10.3	2.4	47.8	219
Hay, wet season, 8 weeks, 80 cm, Thailand	85.0	9.1	33.6	9.2	1.8	46.3	219
Hay, wet season, 10 weeks, 90 cm, Thailand	85.3	5.5	35.1	8.9	1.8	48.7	219
Hay, wet season, 12 weeks, 110 cm, Thailand	84.9	4.2	34.5	10.5	1.6	49.2	219
Hay, dry season, 6 weeks, 40 cm, Thailand	81.2	12.4	30.3	10.7	2.0	44.6	219
Hay, dry season, 8 weeks, 55 cm, Thailand	91.7	9.3	30.0	12.3	2.1	46.3	219
Hay, dry season, 10 weeks, 60 cm, Thailand	85.5	6.5	32.4	10.9	1.8	48.4	219
Hay, dry season, 12 weeks, 65 cm, Thailand	88.8	6.5	32.4	11.1	2.1	47.9	219

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, 45 cm	Sheep	73.5	77.5	54.2	79.8	2.57	297
Fresh, 90 cm	Goats	53.9	56.9	20.9	51.0	1.72	297
Fresh, 100 cm	Sheep	48.4	40.9	23.0	37.1	1.31	297
Fresh, mid-bloom	Sheep	31.6	60.7	50.0	63.5	2.07	82
Fresh, dough stage	Oxen	60.0	67.0	52.0	64.0	2.11	515
Hay, 8 weeks	Sheep	50.0	50.0	35.0	52.0	1.67	219
Hay, 12 weeks	Sheep	35.0	49.0	54.0	51.0	1.64	219

A27 *Brachiaria nigropedata* (Munro) Stapf

Tufted perennial with long wiry leaves that grows on red soil in relatively dry areas. Well liked by all stock.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, full bloom, Kenya		8.5	30.7	9.0	1.6	50.2	133

A28 *Brachiaria ruziziensis* Germ. & C. Eur.

Congo grass, bongo grass

Late-flowering perennial similar to *B. decumbens*, but with the lower glume distant from the rest of the spikelet. Light-green broad hairy leaves and flowers. Cultivated in the humid tropics for pasture. Can be grown with *Desmodium intortum* and *Stylosanthes gracilis*.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh aerial part, Congo		13.9	27.2	9.0	2.3	47.6	428
Fresh, early bloom, Brazil	22.0	7.6	35.4	8.5	1.9	46.3	537

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, vegetative	Sheep	69.2	69.8	38.3	74.1	2.45	428

A29 *Cenchrus biflorus* Roxb. (*Cenchrus catharticus* Del.)

Indian sandbur

Erect annual 15-60 cm high. Adapted to hot dry tropical areas with a short growing season, and generally found on sandy soils. A good pasture grass when young, and also used for hay and silage. Persists almost throughout the dry season and is important as a reliable source of fodder. Mature grass has sharp bristles; but ensiling softens them, so that the silage can be eaten without problems.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Tanzania	20.0	10.3	37.8	6.7	2.0	43.2	174
Fresh, late bloom, Tanzania		11.6	33.9	7.7	2.8	44.0	174
Fresh, mid-bloom, Niger		10.0	34.6	11.1	1.5	42.8	45
Hay, early bloom, India	94.9	9.0	32.9	11.6	1.0	45.5	436

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, early bloom	Sheep	71.0	75.0	64.0	69.0	2.51	174
Fresh, late bloom	Sheep	70.0	72.0	78.0	68.0	2.48	174
Hay, early bloom	Zebu	58.4	58.0	36.9	50.2	1.77	281

A30 *Cenchrus ciliaris* L. [*Pennisetum ciliare* (L.) Link]

Anjan, blue buffalo grass, African foxtail, Rhodesian foxtail, buffel grass

A very variable tufted tussock-forming perennial grass with stems up to 1.5 m high and a large, strong root system. Grows in areas with 400-500 mm of summer rainfall and a long dry season. Found on many types of soil, but prefers sandy soils and is sensitive to waterlogging. High protein content and digestibility. Palatable when young, but protein content and digestibility diminish quickly with age. Good pasture grass for dry areas. Once established, withstands close grazing and fire. Recovers quickly if phosphorus is available. Easily established from seeds, and widely used for reseeding denuded arid pasture lands. Grows well with *Stylosanthes humilis*.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early vegetative, Pakistan	41.4	9.8	38.4	9.8	5.4	36.6	309
Fresh, mature, Pakistan	21.9	7.3	41.9	8.8	4.8	37.2	309
Fresh, early bloom, Tanzania	20.0	11.0	31.9	13.2	2.6	41.3	175
Hay, first cutting, Tanzania	87.0	7.4	35.2	11.7	1.7	44.0	175

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, early bloom	Sheep	76.2	76.2	85.0	72.9	2.50	175
Hay	Sheep	54.0	71.6	47.0	67.5	2.22	175

A31 *Cenchrus setigerus* Vahl

Birdwood grass or anjan

Tufted perennial up to 120 cm high found on a wide variety of soils in areas with 250-500 mm of annual rainfall and long dry seasons. Withstands heavy grazing. Remains green into the dry season. Palatable, but not very productive. Tolerant of heat and saline soils. Can be sown with *Cyamopsis psoralioides*.

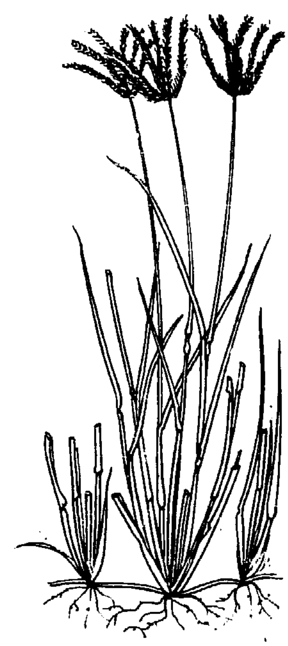
Cenchrus setigerus

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		18.6	28.3	11.9	1.9	39.3	130

A32 *Chloris gayana* Kunth

Rhodes grass

Fine-stemmed leafy turf-forming perennial up to 1.5 m high. Varieties selected for grazing (prostrate) and hay (erect). Grows in areas with 600-1 200 mm of summer rainfall and a four- to six-month dry season. Found on many soils, but prefers fertile soils. Persistent and drought resistant when well grazed and fertilized, but disappears after a few years if not well managed. New pastures should not be heavily grazed or cut until seeds have set once. Cuttings taken at monthly intervals. Palatable and one of the most satisfactory tropical grasses for hay; not suitable for silage. A popular grass very easily established by sowing. Herbage yields reasonable, but not of particularly high quality except for the first one to two months. Usual productive life of three years, which can be extended by heavy fertilization. Combines with a number of legumes, such as lucerne and centro. The Giant Rhodes variety is more palatable, leafy and drought resistant.



Chloris gayana

4

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, pasture, Zimbabwe	28.2	8.9	37.9	6.0	1.0	46.2	499
Fresh, first cutting, early bloom, Tanzania	20.0	9.5	32.5	11.8	1.7	44.5	175
Fresh, second cutting, early bloom, Tanzania	25.0	7.1	38.7	10.2	1.0	43.0	175
Fresh, mature, Hawaii	28.8	8.0	37.2	13.1	2.0	39.7	515
Hay, dry season, 6 weeks, 55 cm, Thailand	84.1	9.9	33.4	8.9	27.0	45.1	219
Hay, dry season, 8 weeks, 60 cm, Thailand	91.5	9.0	35.6	8.3	2.5	44.6	219
Hay, dry season, 10 weeks, 95 cm, Thailand	88.1	6.8	36.5	8.6	2.4	45.7	219
Hay, dry season, 12 weeks, 95 cm, Thailand	90.1	4.1	38.2	6.7	1.8	49.2	219
Hay, first cutting, Tanzania	87.0	3.7	43.5	8.7	1.3	42.8	175
Hay, second cutting, Tanzania	87.0	3.7	42.0	8.7	1.2	44.4	175
Silage, Nigeria	23.6	4.5	37.2	13.4	2.2	42.7	58

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Pasture	Cattle	62.3	75.2	36.0	67.4	2.42	499
First cutting	Sheep	69.5	83.7	47.0	77.8	2.58	175
Second cutting	Sheep	62.0	74.4	30.0	63.3	2.24	175
Mature	Oxen	58.0	70.0	50.0	60.0	2.08	515
Hay, 6 weeks	Sheep	55.0	60.0	45.0	56.0	2.81	219
Hay, 8 weeks	Sheep	54.0	62.0	54.0	56.0	2.01	219
Hay, 10 weeks	Sheep	43.0	61.0	58.0	55.0	1.95	219
Hay, 12 weeks	Sheep	17.0	51.0	36.0	52.0	1.71	219
Hay, first cutting	Sheep	31.4	56.6	46.0	50.9	1.77	175
Hay, second cutting	Sheep	32.4	55.5	42.0	46.6	1.68	175
Silage	Cattle	8.9	72.0	22.7	52.7	1.83	58

A33 ***Chloris prieurii* (Kunth) Maire (*Pennisetum prieurii* Kunth)**

An annual up to 75 cm high, adapted to semiarid and arid tropical areas (common in the Sahel). Regarded as an excellent grazing grass of high palatability.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, mid-bloom, Niger		9.2	37.1	9.2	1.8	42.7	45

A34 ***Chloris roxburghiana* Schult. (*C. myriostachya* Roxb.)**

Tufted perennial 30-120 cm high that grows in arid and semiarid areas, often as a pioneer grass of abandoned cultivation or desert woodland. Readily grazed.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		16.1	30.8	8.8	0.9	43.4	131

A35 *Chloris virgata* Sw.

Blackseed grass or feather finger grass

An annual, usually leafy, up to 90 cm high, widely distributed in the tropics and in the subtropics with a shorter growing season. Palatable grazing when young, and fair hay if cut at the flowering stage.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, full bloom, Kenya		12.9	31.1	13.8	1.8	40.4	133
Hay, Zimbabwe	88.2	10.3	34.2	12.7	1.8	41.0	499

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Hay	Cattle	46.5	58.1	47.3	57.4	1.84	499

A36 *Chrysopogon fulvus* (Spreng.) Chiov. (*C. montanus* Trin.)

Guria grass

Tufted perennial up to 80 cm high that grows under an annual rainfall of 300-1 200 mm. Considered a useful pasture grass and has been used to oversow poor natural pastures. Should not be grazed during the establishment year. Palatable and fairly high-yielding.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
First cutting, India		6.1	36.8	9.7	1.3	46.1	436
Second cutting, India		4.6	36.7	8.7	1.2	48.8	436
Third cutting, India		4.5	31.6	10.8	1.6	51.6	436
Pre-bloom, India		9.0	32.6	11.0	2.1	45.4	442
Hay, post-bloom, India		4.7	36.6	8.7	1.1	48.9	436

A37 *Chusquea baculifera* Alv. Silv.

Bamboo

Native to South America, where it is the dominant vegetation at elevations of 2 000-2 800 m over an extensive area of the Andean and Brazilian highlands. The leaf is good forage.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Dried leaves, Brazil	89.8	8.8	34.4	10.5	3.1	43.2	112

A38 *Chusquea pinifolia* Nees

Bamboo

Tall shrub or climber with short leaves, together with *C. baculifera* the dominant vegetation at high elevations on Serra do Capārao and in Minas Gerais, Brazil. A potentially important source of forage.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Dried leaves, Brazil	87.7	7.6	41.2	7.3	5.0	38.9	112

A39 *Chusquea quita* Kunth

Bamboo

Tall shrub with relatively short leaves that is characteristic of the Andes and Brazilian highlands, where it covers wide areas and forms impenetrable thickets known as Carizales. Can grow at very high altitudes.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Leaves, Chile	56.8	10.0	34.5	11.3	3.6	40.5	315

A40 *Coix lachryma-jobi* L.

Adlay or Job's tears

Robust broad-leaved loose-growing branched grass up to 1.5 m high. The seeds of various colours — yellow, purple, white or brown — are popular ornamental beads. Cultivated as a fodder crop, and the grain from cereal varieties can be used after grinding for poultry feed. Suitable for silage.

Coix lachryma-jobi

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early vegetative, India	29.9	8.5	27.9	8.9	2.8	51.9	442
Fresh, milk stage, Venezuela	38.3	7.0	32.0	11.4	7.2	42.4	537
Seeds, Colombia	90.1	8.1	17.0	5.9	3.6	65.4	537

A41 *Cymbopogon giganteus* (Hochst.) Chiov.

Tufted perennial 1.5-2.4 m high with thick stems that occurs in wooded grasslands. Remains green long into the dry season. Well grazed only if thinly scattered among other grasses. Low nutritive value. Aromatic leaves with a characteristic "pepper" flavour.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		5.0	33.2	6.5	4.1	51.2	130
Fresh, 12 weeks, Ghana	27.9	11.2	24.5	7.5			437
Fresh, 16 weeks, Ghana		5.6	22.9	9.2			437
Fresh, 24 weeks, Ghana	46.8	4.8	27.2	7.1			437
Fresh, 32 weeks, Ghana	45.9	4.3	24.0	11.6			437

A42 *Cynodon aethiopicus* Clayton & Harland

Giant star grass

Stoloniferous perennial with tall robust stems that occurs naturally throughout East Africa at higher altitudes. Palatable and readily eaten by cattle. Very good results reported from experiments with fertilized pastures of this grass. Can be rich in HCN if heavily fertilized and irrigated. Easily propagated from stolons.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, first cutting, India		12.2	26.6	11.9	1.7	47.6	436
Fresh, second cutting, India		9.4	30.4	11.2	0.9	48.1	436
Fresh, third cutting, India		7.2	32.7	8.2	0.9	51.0	436
Fresh, fourth cutting, India		5.4	37.6	10.8	0.9	45.3	436
Hay, pre-bloom, India		6.4	35.6	6.8	0.6	50.6	436

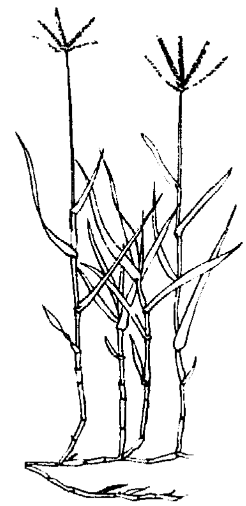
	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Hay, pre-bloom	Cattle	54.0	62.0	19.0	29.0	1.48	436

A43 ***Cynodon dactylon*** **(L.) Pers.**

Bermuda, Bahamas, dhoub, kiri-hiri, devil's, African couch, star or kweek grass

Highly variable perennial with stems up to 120 cm tall that forms a dense turf. Grows almost anyplace with more than 600 mm of rainfall a year and a mean daily temperature above 24°C. Found on many soils, particularly where the pH is above 5.5 and fertility is moderate to high. Withstands temporary waterlogging and prolonged drought, but is unproductive. Responds well to fertilizers and has a very high nutritive value that is retained well into the dry season. Best grazed at 10-15 cm, when it is palatable. Not to be used in temporary pastures, for it is difficult to eradicate from arable land. Tolerates saline soils and high grazing pressure.

The Coastal Bermuda variety has longer and larger leaves, stems and rhizomes, is more resistant to drought and leafspot, and is immune to root-knot nematode. Twice as productive as common Bermuda and less troublesome to eradicate. Best grazed when 25-30 cm high. Introduction of this grass in the southern states of the United States sharply increased herbage production and revolutionized the livestock industry. Can easily be propagated from pieces of stolons and rhizomes.



Cynodon dactylon

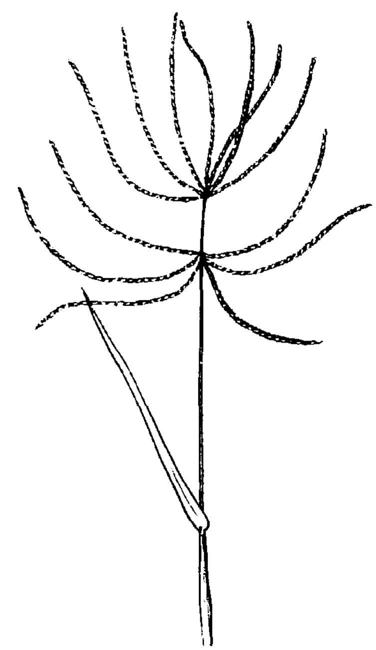
		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, early vegetative pasture	19.1	12.2	33.3	9.6	1.6	43.3	82
Fresh, mature pasture, Trinidad	30.2	8.8	33.3	7.4	1.7	48.8	82
Fresh, 6 weeks, India	29.5	14.2	26.6	12.4	1.9	44.9	190
Fresh, 10 weeks, India	39.8	13.2	29.4	12.0	1.5	43.9	190
Fresh, 14 weeks, India	36.3	11.9	28.5	11.3	1.8	46.5	190
Hay from lawn mowings, India	91.3	11.1	18.4	12.5	1.4	56.6	282
Fresh, Coastal Bermuda, mature, Trinidad	29.1	8.3	29.7	6.5	2.4	53.1	82
Fresh, Coastal Bermuda, mid-bloom, Trinidad	29.0	9.4	30.8	6.9	2.0	50.9	82
Hay, Coastal Bermuda, 35 days, late vegetative, Venezuela		10.9	30.5	8.7	1.8	48.1	84
Hay, Coastal Bermuda, 45 days, late vegetative, Venezuela		12.0	27.3	10.7	2.9	47.1	84
Hay, Coastal Bermuda, 55 days, mid-bloom, Venezuela		10.4	27.9	9.9	3.0	48.8	84

	Animal	Digestibility (%) CP	CF	EE	NFE	ME	Ref.
Fresh, young pasture	Sheep	68.4	66.2	32.9	58.7	2.12	82
Fresh, mature pasture	Sheep	57.9	61.1	49.7	52.2	1.94	82
Hay from lawn mowings	Zebu	54.4	53.1	27.3	46.4	1.59	282
Coastal Bermuda, mature	Sheep	60.7	60.4	45.9	62.0	2.14	82
Coastal Bermuda, mid-bloom	Sheep	64.3	65.8	41.7	60.8	2.18	82
Hay, Coastal Bermuda, 35 days	Sheep	59.7	62.5	32.9	52.8	1.93	84
Hay, Coastal Bermuda, 45 days	Sheep	70.1	67.6	47.6	57.4	2.11	84
Hay, Coastal Bermuda, 55 days	Sheep	65.4	64.0	54.3	51.3	1.97	84

A44 *Cynodon plectostachyus* (K. Schum.) Pilger

Naivasha star grass

Spreading perennial with stout fast-growing stolons forming dense turf. Found on dry lake beds. More tropical in climatic adaptation than Bermuda grass and more productive under dry conditions with 500-800 mm of rain. Considered valuable pasture for drier areas, but is low in competitive vigour.



Cynodon plectostachyus

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, late vegetative, 25 cm, Tanzania	20.0	19.1	22.6	13.0	2.9	42.4	175
Fresh, early bloom, 40 cm, Tanzania	28.0	11.0	30.3	11.4	1.3	46.0	175
Fresh, early bloom, 60 cm, Tanzania	30.0	11.0	30.2	11.6	2.0	45.2	175
Hay, first cutting, Tanzania	88.0	10.5	31.4	10.2	1.6	46.3	175
Hay, second cutting, Tanzania	89.0	8.0	33.4	10.0	3.6	45.0	175
Hay, 6 weeks, Tanzania		10.5	31.4	10.2	1.6	46.3	173
Hay, 16 weeks, Tanzania		8.0	33.4	10.0	3.6	45.0	173
Hay, 22 weeks, Tanzania		7.3	37.1	8.7	1.0	45.9	173
Hay, 38 weeks, Tanzania		5.2	39.7	8.1	0.9	46.1	173
Standing hay, Tanzania	91.0	5.2	39.7	8.1	0.9	46.1	175

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, 25 cm	Sheep	80.1	69.9	48.0	69.8	2.41	175
Fresh, 40 cm	Sheep	73.6	60.1	23.0	63.0	2.08	175
Fresh, 60 cm	Sheep	73.6	63.9	35.0	53.5	1.97	175
Hay, first cutting	Oxen	58.1	62.7	19.0	60.5	2.01	175
Hay, second cutting	Oxen	46.3	54.8	67.0	48.9	1.80	175
Hay, 6 weeks	Cattle	58.5	62.7	17.5	60.5	2.01	173
Hay, 16 weeks	Cattle	46.6	54.8	66.8	48.9	1.80	173
Hay, 22 weeks	Cattle	51.2	53.6	9.6	47.2	1.67	173
Hay, 38 weeks	Cattle	23.0	39.9	22.8	51.4	1.50	173
Standing hay	Oxen	23.1	40.0	22.0	51.4	1.50	175

A45 *Cypholepsis yemenica* (Schweinf.) Chiov.

Tufted perennial 30-45 cm high occurring in arid and semiarid areas, mostly on rocky ground. Useful for reseeding bare rocky ground. Rather stemmy, but well liked by grazing animals.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		15.5	37.9	7.8	1.8	37.0	130

A46 *Dactylis glomerata* L.

Cocksfoot or orchard grass

Strongly tufted deep-rooted long-lived perennial up to 140 cm high, introduced in temperate areas throughout the world. Most valuable for pasture and hay in humid temperate climates. Does not produce seed in the tropics because of the shorter summer photoperiod. Can be propagated from imported seeds or planted slips. Produces a continuous growth of young leaves and can withstand heavy grazing. Grows well also in shade.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, pasture, Chile	26.7	12.6	33.1	9.0	3.5	41.8	315
Hay, Chile	87.5	16.1	37.7	12.2	3.3	30.7	315

A47 *Dactyloctenium aegyptium* (L.) Beauv.

Crowfoot grass

An annual up to 75 cm high with soft, slightly succulent leaves that grows on denuded land in semiarid areas or as a weed on arable land. Reputed to contain cyanogenetic glucosides and therefore to be a danger for stock at certain times. One of the best annual grazing grasses in semiarid areas, but it dries out with the onset of the dry season.

Dactyloctenium aegyptium

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		15.8	26.8	10.0	1.8	45.6	131
Fresh, full bloom, Kenya		15.6	27.9	13.6	1.5	41.4	133
Fresh, mid-bloom, Niger		8.7	32.4	10.6	1.5	46.8	45
Fresh, milk stage, India		7.3	33.7	12.5	1.2	45.3	436
Hay, Zimbabwe	91.3	8.3	36.9	6.5	0.8	47.5	499

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Hay	Cattle	44.3	57.6	38.3	50.0	1.81	499

A48 *Dendrocalamus strictus* (Roxb.) Nees

Bamboo or male bamboo

Tall shrub, native to southern Asia, with a crowded clump habit and large erect culms. Grows on poor, gravelly soils and does well with rainfall of 1 000-1 500 mm annually. A relished roughage, yielding as much as 100 tons per hectare in some areas.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh leaves, Pakistan	27.4	20.5	26.0	14.8	7.5	31.2	308
Fresh leaves, India		14.2	27.6	12.0	1.7	44.5	436

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Leaves	Cattle	66.0	58.0	33.0	50.0	1.83	436

A49 ***Dichanthium annulatum*** **(Forsk.) Stapf (*Andropogon annulatus* Forsk.)**

Marvel or Delhi grass

Tufted perennial 60-120 cm high that occurs occasionally in grassland on rocky ground. Drought resistant and forms open turf under grazing. Usually coarse and stemmy. Very palatable and a popular pasture grass despite its low nutritive value. One of the best-known grasses of India.

Dichanthium annulatum

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, 6 weeks, India	25.0	10.4	34.9	12.1	1.7	40.9	190
Fresh, 10 weeks, India	35.3	6.1	38.8	9.8	1.3	44.0	190
Fresh, 14 weeks, India	37.6	5.9	41.4	9.8	1.1	41.8	190
Fresh, early bloom, Kenya		8.5	39.0	6.9	1.1	44.5	131
Fresh, milk stage, India		4.7	40.7	10.9	1.3	42.4	436
Fresh, first cutting, India		5.2	31.4	11.9	1.6	49.9	436
Fresh, second cutting, India		3.8	35.0	9.9	1.2	50.1	436
Fresh, third cutting, India		2.7	33.3	10.1	1.0	52.9	436
Fresh, grown on saline soil, India		2.6	37.7	10.3	1.7	47.7	378
Hay, late vegetative, India		4.6	38.9	9.5	0.9	46.1	242
Hay, mid-bloom, India		4.1	39.9	10.6	1.0	44.4	436
Hay, mature, India		2.7	39.1	11.5	1.2	45.5	436

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Fresh, 10 weeks	Cattle	47.4	70.3	44.6	46.2	1.89	541
Hay, late vegetative	Zebu	28.0	60.4	29.2	42.4	1.63	242

A50 ***Dichanthium caricosum*** **(L.) A. Camus (*Andropogon caricosus* L.)**

Nadi bluegrass, Antigua hay grass or Indian bluestem

An annual or a creeping perennial, leafy and densely tufted. Persistent under heavy grazing but not very palatable. Withstands rather long dry periods during which it does not grow. Extensively used in some areas as pasture and hay grass.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, mid-bloom, Tanzania	28.0	7.0	36.7	11.7	1.5	43.1	175
Hay, first cutting, Tanzania	88.0	6.1	40.3	11.8	1.7	40.1	175

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Fresh, mid-bloom	Sheep	54.3	77.9	67.0	66.8	2.31	175
Fresh, first cutting	Sheep	45.9	61.3	65.0	47.6	1.79	175

A51 *Digitaria decumbens* Stent

Pangola or pongola grass

Digitaria decumbens

A perennial with semierect stems up to 1 m long, forming open turf. Grows best on moist fertile well-drained soils with annual rainfall above 800 mm. Adapts to a wide variety of soils, and tolerates drought and a high level of acidity, but not prolonged waterlogging, alkaline conditions or copper deficiency. Used primarily for pasture; withstands trampling and overgrazing, but does not persist under continuous close grazing. Poor nutritive value when stems have elongated. Aggressive against weeds. Can be grown with *Trifolium repens* or *Lotononis bainesii* provided that little nitrogen fertilizer is applied. Fertilization with nitrogen and rotational grazing greatly improve the nutritive value (ref. 85). The mean crude protein content of 610 samples of pangola grass was as follows: when fertilized with nitrogen, 13.2%; with rotational grazing, 10.5%; with constant grazing, 5.6%; and ungrazed, 4.9%.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, early bloom, Trinidad	28.6	8.2	33.3	6.9	2.0	49.6	82
Fresh, dough stage, Trinidad	39.3	6.8	29.5	7.8	2.1	53.8	82
Fresh, pasture, 10 days' regrowth after grazing, Trinidad	14.8	14.9	31.0	11.4	3.0	39.7	81
Fresh, pasture, 15 days' regrowth after grazing, Trinidad	20.3	13.7	29.6	10.9	3.5	42.3	81
Fresh, pasture, 21 days' regrowth after grazing, Trinidad	21.4	9.2	35.3	12.2	2.3	41.0	81
Fresh, pasture, 42 days' regrowth after grazing, Trinidad	21.1	4.8	36.3	6.9	1.0	51.0	81
Hay, 35 days, Venezuela		6.9	34.7	9.8	1.8	46.8	84
Hay, 45 days, Venezuela		7.5	33.1	9.8	2.3	47.3	84
Hay, 62 days, Venezuela		5.8	29.6	9.1	2.3	53.2	84
Standing hay, Trinidad	71.8	3.2	33.5	5.9	1.3	56.1	82
Silage, Trinidad	27.2	6.9	29.9	16.2	2.0	45.0	82

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Early bloom	Sheep	60.6	71.9	39.5	67.2	2.35	82
Dough stage	Sheep	47.6	69.4	34.4	68.7	2.27	82
Pasture, 10 days	Sheep	71.5	71.2	50.9	62.0	2.26	81
Pasture, 15 days	Sheep	66.0	69.9	41.1	61.7	2.19	81
Pasture, 21 days	Sheep	57.6	66.1	25.5	58.9	1.99	81
Pasture, 42 days	Sheep	18.8	59.5	19.2	56.2	1.87	81
Hay, 35 days	Sheep	45.0	59.5	40.6	50.9	1.80	84
Hay, 45 days	Sheep	52.9	64.3	47.9	49.7	1.87	84
Hay, 62 days	Sheep	37.8	56.6	49.8	53.9	1.83	84
Standing hay	Sheep	17.5	72.3	28.0	71.9	2.39	82
Silage	Sheep	16.9	72.5	44.5	63.9	1.94	82

A52 *Digitaria exilis* Stapf

Acha or hungry rice

Annual grass suited to poor sandy soils. Cultivated as a cereal in West Africa. Can be cut for silage. Straw from threshing commonly used as fodder.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Straw, Nigeria	97.0	5.4	30.1	7.0	1.7	55.8	204

A53 *Digitaria gazensis* Rendle

Tufted perennial 30-75 cm high that occurs under a wide range of conditions and is commonly found in waterlogged black clays. A good grazing grass of local importance in eastern and southern tropical Africa.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		13.7	28.2	8.1	3.7	46.3	130
Hay, Zimbabwe	91.1	11.5	30.1	13.3	2.4	42.7	499

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Hay	Cattle	56.2	61.5	53.2	54.3	1.88	499

A54 *Digitaria macroblephara* (Hack.) Stapf

Perennial up to 90 cm high that grows in arid and semiarid areas, where it is highly valued as a grazing grass. One of the most drought-resistant species of *Digitaria,* remaining green long into the dry season.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		12.3	32.2	11.2	1.8	42.5	131

A55 *Digitaria milanjiana* (Rendle) Stapf

Tufted perennial up to 90 cm tall that is very common in eastern and southern tropical Africa. Highly palatable. Fairly high yielding.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		8.1	36.8	9.7	2.3	43.1	130
Hay, Malawi	89.6	12.5	29.2	9.2	2.3	46.8	499

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Hay	Cattle	56.4	68.1	41.0	60.1	2.11	499

A56 *Digitaria pentzii* Stent

Woolly finger grass or pangola river grass

Densely tufted perennial with stems up to 120 cm high and variably hairy leaves and sheaths. Grows under a wide range of conditions; often found on sandy soils. Valuable dry-season pasture grass, but intolerant of heavy grazing. Not very palatable during grazing season. Improves soil structure and assists stabilization.

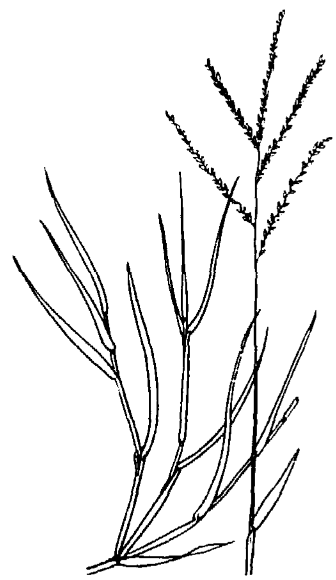
	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, vegetative, 12 cm, Tanzania	20.0	14.0	28.4	14.3	3.0	40.3	175
Fresh, early bloom, 20 cm, Tanzania	28.0	8.7	31.7	11.8	1.9	45.9	175
Fresh, early bloom, 30 cm, Tanzania	30.0	6.7	35.2	11.5	2.3	44.3	175
Hay, South Africa	93.4	10.1	32.9	7.8	2.0	47.2	353

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, 12 cm	Sheep	83.6	82.4	77.0	80.6	2.70	175
Fresh, 20 cm	Sheep	60.9	77.0	37.0	72.8	2.37	175
Fresh, 30 cm	Sheep	55.2	71.3	57.0	60.3	2.13	175
Hay	Sheep	57.3	68.6	40.2	62.5	2.19	353

A57 ***Digitaria scalarum*** **(Schweinf.) Chiov. (*Panicum muticum* Hochst.)**

African couch or Dunn's finger grass

A rhizomatous perennial with stems 35-50 cm high. Common in more humid areas; also a troublesome weed in cultivations. Nutritious and well liked by cattle, but not very productive.



Digitaria scalarum

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, early bloom, Kenya		14.7	29.0	9.5	3.8	43.0	131

A58 *Digitaria setivalva* Stent

Perennial with stems up to 120 cm high, sometimes branched, and usually hairy leaves. Low yielding but palatable.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Hay, Zimbabwe	88.6	13.2	27.7	11.4	2.6	45.1	499
Fresh, late vegetative	29.7	10.4	29.8	11.3	2.4	46.0	537

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Hay	Cattle	54.0	59.4	52.8	58.7	1.97	499

A59 *Digitaria swazilandensis* Stapf

Swaziland finger grass

Grass with many branched stems up to 60 cm high, adapted to tropical and subtropical summer-rainfall areas. Thrives on poor soils and tolerates drought. Low yielding and not very palatable. Can be grown with *Trifolium repens*.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Hay, Zimbabwe	90.5	13.2	34.6	9.7	1.3	41.2	143
Fresh, blooming	30.1	7.5	30.5	11.6	1.9	48.5	537

A60 *Echinochloa colonum* (L.) Link

Jungle rice or shama millet

Trailing or floating annual grass with stems up to 3 m high that grows along the banks of lakes and rivers. Very palatable succulent fodder. Also cultivated for grain. Can give several cuttings.

Echinochloa colonum

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, mid-bloom, Niger		12.5	28.6	12.4	2.4	44.1	45
Fresh, 6 weeks, India	14.3	15.8	28.6	15.2	2.3	38.1	190
Fresh, 10 weeks, India	21.1	9.9	31.3	17.4	1.9	39.5	190
Fresh, 14 weeks, India	27.7	7.2	31.7	16.2	1.5	43.4	190

A61 ***Echinochloa crusgalli* var. *crusgalli* (L.) Beauv. (*E. frumentacea*)**

Japanese millet, barnyard millet, chiwaga, billion dollar grass

Tall robust annual, 60-120 cm high, cultivated as a cereal in the tropics and subtropics. If sown during the rainy season, reaches maturity in about six weeks with good yields of rather coarse fodder. Fertile, moist but well-drained soils required for high yields. Grows vigorously, tolerates temporary flooding, and can sometimes already be grazed three weeks after sowing. Strip grazing recommended, starting when the crop is 30-40 cm high; can be grazed five times. Often occurs as a weed in rice and cotton. Suitable for ensiling, but too succulent for easy haymaking.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, late bloom, USA	24.4	7.4	31.1	8.6	2.9	50.0	391
Hay, USA	89.1	13.5	22.7	10.4	2.5	50.9	366

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Late bloom	Sheep	57.0	59.0	60.0	64.0	2.14	391
Hay	Cattle	60.0	75.0	69.0	76.0	2.50	366

A62 *Echinochloa haploclada* (Stapf) Stapf

Tufted perennial 60-150 cm high occurring on stream banks and in swamps. Well grazed when young. A good seed producer, and easily established from seed on seasonally waterlogged ground.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		13.7	30.7	11.3	3.0	41.3	130

A63 *Echinochloa polystachya* (H.B.K.) Hitchc. [*Echinochloa spectabilis* (Nees) Link]

African wonder cockspur or alemán grass

Similar to *E. stagnina* (see A65). Grows on lake shores and along rivers in Central and South America. An important grass in Brazil. Gives large yields of palatable fodder. Much used for grazing, soilage and hay.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, 2 weeks, Costa Rica	16.0	13.8	32.0	12.7	4.2	37.3	537
Fresh, 4 weeks, Costa Rica	17.0	13.0	31.6	13.3	2.9	39.3	537
Fresh, 6 weeks, Costa Rica	18.5	10.5	33.4	12.9	3.0	40.3	537
Fresh, 8 weeks, Costa Rica	20.7	8.3	35.6	11.5	2.1	46.0	537
Hay, late vegetative, Costa Rica	83.9	12.9	32.2	12.6	3.3	39.0	537
Hay, mid-bloom, Costa Rica	86.4	7.9	35.5	10.5	2.1	44.0	537

A64 *Echinochloa pyramidalis* (Lam.) Hitchc. & Chase

Antelope grass

Tall perennial, usually 1.8-2.4 m high but occasionally reaching 3.4-4.5 m. Grows in wet clay soils, alongside water and in floating meadows. Drought resistant. Provides valuable dry-season grazing or high yields of fodder after coarse rainy-season growth has been burned off.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, full bloom, Kenya		7.0	31.4	8.6	1.1	51.9	133
Hay, Zimbabwe	82.5	15.6	33.5	10.2	2.4	38.3	499

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Hay	Cattle	56.5	54.8	41.2	64.0	2.01	499

A65 *Echinochloa stagnina* (Retz.) Beauv.

Tropical aquatic perennial growing along rivers and in lakes and lagoons in water up to 3 m deep. The long, trailing leafy stems, which float on the water surface, have a high sugar content; if dried, they make coarse but palatable hay. When the water recedes, the stems root at the nodes and produce excellent regrowth for grazing during the dry season. Very productive and highly palatable.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, mid-bloom, Niger		11.3	32.5	9.9	2.2	44.1	45
Fresh, mature, Philippines	19.3	6.7	33.7	11.9	2.1	45.6	298

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Hay	Sheep	59.3	62.5	80.5	51.8	1.92	298

A66 *Eleusine coracana* (L.) Gaertn.

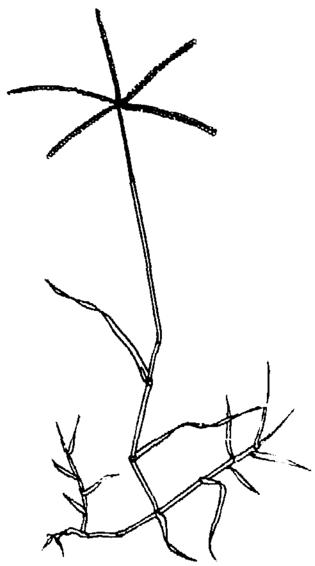
Finger millet, African millet, Indian millet, rupuko or ragi

Stout annual up to 120 cm high grown as a cereal in tropical Africa and Asia. Also used as a fodder catch crop. Called finger millet because the inflorescence resembles a human hand with the palm turned upward and the fingers partially contracted. Matures in 4-5 months. Tolerates under 130 mm of rainfall if well distributed.

Once the grain ripens, the plant loses its high feed value. Straw from the irrigated crop is fibrous but improves after stacking, as fermentation makes it more palatable and less tough. Rainfed straw is of better quality and readily consumed by stock.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, late vegetative, India		7.6	33.6	15.1	1.1	42.6	378
Fresh, dough stage, India		7.1	28.8	12.5	1.7	49.9	378
Straw, India	95.0	3.2	34.2	7.9	1.3	53.4	378
Silage from straw, India		3.6	38.8	9.6	1.5	46.5	436

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Straw	Cattle	16.0	79.6	47.0	59.3	2.20	378
Straw silage	Cattle	8.0	69.0	44.0	52.0	1.90	436



Eleusine indica

A67 *Eleusine indica* (L.) Gaertn.

Rapoka grass, fowlfoot grass or goose grass

An annual 30-60 cm high, widespread throughout the tropics of the eastern hemisphere as a weed on cultivated land. Palatable pasture, but the leaves are said to contain cyanogenetic glycosides which are harmful to stock, especially when the leaves are wilted; can be used without danger, however, for hay or silage.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, 4 weeks, Ghana	19.3	12.8	25.1	12.2			437
Fresh, 8 weeks, Ghana	26.2	8.2	23.7	9.1			437
Fresh, 12 weeks, Ghana	35.9	8.4	30.2	9.2			437
Fresh, 16 weeks, Ghana	38.4	6.0	28.6	10.1			437
Fresh, mature, Thailand	21.2	13.3	28.5	12.0	2.8	43.4	56
Hay, USA	92.1	3.5	35.8	9.9	1.1	49.7	163

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Hay	Sheep	0.0	44.0	10.0	34.0	1.19	163

A68 *Elyonurus argenteus* Nees

Tufted perennial 30-75 cm high occurring in moderately dry areas. A very early grass which provides some grazing at the end of the dry season.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		8.0	37.8	7.5	1.9	44.8	130

A69 *Entolasia imbricata* Stapf

Bungoma grass

Tufted perennial, 60-120 cm high, found in swamps. A rather stemmy grass, but its stems are soft. Very palatable.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		19.5	14.8	8.5	1.1	56.1	130

A70 *Eragrostis caespitosa* Chiov.

Cushion love grass

Low-growing tufted perennial common in arid and semiarid areas, where it is useful for grazing. A valuable grass on poor soils where other grasses are sparse.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		8.7	37.5	8.1	1.8	43.9	130

Eragrostis cilianensis

A71 ***Eragrostis cilianensis*** **(All.) Lutati**

Grey love grass of stinkgrass

An annual up to 45 cm high with numerous relatively soft stems. Grows on partially denuded grassland, on bare ground, at roadsides and as a weed on arable land. One of the first pioneer grasses to appear on denuded land in semiarid areas. The whole plant readily eaten by stock. Suitable for reseeding denuded pastoral land in arid areas.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, late bloom, Kenya		15.3	29.0	10.6	2.4	42.7	133

A72 *Eragrostis curvula* (Schrad.) Nees

Weeping love grass

Variable, strongly tufted grass with flowering stems up to 1.5 m high. Grows in areas with 500-1 000 mm of rainfall on well-drained sandy soils. Drought resistant; useful in dry areas for grazing and hay. Remains green throughout the summer. Palatable only when young. Rotational grazing required for maintenance. Useful as a pasture grass because it is easy to establish from seeds and gives reasonable yields, especially when fertilized.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, pasture, Chile	30.0	13.1	31.5	6.0	2.1	47.3	315
Stem-cured, Kenya	90.5	6.3	34.5	5.5	2.3	51.4	481

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Stem-cured	Sheep	51.4	55.6	21.4	55.2	1.90	481

A73 *Eragrostis lehmanniana* Nees

Lehmann love grass

Tufted perennial grass. Drought resistant; adapted to semiarid tropical and subtropical summer-rainfall areas. Cultivated for pasture and hay. Only about half the annual growth should be grazed off.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Hay, late vegetative, South Africa		10.4	31.9	8.7	1.7	47.3	63
Hay, mature, South Africa		6.7	31.7	9.6	1.8	50.2	63

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Hay, late vegetative	Sheep	68.3	70.3	40.4	61.1	2.21	63
Hay, mature	Sheep	58.6	63.0	51.5	59.4	2.04	63

A74 *Eragrostis superba* Peyr.

Veld love grass or Masai love grass

Tufted perennial, 30-75 cm high, common in arid and semiarid areas. Often an important component of pastures, and well liked by cattle. Also used for reseeding denuded land in dry areas.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, early bloom, Kenya		11.3	32.3	6.6	1.9	47.9	130
Fresh, mature, India		5.3	39.4	6.9	1.1	47.3	436

A75 ***Eragrostis tef*** **(Zucc.) Trotter [*E. abyssinica* (Jacq.) Link]**

Teff

Leafy quick-maturing (10-12 weeks) annual with stems up to 120 cm high that grows in dry areas with a short rainy season. Prefers heavy soils. Resistant to most pests and diseases but not to weed competition. Used as annual hay grass in arid areas, but is stemmy and unproductive elsewhere. Mostly cultivated for its grain; also makes good pasture and can be combined with legumes.

Eragrostis tef

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Hay, late vegetative, South Africa	93.2	10.5	34.2	5.3	1.1	48.9	423
Hay, mature, South Africa	91.8	8.8	33.1	6.9	1.1	50.1	423

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Hay, late vegetative	Sheep	61.2	67.1	22.9	57.8	2.15	423
Hay, mature	Sheep	57.2	74.5	43.2	60.5	2.24	423

A76 *Erianthus ravennae* Beauv. (*Saccharum ravennae* L.)

Ravenna grass or plume grass

Tall coarse reedlike perennial grass with dense silky panicles, often cultivated for ornament. Grows to nearly 6 m tall with leaves 90-150 cm long. Water buffaloes can eat this grass when the plants are young, but it has little fodder value.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Hay, mid-bloom, India		1.9	43.9	6.9	1.6	45.7	436

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Hay, mid-bloom	Cattle	0.0	57.0	24.0	44.0	1.66	436

A77 *Eriochloa nubica* (Steud.) Hack. & Stapf *ex* Thell.

An annual 20-70 cm high that grows on alluvial soil in dry areas as well as on stream banks, at roadsides and as a weed on arable land. Usually produces a reasonable bulk of leafy herbage that is well liked by stock.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, full bloom, Kenya		10.2	33.5	16.2	1.4	38.7	133
Fresh, 4 weeks, Ghana	21.5	13.2	21.2	14.5			437
Fresh, 8 weeks, Ghana	24.3	6.3	26.7	6.8			437
Fresh, 12 weeks, Ghana	31.8	4.2	31.3	8.2			437
Fresh, 20 weeks, Ghana	44.1	5.1	30.2	6.9			437

A78 *Eriochloa polystachya* H.B.K.

Carib grass. Carib cup grass of malojilla

Trailing annual having stems that grow to 2.5 m and root at the lower nodes. Grows in humid areas with evenly distributed rainfall; withstands waterlogging. Similar to *Brachiaria mutica*, but less productive and more palatable.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, whole aerial part, Suriname		10.3	32.9	10.6	1.9	44.3	126
Fresh, stems only, Suriname		7.1	37.1	10.6	1.3	43.9	126
Fresh, leaves only, Suriname		14.4	27.5	10.7	2.8	44.6	126

A79 *Eustachys paspaloides* (Vahl) Lanza & Mattei

Perennial 30-60 cm high that forms slowly spreading colonies. Occurs in arid and semiarid areas, often on seasonally waterlogged ground. Leafy and well liked by grazing animals.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		9.7	33.8	10.0	2.6	43.9	130

A80 *Heteropogon contortus* (L.) Beauv. *ex* Roem. & Schult. (*Andropogon contortus* L.)

Spear, pili or tanglehead grass

Tufted perennial with stems up to 120 cm high and long awns that are twisted together when mature. Widely distributed and abundant in areas with less than 800 mm of annual rainfall. Highly resistant to grass fires. Quick growing and valuable as fodder or hay until awns form, as these can injure the mouths and skin of stock. Good hay obtained if cut before flowering. Seldom cultivated, but normally found wherever grasslands are periodically burned.

Heteropogon contortus

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, pasture, late vegetative, Zimbabwe	28.7	9.4	28.9	6.3	1.0	54.4	499
Fresh, 4 weeks, Ghana	31.3	9.4	31.2	11.7			437
Fresh, 8 weeks, Ghana	36.2	6.3	33.7	6.5			437
Fresh, 16 weeks, Ghana	36.5	7.0	39.2	6.4			437
Fresh, 36 weeks, Ghana	57.5	2.5	25.6	8.4			437
Hay, late vegetative, India		5.9	33.6	13.3	1.1	46.1	436
Hay, dough stage, India	92.6	3.5	40.1	8.2	1.0	47.2	278
Silage, immature, India		6.6	36.9	12.2	1.3	43.0	436

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, late vegetative	Cattle	41.4	40.1	30.4	66.2	1.91	499
Hay, late vegetative	Cattle	42.0	63.0	42.0	50.0	1.74	436
Hay, dough stage	Cattle	22.6	13.4	34.5	47.5	1.07	278

A81 ***Hordeum vulgare* L. (*H. sativum* Pers.)**

Barley

A well-known crop, often grown for fodder and also good for grazing, especially when irrigated. If grazing is not continued until too late in spring, the crop will give a satisfactory grain yield or can be cut for hay or silage. Rough-awned varieties used for hay or silage may damage the mouths of livestock.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, 7 weeks after sowing, South Africa	18.4	22.7	20.2	12.4	5.1	39.6	489
Fresh, 8 weeks after sowing, South Africa	18.9	20.4	20.5	12.1	4.6	42.4	489
Fresh, 9 weeks after sowing, South Africa	20.6	17.2	22.5	11.9	4.4	44.0	489
Fresh, 10 weeks after sowing, South Africa	21.4	14.8	25.0	10.7	4.4	45.1	489
Fresh, 11 weeks after sowing, South Africa	22.3	11.7	26.2	10.8	3.9	47.4	489
Fresh, 12 weeks after sowing, South Africa	22.3	11.3	26.6	11.3	3.6	47.2	489
Fresh, 13 weeks after sowing, South Africa	22.9	10.4	27.0	10.0	3.5	49.1	489
Fresh, 1 month, India		15.8	19.1	16.6	3.1	45.4	436
Fresh, 2 months, India		6.6	31.1	10.6	2.4	49.3	436
Fresh, 3 months, India		5.4	27.0	7.8	2.5	57.3	436
Straw, Kenya		6.0	39.6	9.3	0.6	44.5	416
Straw, Iraq	91.7	2.5	44.6	17.6	1.4	33.9	181

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Fresh, 7 weeks after sowing	Sheep	83.6	80.0	56.4	84.8	2.84	489
Fresh, 8 weeks after sowing	Sheep	80.4	79.7	47.2	84.6	2.77	489
Fresh, 9 weeks after sowing	Sheep	78.5	80.9	44.7	83.5	2.72	489
Fresh, 10 weeks after sowing	Sheep	77.1	82.6	47.2	83.8	2.77	489
Fresh, 11 weeks after sowing	Sheep	74.9	83.2	47.2	85.4	2.77	489
Fresh, 12 weeks after sowing	Sheep	72.3	83.8	47.1	84.7	2.74	489
Fresh, 13 weeks after sowing	Sheep	70.8	81.9	47.5	85.0	2.76	489
Straw	Cattle	26.1	54.0	14.0	47.9	1.62	416
Straw	Sheep	5.5	56.5	45.6	48.4	1.56	181

A82 *Hymenachne amplexicaulis* Nees

Dal grass or bamboo grass

Semiaquatic perennial, rooting at the lower nodes and having stout culms, found in the tropics and subtropics throughout the world. Said to be liked especially by buffaloes, but is also grazed by cattle even in its advanced stages of growth after the floodwater recedes.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, whole aerial part, Suriname		15.8	34.6	9.4	1.9	38.3	126
Fresh, stems only, Suriname		8.9	36.7	11.5	1.0	41.9	126
Fresh, leaves only, Suriname		22.6	32.4	7.2	2.8	35.0	126
Fresh, mid-bloom, India		9.4	22.1	12.2	2.3	54.0	474
Hay, mid-bloom, India		7.5	29.2	12.9	1.4	49.0	474
Silage, mid-bloom, India		6.9	27.8	17.9	1.9	45.5	474

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, mid-bloom	Oxen	61.5	60.5	37.9	67.0	2.11	474
Hay, mid-bloom	Oxen	42.4	70.7	39.1	60.6	2.00	474
Silage, mid-bloom	Oxen	43.9	69.3	40.9	60.3	1.88	474

A83 *Hyparrhenia cymbaria* (L.) Stapf

Coloured hood grass

Tufted perennial grass up to 300 cm high, usually found in bush or at forest edges in medium-rainfall areas. The young stems are slender, and when kept short, it forms leafy swards that are well grazed.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, mid-bloom, Kenya		7.3	30.3	15.1	2.6	44.7	133

A84 *Hyparrhenia dissoluta* (Nees *ex* Steud.) C.E. Hubbard

Tufted perennial grass up to 2 m high. In the very early stage of growth it is completely grazed, but in the later stages the stems are usually left ungrazed and only the leaves are eaten.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		12.9	33.7	8.8	3.0	41.6	131
Fresh, mid-bloom, Niger		6.4	41.0	5.3	1.4	45.9	45
Fresh, 4 weeks, Ghana	25.6	16.7	21.6	10.8			437
Fresh, 8 weeks, Ghana	21.9	10.6	25.2	7.8			437
Fresh, 12 weeks, Ghana	31.8	8.7	31.8	4.9			437
Fresh, 36 weeks, Ghana	38.8	5.2	28.0	6.5			437
Hay, pre-bloom, Zimbabwe	92.6	6.8	36.9	5.8	1.5	49.0	499

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Hay, pre-bloom	Cattle	62.1	71.0	40.2	61.9	2.27	499

A85 *Hyparrhenia filipendula* (Hochst.) Stapf

Tufted perennial up to 1.8 m high, common in Africa under a wide range of conditions, especially those of many savannahs. Recovers rapidly after being burned in the dry season. Low in nutritive value, but relatively high yielding.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		6.6	36.3	5.8	1.8	49.5	130

A86 *Hyparrhenia lintonii* Stapf

A perennial forming broad cushions 15-60 cm high with numerous fine stems and a large quantity of leaves. Often occurs on black clay that is seasonally waterlogged. Well grazed when young but not at later stages of growth.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		11.4	31.8	8.6	5.0	43.2	130

A87 *Hyparrhenia rufa* (Nees) Stapf

Jaragua or thatching grass

Hyparrhenia rufa

Perennial with stems up to 3 m high that is the dominant grass in some tropical regions with 600-1 400 mm of annual rainfall. Requires grazing when young to prevent tussocks from forming. Flowering stands must be mowed or burned. Does not persist under continuous close grazing but withstands heavy rotational grazing and outyields many other grasses where soil fertility is low. Palatable before the formation of tussocks.

Usually established from seed collected locally by hand and sown uncleaned on burned grass and bush without soil preparation. With this method, stands take about two years to establish. If clean seed is sown in a prepared seedbed and fertilized, the grass can be grazed after about five months.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, vegetative, Brazil	29.7	9.2	28.9	14.9	2.6	44.4	240
Fresh, full bloom, Brazil	34.3	3.5	31.4	13.6	1.9	49.6	240
Fresh, milk stage, Brazil	35.5	2.8	33.7	11.5	1.5	50.5	240
Fresh, mature, Nigeria	24.5	4.4	32.3	19.5	1.8	42.0	58
Hay, late vegetative, Brazil	86.3	6.5	35.0	17.9	2.3	38.3	240
Silage, late vegetative, Brazil	32.2	4.3	43.1	9.1	2.5	41.0	240

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, vegetative	Sheep	60.4	61.9	56.2	63.0	2.01	240
Fresh, full bloom	Sheep	25.2	54.5	43.8	52.7	1.67	240
Fresh, milk stage	Sheep	16.5	47.3	42.3	50.2	1.56	240
Fresh, mature	Cattle	18.2	66.6	11.1	40.7	1.44	58
Hay, late vegetative	Sheep	55.7	53.5	51.7	63.3	1.80	240
Silage, late vegetative	Sheep	44.4	55.2	44.6	47.2	1.73	240

A88 *Imperata cylindrica* (L.) Beauv. (*I. arundinacea* Cyr.)

Alang-alang, lalang or Congo grass

Sweet-smelling highland grass up to 40 cm tall. Found mostly on acid soils, but has highly variable habits. Occurs generally in damp conditions adjacent to swampy areas and drainage lines, but is extremely drought resistant and difficult to eradicate. Palatable if cut frequently.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early vegetative, Pakistan		6.6	34.6	7.9	3.3	47.6	275
Fresh, late vegetative, Pakistan		5.2	32.4	8.2	3.2	51.0	275
Fresh, late bloom, India		3.5	39.4	6.7	1.6	48.8	275
Fresh, 4 weeks, Malaysia	36.4	11.8	32.1	7.1	1.9	47.1	292
Hay, late vegetative, India		3.8	39.7	7.8	0.7	48.0	436

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, late bloom	Oxen	30.0	74.0	30.0	57.0	2.14	275
Hay, late vegetative	Oxen	34.0	59.0	40.0	55.0	1.88	436

A89 *Ischaemum aristatum* L.

Toco grass, Batiki bluegrass

Perennial with stems up to 60 cm that grows in seasonally wet or waterlogged areas, where it forms a dense mat. Forms good pasture if well grazed. Recovers quickly from overgrazing and survives poor management. Sometimes causes milk taint.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, vegetative, Trinidad	20.2	9.2	30.7	10.9	1.8	47.4	82
Fresh, 3 weeks, Suriname		14.2	31.6	10.6	2.5	41.1	26
Fresh, 4 weeks, Suriname		10.9	35.9	10.6	1.9	40.7	26
Fresh, 5 weeks, Suriname		10.1	32.4	11.0	1.9	44.6	26
Fresh, 6 weeks, Suriname		10.6	34.8	8.2	1.9	44.5	26
Fresh, 7 weeks, Suriname		9.6	34.3	8.5	2.1	45.5	26
Fresh, 8 weeks, Suriname		8.2	35.0	8.9	1.3	46.6	26

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Fresh, vegetative	Sheep	54.9	71.2	51.1	61.9	2.14	82

A90 *Ischaemum timorense* Kunth

Lucuntu grass

Similar to *I. aristatum* but smaller leaved and more shallow rooted. Grows in areas with over 1 300 mm of annual rainfall and short dry seasons. Prefers heavy soils with a high water table. Dormant during the dry season. Used as pasture grass in more humid areas, but is less productive than some other species. Aggressive and difficult to eradicate.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, 3 weeks, Suriname		10.7	32.7	10.3	2.0	44.3	26
Fresh, 4 weeks, Suriname		10.4	32.7	10.1	2.0	44.8	26
Fresh, 5 weeks, Suriname		8.7	34.6	8.2	2.0	46.5	26
Fresh, 6 weeks, Suriname		7.4	35.4	8.1	1.9	47.2	26
Fresh, 7 weeks, Suriname		6.9	35.8	7.2	1.9	48.2	26
Fresh, 8 weeks, Suriname		5.3	36.7	7.2	1.6	49.2	26
Fresh, whole aerial part, Suriname		9.8	35.0	8.9	1.1	45.2	126
Fresh stems, Suriname		6.2	38.3	8.4	0.8	46.3	126
Fresh leaves, Suriname		15.3	30.0	9.7	1.6	43.4	126
Artificially dried, 4 weeks, Suriname	90.9	8.3	34.2	10.6			124

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Vegetative	Sheep	54.9	71.2	51.1	61.9	2.14	82

A91 *Iseilema laxum* Hack.

Musal grass

Tufted perennial up to 60 cm high, common in southern Asia on seasonally waterlogged soils. Very palatable to cattle but not to sheep. Used mainly for pasture but also for both hay and silage. Should be cut at 40-day intervals for maximum yield.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Pre-bloom, India		5.1	34.2	11.6	1.4	47.7	436
Flowering, India		3.7	38.8	9.9	1.0	46.7	436
In seed, India		2.8	34.5	11.8	1.1	49.8	436
Hay, pre-bloom, India		6.4	35.6	6.8	0.6	50.6	436
Hay, in seed, India		3.1	36.4	11.2	1.0	48.3	281

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Hay, pre-bloom	Cattle	53.0	73.0	35.0	61.0		436
Hay, in seed	Cattle	12.0	62.2	16.7	49.5		281

A92 *Ixophorus unisetus* (C. Presl) Schlecht.

Mexican or Honduras grass

Tufted perennial grass with stems up to 2 m high and large broad leaves that grows in wet areas on moist fertile soils. A valuable and palatable fodder crop, but does not persist when grazed. Stops growing in dry weather.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Mexico		14.3	30.1	13.6	3.5	38.6	537
Fresh, mid-bloom, Mexico		14.4	30.0	14.8	3.0	37.9	537
Fresh, full bloom, Chile	21.9	9.3	30.6	10.4	3.3	46.4	537
Fresh, mature, Cuba	16.1	7.9	30.3	10.0	0.5	51.3	88
Hay, Mexico		5.4	35.3	13.3	0.9	45.1	537

A93 *Lasiurus hirsutus* (Forsk.) Boiss. (*Elyonurus hirsutus* Forsk.)

Sewan grass

Many-branched perennial up to 1 m high that occurs naturally in dry areas of North Africa and Asia. One of the most important grazing grasses in northern India in areas with less than 250 mm of rainfall, where it is sown for permanent pasture. The low yield can be improved by annual seeding of legumes such as guar bean or moth bean.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Pre-bloom, Pakistan		10.4	34.1	11.9	8.2	35.4	309
Early bloom, Pakistan		8.9	41.3	8.8	3.0	38.1	309
Hay, post-bloom, India		5.9	38.0	11.0	0.3	44.7	436

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Hay, post-bloom	Cattle	51.0	54.0	0.0	47.0		436

A94 *Latipes senegalensis* Kunth

Hook grass

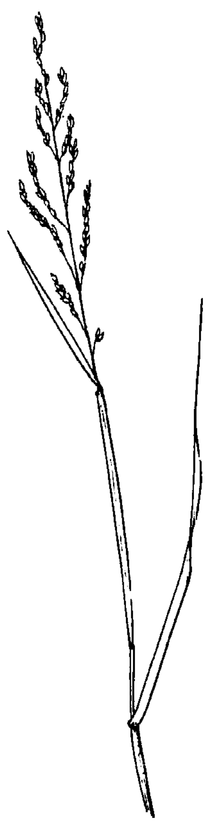
Small short-lived tufted perennial 15-50 cm high with numerous short leaves on the stems. Grows in semiarid areas, where it is well grazed and reputed to be palatable also in the dry season; however, its productivity is low.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		9.3	38.9	7.5	1.3	43.0	133

A95 *Leersia hexandra* Sw.

Rice cut-grass, clubhead cut-grass or southern cut-grass

Perennial grass with stems up to 120 cm high that grows on fertile soils along watercourses and in swamps in the humid tropics and subtropics throughout the world. Tolerates waterlogging and overgrazing. Palatable when young. Burned to provide dry-season grazing.



Leersia hexandra

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, vegetative, Tanzania	30.0	10.1	25.6	10.4	1.8	52.1	175
Fresh, early bloom, Tanzania		5.8	28.4	16.7	2.1	47.0	476
Hay, India		6.3	31.4	14.9	1.5	45.9	476

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Vegetative	Sheep	69.3	60.9	33.0	71.8	2.27	175
Early bloom	Oxen	40.0	63.0	23.0	54.0	1.70	476
Hay	Oxen	38.0	66.0	31.0	50.0	1.72	476

A96 *Leptochloa obtusiflora* Hochst.

Medium-sized tufted perennial that grows in dry bush. Varying considerably in leafiness, the leafy forms are well grazed. A good seed producer, it can be used for reseeding denuded land in not very dry areas.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		18.4	28.0	9.5	1.7	42.4	131

A97 *Melinis minutiflora* Beauv.

Whynne grass, molasses grass

Spreading perennial forming large tussocks with hairy stems, sometimes up to 180 cm high, and leaves that are reddish, sticky and strong-smelling. Wide variations in vigour, leafiness, hairiness and growth habit. Grows in areas with annual rainfall of 800-1 800 mm on well-drained sites protected from overgrazing. Valued as an easily established (by sowing) and productive grass of acceptable nutritive value; also used for soil conservation on steep slopes with poor soils. Resistant to drought but not to fire or waterlogging. Continues to grow throughout the year with some rainfall. Must be well established before grazing. Palatable to cattle once they become used to the smell. Reported to repel insects and snakes and to be useful for controlling ticks.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, pasture, fertilized, Puerto Rico	25.6	9.0	36.5	7.8	3.0	44.7	32
Hay, leaves, pre-bloom, 60 cm, Lao	90.5	13.8	32.3	7.4	4.1	42.4	95
Hay, stem, pre-bloom, 60 cm, Lao	89.6	10.5	33.7	10.2	3.1	42.5	95
Hay, late vegetative, India	91.2	4.4	37.8	8.8	1.0	48.0	436
Hay, mid-bloom, India	91.3	4.2	36.8	10.1	1.1	47.8	436
Stem-cured, Kenya	88.9	6.1	32.3	8.4	1.7	51.5	481

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Pasture	Sheep	42.0	61.0	48.0	51.0	1.89	32
Hay, late vegetative	Cattle	37.0	64.0	11.0	62.0	2.03	436
Hay, mid-bloom	Cattle	31.0	62.0	14.0	58.0	1.89	436
Stem-cured	Sheep	45.6	44.2	33.2	51.8	1.64	481

A98 *Oryza sativa* L.

Rice

There are many distinct varieties. Most varieties ("swamp rice") must be planted in stagnant water, whereas others ("mountain rice" or "upland rice") require less irrigation. The regrowth after harvesting can be used as pasture. Rice may also be grown thickly until semisolid kernels are formed, and then cut and cured into a fairly palatable hay that is suitable for long-term storage and long-distance transport. Dry rice stalks minus the flowers or grains, called rice straw, are fairly palatable but usually insufficient for animal maintenance. Excessive feeding of rice straw produces harmful effects, as it contains oxalic acid which binds the calcium in the diet. This effect can be reduced by soaking the straw in water or by neutralizing it with a weak solution of calcium carbonate or calcium hydroxide.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, vegetative, India		7.0	25.9	18.0	1.8	47.3	378
Fresh, dough stage, India		5.8	29.5	18.3	2.2	44.2	378
Fresh, regrowth after harvest, Trinidad	32.8	9.0	28.3	15.9	1.8	45.0	82
Hay, India	85.0	8.2	32.0	15.7	1.8	42.3	474
Straw, Philippines	80.8	3.9	33.5	21.4	2.1	39.1	5
Straw, India	93.8	2.4	36.5	16.5	0.9	43.7	280
Silage of straw, India		5.9	30.0	11.4	1.7	51.0	436

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, regrowth	Sheep	58.0	63.0	35.3	69.4	2.05	82
Hay	Oxen	50.0	74.0	22.0	55.0	1.90	474
Straw	Cattle	9.8	60.6	24.8	39.1	1.34	5
Straw	Zebu	0.0	60.7	46.7	42.4	1.50	280

A99 *Panicum antidotale* Retz.

Giant panic grass, blue panic

Vigorous many-branched perennial with wiry stems up to 2.5 m high and long blue-green leaves. Grows in areas with annual summer rainfall of 500-800 mm and under irrigation. Found on all types of soils, but prefers sandy loams. Resistant to drought, fire and heavy grazing. Palatable pasture and valuable as a fodder crop for light sandy soils in dry areas. When cut or grazed, 25-30 mm of stubble must be left. Stems rapidly become hard and woody and should be grazed or cut before flowering. At the late flowering stage it can acquire a bitter taste and accumulate large amounts of oxalic acid, which may cause kidney disorders.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early vegetative, Pakistan	43,0	18.8	28.0	10.1	3.0	40.1	309
Fresh, mature, Pakistan	46.9	8.4	36.6	8.7	9.7	36.6	309
Fresh, first cutting, India		13.9	34.6	12.2	2.7	36.6	436
Fresh, second cutting, India		10.4	33.5	13.3	1.8	41.0	436

A100 *Panicum coloratum* L.

Coloured Guinea grass or small buffalo grass

Tufted perennial up to 120 cm high that grows in areas with annual summer rainfall of 500-900 mm. Found mostly on heavy soils with impeded drainage. Palatable.

The very drought-resistant and palatable Makarikariense variety is selected for areas with 400-700 mm rainfall and fertile clay soils. It is valued as a high-yielding pasture grass that can withstand prolonged flooding.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, heading, Ethiopia		17.1	25.4	15.6	1.9	40.0	527
Fresh, early bloom, Kenya		18.9	28.6	11.0	2.6	38.9	130
Fresh, in bloom, Ethiopia		11.5	27.5	12.4	2.2	46.4	527
Hay, South Africa		9.0	36.7	7.9	2.8	43.6	489

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Hay	Oxen	59.0	62.1	33.8	68.0	2.20	489

A101 *Panicum laevifolium* Hack.

Land grass or sweet grass

Annual summer grass found on old land. Usually grows luxuriantly on unploughed lands for the first two years. Because it has fairly thick fibrous stems and does not dry readily, the hay is most often not of very good quality.

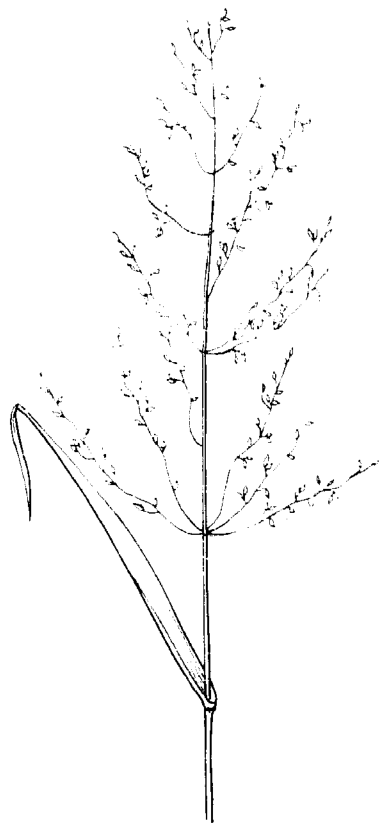
	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, mature, Kenya		5.4	40.2	10.5	1.5	42.4	436
Hay, South Africa		8.7	39.9	7.4	1.9	42.1	489

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Hay	Sheep	45.1	66.4	37.2	54.6	2.01	489

A102 *Panicum masaiense* Mez

Tufted perennial that forms cushions up to 60 cm and occasionally 120 cm high. A valuable grass in arid areas and well liked by cattle.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		19.7	24.0	10.7	2.5	43.1	131



Panicum maximum

A103 *Panicum maximum* Jacq.

Guinea grass, colonial grass, Tanganyika grass

Tall vigorous tufted perennial with stems up to 3.5 m tall that varies widely in growth habit. Grows in tropical and subtropical areas with 1 000-1 800 mm of rainfall on a wide range of soils. Tolerant of shade and fire, but not of waterlogging or severe drought. Produces high yields of palatable fodder and responds well to manuring, but rapidly declines in nutritive value with age. Dies if continually grazed close to the ground, and needs rest late in the growing season.

For the most nutritious grass it is best cut when it is 60-90 cm tall; but for higher yields it can be cut when it is up to 1.5 m tall, as it does not become coarse even if left to grow to that height. To maintain yield, one third or one fourth of the plants should be replanted each year. Mixtures with a number of legumes (e.g., *Centrosema pubescens* and *Stylosanthes guianensis*) have been successfully established.

Green panic or slender Guinea (*P. maximum* var. *trichoglume* Eyles) is a variety with fine stems up to 1.8 m high and short leaves.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, vegetative, 40 cm, Tanzania	25.0	8.8	29.9	11.2	1.6	48.5	175
Fresh, vegetative, 80 cm, Tanzania	25.0	8.8	32.8	12.9	1.5	44.0	175
Fresh, early bloom, Tanzania	28.0	5.3	39.6	10.6	1.4	43.1	175
Fresh, cut at intervals of 1 week, Malaysia	22.0	20.5	24.1	11.4	0.9	43.1	292
Fresh, cut at intervals of 2 weeks, Malaysia	23.0	14.3	27.4	12.2	0.9	45.2	292
Fresh, cut at intervals of 3 weeks, Malaysia	23.0	12.6	28.7	13.0	0.9	44.8	292
Fresh, cut at intervals of 4 weeks, Malaysia	23.0	11.7	30.9	13.0	1.3	43.1	292
Fresh cut at intervals of 5 weeks, Malaysia	24.5	10.2	30.6	13.9	0.8	44.5	292
Fresh, cut at intervals of 6 weeks, Malaysia	25.0	9.6	31.2	13.2	1.2	44.8	292
Fresh, mature, Nigeria	25.7	7.8	33.4	12.2	1.4	45.2	58
Hay, wet season, 6 weeks, 70 cm, Thailand	83.4	6.8	36.3	11.3	1.8	43.8	219
Hay, wet season, 8 weeks, 110 cm, Thailand	86.9	7.7	39.0	10.9	1.6	40.8	219
Hay, wet season, 10 weeks, 170 cm, Thailand	87.3	5.5	40.1	10.8	1.6	42.0	219
Hay, wet season, 12 weeks, 170 cm, Thailand	86.5	5.5	40.1	10.4	1.4	42.6	219
Hay, dry season, 6 weeks, 65 cm, Thailand	88.6	11.9	31.7	12.0	3.2	41.2	219
Hay, dry season, 8 weeks, 70 cm, Thailand	90.8	8.3	35.7	13.0	2.0	41.0	219
Hay, dry season, 10 weeks, 70 cm, Thailand	89.7	6.6	35.5	13.2	1.8	42.9	219
Hay, dry season, 12 weeks, 95 cm, Thailand	91.1	7.2	36.4	12.5	2.1	41.8	219
Silage, Tanzania	20.0	6.3	39.7	19.6	2.7	31.7	175

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, 40 cm	Sheep	64.8	71.6	31.3	67.0	2.23	175
Fresh, 80 cm	Sheep	43.2	73.5	13.3	59.8	2.00	175
Early bloom	Sheep	50.9	63.9	50.0	53.4	1.91	175
Mature	Cattle	60.3	53.0	42.9	65.0	1.95	58
Hay, 6 weeks	Sheep	62.0	58.0	61.0	57.0	1.93	219
Hay, 8 weeks	Sheep	49.0	56.0	53.0	49.0	1.74	219
Hay, 10 weeks	Sheep	36.0	58.0	47.0	54.0	1.80	219
Silage	Sheep	34.9	82.4	40.7	51.7	1.95	175

A104 *Panicum miliaceum* L.

Proso, broomcorn millet, hog millet or Indian buffalo grass

Quick-maturing annual cereal whose grains are used for human food and for poultry feed. A useful catch crop for emergency fodder.

Panicum miliaceum

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Hay	86.6	12.5	33.9	6.6	2.5	44.5	512
Straw, India		4.8	35.5	8.9	1.2	49.6	379

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Hay	Sheep	56.5	59.9	40.9	60.8	2.10	512

A105 *Panicum repens* L.

Torpedo grass, panic rampant

Perennial with stems up to 120 cm high and hairy leaves. Widespread in marshy areas near fresh or salt water and on sandy soils. Tolerates flooding and drought. Palatable pasture grass, resistant to grazing and trampling. Remains palatable and nutritious over a long growing season. Liable to become a troublesome weed in ditches and drains.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, cut after 4 weeks, Malaysia	28.3	14.0	32.6	13.4	2.1	37.9	292

A106 *Panicum trichocladum* Hack. *ex* K. Schum.

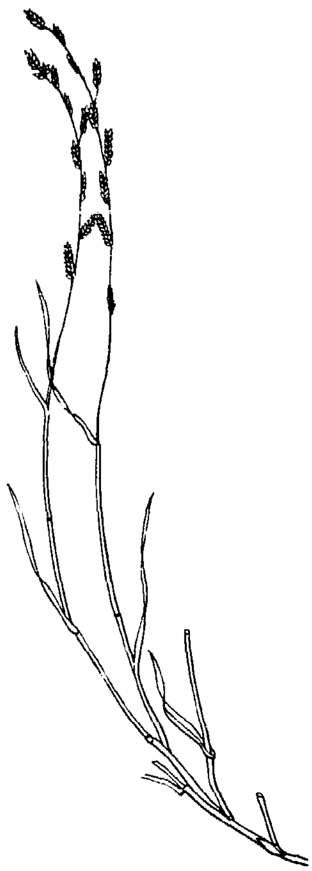
Donkey grass

Creeping, rambling perennial with numerous short leaves that grows in bush and at forest edges. Palatable to cattle. The young leaves regarded as especially suitable for calves, and it is still grown to a limited extent as a calf feed.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, early bloom, Kenya		9.6	35.0	8.5	2.5	44.4	131

A107 *Paspalidium desertorum* (A. Rich.) Stapf

Perennial grass with trailing stems and long narrow succulent leaves. Grows in arid areas and is well grazed. A valuable grass as it penetrates annual-grass zones where only a few perennials can survive the long dry seasons.



Paspalidium desertorum

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, full bloom, Kenya		13.8	29.4	13.0	1.2	42.6	133

A100 *Panicum coloratum* L.

Coloured Guinea grass or small buffalo grass

Tufted perennial up to 120 cm high that grows in areas with annual summer rainfall of 500-900 mm. Found mostly on heavy soils with impeded drainage. Palatable.

The very drought-resistant and palatable Makarikariense variety is selected for areas with 400-700 mm rainfall and fertile clay soils. It is valued as a high-yielding pasture grass that can withstand prolonged flooding.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, heading, Ethiopia		17.1	25.4	15.6	1.9	40.0	527
Fresh, early bloom, Kenya		18.9	28.6	11.0	2.6	38.9	130
Fresh, in bloom, Ethiopia		11.5	27.5	12.4	2.2	46.4	527
Hay, South Africa		9.0	36.7	7.9	2.8	43.6	489

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Hay	Oxen	59.0	62.1	33.8	68.0	2.20	489

A101 *Panicum laevifolium* Hack.

Land grass or sweet grass

Annual summer grass found on old land. Usually grows luxuriantly on unploughed lands for the first two years. Because it has fairly thick fibrous stems and does not dry readily, the hay is most often not of very good quality.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, mature, Kenya		5.4	40.2	10.5	1.5	42.4	436
Hay, South Africa		8.7	39.9	7.4	1.9	42.1	489

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Hay	Sheep	45.1	66.4	37.2	54.6	2.01	489

A102 *Panicum masaiense* Mez

Tufted perennial that forms cushions up to 60 cm and occasionally 120 cm high. A valuable grass in arid areas and well liked by cattle.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		19.7	24.0	10.7	2.5	43.1	131

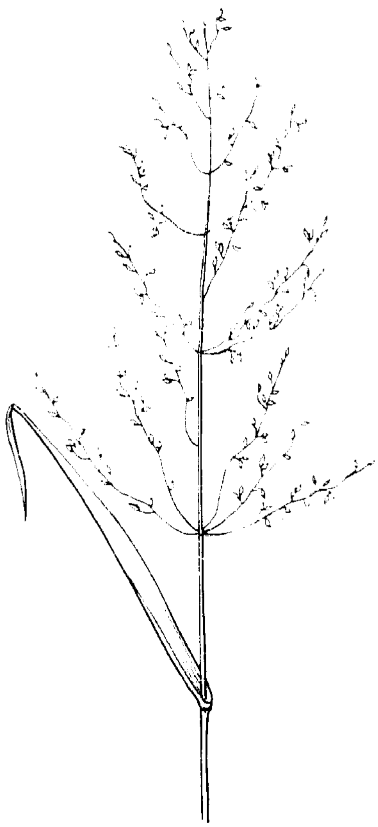
A103 *Panicum maximum* Jacq.

Guinea grass, colonial grass, Tanganyika grass

Tall vigorous tufted perennial with stems up to 3.5 m tall that varies widely in growth habit. Grows in tropical and subtropical areas with 1 000-1 800 mm of rainfall on a wide range of soils. Tolerant of shade and fire, but not of waterlogging or severe drought. Produces high yields of palatable fodder and responds well to manuring, but rapidly declines in nutritive value with age. Dies if continually grazed close to the ground, and needs rest late in the growing season.

For the most nutritious grass it is best cut when it is 60-90 cm tall; but for higher yields it can be cut when it is up to 1.5 m tall, as it does not become coarse even if left to grow to that height. To maintain yield, one third or one fourth of the plants should be replanted each year. Mixtures with a number of legumes (e.g., *Centrosema pubescens* and *Stylosanthes guianensis*) have been successfully established.

Green panic or slender Guinea (*P. maximum* var. *trichoglume* Eyles) is a variety with fine stems up to 1.8 m high and short leaves.



Panicum maximum

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, vegetative, 40 cm, Tanzania	25.0	8.8	29.9	11.2	1.6	48.5	175
Fresh, vegetative, 80 cm, Tanzania	25.0	8.8	32.8	12.9	1.5	44.0	175
Fresh, early bloom, Tanzania	28.0	5.3	39.6	10.6	1.4	43.1	175
Fresh, cut at intervals of 1 week, Malaysia	22.0	20.5	24.1	11.4	0.9	43.1	292
Fresh, cut at intervals of 2 weeks, Malaysia	23.0	14.3	27.4	12.2	0.9	45.2	292
Fresh, cut at intervals of 3 weeks, Malaysia	23.0	12.6	28.7	13.0	0.9	44.8	292
Fresh, cut at intervals of 4 weeks, Malaysia	23.0	11.7	30.9	13.0	1.3	43.1	292
Fresh cut at intervals of 5 weeks, Malaysia	24.5	10.2	30.6	13.9	0.8	44.5	292
Fresh, cut at intervals of 6 weeks, Malaysia	25.0	9.6	31.2	13.2	1.2	44.8	292
Fresh, mature, Nigeria	25.7	7.8	33.4	12.2	1.4	45.2	58
Hay, wet season, 6 weeks, 70 cm, Thailand	83.4	6.8	36.3	11.3	1.8	43.8	219
Hay, wet season, 8 weeks, 110 cm, Thailand	86.9	7.7	39.0	10.9	1.6	40.8	219
Hay, wet season, 10 weeks, 170 cm, Thailand	87.3	5.5	40.1	10.8	1.6	42.0	219
Hay, wet season, 12 weeks, 170 cm, Thailand	86.5	5.5	40.1	10.4	1.4	42.6	219
Hay, dry season, 6 weeks, 65 cm, Thailand	88.6	11.9	31.7	12.0	3.2	41.2	219
Hay, dry season, 8 weeks, 70 cm, Thailand	90.8	8.3	35.7	13.0	2.0	41.0	219
Hay, dry season, 10 weeks, 70 cm, Thailand	89.7	6.6	35.5	13.2	1.8	42.9	219
Hay, dry season, 12 weeks, 95 cm, Thailand	91.1	7.2	36.4	12.5	2.1	41.8	219
Silage, Tanzania	20.0	6.3	39.7	19.6	2.7	31.7	175

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, 40 cm	Sheep	64.8	71.6	31.3	67.0	2.23	175
Fresh, 80 cm	Sheep	43.2	73.5	13.3	59.8	2.00	175
Early bloom	Sheep	50.9	63.9	50.0	53.4	1.91	175
Mature	Cattle	60.3	53.0	42.9	65.0	1.95	58
Hay, 6 weeks	Sheep	62.0	58.0	61.0	57.0	1.93	219
Hay, 8 weeks	Sheep	49.0	56.0	53.0	49.0	1.74	219
Hay, 10 weeks	Sheep	36.0	58.0	47.0	54.0	1.80	219
Silage	Sheep	34.9	82.4	40.7	51.7	1.95	175

Panicum miliaceum

A104 *Panicum miliaceum* L.

Proso, broomcorn millet, hog millet or Indian buffalo grass

Quick-maturing annual cereal whose grains are used for human food and for poultry feed. A useful catch crop for emergency fodder.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Hay	86.6	12.5	33.9	6.6	2.5	44.5	512
Straw, India		4.8	35.5	8.9	1.2	49.6	379

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Hay	Sheep	56.5	59.9	40.9	60.8	2.10	512

A105 *Panicum repens* L.

Torpedo grass, panic rampant

Perennial with stems up to 120 cm high and hairy leaves. Widespread in marshy areas near fresh or salt water and on sandy soils. Tolerates flooding and drought. Palatable pasture grass, resistant to grazing and trampling. Remains palatable and nutritious over a long growing season. Liable to become a troublesome weed in ditches and drains.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, cut after 4 weeks, Malaysia	28.3	14.0	32.6	13.4	2.1	37.9	292

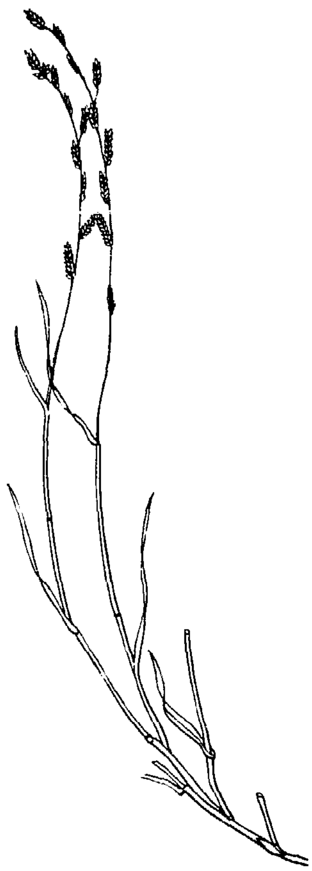
A106 *Panicum trichocladum* Hack. *ex* K. Schum.

Donkey grass

Creeping, rambling perennial with numerous short leaves that grows in bush and at forest edges. Palatable to cattle. The young leaves regarded as especially suitable for calves, and it is still grown to a limited extent as a calf feed.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		9.6	35.0	8.5	2.5	44.4	131

A107 *Paspalidium desertorum* (A. Rich.) Stapf



Paspalidium desertorum

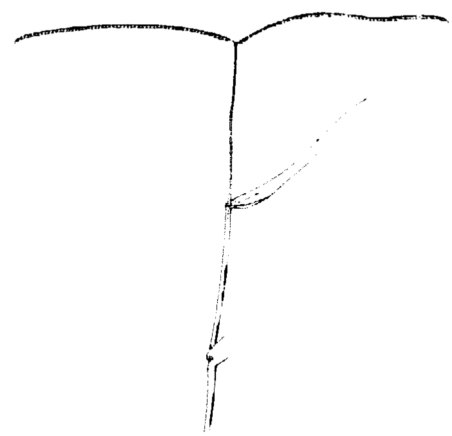
Perennial grass with trailing stems and long narrow succulent leaves. Grows in arid areas and is well grazed. A valuable grass as it penetrates annual-grass zones where only a few perennials can survive the long dry seasons.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, full bloom, Kenya		13.8	29.4	13.0	1.2	42.6	133

A108 *Paspalum conjugatum* Berg.

Cow grass, sour paspalum or sourgrass

Spreading perennial with long creeping stolons and erect flowering stems 20-50 cm high. Widespread in the tropics and subtropics. Adapted to the more humid tropics, where it is common in natural pastures on moist heavy soils. Should be grazed when young, as the seeds tend to stick in the throats of livestock and choke them. Low yielding and not very palatable when mature.



Paspalum conjugatum

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, vegetative, Malaysia	21.3	13.6	26.3	13.6	1.9	44.6	292
Fresh stems, mature, 20 cm, Lao		6.8	40.6	3.8	2.0	46.8	95
Fresh leaves, mature, 20 cm, Lao		14.9	28.0	4.9	4.9	47.3	95
Fresh, 25 cm, Philippines	19.0	10.5	30.5	12.6	16.0	44.8	297

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, 25 cm	Sheep	64.7	63.4	45.2	66.2	2.62	297

Paspa...n dilatatum

A109 *Paspalum dilatatum* Poir.

Dallis grass

Strongly tufted, rather coarse, leafy and deep-rooted perennial 60-150 cm high. Found in humid areas, especially in the subtropics where rainfall is above 900 mm a year. Tolerates both waterlogging and drought. Very palatable and nutritious, but not high-yielding unless heavily manured. Recovers rapidly after drought or grazing, but should not be cut below 5-9 cm. Valued for its vigour, persistence and ability to withstand heavy grazing.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, mid-bloom, Trinidad	19.1	9.9	35.7	8.2	1.8	44.4	82
Fresh, first cutting, early bloom, Tanzania	25.0	6.7	31.8	11.5	1.6	48.4	175
Fresh, second cutting, early bloom, Tanzania	30.0	6.2	31.9	10.3	1.5	50.1	175
Fresh leaves only, at 50 cm high, South Africa		13.3	36.2	6.9			100
Fresh stems only, at 50 cm high, South Africa		8.8	43.2	6.4			100

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Mid-bloom	Sheep	54.1	69.4	31.7	58.2	2.10	82
Early bloom, first cutting	Sheep	49.3	77.4	56.3	73.8	2.39	175
Early bloom, second cutting	Sheep	53.2	76.5	53.3	75.8	2.46	175

10 *Paspalum fasciculatum* Willd. *ex* Flügge

nezuela grass, bamboo grass, gamalote

Robust perennial up to 2 m high, forming broad tufts. Common South America on river banks and in seasonally flooded areas. ed as a natural pasture grass, but also planted for pasture in ıer countries.

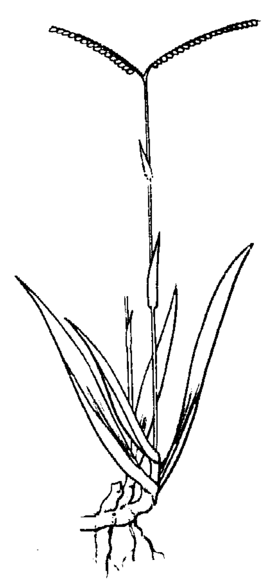
	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
/eeks, Trinidad	20.8	19.3	25.3	13.3	2.0	40.1	117
weeks, Trinidad	32.0	6.3	34.6	14.4	1.4	43.3	117
ture pasture, Trinidad	32.0	6.9	28.3	14.7	1.3	48.8	82

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
ture pasture	Sheep	57.9	64.2	63.8	64.0		82

.11 *Paspalum notatum* Flügge

hia grass

A grass with stems up to 50 cm high that forms dense turf. ten found on coastal sands and other sandy soils. Grows in areas th moderate to high rainfall and a short dry season. Drought ;istant. Persists on poor soils and under heavy grazing. Rather palatable. The nutritive value remains high when mature, but it not very productive. Recommended for protection against ero- n on sloping ground. Tolerant of flooding and salinity.



Paspalum notatum

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Brazil		7.4	31.3	12.0	1.2	48.0	537
Fresh, mid-bloom, Brazil		8.4	28.1	13.5	2.3	47.8	537
Fresh, late bloom, Lao		13.0	34.5	6.8	4.0	41.7	595
Hay, Brazil		12.3	33.5	11.4	1.4	41.4	537

A112 *Paspalum scrobiculatum* L. (*P. scrobiculatum* var. *frumentaceum* Stapf)

Scrobic millet, koda or ditch millet

Erect annual, 60-90 cm high, widely distributed in the tropics of the eastern hemisphere. Cultivated for grain, pasture and hay; however, the grain sometimes contains a poisonous principle that may be fatal to both humans and animals.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early vegetative, India		11.4	28.8	14.3	1.4	44.1	436
Fresh, dough stage, India		5.7	31.6	12.1	1.5	49.1	436
Fresh, 4 weeks, Ghana	22.1	12.8	25.1	12.2			437
Fresh, 8 weeks, Ghana	15.5	7.9	29.3	6.9			437
Fresh, 12 weeks, Ghana	24.6	7.3	29.5	6.9			437
Fresh, 36 weeks, Ghana	45.3	3.9	30.1	5.8			437
Straw, India		3.5	34.3	12.3	1.5	48.4	436

A113 *Pennisetum americanum* (L.) Leeke [*P. glaucum* (L.) R. Br. *sens. Amer. auct.*]

Bulrush millet, cattail millet, pearl millet, Indian millet, horse millet or bajra

Tall erect annual, very variable, with stems up to 3 m high. Grows in drier areas on sandy soils and matures with no more than 300 mm of rainfall. Cultivated extensively for grain and also for hay. Utilizes nutrients deep below the surface. Grows rapidly and matures quickly when the rains come For an unknown reason, a depression in the butterfat test is sometimes noted when cows are grazed on a pearl millet pasture. Cutting or grazing can begin 4-6 weeks after sowing. For hay, a single cutting just before flowering is common practice, but five cuttings can be taken.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, 40 cm, South Africa	15.3	17.7	21.1	13.4	3.2	44.6	489
Fresh, 45 cm, South Africa	18.7	16.4	22.3	13.0	3.0	45.3	489
Fresh, 50 cm, South Africa	17.0	13.9	25.5	13.0	3.3	44.3	489
Fresh, 65 cm, South Africa	18.6	11.4	26.4	11.9	2.8	47.5	489
Fresh, 90 cm, South Africa	16.1	9.6	28.4	12.7	1.7	47.6	489
Fresh, 100 cm, South Africa	18.3	6.6	29.9	11.7	1.4	50.4	489
Fresh, 135 cm, South Africa	19.0	6.2	31.8	10.1	1.4	50.4	489
Fresh, 150 cm, early bloom, Tanzania	15.0	13.7	27.5	14.9	1.7	42.2	175
Fresh, mid-bloom, India		11.4	26.3	12.6	2.4	47.3	378
Fresh, milk stage, India		10.6	28.0	9.2	2.1	50.1	436
Fresh, dough stage, India		8.8	24.9	8.2	1.9	56.2	436
Hay, South Africa		6.6	41.2	10.0	1.3	40.9	489
Straw, India	94.5	3.8	37.3	5.9	1.5	51.5	436
Straw, Tanzania		4.3	43.6	9.3	0.9	41.9	175

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Fresh, 40 cm	Sheep	72.3	68.0	55.9	78.9	2.48	489
Fresh, 45 cm	Sheep	70.8	74.5	58.9	78.2	2.52	489
Fresh, 50 cm	Sheep	67.9	73.5	62.7	77.1	2.48	489
Fresh, 65 cm	Sheep	68.0	70.3	61.1	77.4	2.47	489
Fresh, 90 cm	Sheep	64.1	74.5	45.8	76.4	2.41	489
Fresh, 100 cm	Sheep	51.5	75.4	23.7	73.1	2.32	489
Fresh, 135 cm	Sheep	51.6	70.1	36.1	74.9	2.35	489
Fresh, 150 cm	Sheep	66.4	73.8	47.1	70.9	2.27	175
Hay	Sheep	32.9	66.5	45.8	57.3	1.97	489
Straw	Oxen	12.9	57.2	45.3	42.7	1.68	175

A114 *Pennisetum clandestinum* Hochst. *ex* Chiov.

Kikuyu grass

Low-grade perennial with stems up to 1.2 m high that thrives only on fertile soils with good drainage. Drought resistant and palatable. Suitable solely for permanent pasture at high elevations with well-distributed rainfall. High protein content and digestibility even when mature. The turf needs to be broken up regularly and well manured. Vigorous and aggressive, it withstands heavy grazing, but stocking rates should be light until the runners are growing vigorously and all bare soil is covered. Established from planted pieces of stolons spaced 50 × 50 cm.

Pennisetum clandestinum

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, 10 cm, Kenya	25.0	24.8	20.9	9.5	4.0	40.8	480
Fresh, 25 cm, Kenya	15.0	23.5	24.5	13.4	3.0	35.6	480
Fresh leaves only, at 40 cm, South Africa		13.8	30.5	7.6			100
Fresh stems only, at 40 cm, South Africa		11.6	33.9	7.6			100
Hay, Kenya		12.1	35.2	10.5	0.8	41.4	415

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, 10 cm	Sheep	73.6	69.4	61.4	75.4	2.62	480
Fresh, 25 cm	Sheep	67.0	52.5	57.3	58.2	2.03	480
Hay	Sheep	53.2	67.1	0.0	49.8	1.87	415

A115 *Pennisetum orientale* Rich.

Deep-rooted tussock-forming perennial up to 1.5 m high. Valuable for pasture on rich moist soils. Drought resistant, remaining green throughout the year. Palatable.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, vegetative, Pakistan	39.9	11.0	37.3	7.3	7.7	36.7	309
Fresh, mature, Pakistan	51.6	8.7	44.4	15.4	6.6	24.9	309
Fresh, vegetative, India	28.4	7.9	27.8	15.4	1.7	47.2	442

A116 *Pennisetum pedicellatum* Trin.

Nigeria grass

Many-branched leafy annual 30-90 cm high that grows well with a rainy season of 4-6 months. High yields of hay or green fodder. For the highest yield, should be cut four months after sowing to 8 cm from ground level.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, mid-bloom, Niger		12.5	35.2	12.0	1.9	38.4	45
Fresh, mature, Nigeria	15.3	5.5	33.0	11.7	2.8	47.0	58
Silage, Nigeria	32.9	5.7	40.8	13.6	1.9	38.0	58

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Mature	Cattle	47.3	53.3	71.4	67.2	2.04	58
Silage	Cattle	47.4	61.0	26.3	18.9	1.31	58

A117 *Pennisetum polystachyon* (L.) Schult.

Kyasuwa grass, China grass or thin Napier grass

An annual or a perennial with stems up to 2 m tall that grows in areas with long dry seasons and 600-900 mm of rain. Resistant to drought and waterlogging. Valuable as a short-season leafy pasture or hay crop. High herbage yields. Can be introduced to supplant coarse, less nutritive grasses that form the natural vegetation in high-rainfall areas with acidic soils.

Pennisetum polystachyon

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, early bloom, Kenya		17.6	27.1	11.9	2.7	40.7	133
Fresh, first cutting, India		17.4	23.0	16.0	1.4	42.2	436
Fresh, second cutting, India		12.3	31.4	10.4	1.7	44.2	436

A118 *Pennisetum purpureum* Schumach.

Elephant grass, Napier grass, Uganda grass

Tall erect perennial with thick stems up to 4.5 m high, found on moist soils in areas with over 1 000 mm of rainfall annually and widely distributed along the banks of watercourses. Grows best on deep soils of moderate to fairly heavy texture. Tolerates short droughts, but does not withstand waterlogging. The most widely grown fodder grass. Sometimes grazed for six to eight weeks at a time. Yields very large quantities of dry matter, but is low in protein content unless cut very young. With poor drainage, best grown on raised beds. Should not be cut closer than 10-15 cm from the ground. Under normal management, stands are invaded by weeds and "run out" after two or three years, so that they have to be ploughed up and replanted.

The grass is planted in the same way as sugar cane (*Saccharum officinarum* L.): the culms are cut into pieces, each with three nodes, and are buried in the soil just deep enough to cover the second node and to leave the third above the ground.

The hybrid Giant Napier (*P. purpureum* × *P. typhoides*) has a high sugar content and leaf-stem ratio, but it needs highly fertile soil.

Pennisetum purpureum

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, vegetative, 40 cm, Tanzania	20.0	9.8	29.7	14.0	2.6	43.9	175
Fresh, vegetative, 80 cm, Tanzania	20.0	9.0	28.6	14.8	1.1	46.5	175
Fresh, early bloom, 240 cm, Tanzania	25.0	7.2	36.1	12.4	1.0	43.3	175
Fresh, tops only, 220 cm, Tanzania		13.2	32.9	10.3	2.4	41.2	312
Fresh, cut at intervals of 6 weeks, Malaysia	19.0	10.0	31.6	15.3	2.1	41.0	292
Fresh, cut at intervals of 8 weeks, Malaysia	19.5	9.7	33.3	16.4	1.5	39.1	292
Fresh, cut at intervals of 10 weeks, Malaysia	21.0	7.6	35.2	14.8	1.4	41.0	292
Hay, vegetative, South Africa		15.1	34.9	12.1	2.4	35.5	489
Hay, mature, South Africa		7.5	40.3	11.7	1.4	39.1	489
Silage, 120 cm, Zimbabwe	23.5	6.8	35.8	13.7	0.9	42.8	143
Silage, 210 cm, Zimbabwe	21.4	4.2	35.3	15.2	1.2	44.1	143
Fresh, var. *merkeri*, late bloom, Puerto Rico	24.0	8.6	36.1	10.2	3.1	42.0	33
Fresh, var. *merkeri*, cut every 6 weeks, Malaysia	20.5	9.8	32.2	12.2	1.5	44.3	292
Fresh, var. *merkeri*, cut every 8 weeks, Malaysia	20.5	8.8	34.6	14.1	1.5	41.0	292
Fresh, var. *merkeri*, cut every 10 weeks, Malaysia	23.5	7.7	35.7	14.0	0.9	41.7	292
Fresh, Giant Napier, 4 weeks, 50 cm, Thailand	15.8	10.8	28.5	13.9	3.8	43.0	219
Fresh, Giant Napier, 6 weeks, 75 cm, Thailand	17.1	8.8	32.2	12.9	3.5	42.6	219
Fresh, Giant Napier, 8 weeks, 135 cm, Thailand	18.3	8.7	32.8	10.9	3.3	44.3	219
Fresh, Giant Napier, 10 weeks, 150 cm, Thailand	18.5	6.5	33.0	11.4	2.7	46.4	219
Fresh, Giant Napier, 12 weeks, 150 cm, Thailand	20.4	5.9	31.9	10.3	2.9	49.0	219

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, vegetative, 40 cm	Sheep	61.2	74.7	50.0	71.8	2.30	175
Fresh, vegetative, 80 cm	Sheep	54.4	60.5	45.0	62.2	1.92	175
Fresh, early bloom, 240 cm	Sheep	50.0	60.1	30.0	52.9	1.79	175
Fresh, tops only	Zebu	73.4	65.7	66.4	57.0	2.17	312
Hay, vegetative	Oxen	73.2	77.2	66.5	67.8	2.44	489
Hay, mature	Oxen	40.7	56.0	30.9	33.8	1.46	489
Merker grass, late bloom	Sheep	66.0	61.0	57.0	58.0	2.06	143
Giant Napier, 75 cm	Sheep	33.0	62.0	53.0	62.0	1.94	143
Giant Napier, 135 cm	Sheep	38.0	64.0	53.0	58.0	1.96	33
Giant Napier, 10 weeks, 150 cm	Sheep	50.0	60.0	54.0	54.0	1.87	219
Giant Napier, 12 weeks, 150 cm	Sheep	28.0	60.0	39.0	54.0	1.81	219

Pennisetum squamulatum Fres.

ɔust perennial 90-120 cm high, occurring on rocky ground in reas. Usually very fibrous. Low in productivity, but remains long into the dry season. Great tolerance of both extremely ɪd near-freezing temperatures.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
early bloom, Kenya		7.0	39.3	8.6	2.5	42.6	130

Pennisetum stramineum A. Peter

ɔsely tufted perennial 30-90 cm high. Important in dry scat- -tree grassland with annual rainfall of 500-600 mm on tropi- lack-earth soils. Valuable as pasture.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
early bloom, Kenya		11.9	35.8	10.6	3.2	38.5	130
ɔured, Kenya	90.3	10.0	36.8	11.7	1.9	39.6	481

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
ɔured	Sheep	59.8	45.9	34.9	46.0	1.58	481

A121 *Pennisetum trachyphyllum* Pilger

Tall perennial with rather thick rambling stems and large leaves. Grows in woodlands, often forming dense stands along stream banks. The leaves are readily eaten by cattle, but the stems are left untouched.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		10.2	30.0	10.4	2.0	47.4	131

A122 *Phalaris aquatica* L.

Phalaris or toowoomba canary grass

Tufted perennial with culms 60 cm or higher. Deep-rooted, persistent and palatable. Should be only lightly grazed until fully established. May be toxic (causing "Phalaris staggers") during early growth after first rains. Combines well with kudzu.

The variety *P. stenoptera* (Hack.) Hitchc., called Harding grass, is similar to *P. aquatica,* but is more robust and has short creeping rhizomes. Used as a pasture grass in winter-rainfall areas.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, mature, India	31.2	12.8	23.7	10.8	5.1	47.6	190
Fresh, average value, Chile	21.6	15.1	28.1	13.2	3.6	40.0	315

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, mature	Sheep	61.0	60.0	34.0	68.0	2.16	190

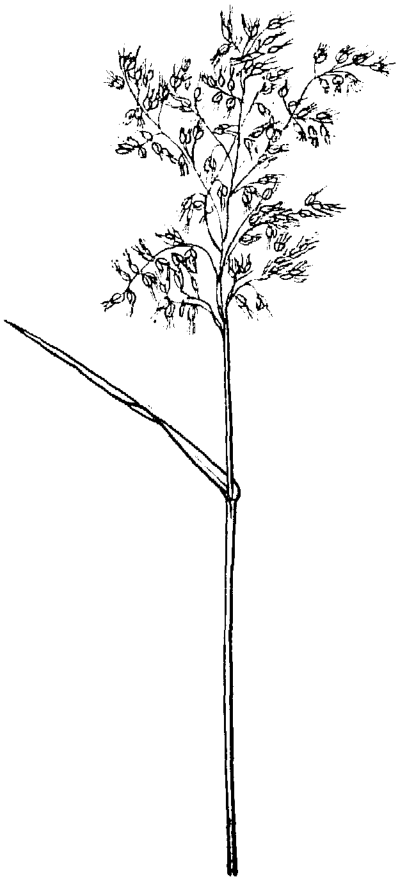
A123 *Phalaris minor* Retz.

Small canary grass

Quick-growing annual that is native to the Mediterranean area. Provides grazing within two months of sowing, but may be toxic in its young stage. When used for fodder, the first cutting should be taken two weeks before the grass flowers so as to secure a second cutting.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, vegetative, India		10.0	21.2	17.5	3.7	47.6	436

A124 ***Rhynchelytrum repens*** **(Willd.) C.E. Hubb. [*R. roseum* (Nees) Stapf & C.E. Hubb. *ex* Bews; *Tricholaena rosea* Nees]**



Rhynchelytrum repens

Natal grass, Natal redtop

Annual grass with slender culms and flat blades up to 1 m high. The panicle has reddish silky hairs. Often found as a weed on cultivated land and takes possession of fallow ground. Grows well in arid or semiarid areas on poor sandy soils. Usually stemmy and rather low in palatability.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		11.3	31.8	9.8	2.3	44.8	131
Fresh, 8 weeks, Ghana	21.6	11.5	30.6	7.1			437
Fresh, 12 weeks, Ghana	24.5	7.0	32.1	6.1			437
Fresh, 16 weeks, Ghana	29.9	9.0	31.9	6.5			437
Fresh, 20 weeks, Ghana	39.9	5.6	35.0	6.4			437
Fresh, 32 weeks, Ghana	44.0	5.7	27.1	6.2			437
Hay, India		5.6	41.6	8.0	1.4	43.4	436

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Hay	Cattle	43.0	63.0	29.0	54.0	1.93	436

A125 *Rottboellia exaltata* L.f.

Buffalo bean grass, corn grass or itchgrass

Annual with stems up to 3 m high, widespread in shady wet places on disturbed soils. Excellent fodder grass, but unpalatable when tall as its stiff hairs cause irritation. Suitable for ensiling.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		11.1	32.9	10.9	2.3	42.8	133
Straw, India		5.3	31.1	10.8	0.8	52.0	436

A126 *Saccharum officinarum* L.

Sugar cane, noble cane

See feed information summary I3-I9.

A127 *Saccharum sinense* Roxb.

Japanese cane, uba cane

Hardier than sugar cane and more adapted to poor soils and dry conditions; also leafier, with thin hard canes. May be cultivated for fodder in the same way as elephant grass (*Pennisetum purpureum* Schumach.), but feed value and yields are lower. Cut for fodder at intervals of three to four months.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, mature, Trinidad	23.4	10.3	32.1	6.3	2.5	48.8	117
Fresh, whole plant, Suriname		8.3	34.1	9.2	2.4	46.0	126
Fresh leaves, Suriname		9.5	33.4	88.0	2.8	45.5	126
Fresh stems, Suriname		5.3	35.9	10.5	1.5	47.0	126

A128 *Saccharum spontaneum* L. (*S. biflorum* Forsk.; *S. aegyptiacum* Willd.)

Wild cane

Vigorous perennial with erect culms up to 5 m high. Very variable. Common on river banks and in damp depressions and swamps. Can grow in poor soils. Occasionally used for browsing and emergency feed. A pernicious weed.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, late vegetative, India		5.3	40.0	4.2	1.4	49.1	254
Fresh, stem-cured, India		3.4	40.2	7.2	1.2	48.0	254

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, late vegetative	Zebu	59.0	76.0	60.0	61.0	2.38	254
Stem-cured	Zebu	11.0	66.0	30.0	35.0	1.61	254

A129 *Secale cereale* L.

Rye

Annual cereal grown on poorer soils for winter pasture in many subtropical countries. Less palatable than other small-grain cereals. Can be used for silage.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, average, Chile	16.4	21.4	24.8	15.2	4.8	33.8	315

A130 *Sehima nervosum* (Rottl. *ex* Willd.) Stapf

Sain grass

Tufted perennial with harsh fragile leaves that grows on lava rocks and on seasonally waterlogged black clays. Low palatability to cattle, but relished by sheep.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		7.0	38.7	8.8	1.3	44.2	133

A131 *Setaria chevalieri* Stapf & C.E. Hubb.

Tall tufted perennial 250 cm high or even taller with few but large folded fanlike leaves which are eaten occasionally by cattle. Grows in woodlands.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		8.3	33.5	12.1	1.8	44.3	131
Hay, Zimbabwe	90.4	12.3	26.4	12.4	2.4	46.5	499

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Hay	Cattle	64.5	61.4	61.0	65.7	2.15	499

A132 *Setaria italica* (L.) Beauv.

Foxtail millet, Boer millet, Nunbank setaria

Fast-growing fine-stemmed and leafy annual cereal that may be cut for hay or for zero grazing within 50 days of sowing or used as pasture and green fodder. The seed is used as bird feed. The feed value is greatest from bloom until milk stage. Many varieties, especially the dwarf variety, are used for grain only.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, 8 weeks, Israel	35.6	9.0	33.7	10.1	2.2	45.0	365
Hay, South Africa		7.6	45.1	9.7	1.7	35.9	489

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Fresh, 8 weeks	Sheep	55.0	60.0	53.0	66.0	2.11	365
Hay	Sheep	57.2	65.5	47.3	58.1	2.07	489

A133 *Setaria sphacelata* (Schumach.) Stapf & C.E. Hubb. (*S. anceps* Stapf)

Golden timothy, golden millet or Rhodesian grass

Stout, usually tufted perennial with stems up to 1.8 m high. A variable species, of which numerous subspecies and varieties have been described. Adapted to areas with over 600 mm of rain annually. Withstands drought and waterlogging. Prefers moist fertile soils. Grazed or cut only during the rainy season as it is unproductive in dry periods. One of the first grasses to produce fresh growth at the onset of the rains.

The Nandi variety is superior to most for higher rainfall areas at high altitudes.

The Kazungula variety is very tall and leafy with thick stems and broad bluish-green leaves. It is used for grazing and for cutting, giving high yields. For grazing it should never be higher than 20-30 cm. The herbage is rich in oxalic acid.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, 4 weeks, Ghana	19.5	19.4	22.9	13.0			437
Fresh, 8 weeks, Ghana	18.3	15.4	25.4	9.6			437
Fresh, 12 weeks, Ghana	22.8	13.3	27.0	14.0			437
Fresh, 20 weeks, Ghana	41.9	6.5	31.1	8.8			437
Fresh, 24 weeks, Ghana	67.5	6.1	32.2	7.4			437
Fresh, mature, Trinidad	15.0	6.4	32.4	8.2	2.9	50.1	82
Fresh, regrowth, 18 days, Congo		18.4	24.0	13.1	4.7	39.8	428
Fresh, mature, Trinidad	20.7	7.0	34.4	8.0	2.4	48.2	82
Fresh, 20 cm, South Africa	12.9	16.9	27.8	15.3	4.6	35.4	489
Fresh, 30 cm, South Africa	14.0	15.3	28.0	15.6	4.9	36.2	489
Fresh, 45 cm, South Africa	13.9	16.7	29.2	12.9	4.9	36.3	489
Fresh, 60 cm, Tanzania		15.3	35.2	14.6	2.9	32.0	487
Fresh, mid-bloom, 120 cm, Tanzania		8.7	42.0	10.4	2.8	36.1	487
Fresh, stem-cured, 180 cm, Tanzania		4.1	36.3	7.8	1.3	50.5	487

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, mature	Sheep	44.1	76.8	42.8	71.3	2.41	82
Fresh, regrowth	Sheep	71.8	71.3	52.2	75.7	2.47	428
Kazungula, mature	Sheep	51.5	65.1	49.5	67.9	2.24	82
Kazungula, 20 cm	Sheep	77.3	74.1	64.4	74.6	2.49	489
Kazungula, 30 cm	Sheep	75.9	72.0	66.7	73.5	2.44	489
Kazungula, 45 cm	Sheep	77.4	74.2	70.2	74.3	2.58	489

A134 *Setaria splendida* Stapf

Giant setaria

Tall tufted perennial that grows on sandy soils in areas with high rainfall (1 000 mm). A palatable and high-yielding fodder grass for grazing, soilage and ensiling.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, 120 cm, Tanzania		11.3	39.2	15.3	3.5	30.7	487
Fresh, regrowth, vegetative, 25 days, Congo		11.4	27.8	12.1	3.0	45.7	428

	Animal	Digestibility (%) CP	CF	EE	NFE	ME	Ref.
Fresh, regrowth	Sheep	65.2	75.2	56.7	76.5	2.47	428

A135 *Sorghum almum* Parodi

Columbus grass, five-year sorghum

Robust perennial with stems up to 4.5 m high and large waxy leaves. Found on cleared scrubland with fertile soil and 500-800 mm of rainfall. A fast-growing and high-yielding short-term crop. Withstands drought better than maize, but is less digestible. Very palatable, and high in nutritive value when young, but poor when mature.

Suitable for rotational grazing as it does not resist trampling. Valued for its good seed production, ease of establishment, drought and salt resistance and reasonably high yields.

	DM	As % of dry matter CP	CF	Ash	EE	NFE	Ref.
Fresh, wet season, 4 weeks, 85 cm, Thailand	17.6	9.7	31.3	9.7	2.8	46.5	219
Fresh, wet season, 6 weeks, 140 cm, Thailand	17.7	8.5	34.5	9.0	2.8	45.2	219
Fresh, wet season, 8 weeks, 160 cm, Thailand	23.2	7.8	36.6	7.3	2.6	45.7	219
Fresh, dry season, 4 weeks, 85 cm, Thailand	16.0	11.3	29.4	9.4	3.8	46.1	219
Fresh, dry season, 6 weeks, 140 cm, Thailand	17.6	9.7	31.8	9.1	3.4	46.0	219
Fresh, dry season, 8 weeks, 165 cm, Thailand	23.9	7.9	33.5	7.5	2.9	48.2	219

	Animal	Digestibility (%) CP	CF	EE	NFE	ME	Ref.
Fresh, wet season, 6 weeks	Sheep	39.0	54.0	53.0	49.0	1.73	219
Fresh, wet season, 8 weeks	Sheep	27.0	14.0	43.0	6.0	0.46	219

A136 *Sorghum bicolor* (L.) Moench (*S. vulgare* Pers.)

Guinea corn, sorghum, dari, kaffir, feterita, durra, milo, hegari or jowar

A species comprising a wide range of cultivated sorghums (grain sorghums and sweet sorghums). When grain sorghums are grown for cereal, the stalks may be used as animal feed. Sweet sorghums may be grown as a summer fodder crop where the temperature is too high and the rainfall insufficient for maize; in this case it is preferably mixed with a climbing legume, such as lablab. It is cut when the grain is in dough stage and the feed value of fodder is maximum. Some varieties contain prussic acid, which is destroyed by ensiling or curing for hay; however, care must be taken when sorghum is used as a soiling crop or for pasture. The danger is greatest in the second growth following the harvesting of the first crop or when the young plants are stunted, particularly during periods of drought or following light frost.

Also some grain sorghums are of interest as fodder plants, although they usually yield only about two thirds as much forage as fodder varieties. If the entire plant is to be used for silage, it should be cut before the seeds mature; otherwise a large portion of the small hard seeds will be wasted as they are not easily digested. The durras have little forage value because the stalks are dry and sparsely leafed. The hegaris can be regarded as dual-purpose sorghum, being suitable for grain production and having value as fodder. This is also true of the kaffirs, which have even juicier stems. The milos have a limited fodder value.

Hybrid sorghum (*S. bicolor* × *S. sudanense*) has sweet juicy stems and is suitable for ensiling. A number of hybrid cultivars exist; one of the more valued is sweet Sudan grass.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, mature, Peru	23.3	8.2	22.6	5.8	1.5	61.9	370
Fresh, post-ripe, 200 cm, Tanzania	20.0	7.6	32.6	7.8	1.5	50.5	175
Hay, Sudan		4.2	32.1	7.9	0.8	55.0	98
Hay without stalks, Nigeria	94.0	3.0	35.0	8.0	1.9	52.1	58
Straw, Tanzania		4.3	37.2	10.3	1.3	46.9	175
Straw, India	93.7	3.7	41.8	9.4	1.1	44.0	378
Silage, sweet variety, dough stage, USA	26.6	7.5	26.4	6.1	2.5	57.5	305
Silage, dual-purpose variety, dough stage, USA	24.4	7.3	27.5	6.0	2.8	56.4	305
Silage, grain variety, mature, USA	30.4	8.0	22.8	6.8	3.0	59.4	305

	Animal	Digestibility (%) CP	CF	EE	NFE	ME	Ref.
Fresh, mature	Sheep	50.6	54.3	44.9	59.0	2.00	370
Fresh, post-ripe	Sheep	56.6	68.1	66.7	64.2	2.24	175
Hay	Sheep	37.6	66.0	58.3	62.9	2.12	98
Hay without stalks	Cattle	6.7	54.3	31.6	46.4	1.61	58
Straw	Oxen	30.5	62.0	89.3	56.3	1.93	175
Straw	Zebu	31.6	74.4	38.3	50.3	2.00	378
Silage, sweet variety	Sheep	54.6	49.0	76.0	69.7	2.24	305
Silage, dual-purpose variety	Sheep	53.2	53.1	77.8	68.9	2.27	305
Silage, grain variety	Sheep	58.0	50.2	80.7	72.7	2.37	305

A137 *Sorghum halepense* (L.) Pers.

Johnson grass

Perennial with vigorous spreading rootstocks that soon takes full possession of the land and is difficult to eradicate. In general appearance it is similar to Sudan grass (*Sorghum sudanense*) but has persistent underground rootstocks that produce shoots from their nodes. Two or three crops of hay are frequently harvested in a season. Valuable pasture, but young plants may contain appreciable amounts of HCN and must therefore be grazed with care.

	DM	As % of dry matter CP	CF	Ash	EE	NFE	Ref.
Fresh, 6 weeks, India	15.9	16.1	29.6	11.1	2.8	40.4	190
Fresh, 10 weeks, India	20.9	12.7	34.1	9.9	2.6	40.7	190
Fresh, 14 weeks, India	27.7	7.4	38.7	9.2	1.6	43.1	190
Fresh, first cutting, India		10.3	35.9	8.2	2.3	43.3	436
Fresh, second cutting, India		5.1	36.4	9.4	1.5	47.6	436
Hay, USA	87.7	6.6	34.6	5.9	1.9	51.0	146

	Animal	Digestibility (%) CP	CF	EE	NFE	ME	Ref.
Hay	Goats	45.0	58.0	40.0	54.0	1.91	146

A138 *Sorghum lanceolatum* Stapf

An annual grass up to 1.8 m tall that likes sandy soils and thrives especially on wet sites. The grains are used for human consumption.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, mid-bloom, Niger		17.3	37.2	10.9	1.4	33.2	45

A139 *Sorghum sudanense* (Piper) Stapf

Sudan grass

Slender annual with leafy stems up to 3 m high that grows on a variety of soils in areas with 500-900 mm of rain annually. Drought resistant. Cultivated primarily for hay or as a pioneer grass. With good fertility, yields two to five cuttings of very palatable fodder. May contain prussic acid when green.

Usually grazed at 60-70 cm. Cut for hay somewhat later, normally at flowering and to about 10 cm from the ground. Seldom used for silage. Valued in areas with hot dry summers for ease of establishment and for its ability to recover after grazing or cutting.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, 20 cm, Chile	21.6	6.8	31.0	8.5	2.9	50.8	315
Fresh, 40 cm, Chile	21.6	6.9	28.5	9.4	2.5	52.7	315
Fresh, 80 cm, Chile	21.6	7.3	30.2	9.4	3.0	50.1	315
Fresh, 60 cm, South Africa	19.3	15.4	23.4	9.9	3.7	47.6	489
Fresh, 65 cm, South Africa	22.1	13.1	24.1	10.4	3.0	49.4	489
Fresh, 80 cm, South Africa	20.0	11.1	26.4	9.5	3.1	49.9	489
Fresh, 90 cm, South Africa	22.9	9.3	28.7	9.3	2.9	49.8	489
Fresh, 100 cm, South Africa	22.0	9.3	29.1	9.5	1.8	50.3	489
Fresh, 125 cm, South Africa	24.3	8.0	32.1	9.1	1.6	49.2	489
Hay, South Africa		7.3	35.7	8.9	2.0	46.1	489

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, 60 cm	Sheep	77.8	73.3	65.6	81.3	2.75	489
Fresh, 65 cm	Sheep	74.8	72.0	62.7	76.8	2.57	489
Fresh, 80 cm	Sheep	70.8	68.6	63.0	74.5	2.49	489
Fresh, 90 cm	Sheep	65.9	66.4	66.7	72.4	2.41	489
Fresh, 100 cm	Sheep	64.3	63.6	46.2	70.1	2.27	489
Fresh, 125 cm	Sheep	59.3	63.3	40.4	67.5	2.19	489
Hay	Sheep	47.7	62.9	54.1	62.0	2.08	489

A140 *Sorghum verticilliflorum* (Steud.) Stapf

Wild Sudan grass

Tall annual up to 3 m high with large loose panicles. Grows on disturbed soil; also occurs on black clay soils of seasonally waterlogged plains. Readily grazed, although it can be rich in HCN.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		8.3	35.0	11.0	1.5	44.2	133
Fresh, hybrid, mid-bloom, Kenya	93.7	7.9	36.8	6.4	1.4	47.5	140

A141 *Sporobolus helvolus* (Trin.) Dur. & Schinz.

A perennial that spreads by means of long stolons and also forms small tufts. Grows in arid and semiarid areas as well as in seasonally waterlogged black soils or in volcanic ash. Valuable grazing grass.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		12.9	30.6	10.3	0.8	45.4	131
Fresh, vegetative, Pakistan		16.8	28.0	10.1	4.0	41.1	309
Fresh, mature, Pakistan		13.0	32.5	9.2	7.1	38.2	309

A142 *Sporobolus longibrachiatus* Stapf

Tufted perennial 25-50 cm high that grows on dry open grassland, sometimes forming extensive colonies. Can be leafy and is readily grazed.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		16.2	22.4	12.2	2.2	47.0	131

A143 *Sporobolus marginatus* Hochst. *ex* A. Rich.

Low-growing stoloniferous perennial that forms slow-spreading dense leafy colonies on soils rich in soda. Provides grazing of excellent quality but is not productive. Avidly grazed.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		23.3	25.7	9.3	3.1	38.6	133

A144 *Sporobolus pyramidalis* Beauv.

Whorled dropseed

Tufted perennial 60-90 cm high with tough stems and leaves. Low palatability. Found in overgrazed pastures.

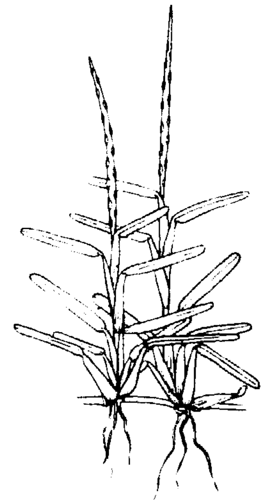
	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, early bloom, Kenya		7.7	35.9	6.2	1.8	48.4	130
Fresh, 4 weeks, Ghana	45.4	14.3	27.7	10.0			437
Fresh, 8 weeks, Ghana	29.6	11.1	26.8	9.4			437
Fresh, 12 weeks, Ghana	34.1	9.0	28.9	7.7			437
Fresh, 16 weeks, Ghana	39.8	7.0	27.5	9.7			437
Fresh, 36 weeks, Ghana	64.8	4.3	30.0	7.7			437
Hay, Zimbabwe	91.1	10.0	34.4	9.0	1.9	44.7	499

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Hay	Cattle	43.6	69.2	53.5	66.4	2.20	499

A145 *Stenotaphrum secundatum* (Walt.) Kuntze

St. Augustine grass, buffalo grass, crabgrass, pimento grass, salt grass

Rather coarse perennial with stems up to 50 cm high, forming a continuous sward, and with broad smooth leaves. Found in humid areas on coastal sands and alkaline soils, but will grow on almost all types of soils and in shade. Withstands salt spray. Young growth palatable and persistent under heavy grazing and trampling. Herbage matures and becomes unpalatable very rapidly. Should be grazed down to 6 cm every second week. Propagated vegetatively.



Stenotaphrum secundatum

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Hay, USA		6.7	32.5	3.7	2.7	54.4	314

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Hay	Cattle	30.7	49.3	57.0	58.3	1.93	314

A146 *Tetrapogon spathaceus* (Hochst. *ex* A. Steud.) Hack. *ex* Dur. & Schinz.

Hairy herringbone grass

Small short-lived annual up to 30 cm high that grows in semiarid or arid areas, often on denuded land, where it is one of the first pioneer grasses to appear.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, full bloom, Kenya		12.6	34.6	8.7	1.7	42.4	133

A147 *Themeda triandra* Forsk.

Red oat grass, kangaroo grass or bluegrass

Tufted perennial, very variable in size and habit, normally 30-90 cm high, but sometimes 3.5 m high, with blue or green hairy or smooth leaves. Grows on clay soils and with annual rainfall of 600-1 000 mm. Kept dominant by annual burning, from which it recovers after rain has fallen; not found in areas that are persistently overgrazed or protected from fire. Poor nutritive value. Easily overgrazed when young, and unpalatable when mature. Low carrying capacity. The most common grass on the natural grasslands of Africa.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, vegetative, South Africa		6.9	32.3	12.0	3.0	45.8	63
Fresh, mature, South Africa		2.7	34.2	12.5	1.9	48.7	63
Hay, mean value, Uganda		3.3	39.3	8.3	1.2	47.9	313
Hay, mature, Kenya	91.6	4.4	40.4	10.3	1.6	43.3	481

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Fresh, vegetative	Sheep	51.9	59.2	50.4	56.9	1.90	63
Hay, mature	Zebu	7.4	70.6	40.7	52.1	1.95	313
Hay, mature	Sheep	13.5	59.2	25.4	39.6	1.54	481

A148 *Trachypogon spicatus* (L.f.) Kuntze

Horo

Tufted perennial 60-90 cm high, common on the savannahs of Africa and South America. Grazed only when young. Mature herbage should be burned at the end of the dry season.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, early bloom, Kenya		5.7	40.2	9.6	1.8	42.7	130

A149 ***Tripsacum fasciculatum* Trin. *ex* Aschers. (*T. laxum* Nash)**

Guatemala grass, Honduras grass

Tall broadleaved perennial with stems up to 3.5 m that grows in humid areas on rich soils. Tolerates acidity. Essentially cultivated for fodder as it is unsuitable for grazing. More persistent than elephant grass, but less productive and lower in nutritive value. Can be grown together with *Desmodium intortum* or *D. uncinatum* to increase yield of dry matter and crude protein. Should not be cut closer than 25 cm from the ground.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, 3 weeks, Suriname		15.9	31.4	9.6	2.8	40.3	26
Fresh, 4 weeks, Suriname		12.7	33.5	9.6	1.7	42.5	26
Fresh, 5 weeks, Suriname		10.9	33.2	8.8	1.4	45.7	26
Fresh, 6 weeks, Suriname		7.3	33.4	7.0	2.4	49.9	26
Fresh, 7 weeks, Suriname		7.1	35.9	6.5	2.4	48.1	26
Fresh, 8 weeks, Suriname		7.5	35.2	6.7	2.0	48.6	26
Fresh, 120 cm, Philippines	25.3	5.9	36.0	8.7	2.0	47.4	297
Fresh, mature, Trinidad	20.3	7.8	33.2	6.3	1.5	51.2	82
Fresh, first cutting, vegetative, fertilized, Puerto Rico	24.6	5.2	35.6	8.7	2.9	47.6	31
Fresh, second cutting, vegetative, fertilized, Puerto Rico	30.4	4.6	31.2	8.2	2.7	53.3	31
Fresh, cut at intervals of 8 weeks, Malaysia	20.0	12.0	35.0	14.0	1.5	37.5	292
Fresh, cut at intervals of 10 weeks, Malaysia	19.0	8.4	34.7	15.8	1.0	40.1	292
Fresh, cut at intervals of 12 weeks, Malaysia	19.5	5.1	35.9	16.4	1.5	41.1	292
Fresh leaves, Suriname		6.1	40.4	5.3	3.4	44.8	126
Fresh stems, Suriname		4.6	36.1	6.4	1.9	51.0	126
Artificially dried, Suriname	88.7	9.3	37.5	5.3			124

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Fresh, 120 cm	Sheep	51.8	60.7	62.3	61.2	2.07	297
Fresh, mature	Sheep	50.5	69.7	46.7	63.9	2.24	82
Fresh, first cutting	Sheep	56.0	66.0	74.0	65.0	2.26	31
Fresh, second cutting	Sheep	58.0	60.0	74.0	72.0	2.33	31

A150 *Tripsacum latifolium* Hitchc.

Perennial leafy grass up to 2.5 m high, native to Central America. Similar to Guatemala grass, though somewhat less leafy, and used in the same way.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, mature, Cuba	41.8	9.3	32.5	7.0	0.7	50.5	88

A151 *Triticum aestivum* L. (*T. vulgare* Vill.; *T. sativum* Lam.)

Wheat

Extensively cultivated as a cereal crop. Frequently utilized for grazing in a manner that does not sacrifice grain production, as may be the case if grazing is continued too late in the spring. Wheat planted in the autumn can be grazed within about five weeks and support about ten sheep to the hectare without impairing the wheat as a grain crop. In some instances it is sown principally as a pasture crop. Fodder varieties have been developed. It should be harvested for silage or hay when the grain is in milk stage and while the stems and leaves are quite green.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, 16 weeks after sowing, South Africa	30.0	18.1	15.5	7.6	3.7	55.1	489
Fresh, 19 weeks after sowing, South Africa	31.1	12.3	15.5	7.1	3.2	61.9	489
Fresh, 20 weeks after sowing, South Africa	34.2	10.8	15.1	6.3	1.9	65.9	489
Fresh, 21 weeks after sowing, South Africa	35.0	10.4	15.6	6.2	1.8	66.0	489
Fresh, 22 weeks after sowing, South Africa	35.0	8.5	18.7	6.5	2.1	64.2	489
Fresh, 23 weeks after sowing, South Africa	34.0	8.6	20.1	6.1	2.6	62.6	489
Fresh, vegetative, India		23.3	21.5	11.6	3.5	40.1	378
Fresh, milk stage, India		11.8	31.9	12.9	2.0	41.4	378
Fresh, dough stage, India		6.4	26.3	9.7	1.4	56.2	378
Straw, Iraq	92.0	3.1	45.4	10.2	1.1	40.2	181
Hay, India		5.1	35.1	7.2	1.3	51.3	436
Silage of straw, India		3.5	39.4	14.6	0.5	42.0	436

	Animal	Digestibility (%) CP	CF	EE	NFE	ME	Ref.
Fresh, 16 weeks after sowing	Sheep	78.2	79.5	61.5	88.7	3.00	489
Fresh, 19 weeks after sowing	Sheep	69.2	80.4	59.2	90.0	2.98	489
Fresh, 20 weeks after sowing	Sheep	64.1	76.0	40.6	88 6	2.89	489
Fresh, 21 weeks after sowing	Sheep	58.8	73.5	47.0	88.1	2.85	489
Fresh, 22 weeks after sowing	Sheep	56.3	77.6	30.2	86.0	2.78	489
Fresh, 23 weeks after sowing	Sheep	58.8	73.4	46.9	85.9	2.79	489
Straw	Sheep	0.5	61.3	33.6	18.8	1.30	181
Silage of straw	Cattle	25.0	65.0	24.0	52.0	1.76	436

A152 *Urochloa bolbodes* (Steud.) Stapf

Dubi grass

Tufted perennial up to 1 m high that grows in open grassland and in bush. Very palatable. Low yielding and not persistent under grazing.

	DM	As % of dry matter CP	CF	Ash	EE	NFE	Ref.
Fresh, early bloom, Kenya		13.7	30.0	10.6	2.8	42.9	131
Hay, Zimbabwe	89.3	17.7	24.6	12.9	2.0	42.8	499

	Animal	Digestibility (%) CP	CF	EE	NFE	ME	Ref.
Hay	Cattle	37.6	53.0	66.2	62.5	1.88	499

A153 *Urochloa mosambicensis* (Hack.) Dandy

Sabi grass

Perennial up to 120 cm high. Drought resistant and palatable grazing of good nutritive value even when dry.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, first cutting, India		11.0	22.4	28.2	2.0	36.4	436
Hay, Zimbabwe	88.5	14.9	26.1	12.9	1.5	44.6	499

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Hay	Cattle	45.6	57.1	62.9	65.1	1.96	499

A154 *Urochloa panicoides* Beauv.

Annual 25-60 cm high with broad leaves and semiprostrate spreading stems. Grows on roadside verges, on alluvial soil and as a weed on cultivated land. Palatable.

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Late bloom, Kenya		14.7	29.9	14.9	1.7	38.8	133

A155 *Zea mays* L.

Maize, Indian corn

Grown wherever summers are reasonably warm, it is the staple cereal of the human diet in Central and tropical South America and in many parts of Africa. Frequently cultivated as a catch crop for green fodder or silage. Very palatable and high in nutritive value. Grown during the dry season when other forages are not plentiful. Best harvested at milk stage when the leaves are still green and tender. Only one crop can be harvested from each planting. To reduce the stem size and increase the proportion of leaf, closer than normal spacing should be used. All varieties can be grown for fodder, but hybrid varieties give the highest yield. When maize is grown for grain, the stalks left after husking can be an important feed for stock. When cattle have access to good lucerne or clover hay, the stover can profitably be used as half the roughage ration for fattening cattle and sheep; for stock cattle an even higher proportion can be used. Forage maize hybrids suitable for the tropics have been developed by cross-pollinating different cultivars.

		As % of dry matter					
	DM	CP	CF	Ash	EE	NFE	Ref.
Fresh, 8 weeks, Israel	15.7	8.9	31.2	10.2	1.9	47.8	365
Fresh, 10 weeks, Israel	21.9	10.0	31.5	8.7	1.4	48.4	365
Fresh, 7 weeks, irrigated, Israel	12.6	10.3	28.6	10.3	2.4	48.4	365
Fresh, 10 weeks, irrigated, Israel	18.1	8.8	30.9	10.5	2.2	47.6	365
Fresh, mid-bloom, fertilized, Puerto Rico	23.8	9.5	30.9	6.0	4.3	49.3	31
Fresh, milk stage, 200 cm, Tanzania	17.0	8.8	28.1	7.4	0.9	54.8	175
Fresh, whole plant, milk stage, Malaysia	16.0	11.3	29.4	8.1	1.9	49.3	292
Fresh, stems only, milk stage, Malaysia	13.0	7.7	46.2	8.5	0.8	36.8	292
Fresh, leaves and cobs, milk stage, Malaysia	20.0	15.0	12.5	8.5	3.0	61.0	292
Dried stalks, Egypt	84.1	5.9	38.5	9.8	1.8	44.0	36
Dried stalks, South Africa		6.3	35.0	7.4	1.3	50.0	489
Hay, South Africa		7.0	27.0	6.9	1.4	57.7	489
Silage (clamp), mid-bloom, Tanzania		7.4	31.4	6.2	1.9	53.1	169
Silage (pit), milk stage, Tanzania		6.5	31.9	5.0	3.3	53.3	169
Silage (clamp), milk stage, Tanzania		6.2	31.9	6.8	2.4	52.7	169

	Animal	Digestibility (%) CP	CF	EE	NFE	ME	Ref.
Fresh, 7 weeks	Sheep	59.0	62.0	73.0	76.0	2.37	365
Fresh, 10 weeks	Sheep	55.0	60.0	69.0	71.0	2.22	365
Fresh, mid-bloom	Sheep	67.0	72.0	82.0	54.0	2.31	31
Fresh, milk stage	Sheep	56.8	66.5	22.2	72.8	2.35	175
Dried stalks	Sheep	36.0	67.0	59.0	60.0	2.06	36
Dried stalks	Sheep	39.7	62.5	51.4	60.1	2.04	489
Hay	Sheep	37.1	64.1	50.7	66.3	2.18	489
Silage (clamp), mid-bloom	Sheep	35.0	71.7	69.4	74.7	2.46	169
Silage (pit), milk stage	Sheep	36.1	63.2	78.5	61.8	2.22	169
Silage (clamp), milk stage	Sheep	18.7	43.2	63.0	53.6	1.69	169

A156 *Zea mays* subsp. *mexicana* (Schrad.) Iltis (*Euchlaena mexicana* Schrad.)

Buffalo grass or teosinte grass

Coarse maizelike annual 2.5-4 m high that grows well on fertile soils in wet areas, but is inferior to sorghum or maize in drier areas and on poor soils. Cultivated as a high-yielding fodder crop in some areas. Usually harvested when the plants are about 2 m high and then cut 25-30 cm from the ground to allow further tillering. Unlike maize, it is not affected by serious pests or diseases.

Zea mays subsp. *mexicana*

	DM	As % of dry matter					Ref.
		CP	CF	Ash	EE	NFE	
Fresh, mid-bloom, India		9.5	27.3	9.0	2.6	51.6	246
Fresh, blooming, Chile	26.2	9.5	23.0	8.0	2.9	56.6	537

	Animal	Digestibility (%) CP	CF	EE	NFE	ME	Ref.
Mid-bloom	Zebu	63.2	63.1	45.9	50.6	1.92	246

B. Legumes

Useful reference: 149

Legumes vary greatly, but all bear pods and are able to bind nitrogen from the air and convert it to protein through the action of bacteria of the *Rhizobium* spp. that grow and multiply in nodules on the roots. When legumes are planted in a soil for the first time, it is usually necessary to inoculate the seed with the proper strain of bacteria before sowing.

Rhizobium bacteria can survive nonsymbiotically in the soil, ready to penetrate the root of a suitable legume and form nodules. Some are highly specific and can enter into symbiotic relation only with certain species of legume, whereas others are less selective. For productive symbiotic fixation of nitrogen, the nutrient requirement of both bacteria and plants has to be satisfied. Phosphorus and molybdenum at first usually limit production. Fertilization with potassium and sulphur can give a good response, while addition of nitrogen may retard fixation.

Legumes have a high feed value as they are rich in protein and minerals. Some legumes are well suited to mixed cultivation with grasses in pastures. In some areas the introduction of legumes in grasslands has been extremely successful, with a great improvement in productivity. Many leguminous trees are useful for shade in pastures and may also serve as a source of nutritious fodder when required.

Beans are not very palatable to stock. Also, they are not particularly digestible when fed raw, especially to pigs. Bean meals have the disadvantage of developing a rancid, bitter taste after a few weeks of storage.

B1 *Acacia albida* Del.

Ana tree

A tree up to 20 m high with light-brown bark and hairy leaves 5-10 cm long with thorns at the base. Bears leaves only during the dry season. Light-yellow flowering spikes and crescent-shaped or circular light-brown pods 10 cm long and 1-2 cm broad. Found chiefly along rivers. Prefers sandy soils. Pods readily eaten by game and stock, and leaves eaten by all farm animals except horses. No recorded indications of poisoning. Highly promising as a forage plant in areas with a prolonged dry season. A full-grown tree able to produce well over 100 kg of pods a year.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh flowers, Sudan	17.8	19.0	12.5	9.7	1.6	57.2			64
Fresh whole leaves, Niger		19.7	19.6	7.2	1.6	51.9	1.00	0.23	45
Fresh leaflets, Sudan	36.3	17.1	12.4	8.4	2.3	59.8			64
Pods, Tanzania		8.8	24.4	3.7	1.4	61.7	0.65	0.23	166
Pods, Niger		14.3	24.7	6.3	1.5	53.2	1.11	0.14	45

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Pods	Cattle	51.0	16.5	71.4	74.8	2.09	166

·2 *Acacia aneura* F. v. Muell.

ſulga

Gregarious tree forming the "mulga" scrubs in Australia. Impor-
ınt fodder tree in arid regions as it grows without rainfall.

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
resh leaves and shoots, Australia	38.0	9.2	30.1	5.6	4.6	50.5	0.87	0.07		468

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
eaves and shoots	Cattle	38.4	32.9	26.0	57.2	1.65	468

¦3 *Acacia brevispica* Harms

Shrub 2.5-4.5 m high with long thin rambling branches covered
ˈith numerous small scattered thorns. Occurs mostly on well-
rained slopes in deep fertile soil. Browsed to a considerable
xtent by goats, but seldom eaten by cattle because of its thorny
ranches.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
resh leaves, early fruiting stage, Kenya		18.8	18.0	6.5	5.7	51.0	1.86	0.31	129
ods, early fruiting stage, Kenya		17.5	24.0	4.6	1.1	52.8	0.46	0.27	129

B4 *Acacia catechu* (L.f.) Willd.

Black cutch or catechu

Moderate-sized deciduous tree of commercial value. The leaves and small lower branches eaten by cattle.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, India		13.0	22.6	9.8	4.6	50.0	2.74	0.17	436

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Leaves	Cattle	24.0	31.0	60.0	60.0	1.69	436

B5 *Acacia farnesiana* (L.) Willd.

Mimosa bush or sweet acacia

Very thorny bush, sometimes used for hedges. The leaves and pods are excellent browse for sheep.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves and twigs, Hawaii	40.0	17.2	17.9	5.2	2.1	57.1			245
Whole pods, Australia		17.2	19.4	4.1	1.6	57.7	0.55	0.20	195
Seeds, Australia		20.9	18.3	3.8	2.3	54.7	0.39	0.27	195

B6 *Acacia galpinii* Burtt Davy

Tree 15-20 m high with light-brown bark and leaves 10-15 cm long having a recurved thorn at their base. Flowering spikes light yellow, 5 cm long. Pods straight, light brown, 10 cm long and 0.5 cm broad. Occurs mainly along rivers.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Pods, South Africa	91.2	12.7	26.3	3.8	5.4	51.8			193

B7 *Acacia gerrardii* Benth. (*A. hebecladoides* Harms)

Medium to large tree with dense crown and large pods. The leaves, though unpalatable to livestock, are lopped to feed goats and cattle when more attractive browse is not available.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh browse, early vegetative, Kenya		17.7	24.2	6.0	1.6	50.5	0.63	0.25	129
Fallen pods, Mozambique	90.1	20.9	27.4	5.1	1.3	45.3			499

B8 *Acacia giraffae* Willd. (*A. erioloba* E. Mey.)

Camel thorn

Tree up to 15 m high with dark-grey bark and straight leaves 5-8 cm long with white thorn at their base. Flower heads golden yellow, spherical. Pods almost straight or crescent-shaped, 10 cm long and 5 cm broad, covered by a grey feltlike indumentum. Occurs on savannahs and along riverbeds. Fallen pods readily eaten by game and stock. Cases of stock poisoning frequently recorded; picked green pods suspected cause of poisoning.

		As % of dry matter								
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Pods, Zimbabwe	91.6	13.8	32.9	3.6	1.7	48.0	0.71	0.11	499
Pods, mature, South Africa		13.6	35.7	3.7	1.9	45.1	0.55	0.08	489
Pod husks, South Africa		9.2	31.8	7.3	1.0	50.7			490

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Pods, young	Sheep	59.6	49.7	58.9	62.8	2.11	499
Pods, mature	Sheep	55.7	28.9	79.7	70.0	1.96	489

B9 *Acacia karroo* Hayne

Sweet thorn

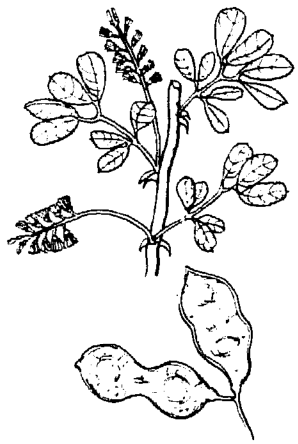
Shrub or tree up to 20 m high with blackish-brown bark and leaves 5-10 cm long, usually having long, straight, white thorns at the base. Flower heads golden yellow and spherical. Pods straight and slender, slightly constricted between the seeds, dark brown, 5-10 cm long and 0.5 cm broad. Occurs along rivers. The leaves and fruit seldom eaten by stock, probably because of the long thorns. No prussic acid in the leaves and thorns.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, South Africa	92.0	13.6	16.7				2.70	0.08	193

B10 *Acacia laeta* R. Br. *ex* Benth.

Evergreen tree found in heavier and sandy soils in dry climates. Camels are very fond of the leaves, and all animals except horses eat the ripe pods.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, Niger		26.4	18.9	9.2	3.0	42.5	2.02	0.18	45



Acacia mellifera

B11 ***Acacia mellifera* (Vahl) Benth.**

Shrub or small tree with small leaves and branches covered with very sharp thorns. Found in arid areas. Goats are very fond of the leaves, which they either browse or pick up from the ground. Not eaten by cattle.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, very young, Kenya		42.8	16.2	6.2	2.6	32.2	0.51	0.58	129
Fresh leaves, Sudan	34.1	21.3	14.1	8.6	2.6	53.4			64

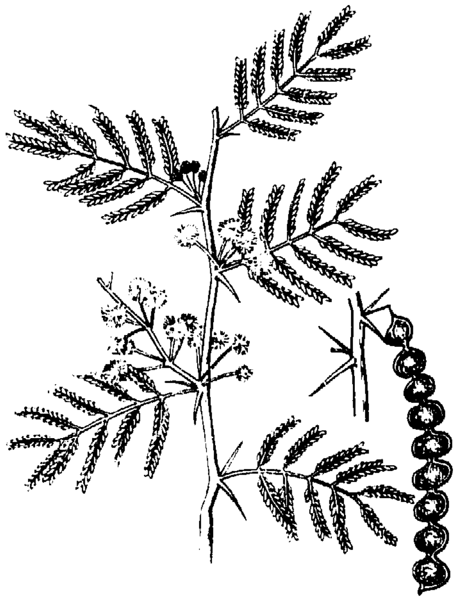
B12 *Acacia nilotica* (L.) Del.

Babul or gum arabic tree

Medium-sized thorny evergreen with rough black trunk and straight sharp spikes. Grows in dry regions, but also endures floods. A browse tree with pods and leaves that are excellent fodder and are available when there is no grass. Pods also collected as a supplement for dairy cattle. Used in rotation with grass to improve the soil. The pods are reported to contain tannic acid and must be ground before feeding to cattle, as otherwise the seeds pass undigested with faeces.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, Nigeria		12.9	11.3	6.4	12.6	56.8	1.14	0.18	58
Pods, India		13.1	12.3	5.3	2.3	67.0	1.09	0.28	379
Pods, Tanzania		12.9	15.2	5.6	2.5	63.8	0.51	0.17	167
Fallen pods, Mozambique	90.1	12.1	28.5	5.2	3.0	51.2			499

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Pods	Sheep	51.7	21.2	88.2	79.0	2.40	167



Acacia nilotica

B13 ***Acacia nilotica* (L.) Del. subsp. *subalata* (Vatke) Brenan (*A. subalata* Vatke; *A. benthami* Rochebr.)**

Small tree 2.5-4.5 m high with a dense crown that provides good shade. The thick pods, fleshy when young, readily eaten by livestock. Leaves of young trees occasionally eaten by goats. The seeds commonly included in calf starters in some countries.

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Top branches and leaves, Kenya		11.9	21.4	5.5	2.2	59.0	0.87	0.13		129
Pods, mature, Kenya		10.4	19.8	6.6	0.8	62.4	0.53	0.16		129
Seeds, Zimbabwe	92.9	13.6	10.2	3.8	5.0	67.4				499

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Seeds	Cattle	67.8	58.7	70.1	55.6	2.24	499

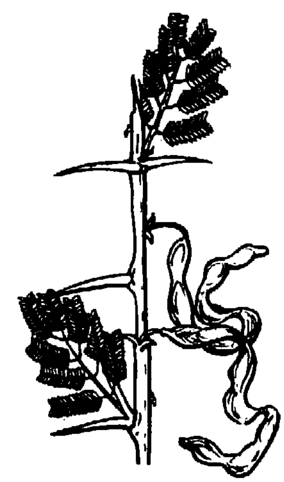
B14 *Acacia nubica* Benth.

Grey-green multistemmed bush about 3-4.5 m high with straight thorns and straw-coloured pods. An important browse shrub in parts of Africa during the dry season.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh mature leaves, Kenya		32.4	15.8	8.8	1.7	41.3	1.71	0.44	129
Pods, mature, Kenya		15.2	37.4	7.5	1.9	38.0	1.46	0.23	129

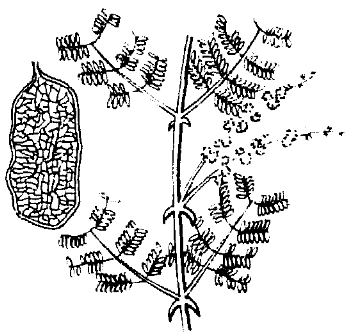
B15 *Acacia raddiana* Savi

Evergreen tree that grows on sandy soils in dry climates. The leaves eaten mostly by camels; the ripe fruits used as cattle feed.



Acacia raddiana

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, Niger		17.9	17.2	7.7	4.7	52.5	1.55	0.21	45
Young branches, Niger	32.5	16.2	28.2	6.0	2.4	47.2	1.02	0.19	537
Green pods, Niger	31.0	14.1	21.8	6.8	1.5	55.8	0.72	0.25	537
Fallen pods, Niger	90.1	17.5	20.4	6.2	1.8	54.1	0.90	0.26	537



Acacia senegal

B16 *Acacia senegal* (L.) Willd.

Senegal gum

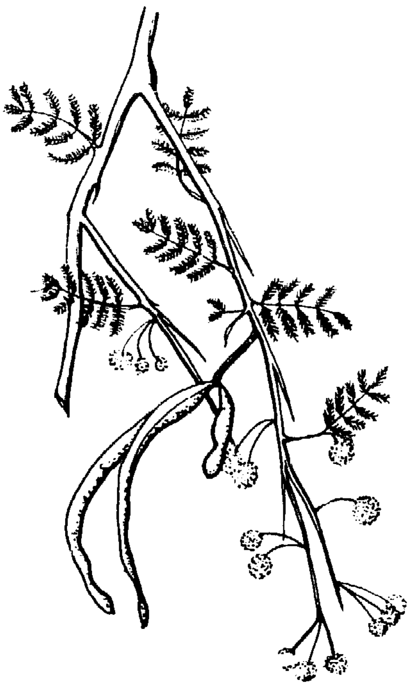
Small tree, 2-3 m high, quite widespread, often found in transitional steppe areas and can grow even under the most adverse heat and drought conditions. Yields the true gum arabic of commerce. The foliage readily browsed by goats and camels. Produces numerous small flat pods which are willingly eaten by cattle.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Dry leaves, Senegal	88.4	18.2	11.2	8.4	6.7	55.5	1.32	0.14	537
Pods, Uganda		22.0	39.0	7.1	1.0	30.9			506
Seeds, Senegal	86.7	40.1	13.7	5.0	5.8	35.4	0.75	0.31	537

B17 *Acacia seyal* Del.

Shittimwood

Slender tree, usually 6-12 m high, with a thin crown. The smooth greenish-yellow bark, thick and soft when fresh, is extensively used for feeding livestock during the dry season, usually by cutting tree to a height of about 1.5-2.5 m or by trimming off the thick branches so that the animals can browse the bark on the ground. The daily intake per head of up to 5-6 kg is claimed to be sufficient for maintenance and even some milk production. The flowers are very palatable to sheep and goats.



Acacia seyal

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Bark, dry season, Kenya		4.3	20.7	6.6	0.7	67.7	4.09	0.03		129
Bark, early wet season, Kenya		10.6	22.2	8.8	0.9	57.5	2.50	0.07		129
Fresh leaves, Sudan	43.6	22.6	8.4	9.0	4.0	56.0	3.83	0.21		64
Pods, immature, Sudan	31.5	21.3	18.6	6.1	1.8	52.2	0.98	0.43		64
Pods, mature, dry, Sudan	95.3	20.9	20.2	9.3	1.9	47.7	1.33	0.37		64

B18 ***Acacia sieberiana*** **DC. var.** ***woodii*** **(Burtt Davy) Keat & Brenan (*A. woodii* Burtt Davy)**

Paperbark thorn

Tree up to 15 m high with light-coloured bark and often with a flat crown. The leaves, 10-15 cm long, have straight white thorns at their base. The branches and often the leaves are covered with yellow hairs. The flower heads are cream-coloured and spherical. The straight, often hairy pods, 8-12 cm long and 2-3 cm broad, are readily eaten by stock; no cases of prussic acid poisoning have been reported. The tips of young shoots are intensively browsed, particularly toward the end of the dry season.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Pods, Nigeria	89.8	12.8	20.2	9.0	1.3	56.7			58
Pods, Zimbabwe	94.5	8.4	25.1	6.7	1.9	57.9	0.10	0.14	499
Fresh leaves, Senegal	48.8	15.8	23.6	11.6	6.3	42.7	2.50	0.10	537

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Pods	Cattle	57.6	59.2	68.4	60.2	2.11	499

B19 ***Acacia tortilis*** **(Forsk.) Hayne subsp.** ***heteracantha*** **(Burch.) Brenan (*A. heteracantha* Burch.; *A. litikunensis* Burch.)**

Umbrella thorn

Tree up to 10 m high with dark-grey bark and a flat crown. The leaves, 5 cm long, are usually hairy and have pairs of white thorns, both straight or one recurved, at their base. The flower heads are cream-coloured, spherical. The pods, irregularly twisted, are 3-5 cm long and generally less than 1 cm broad. The leaves and fruits are often eaten by stock. Cases of poisoning are rarely reported.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, South Africa		19.2	11.6	8.7	6.1	54.4	2.27	0.17	213
Pods, South Africa		17.3	24.8	5.7	3.1	49.1	0.79	0.34	213
Seeds, South Africa		37.8	10.9	5.9	6.0	39.7	0.56	0.73	213
Pod husks, South Africa		8.7	34.3	6.2	1.6	49.2	1.10	0.14	213

B20 *Acacia tortilis* (Forsk.) Hayne subsp. *spirocarpa* (Hochst. *ex* A. Rich.) Brenan (*A. spirocarpa* Hochst. *ex* A. Rich.)

Medium to large flat-topped tree with ring-shaped pods. Common in desert grass-bush zones. The leaves of young trees are browsed by goats and sheep, but the tree is valuable mainly for its numerous pods, which are picked up from the ground by livestock.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, Sudan	90.9	13.3	9.4	9.6	8.3	59.4	4.00	0.15	64
Pods, Tanzania		12.3	22.4	5.6	1.8	57.9	0.98	0.24	166
Pods, Kenya		17.8	17.5	8.4	1.7	54.6	1.34	0.36	129

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Pods	Cattle	46.2	42.0	74.0	76.6	2.30	166

B21 *Adenanthera pavonina* L.

Red sandalwood or sanderswood

Medium-sized tree up to 15 m high, spread throughout the world tropics. The bright-red seeds are used for ornaments and sometimes for food.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Twigs, young, Malaysia	25.8	24.8	14.0	5.8	3.5	51.9	0.19	0.24	292

B22 *Albizia amara* Boiv.

Tree 3-6 m high with a wide dense crown. The leaves, though not very palatable, are eaten from lopped branches when better-liked browse is not available. The numerous flowers are very palatable and are picked up by goats from the ground. The mature pods are eaten by game and stock.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh flowers, Kenya		26.8	21.4	7.0	1.7	43.1	1.02	0.28	129
Fresh young twigs, Kenya		26.8	26.8	6.1	1.9	38.4	0.47	0.25	129
Pods, Zimbabwe	90.6	13.7	35.2	4.3	7.5	39.3			499

B23 *Albizia chinensis* (Osb.) Merr. [*A. stipulata* (Roxb.) Boiv.]

Important browse tree in hilly areas; also grown for shade on plantations and for the manurial value of the fallen leaves. The branches are used for fodder at the end of the growing season when the leaves are past their succulent stage. Leaves in the early stages may be toxic to animals as they contain saponin, and prolonged feeding even of mature leaves may cause toxic symptoms.

	DM	As % of dry matter CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, India		15.1	31.6	5.3	4.4	43.6	1.17	0.14	445

	Animal	Digestibility (%) CP	CF	EE	NFE	ME	Ref.
Leaves	Sheep	32.3	2.0	40.4	69.6	1.47	445

B24 ***Albizia lebbek* (L.) Benth. (*Mimosa lebbek* L.; *Acacia lebbek* Willd.)**

Kokko or lebbek tree

Common roadside tree with large spreading crown. The leaves and twigs are common fodder; it is also a good shade tree on tea and coffee plantations. Cultivated for fodder in some areas.

	DM	As % of dry matter CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, India	39.6	18.1	26.5	8.0	4.7	42.7	2.02	0.14	441
Fresh leaves, Pakistan	31.7	22.0	26.5	7.0	10.0	34.5	1.84	0.20	308
Pods, Thailand	91.5	21.1	23.0	4.6	4.6	46.7			56

	Animal	Digestibility (%) CP	CF	EE	NFE	ME	Ref.
Leaves	Zebu	64.5	62.2	44.6	37.6	1.84	258

B25 *Alysicarpus rugosus* (Willd.) DC.

Alyce clover

Erect perennial herb up to 150 cm high, but usually much lower, which has been introduced into natural grasslands. As it reseeds itself well, the stand is maintained despite indiscriminate grazing and cutting. Very palatable when young, but usually low yielding. Suitable for making silage.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, India		14.7	39.1	10.0	1.8	34.4	1.26	0.23	436

B26 *Alysicarpus vaginalis* (L.) DC.

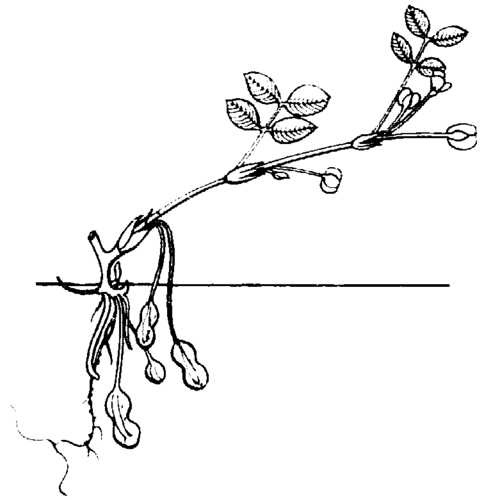
Alyce clover or one-leaf clover

Spreading, moderately branched perennial up to 1 m high. The leaves are unifoliate, broadly oval on short stalks. The pods are about 2 cm long. Does not tolerate wet lands and grows poorly on low-fertility soils. Often grown as a summer annual for hay or pasture as a substitute for lucerne. Palatable with the advantage over introduced temperate legumes of not causing bloat in cows. Susceptible to root-knot nematodes.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, Thailand	88.5	14.0	29.3	10.1	6.3	40.3			56
Fresh shoots, Malaysia	28.0	13.9	21.4	12.9	2.5	49.3			292
Seeds, Thailand	90.2	12.0	48.9	11.0	1.4	26.7			56

B27 *Arachis hypogaea* L.

Groundnut, peanut, earthnut, monkey nut, Manila nut, Chinese nut, pindar or goober pea



Arachis hypogaea

Spreading summer-annual herb 25-50 cm high. Grown mainly for the pods, but also sometimes for hay, silage and pasture, usually on poorer soils. For high yields a growing period of 4-5 months with a steady, rather high temperature is required.

Haulm. When groundnuts are harvested, the aerial portions become available in large quantities for stock feed. These have proved to be an excellent feed and are also exceptionally palatable. For the best haulm the crop should be harvested as soon as it reaches full seed production.

Hay. Whole cured plants can be fed with advantage to dairy and beef cattle, but scouring results from the use of too high a proportion in the diet. Large cattle herds in parts of South America are allowed to graze on perennial wild groundnut plants.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves and stems, Malaysia	26.9	17.5	20.1	8.6	2.2	51.6	0.93	0.20	292
Haulm, South Africa		9.9	21.1	9.3	2.4	57.3	1.48	0.08	489
Hay, Chile	88.8	26.2	27.9	11.6	2.7	31.6	3.15	0.81	315
Hay, mature, Israel	89.2	12.8	29.0	8.5	1.9	47.8	1.18	0.16	365

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Haulm	Sheep	64.1	55.6	44.6	84.2	2.53	489
Hay, mature	Sheep	65.0	51.0	56.0	75.0	2.27	365

B28 *Bauhinia galpinii* N.E. Br.

Pride of the Cape

Dense bush or rambler up to 1.5 m high. The leaves are two-lobed, resembling a butterfly in shape, and 2-3 cm long. It bears a profusion of red flowers about 2-5 cm in diameter. The pods are straight, dark brown, 10-15 cm long and 2-3 cm broad. Usually occurs in sheltered areas along rivers and gorges. Cannot withstand frost.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Pods, South Africa	99.2	17.2	20.1	3.6	3.1	56.0	0.20	0.20	193

B29 *Bauhinia variegata* L. (*B. candida* Roxb.)

Orchid tree, mountain ebony or Napoleon's hat

Small deciduous tree with variegated lavender orchidlike flowers and cleft leaves resembling an animal hoof. The pod is about 50 cm long. Grows well in all tropical countries and is an important browse.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, India	49.8	13.8	26.1	6.3	2.0	51.8	1.81	0.22	443
Fresh leaves, Pakistan	35.9	18.5	10.5	10.0	9.0	52.0	1.73	0.16	308

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Leaves	Sheep	36.0	32.7	10.6	66.4	1.79	443

B30 *Caesalpinia spinosa* (Mol.) Kuntze

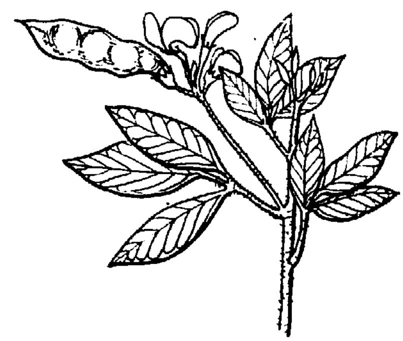
Tara

Shrub or small tree up to 5 m high with reflexed prickles along its branches. Leaves bipinnate with oval leaflets about 2 cm long. Terminal spikes about 10 cm long with yellow flowers. The red straight pods, 5-10 cm long and 1 cm broad, have a high tannin content and may be lethal if consumed in large quantities.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Pods, South Africa	92.0	8.8	9.6	8.2	1.6	71.8	0.22	0.20	193

B31 *Cajanus cajan* (L.) Huth

Pigeon pea, Congo pea, red gram, non-eye pea or dahl



Cajanus cajan

Erect short-lived perennial shrub attaining a height of 2-4 m. One of the most common legumes of the tropics and subtropics because of its very wide adaptability. Deep rooted and drought resistant, growing especially well on semidry land. Because of its poisonous roots, often planted as a hedge around cassava patches to keep out mole rats, and sometimes around houses for protection against termites. Pods, seeds and leaves are excellent fodder for cattle, which can be folded on the unharvested crop. Widely used for hay and silage (often with molasses), especially the small-seeded varieties. If cut for hay when the pods are well developed, it should be cut successively higher. Grazing may damage the plants. The ground seeds can be incorporated as a source of protein in poultry rations. Up to 30% has been included in the ration of starting chickens with the same weight gain obtained from an isonitrogenous mixture of soybean oil meal and maize.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh upper third of the plant, Hawaii	29.5	24.1	34.6	8.8	5.8	26.7			273
Fresh aerial part, late vegetative, Puerto Rico	24.4	21.4	30.8	5.8	6.0	36.0	0.89	0.24	32
Fresh aerial part, milk stage, Hawaii	49.7	18.9	29.7	5.7	5.3	40.4			515
Dried leaves, India		11.0	18.3	18.5	6.9	45.3			378
Hay, aerial part, Hawaii	88.8	16.7	32.5	3.9	1.9	45.0			273
Pods, Hawaii	87.3	20.3	35.2	3.3	1.7	39.5			273
Seëds, Malaysia	89.0	23.4	10.6	4.3	0.9	60.8	0.14	0.45	292
Seeds, cracked, India	91.8	20.2	6.2	4.0	1.9	67.7			378
Pod husks, Trinidad	93.0	6.7	38.0	4.1	0.3	50.9	1.10	0.09	117

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Browse, pre-bloom	Sheep	60.0	36.0	59.0	65.0	2.08	32
Browse, milk stage	Cattle	69.0	50.0	69.0	78.0	2.53	515
Seeds, dried	Pigs	84.8	48.8	57.3	81.6	2.93	378
Seeds, fresh	Pigs	92.0	86.0	36.0	86.0	3.55	168

B32 *Calopogonium mucunoides* Desv.

Calopo

Vigorous short-lived winding creeper native to South America. Easily established from seed, in about five months forming a dense mat of foliage 30-50 cm high. Not persistent in low-rainfall areas. Relatively unpalatable because of its very hairy stems and leaves; seldom used alone as a forage, but is grown with another grass, such as *Chloris gayana*. Does not grow in shade.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves and stems, India		15.0	35.2	7.1	1.5	41.2	0.56	0.27	436
Fresh leaves and stems, Malaysia	25.7	15.6	31.5	6.2	2.3	44.4	1.42	0.19	292

B33 *Canavalia ensiformis* (L.) DC.

Jack bean or sword bean

Fast-growing, usually erect, sometimes shrubby twining annual up to 1 m high, with runners occasionally extending to 10 m. Deep rooted and drought resistant. The seeds are edible but somewhat toxic if consumed in large quantities. Mostly used for human food or green manure, but in some countries cultivated under irrigation as fodder. The forage is palatable only when dried. Due to toxicity, caution is required in feeding herbage and pods of jack bean, and seed meals must be limited to a maximum of 30% of the total feed for cattle. Heat-treated seeds and pods are harmless. Raw jack beans cannot be included in rations containing urea, as they contain urease, which rapidly releases ammonia from urea.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, Hawaii	23.2	22.5	274	11.6	2.1	36.4			245
Seeds	86.7	36.3	9.9	2.9	2.5	48.4	0.19	0.27	44
Seeds, Zimbabwe	91.1	33.9	11.2	3.1	2.2	49.6	0.10	0.37	143
Pod husk, Ghana		4.5	48.1	3.8	1.5	42.1	0.30	0.01	294

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Seeds	Sheep	80.5	72.9	72.1	99.1	3.40	44

B34 *Canavalia gladiata* (Jacq.) DC.

Twining or climbing herb, similar to sword bean, but with white to pink flowers, rough-surfaced straight pods, and flatter, less rounded seeds, which contain a toxic saponin. Used in the same way as jack bean.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Seeds, Uganda	89.0	33.2	8.0	3.6	2.6	52.6			70

B35 *Cassia fistula* L.

Golden shower tree, pudding-pipe tree or purging cassia

Medium-sized tree with large compound leaflets 5-15 cm long and large clusters of bright-yellow cascading blossoms. Pods up to 1 m long. Twigs commonly lopped for fodder.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, Pakistan	33.3	17.6	30.2	7.8	7.8	36.6	3.27	0.33	308

B36 *Cassia laevigata* Willd.

Shrub 2-3 m high with yellow flowers and pinnate leaves consisting of three or four pairs of ovate leaflets. The pods are cylindrical, 7-10 cm long, containing shiny seeds. Widespread in the tropics and extensively browsed by cattle.

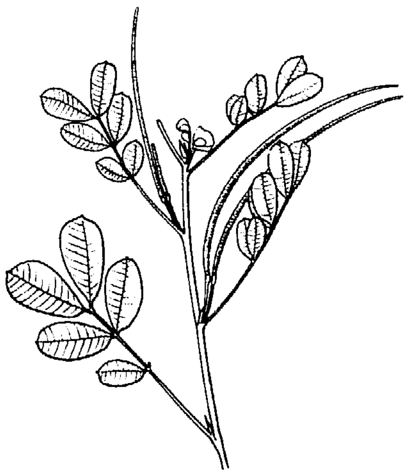
		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Browse, Zimbabwe	91.3	17.9	24.7	7.4	6.2	41.1			499

B37 *Cassia siamea* Lam.

Siamese senna

A tree sometimes cultivated as a shrub for fodder browse. Also planted around paddocks as a fence, at the same time serving as browse.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh twigs, young, Malaysia	33.9	20.0	16.5	5.3	5.6	52.6	1.14	0.14	292
Leaves, Thailand	91.3	16.8	19.8	5.4	11.2	46.8			56



Cassia tora

B38 *Cassia tora* L.

Wild senna or sickle senna

Herb or small bush with pinnate leaves. The fresh herbage is evil smelling and unpalatable to animals. The seed has been included up to 10% in poultry diets without adverse effects. The leaf meal may be used to the extent of 5% in a standard poultry mash. Milk cows can tolerate up to 15% seeds in their rations.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Seeds, India		18.2	4.6	9.1	7.4	60.7	0.72	0.20	379
Leaves and fruit	41.3	13.2	19.9	9.9	4.4	52.7	2.81	0.57	537

B39 *Centrosema pubescens* Benth.

Centro

Creeping, twining perennial herb, native to South America, with trifoliate leaves and large flowers. Very leafy, without any woody growth even when 18 months old. Adaptable to dry conditions and fairly drought resistant. Moderately palatable once animals have become accustomed to it; also makes good hay. Valued as a companion legume for many grasses because of its vigorous and productive growth, good quality herbage and ability to form balanced mixtures with grass.

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Fresh aerial part, 4 weeks, 25 cm, Thailand	20.2	24.3	30.2	9.9	3.5	32.1	1.19	0.40		219
Fresh aerial part, 6 weeks, 30 cm, Thailand	19M5	23.6	31.8	8.2	3.6	32.8	1.03	0.41		219
Fresh aerial part, 8 weeks, 35 cm, Thailand	15.4	25.3	31.8	7.8	3.2	31.9	1.04	0.32		219

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh	Sheep	57.0	33.0	52.0	67.0	1.90	219

B40 *Ceratonia siliqua* L.

Carob, St. John's bread or locust bean

Evergreen tree up to 10 m high with smooth grey bark. The glossy dark-green leaves are bipinnate with almost round, leathery leaflets, 2-5 cm long. The green flowers occur in short spikes on woody branches. The pods are brown, usually straight and 10-20 cm long. The seeds are embedded in the thick fleshy sugar-rich pods. The seeds, all being the same size, are used as weights in eastern Mediterranean countries (the word "carat" comes from the Arabic name of the seeds).

The tree is native to the Mediterranean countries but is now found in many arid areas of the subtropics. The species is trioecious: some bear only staminate flowers, others only pistillate flowers, and still others only hermaphrodite flowers. For this reason the trees should be planted in groups of ten or more, as otherwise pollination may not take place.

Carob is cultivated for its abundance of pods, rich in sugar when ripe, which are used for the production of alcohol or ground with the seeds to make carob bean meal for animal feed. The seeds, representing about 10% of the whole pods, are processed for mannogalactan, and germ meal is produced as a by-product. The seeds are extremely hard; unless ground before feeding they are not digestible.

Carob beans are very palatable to cattle and pigs, but they contain tannic acid, which reduces digestibility, especially of protein. If large amounts are fed, the tannic acid will reduce also the digestibility of other feeds used together with carob. Carob bean meal has been used as a substitute for grain in the diet for ruminants; 10% is a common level but higher proportions have been used. If used for pigs, the liveweight gain decreases in proportion to the amount of carob bean meal included in the diet; a level of 10% or less will affect the liveweight gain only very slightly. The maximum amount of carob bean meal that can be included in the pig diet is about 20% of the total ration. For poultry the only available nutrient component seems to be the sugar, and poor results are obtained because of the bulkiness. If supplemented with fat to increase the energy intake, carob bean meal gives satisfactory results when it constitutes up to 20% of the diet.

Carob germ can be used for all classes of livestock, and up to 20% without supplementation has been used in poultry diets with good results.

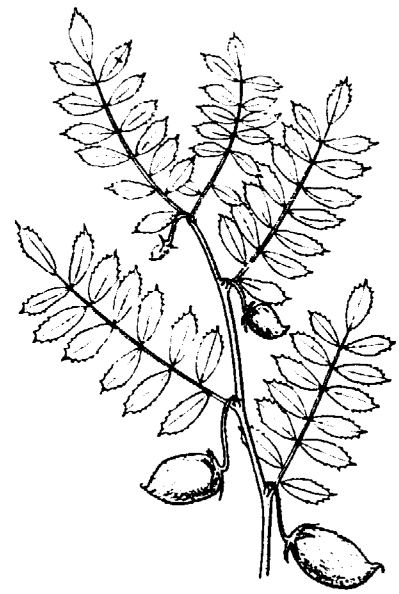
The pulp obtained from the industrial processing of alcohol has a satisfactory chemical analysis, but is nearly indigestible and unpalatable to animals.

Carob beans have been used as substrate in the production of microbial protein for animal feeds in Cyprus.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Pods ground	89.3	6.9	12.0	3.7	1.2	76.2	0.56	0.12	229
Pods, Cyprus	90.7	5.4	6.3	3.3	0.4	84.6			369
Seeds, Italy		18.5	8.0	3.5	2.0	68.0			327
Pod husk, Zimbabwe		4.2	10.2	2.8	2.4	80.4			19
Germ meal	89.4	45.1	3.6	5.9	5.2	40.2	0.11	0.97	121
Residue after alcohol production, Cyprus		7.7	15.0	4.5	0.2	72.6		0.10	369
Residue after sugar extraction, Cyprus		6.5	13.4	2.4	0.3	77.4			369

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Pods	Sheep	2.2	40.3	64.4	62.3	2.03	327
Seeds	Sheep	67.0	64.8	70.5	87.8	3.00	327
Germ meal	Sheep	90.3	85.2	82.9	11.1	2.36	121
Fermented residue	Sheep	15.0	49.0	0.0	79.0	2.40	365
Pods, ground	Pigs	15.0	46.0	99.9	80.0	2.84	229

B41 *Cicer arietinum* L.



Cicer arietinum

Chickpea, garbanzo bean, Egyptian pea, gram pea, Bengal gram

Erect shrubby quick-growing annual about 50 cm high, native to western Asia. Adapted to a tropical climate with moderate temperatures and successfully cultivated under irrigation in the cool season of many tropical countries. The grain, young shoots and pods are used mostly for human consumption, and the rest of the plant for fodder after threshing. The hay is somewhat toxic. The seeds have been used at high levels in poultry diets, and normal egg production has been maintained with up to 80% pea meal in diets for layers if supplemented with 2% blood meal. Better results are obtained with autoclaved seeds (0.70 kg/cm^2 or 10 lb/in^2 for 30 minutes) than with raw or soaked seeds; up to 15 kg per day have been fed to high-yielding cows with good results. Raw chickpeas support satisfactory growth in pigs even when constituting 80% of the diet. At high rates of inclusion, methionine supplementation of 0.2% improves growth.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh aerial part, India		11.3	27.2	11.4	2.2	47.9	1.41	0.25	436
Straw, India	90.6	6.0	44.4	13.3	0.5	35.8	0.34	0.12	282
Hay, India		12.9	35.3	11.2	1.5	39.1	1.53	0.20	436
Pods, India	95.1	17.0	25.0	9.6	2.9	45.5	1.39	0.24	436
Seeds, Malaysia	88.9	25.8	10.1	3.6	3.9	56.6			292
Seeds, India		18.1	9.8	3.5	4.9	63.7	0.26	0.41	436
Bran, Chile	88.4	15.7	24.3	7.0	4.2	48.8	1.56	0.31	315
Pod husk, India		5.8	48.4	6.0	0.9	38.9			436

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Straw	Cattle	40.0	40.0	0.0	47.0	1.35	282
Seeds	Sheep	66.2	56.9	63.6	93.0	3.11	512

B42 ***Clitoria ternatea*** **L.**

Kordofan pea, butterfly pea or Asian pigeonwings

Tall slender climber with pubescent stems, widespread in the tropics throughout the world. Used for grazing and combines well with Sudan grass, sweet sorghum and especially sunn hemp. Fast initial growth: up to 24 tons of fresh material per hectare obtained after only two months.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, Philippines		19.5	11.8	8.6	4.5	55.6	3.29	0.17	165

B43 ***Crotolaria anagyroides*** **H.B.K.**

Tall vigorous perennial bush, native to South America. Grows rapidly to more than 4 m high and is resistant to drought. A common cover crop on tea and coffee estates. Can yield a large quantity of leafy herbage. Not toxic and well liked by cattle.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh, early vegetative, Kenya		23.0	28.0	7.2	2.2	39.6	0.57	0.28	134

B44 ***Crotolaria arenaria*** **Benth.**

Perennial plant up to 40 cm tall. Found in dry areas, and remains green during the dry season. Eaten by all animals except horses and asses.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, mid-bloom, Niger		14.3	37.5	12.1	1.7	34.4	1.23	0.22	45

B45 *Crotolaria brevidens* Benth. var. *brevidens* (*C. intermedia*)

Slenderleaf

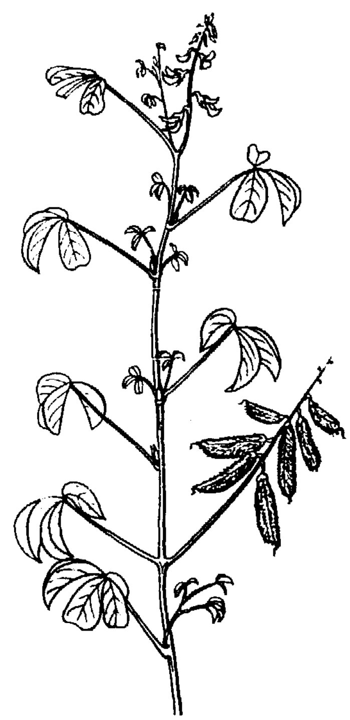
Nonpoisonous annual adaptable to a variety of soils and climates. Produces a high yield of forage and can be used as pasture, but has a rather low palatability and the animals have to get accustomed to the taste. Makes a stemmy and coarse hay.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh, early bloom, Kenya		28.9	22.1	9.9	3.3	35.8	0.44	0.27	134

B46 *Crotolaria incana* L.

Shackshack

Perennial bushy shrub 1.5-2 m high, native to South America. Produces a large amount of leafy herbage, which is nontoxic. Low palatability for cattle and sheep.



Crotolaria incana

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Fresh browse, early vegetative, Kenya		23.8	27.1	9.9	2.9	36.3	0.81	0.26		134

B47 *Crotolaria juncea* L.

Sunn hemp

Branched erect annual 2-3 m high with elliptical lanceolate leaves and yellow terminal flowers. The pods are small and inflated, having stiff hairs. Commonly grown in India for fodder. The seeds and pods are sometimes toxic and should therefore be removed before feeding. Yield of herbage can be high, especially when fertilized with phosphorus. Can be used as fresh forage or made into hay. In Andhra Pradesh (India) it is stacked in alternate layers with rice straw to increase the value of the straw. Young plants are not palatable.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, India		15.0	30.0	8.2	5.8	41.0	2.08	0.51	436
Hay, Zimbabwe	92.3	12.5	45.7	5.5	1.0	35.3			499
Seeds, Nigeria	96.0	40.3	10.0	5.6	1.4	42.7			374

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Hay	Cattle	59.3	46.8	91.2	58.7	1.91	499

B48 ***Crotolaria macrocalyx*** **Benth.**

Perennial plant 40-50 cm high that grows in clay soils in the zone extending from tropical West Africa to Ethiopia. Low palatability.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh, mid-bloom, Niger		15.1	37.7	6.2	2.4	38.6	0.56	0.12	45

B49 ***Cyamopsis tetragonoloba*** **(L.) Taub. (*C. psoralioides* D.C.)**

Guar or cluster bean

Erect annual herb 1-2 m high with trifoliate leaves and rose-coloured flowers. Drought resistant. Cultivated as grain, fodder or vegetable. Poor for grazing because of its hairy, nettly leaves. Begins fruiting two months after sowing. Can be cut for fodder as soon as the pods begin to develop. Palatable to stock if cut and wilted. Often grown with sorghum.

The seeds are used for extraction of gum (mannogalactan). The residue, guar meal, is unpalatable and toxic. Untreated guar meal can constitute up to 25% of cattle rations, and up to 10% of poultry rations. Owing to residual gum in the meal the faeces will be watery and sticky.

Detoxified meal can be used as the sole protein component of cattle diets.

Cyamopsis tetragonoloba

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, pre-bloom, India		16.0	22.7	17.0	1.9	42.4	1.80	0.10	279
Seed-harvested vines, India		10.6	23.9	10.6	1.5	53.4	1.27	0.26	378
Fresh, stems, India		6.8	48.0	4.5	1.0	39.7	0.75	0.12	378
Leaf meal, India	85.8	22.5	9.7	14.4	3.5	49.9			96
Hay, India		25.2	13.8	16.5	0.9	43.6	2.42	0.27	436
Pods, India		10.6	23.9	8.4	1.3	55.8	1.16	0.26	436
Seeds, India	92.4	28.0	5.0	4.0	3.7	59.3		0.42	378
Detoxified guar meal, Pakistan	94.2	42.9	7.2	8.8	5.2	35.9			238
Untreated guar meal, Pakistan		94.8	41.1	6.8	7.6	5.0	39.5		238
Gum, India		6.1	47.6	4.7	1.0	40.6	0.82	0.10	436

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Browse, pre-bloom	Cattle	77.0	26.0	39.0	70.0	1.88	279
Vines	Cattle	61.5	75.8	24.2	78.3	2.48	378
Seeds	Cattle	79.3	0.0	59.5	72.0	2.68	378
Detoxified meal	Cattle	93.9	27.7	91.0	63.2	3.00	238
Untreated meal	Cattle	95.5	26.4	88.6	53.0	2.86	238

B50 *Cytisus proliferus* L.f.

White-flowered tree lucerne, tagasaste or escabon

Ornamental shrub, native to the Mediterranean, which is drought resistant and grows in sandy soils. A highly valued fodder bush from which heavy yields can be obtained year after year. Animals accustomed to grazing on it consume even the thick stems, so that the shrubs are eaten back to a compact base very quickly. The green leaves can also be lopped for poultry.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh browse, Australia		25.0	22.0	5.0	4.0	44.0	0.57	0.19	454

B51 *Dalbergia sissoo* Roxb.

Sissoo or rosewood

Large deciduous tree growing in light soils and requiring a large amount of water. The rather small leaves are good fodder. Cattle are very fond of the leaves and young shoots, on which they browse freely. The leaves can be ensiled.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, young, India	25.1	24.1	12.5	6.6	2.0	54.8	0.84	0.42	344
Fresh leaves, Nigeria		21.8	15.6	8.7	3.6	50.3	1.18	0.25	234
Silage of leaves, India	24.6	14.0	30.0	18.3	3.6	34.1			277

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Leaves	Cattle	56.0	30.0	27.0	72.0	2.19	436
Silage of leaves	Cattle	51.8	34.0	28.1	50.0	1.38	277

B52 *Delonix regia* (Boj. *ex* Hook.) Raf. (*Poinciana regia* Boj. *ex* Hook.)

Flamboyant, royal poinciana or flame tree

Rapidly growing tree up to 20 m high with bipinnate leaves 15-20 cm long and leaflets 0.5-1 cm long. Red flowers 3-4 cm in diameter on terminal branches. Dark-brown pods about 40 cm long and 5 cm wide. Native to Madagascar. Grows well only in frost-free areas.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Pods, South Africa	89.4	11.1	49.7	4.7			0.23	0.14	193

B53 *Desmanthus virgatus* Willd.

Dwarf koa or bundle flower

Erect bush, native to tropical and subtropical America, resembling koa haole (see B82) except for its slender angular pithy stems, smaller leaflets and narrow pods. Used for both fodder and grazing as it is palatable, has an excellent growth rate and withstands cutting and grazing.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh browse, Hawaii	38.3	11.5	39.3	5.8	2.4	41.0			516

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Aerial part	Cattle	44.0	44.0	47.0	59.0	1.80	516

B54 *Desmodium barbatum* Benth.

Perennial plant with erect stems up to 70 cm high. A proposed substitute for lucerne in tropical climates. Can be used as a pasture plant.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Browse, Brazil	83.0	10.4	34.7	3.9	4.0	47.0	0.34	0.05	88

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Aerial part	Cattle	73.0	55.0	62.0	76.0	2.50	88

B55 *Desmodium discolor* Vog.

Perennial shrub growing in tropical and subtropical climates. Very palatable. A possible substitute for lucerne in hot climates and on acid and calcium-deficient soils. High herbage yields. Suitable for hay and silage.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Browse, Cuba	78.6	18.7	33.4	10.0	0.3	37.6			88
Fresh browse, fruiting, Brazil	22.7	12.1	35.1	6.7	2.8	43.3	1.25	0.19	88

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh browse, fruiting	Cattle	73.0	55.0	65.0	76.0	2.41	88

B56 *Desmodium gyroides* DC.

Erect prostrate bush with trifoliate leaves and purple flowers. Adapts to shade and is commonly grown on tea and rubber plantations for cover. Makes good fodder.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Browse, India		11.5	45.2	8.5	0.7	34.1	0.97	0.40	436

B57 *Desmodium heterophyllum* DC.

Prostrate perennial herb that is a rather good pasture plant, forming a dense sward and growing well with grasses. Palatable and tolerant of close grazing. Needs to be inoculated with its own specific *Rhizobium* strain to fix atmospheric nitrogen.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, Malaysia	28.0	8.9	27.1	12.5	1.4	50.1	0.74	0.10	292

B58 *Desmodium intortum* (Mill.) Fawc. & Rendle

Greenleaf desmodium, Kuru vine

Rambling perennial, native to South America and cultivated as a fodder plant in other parts of the world. Cannot withstand close grazing. Artificially dried leaves have successfully been used as a substitute for lucerne meal. Tolerates moderately low temperatures. Popular as it produces a large bulk of palatable herbage; now being introduced on farms in a number of countries as a companion legume to some grass species.

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Fresh, wet season, 4 weeks, 20 cm, Thailand	16.5	17.0	30.3	10.9	3.0	38.8	1.27	0.55		219
Fresh, wet season, 6 weeks, 40 cm, Thailand	17.2	15.1	30.2	8.7	3.5	42.5	1.40	0.47		219
Fresh, wet season, 8 weeks, 55 cm, Thailand	19.2	13.0	31.8	7.8	3.6	43.8	1.09	0.42		219
Fresh, wet season, 13 weeks, 75 cm. Thailand	25.7	10.1	35.4	7.0	3.1	44.4				219
Fresh, dry season, 4 weeks, 20 cm, Thailand	21.3	20.7	25.4	9.4	3.3	41.2	1.41	0.52		219
Fresh, dry season, 6 weeks, 40 cm, Thailand	20.2	18.3	27.2	8.9	4.5	41.1	1.24	0.74		219
Fresh, dry season, 8 weeks, 45 cm, Thailand	21.4	16.4	29.0	8.4	3.7	42.5	1.21	0.42		219

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, 75 cm	Sheep	14.0	33.0	41.0	49.0	1.37	219

B59 *Desmodium pabularis* Hoehne

Erect plant up to 3 m high, native to tropical America. Abundant in relatively cool areas, mostly in grass-bush habitats. A valuable forage plant which makes good hay. Promising for introduction on farms.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh browse, milk stage, Cuba	27.4	23.8	23.4	10.2	2.3	40.3			88

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, post-bloom	Cattle	73.0	55.0	62.0	76.0	2.43	88

B60 *Desmodium scorpiarus* Desv.

Samoan clover

Perennial herb with a creeping habit. Extremely drought resistant and recovers quickly after grazing. Moderately palatable; usually mixed with *Axonopus affinis, Panicum maximum* or *Paspalum scrobiculatum.*

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Fresh aerial part, Nigeria	16.8	15.5	29.3	9.7	3.0	42.5				58

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Aerial part	Cattle	49.7	38.2	23.3	59.1	1.70	58

B61 *Desmodium triflorum* (L.) DC.

Three-flower beggarweed

Perennial herbaceous creeping plant found in the tropics throughout the world. Used as a cover crop in rubber plantations and produces good fodder. Recovers well after grazing.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, Malaysia	25.0	8.8	29.2	8.8	2.8	50.4	0.74	0.12	292
Fresh aerial part, Cuba	35.4	13.6	35.0	7.3	2.5	41.6			88

B62 ***Desmodium uncinatum* (Jacq.) DC.**

Spanish clover, thick clover, silverleaf desmodium

Spreading perennial native to tropical America. Its upright stems spread and its roots node at the stem when cut. It has a large root system but grows best in wet lowland because the roots are shallow. Grows well with grasses (e.g., Kikuyu). Tolerates frost. High herbage and seed yields.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh aerial part, India		12.8	29.7	9.1	3.4	45.0	1.06	0.41	436
Fresh, mid-bloom, Australia	22.0	18.2	32.5	7.6	4.6	37.1			340
Fresh, mature, Australia	26.0	11.8	41.3	6.8	2.6	37.5			340

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Fresh, mid-bloom	Sheep	67.5	33.5	71.2	70.4	2.12	340
Fresh, mature	Sheep	53.7	45.2	57.7	60.2	1.88	340

B63 ***Dichrostachys cinerea* Wight & Arn.**

Sicklebush or Christmas bush

Shrub up to 3 m high with grey bark and solitary thorns often bearing one or two leaves. Leaves bipinnate and finely pubescent, 2-8 cm long. Pendulous flower heads that are pink in the upper part and yellow in the lower part. Dark-brown pods, borne in clusters, twisted, each 5-8 cm long and 0.5-1 cm broad. Pods eaten by stock. In bush country often causes serious problems in overgrazed areas and forms impenetrable thickets. Browsed during the dry season.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Pods, South Africa	92.5	16.6	22.1	5.6	5.4	50.3	0.92	0.12	193

B64 *Dichrostachys glomerata* (Forsk.) Chiov. (*D. nutans* Benth.; *Acacia spinosa* E. Mey.)

Chinese lantern tree

Small tree or shrub with twisted branches and stout straight or slightly curved thorns. Can form dense impenetrable thickets and is most difficult to eradicate. The pods, twisted and borne in large bunches, are much relished by cattle and game.

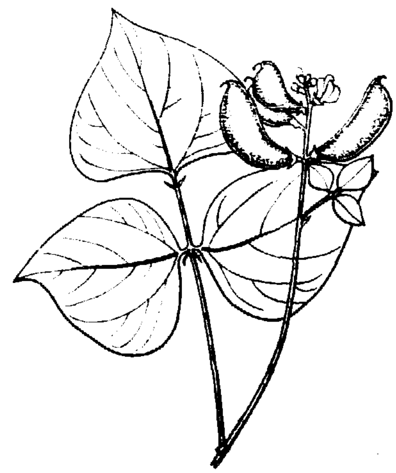
	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Pods, Nigeria		11.4	25.6	5.5	1.2	56.3			58
Pods, Tanzania	90.0	10.8	26.6	5.4	1.4	55.8	0.51	0.20	167

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Pods	Sheep	37.2	55.3	69.0	67.3	2.14	167

B65 ***Dolichos lablab* L. [*Lablab vulgaris* Savi; *L. niger* Medik.; *L. purpureus* (L.) Sweet]**

Lablab, Egyptian bean, hyacinth bean or bonavist bean

Annual or perennial robust twiner, native to India. Similar in climatic adaptation to the cowpea. Cultivated mainly for the edible seeds, but also important for hay and silage in many countries. Grown alone or mixed with maize or sorghum. After the mature beans have been harvested, the field can be grazed by stock. Pods and seeds can be fed to stock as concentrates. Fast growing and able to withstand heavy grazing when young.



Dolichos lablab

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, Malaysia	18.4	13.6	31.5	12.5	4.9	37.5	1.61	0.31	292
Fresh aerial part, India		14.2	28.1	14.8	3.5	39.4	1.98	0.26	436
Hay, Sudan		16.6	37.1	9.3	2.9	34.1			98
Pods, India		10.1	36.2	6.2	0.8	46.7	0.90	0.12	436
Seeds, Zimbabwe	92.0	28.0	8.6	4.2	1.2	58.0	0.99	0.36	499
Seeds, Uganda	89.3	24.2	8.5	4.4	0.8	62.1			70

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Hay	Cattle	74.1	66.8	62.1	53.1	2.22	98
Seeds	Cattle	65.2	53.0	56.0	88.0	2.86	499

B66 ***Enterolobium cyclocarpum* (Jacq.) Griseb.**

Elephant's ear, earpod, mulatto ear or monkey ear

Spreading deciduous tree with a huge grey trunk. In the dry season, when bare of its feathery foliage, the brown ear-shaped seed pods can be seen dangling high on the tree. The seeds are sometimes used as human food.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh twigs, young, Malaysia	43.5	16.8	12.2	5.0	5.3	60.7	0.67	0.14	292
Seeds, Costa Rica	88.7	21.8	13.5	4.1	1.7	59.0			537

B67 ***Gleditsia triacanthos* L.**

Honey locust or sweet locust

Tree up to 22 m high, with or without branched thorns. Bipinnate leaves 15-20 cm long with oval undulate leaflets 1-3 cm long. Small flowers in spikes, 3-10 cm long. Pods straight, crescent-shaped, rarely twisted, 40-50 cm long. Cultivated especially in drier areas as a fodder plant.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Pods, South Africa		23.1	12.7	5.4	4.6	54.2			296
Seeds, South Africa	92.8	10.6	21.1	3.9	0.8	63.6	0.28	0.32	193

B68 ***Gliricidia maculata*** **H.B.K. (*G. sepium* H.B.K.)**

Gliricidia or Nicaraguan shad

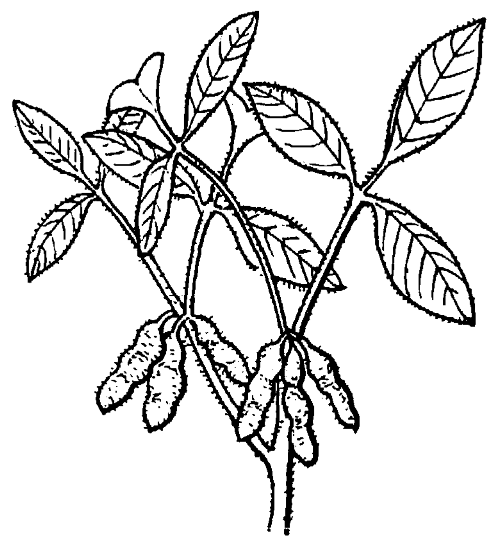
Medium-sized fast-growing tree, native to South America. Good browse and can be planted as a hedge or as fence posts along pastures to provide forage. Withstands grazing and lopping, and can be trimmed to 1-1.5 m in height to be within the reach of animals.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh twigs, Trinidad	14.1	20.5	30.2	10.2	1.5	37.6			117
Fresh twigs, young, Malaysia	27.1	18.8	15.5	6.3	3.7	55.7	0.66	0.11	292
Fresh leaves, Trinidad	25.4	30.0	14.1	8.0	4.3	43.6			117

B69 ***Glycine max*** **(L.) Merr. (*G. soja* Sieb. & Zucc.)**

Soybean, soya bean, soja bean or Manchurian bean

Annual summer herb up to 1 m high, usually erect though some varieties twine. The plant is entirely covered with fine brown or grey hairs. The trifoliate leaves usually drop before the seeds are mature. The climatic adaptation is about the same as that of maize — it needs warm but not too hot summers for development and can be grown on most types of soil, even if poor. After the plant is well started, it withstands short periods of drought and is not seriously retarded by a wet season. Less susceptible to frost than maize, cowpeas or field beans.



Glycine max

Straw. Residue of threshing of the beans from the plants. Low in digestible protein and high in fibre, but a relatively poor roughage. Should be combined with a good legume hay even for heifers and dry cows.

Hay. Digestive troubles may be caused by feeding soybean hay alone as it usually contains coarse woody stems; but this might be overcome to an extent by heavier rates of seeding and by early harvesting. The hay yield at full-bloom stage is approximately half that obtained when seeds are one half to three fourths developed. The percentage of leaves in the hay decreases with maturity.

Silage. Soybean is seldom ensiled alone because of its bitter taste; but it makes good silage if ensiled with maize, for example.

Pasture. Soybean is not a satisfactory pasturage for cattle as trampling damages the growing plant; it is used as pasturage for poultry and is an excellent supplementary pasturage for pigs. For the best results the beans should be allowed to ripen before the crop is grazed. Varieties at different stages of maturity can be mixed in the same pasture to secure a longer grazing period. A soybean pasture can be regrazed after about a month's regrowth.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh, 20 cm, Chile	26.1	10.2	33.6	8.6	3.8	43.8	1.47	0.25	315
Fresh, 40 cm, Chile	26.1	11.3	35.4	8.4	3.5	41.4	1.33	0.26	315
Fresh, 80 cm, Chile	26.1	12.2	34.2	8.2	4.2	41.2	1.27	0.25	315
Fresh, mid-bloom, fertilized, Puerto Rico	16.0	16.6	31.0	11.8	2.8	37.8	1.57	0.25	32
Fresh, mature, fertilized, Puerto Rico	25.0	16.1	29.6	11.9	6.2	36.2	1.22	0.24	32
Hay, including all leaves, South Africa		13.9	35.5	5.5	2.5	42.6	0.94	0.18	489
Hay, overripe, few leaves, South Africa		19.5	25.7	12.1	7.4	35.2	0.78	0.31	489

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Fresh, mid-bloom	Sheep	76.0	57.0	51.0	74.0	2.31	32
Fresh, mature	Sheep	77.0	53.0	83.0	67.0	2.38	32
Vines, few leaves	Sheep	68.4	43.1	46.3	72.2	2.17	489
Vines, with leaves	Sheep	83.1	56.5	92.0	71.4	2.66	489

B70 ***Glycine wightii* (Grah. *ex* Wight & Arn.) Verde (*G. javanica* L.)**

Glycine

Glycine wightii

Slender perennial legume growing on lighter types of soil. In hotter climates forms seeds which germinate readily, but can also be propagated from cuttings and roots. An excellent substitute for kudzu, not as high yielding but easier to propagate. Palatable and capable of producing herbage during the dry season. Valued for its drought resistance, adaptability to different soil conditions, good yields of herbage and ability to mix well with grasses. A number of cultivars exist.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh, late vegetative, Tanzania		17.9	30.3	8.8	2.3	40.7			487
Fresh, mature, India		10.1	32.7	8.6	0.7	47.9	0.53	0.33	436
Hay, Brazil	88.9	14.4	34.2	8.5	2.6	40.3	0.99	0.31	381

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Hay	Sheep	71.2	54.6	44.4	68.9	2.21	381

B71 *Hedysarum coronarium* L.

Sulla or French honeysuckle

Perennial herb 1-1.5 m high and rather deep rooted. The pods have a yellow thorny surface which turns brown at maturity. Grows in a warm but not tropical climate with mild winters. Drought resistant. Of great importance in northern Africa and southern Europe as a green fodder and hay crop.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh, early bloom, Italy	12.0	19.6	24.0	14.0	2.4	40.0	1.12	0.34	319
Fresh, mid-bloom, Italy		13.3	30.5	10.5	2.3	43.4			319
Pods, Italy		13.8	23.6	15.5	2.1	45.0			319
Straw, Italy		5.8	51.8	7.5	0.3	34.6			319
Hay, Italy		13.6	30.0	10.7	2.0	43.7			319

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, early bloom	Sheep	70.7	61.0	68.9	82.4	2.45	319
Fresh, mid-bloom	Sheep	56.4	47.4	61.7	72.2	2.09	319
Hay	Sheep	59.8	39.9	63.1	66.1	1.93	319

B72 *Indigofera arrecta* Benth. *ex* Harv. & Sond.

Erect woody bush, usually grown for cover and green manure, but also used as a browse shrub. Not very palatable during the rainy season, but well browsed toward the end of the dry season, when the young subsidiary shoots are also readily eaten.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh, mid-bloom, Kenya		26.2	25.5	8.9	2.2	37.2	1.36	0.35	134

B73 *Indigofera diphylla* Vent.

Perennial plant 40-50 cm tall that prefers sandy soils. Grows in drier areas, where it stays green through most of the dry season.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh, mid-bloom, Niger		15.8	38.8	5.9	5.4	34.1	0.57	0.15	45

B74 *Indigofera hirsuta* L.

Hairy indigo

Erect-prostrate climbing annual, producing heavy foliage on fine stems that become rather coarse in later stages of development. Grows well on poor sandy land. Yields good quality forage that can be used for hay and pasture. Somewhat toxic; should not constitute the entire ration for cattle.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, Thailand	21.8	19.5	22.7	10.3	2.9	44.6	1.59	0.20	56
Fresh, mid-bloom, Niger		18.0	25.2	11.0	1.7	44.1	1.84	0.23	45

B75 ***Indigofera retroflexa*** **Baill. (*I. subulata* Vahl *ex* Poir.)**

Perennial 0.5-1 m high that is resistant to drought and light frosts. Regarded as a promising forage crop. Palatable.

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Fresh aerial part, East Africa		16.8	31.8	9.5	1.1	40.8				413

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Aerial part	Sheep	72.5	46.3	43.3	59.0	1.97	413

B76 ***Indigofera secundiflora*** **Poir.**

Perennial up to 80 cm tall that grows in sandy soils in drier areas.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh, mid-bloom, Niger		16.9	19.1	17.2	1.9	44.9	4.26	0.23	45

B77 ***Indigofera spicata*** **Forsk. (*I. endecaphylla* Lam.)**

Trailing indigo or creeping indigo

Perennial creeping herb with a strong root system. Can be cultivated with grasses and grazed or cut for fodder. Some strains are toxic and can cause abortion or stillbirth in cows and heifers. Other symptoms are loss of weight, nervous disorders, nasal discharge and diarrhoea. Despite its toxicity, palatable to cattle.

Indigofera spicata

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, India		12.3	38.4	11.7	0.8	36.8	1.23	0.40	436

Lathyrus sativus

B78 *Lathyrus sativus* L.

Chickling vetch or grass pea

Annual herb of many varieties, differing in flower and seed colour, plant size and shape. Foliage and seeds used for forage; the latter also for human consumption. Not toxic if fed together with a good source of vitamin A, such as fresh green feed. Heat treatment of the seeds improves their nutritive value.

If sown among transplanted rice plants, it will grow up after the rice is harvested and provide graze for cattle.

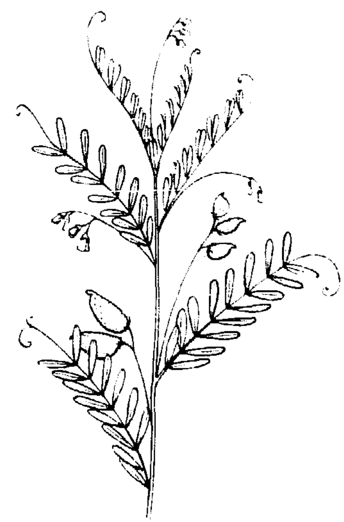
	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh, late vegetative, Israel	17.4	20.7	23.0	10.9	3.4	42.0	1.32	0.34	365
Fresh, early bloom, Israel	21.8	14.7	29.8	14.2	2.8	38.5	1.56	0.37	365
Fresh, mid-bloom	28.0	17.9	30.4	12.5	2.4	37.1	1.00	0.21	365
Hay, Israel	88.9	18.2	30.5	11.1	3.3	36.9			365
Seeds, Israel	89.6	27.6	8.4	5.1	0.9	58.0			365
Seeds, Chile	89.4	20.9	5.9	2.6	2.0	68.6	0.65	0.30	315

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, pre-bloom	Sheep	79.0	63.0	52.0	88.0	2.70	365
Fresh, early bloom	Sheep	74.0	55.0	48.0	81.0	2.29	365
Fresh, mid-bloom	Sheep	75.0	73.0	34.0	63.0	2.29	365
Hay	Sheep	75.0	61.0	57.0	72.0	2.37	365
Seeds	Sheep	90.0	86.0	99.9	94.0	3.38	365

B79 ***Lens culinaris*** **Medik. (*L. esculenta* Moench)**

Lentil, split pea or red dahl

Erect annual bushy herb about 50 cm high, native to Asia. Widely cultivated in temperate and subtropical climates and in the tropics at high altitudes. An extremely important grain legume in the Near East and India. The seeds used mostly for human consumption, and the harvested vines for cattle feed.



Lens culinaris

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Seeds with hulls, Uganda	90.5	26.5	2.9	3.0	1.0	66.6			70
Seeds without hulls, Uganda	89.6	26.7	0.5	12.0	1.2	59.6			70
Bran, Chile	87.6	26.4	8.4	2.8	1.1	61.3			315
Pod husks	88.0	12.6	29.0	3.5	0.8	54.1			512

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Seeds with hulls	Sheep	85.9	52.9	63.2	92.9	3.33	512
Pod husks	Sheep	11.8	67.2	99.9	70.3	2.21	512

13

B80 *Lespedeza cuneata* (Dum.) G. Don (*L. sericea* Miq.)

Sericea or sericea lespedeza

Perennial herb normally between 40 cm and 1 m high with stems that are densely beset with small leaves. Produces a good bulk of forage in its second year. Drought resistant. Good grazing either alone or mixed with grass. Because it contains tannic acid, palatability and digestibility are low. For hay it should be cut when about 30 cm high to ensure a high protein and low tannic acid content. It should be left in the swath in bright sunlight for not more than one hour, then windrowed and brought to the barn the day it is cut.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh, early bloom, USA	25.0	16.4	32.0	12.8	2.0	36.8	1.35	0.21	356
Hay, USA		11.3	42.6	3.4	2.3	40.4			314

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Hay	Cattle	35.0	55.3	53.7	46.7	1.80	314

B81 *Leucaena leucocephala* (Lam.) de Wit [*L. glauca* (L.) Benth.]

Koa haole, ipil-ipil, white popinac, lead tree, wild tamarind, cow tamarind or shackshack

Deep-rooted tree or arborescent shrub up to 10 m high with bipinnate leaves, lanceolate leaflets and yellow-white flowers in long-stalked heads. (The flat pods contain small seeds that are popular in jewellery and novelties.) Native to Mexico, but cultivated widely in the tropics as a fodder plant, especially on dry wastelands where little else will grow. For prepared fields and planted pastures it is desirable to interplant koa haole with a grass cover, most commonly Guinea grass — a mixture that has proved excellent for fattening. Koa haole cannot be grazed heavily and continuously without being exterminated; it should not be used for grazing more than five months a year. Topping the plants about 1 m above the ground keeps the young shoots within reach of browsing cattle and prevents cows from snagging their udders on the stumps. On acid soils, liming is essential.

Toxicity. The leaves and seeds contain the glucoside mimosine, which may cause loss of hair in horses and young cattle. The addition of iron salts decreases toxicity, and if the treated material is allowed to stand for a week before being mixed with feeds, little toxicity remains. The mimosine content can also be reduced by soaking in water and drying. Sheep should be introduced to koa haole gradually to increase their ability to detoxify the feed. The ill effects of mimosine are erratic, and sometimes no effects are observed even when koa haole is the sole feed.

The young foliage is very palatable to cattle, rich in protein and nutritious. Pods and seeds are used in some countries as a concentrate for cattle.

Feeding trials with swine have shown no ill effects from rations consisting of up to 15% koa haole leaves. The leaves should not be fed to breeding animals, however, as they may affect reproduction. When included in poultry rations, production usually decreases and the birds take longer to reach sexual maturity. A small (5%) inclusion of dried koa haole seems to increase the hatchability of eggs in some cases.

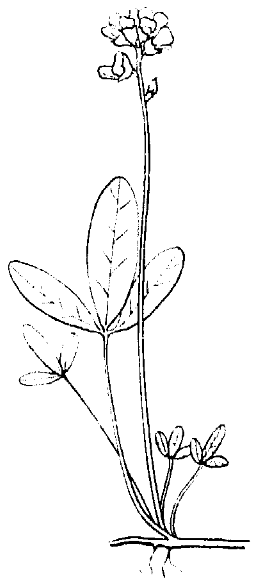
Leucaena leucocephala

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, Thailand		21.0	18.1	8.4	6.5	46.0			56
Fresh twigs, young, Malaysia	31.6	27.8	10.4	3.5	3.2	55.1	0.54	0.29	292
Fresh browse, dough stage, Hawaii	30.7	24.2	24.2	8.9	2.7	40.0			515
Pods, Zimbabwe		21.7	25.6	5.8	1.4	45.5			19
Seeds, Zimbabwe	91.0	35.8	11.4	4.4	7.5	40.9			499

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Browse	Cattle	65.0	35.0	36.0	74.0	2.13	515

B82 *Lotononis bainesii* Baker

Miles lotononis



Lotononis bainesii

Perennial herb with creeping stems that produce upright shoots up to 50 cm high. Mixes well with a number of grasses but can also be grown in pure stands for rotational grazing or for cutting every second month. High yielding only when inoculated with its specific *Rhizobium* strain. Has been used to increase carrying capacity of natural grasslands.

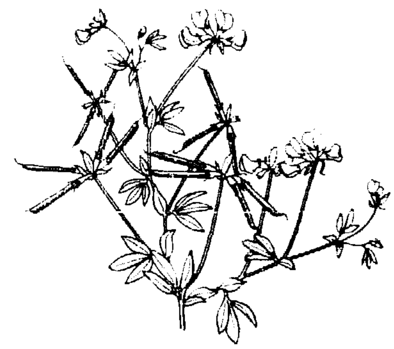
	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Late flower, Australia		19.3	27.0	8.1	4.0	41.6	0.65	0.32		341

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Late flower, Australia	Sheep	74.0	47.0	54.0	64.0		341

B83 ***Lotus corniculatus* L.**

Bird's-foot trefoil

Fine-stemmed leafy perennial with long narrow pods. Adapted to cooler climates and drought resistant. Used for pasture and hay.



Lotus corniculatus

		As % of dry matter								
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh aerial part, Chile	21.2	13.4	26.4	8.8	4.3	46.9	1.13	0.23	315

B84 *Lupinus* spp.

L. albus L.	White lupin
L. angustifolius L.	Blue lupin or narrow-leaved lupin
L. luteus L.	Yellow lupin

These are the three most important species of cultivated lupin. They are annual upright plants with coarse stems and medium-sized fingerlike leaves. In thin stands they branch quite freely. They require cool weather for full development and grow best in sandy soils.

All three exist in bitter and sweet varieties. The bitter varieties contain a toxic alkaloid and should not be fed to animals unless the alkaloid is removed by soaking in water. The sweet (alkaloid-free) varieties, which can be distinguished by taste and smaller growth, are palatable to stock. Because of their thick juicy stems they are not suitable for haymaking, but they can be used as fresh forage or ensiled with maize or other cereals. All three species have a similar chemical composition. The seeds make a valuable protein-rich concentrate that can be used with confidence in balanced mixtures for all stock. Seeds from the blue variety are generally less palatable than those from the yellow variety. Up to 20% ground seeds can be included in rations for monogastric animals. For sheep and cattle they can be the sole concentrated protein feed.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh sweet lupin, aerial part, Thailand	11.7	26.6	19.1	13.9	2.6	37.8	1.28	0.25	56
Seeds, Germany (F.R.)	89.5	45.0	16.2	4.8	5.0	29.0	0.37	0.20	183

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Aerial part	Cattle	88.4	87.8	89.0	83.3	2.94	267
Aerial part	Pigs	88.3	27.7	51.8	90.8	2.88	267
Seeds	Pigs	90.0	81.0	88.0	83.0	3.86	183

B85 ***Macroptilium atropurpureum*** **(DC.) Urb. (*Phaseolus atropurpureus* DC.)**

Siratro or purple bean

Perennial with trailing or creeping stems. Grows wild in Central and South America, but only the cultivar Siratro, developed in Australia and now introduced in most tropical countries, is of agronomic interest. Has become one of the most popular leguminous pasture plants in the tropics. Withstands some drought and frost. Fairly good yields of herbage. Usually sown together with grass or used to oversow natural grassland. Should not be cut or grazed close to the ground. Palatable to both cattle and sheep.

Macroptilium atropurpureum

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Fresh, 8 weeks, Senegal	19.8	17.7	27.7	7.2	2.6	44.8	0.80	0.20		537
Fresh, 11 weeks, Senegal	21.1	16.5	33.6	7.6	7.8	39.5	0.85	0.17		537
Fresh, 13 weeks, Senegal	23.6	15.3	34.7	6.6	2.9	40.5	0.78	0.13		537
Fresh, 16 weeks, Senegal	26.6	14.3	35.5	6.2	2.6	41.4	0.70	0.09		537
Fresh, 20 weeks, Senegal	29.2	11.5	36.6	5.9	2.2	43.8	0.64	0.10		537
Fresh, early vegetative, India		23.0	30.4	13.7	3.1	29.7	1.42	0.21		546

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, early vegetative	Sheep	82.9	39.5	80.0	52.5	2.01	546

B86 *Medicago lupulina* L.

Black medick or yellow trefoil

Annual or biennial semierect clover adapted to a wide variety of soils with a good supply of lime in moist temperate climates. Not very high yielding or drought resistant, but reseeds itself and grows naturally in pastures and meadows. Remains green much longer than most other winter annuals.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, Chile	20.9	25.2	21.3	12.7	3.3	37.5	1.61	0.41	315

B87 *Medicago polymorpha* L. (*M. hispida* Gaertn., *M. denticulata* Willd.)

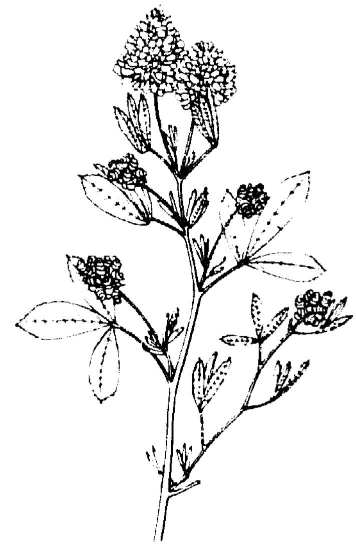
Californian bur clover, toothed medick or toothed bur clover

A clover with weak stems, trifoliate leaves and inconspicuous yellow flowers. Thrives in climates with mild winters and summer drought. An important pasture plant, the dry fruits constituting a valuable concentrated fodder for pasture animals during the dry season. Not suitable for sheep pasture as the fruits become entangled in the wool. For permanent pasture a combination of *Cynodon dactylon* and *Medicago hispida* has been very successful; the grass furnishes pasturage during the warm months and the clover provides pasturage during the winter and spring months.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, Brazil	21.4	20.1	14.0	13.1	2.3	50.5			88
Fresh aerial part, Chile	20.9	26.7	21.4	14.5	3.6	33.8	1.62	0.47	315
Seeds, Chile	94.1	17.4	38.6	7.4	2.5	34.1	1.83	0.19	315

8 *Medicago sativa* L.

:erne, alfalfa, purple medick, snail clover or Chilean clover



Medicago sativa

)eep-rooted perennial herb with a thick trunk root, occurring in /ide range of varieties. From the root crown arise a number of ms carrying trifoliate leaves and purple flowers in clusters of ten seventy. Demands sunshine and tolerates high temperatures as g as they are not combined with high air moisture.

.ucerne is generally grown alone but can also be mixed with sses or other legumes. It is used for green fodder, for hay or ge, and for pasture, although it does not tolerate close grazing ll. It is extensively grown under irrigation. The leaves are highly ritive and are often dried for 2.5-5% inclusion in animal feeds a source of vitamin A and other nutrients. During gestation and tation a minimum of 10% lucerne leaf meal is usually included the diet of sows. Unfortunately, the leaves are easily lost in 'making. Good hay can be machine threshed so that the stems serve as roughage, and the leaves can be used in concentrate :tures. Sun-cured leaves contain less vitamin A than artificially :d leaves but provide vitamin D instead. Where lucerne can ily be grown, it is regarded as a key forage for high-producing ninants because of its richness in protein, palatability and high :ium and vitamin content. In many cases supplements are not uired by animals feeding on lucerne. It should be harvested ore full bloom; the nutritive value and digestibility are lower :r bloom. It can be used as pasture also for pigs and poultry.

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
sh, 1-year-old stand, Iraq	20.3	17.1	19.4	12.6	2.7	48.2				196
sh, 2-year-old stand, Iraq	21.4	16.5	21.3	11.5	2.8	47.9				196
sh, 3-year-old stand, Iraq	21.4	16.2	22.3	10.8	2.7	48.0				196
sh, 1 month, India		24.5	16.2	15.7	2.6	41.0	1.96	0.42		436
sh, 2 months, India		20.3	25.7	14.8	3.1	36.1	2.24	0.35		436
sh, 3 months, India		16.0	29.7	10.7	3.5	40.1	1.89	0.24		436
sh, first cutting, Chile	20.9	14.4	30.6	8.1	2.9	44.0	1.74	0.17		315
sh, second cutting, Chile	20.9	14.8	27.3	8.6	4.3	45.0	1.53	0.25		315
sh, pre-bloom, Israel	17.0	25.3	23.5	11.8	2.9	36.5	2.41	0.35		365
sh, early bloom, Israel	22.7	22.9	26.0	11.5	3.5	36.1	2.56	0.31		365
sh, mid-bloom, Israel	29.0	19.0	30.0	10.3	3.4	37.3	1.76	0.24		365
f meal, South Africa		21.7	20.1	17.0	2.4	38.8	1.44	0.20		489
n meal, Malaysia	88.1	11.5	30.4	7.7	1.0	49.4	0.51	0.34		292
', pre-bloom, South Africa		18.7	34.4	9.8	2.6	34.5	1.26	0.18		489
', early bloom, South Africa		17.0	38.2	8.7	2.5	33.6	1.20	0.18		489
', mid-bloom, South Africa		15.4	40.1	8.6	2.1	33.8	1.09	0.16		489
ge, Chile	24.6	20.4	20.9	12.6	8.9	37.2				315

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, 1-year-old stand	Sheep	85.9	68.4	59.6	80.7	2.65	196
Fresh, 2-year-old stand	Sheep	87.4	79.5	55.6	76.7	2.68	196
Fresh, 3-year-old stand	Sheep	88.1	70.8	33.9	80.5	2.66	196
Fresh, pre-bloom	Sheep	89.0	45.0	50.0	76.0	2.47	365
Fresh, early bloom	Sheep	79.0	49.0	38.0	78.0	2.36	365
Fresh, mid-bloom	Sheep	69.0	45.0	50.0	61.0	2.01	365
Leaf meal	Sheep	79.4	59.9	0.0	77.7	2.27	489
Hay, pre-bloom	Sheep	75.9	50.6	29.6	71.4	2.19	489
Hay, early bloom	Sheep	74.1	51.0	25.4	68.1	2.12	489
Hay, mid-bloom	Sheep	74.2	51.0	21.0	68.7	2.10	489

B89 *Medicago truncatula* Gaertn. (*M. tribuloides* Desr. *ex* Lam.)

Barrel medick

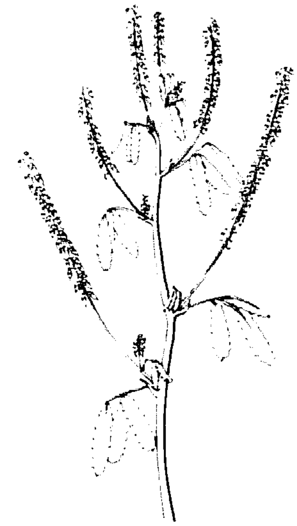
A clover with small yellow flowers, low-growing and furnishing good pasture in mild regions. Combines well with Bermuda grass, but cannot be grazed too closely as it does not reseed.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, Chile	20.9	25.8	24.0	15.2	3.1	31.9	2.13	0.46	315

B90 *Melilotus indica* (L.) All. (*M. parviflora* Desf.)

Yellow annual sweet clover, sour clover or Indian sweet clover

Glabrous sweet-smelling erect herb up to 1 m high with yellow flowers and small pods. If poorly harvested or ensiled it produces a coumarin-like substance that interacts with the coagulation of blood in the animals eating it; deaths from internal bleeding have been reported. It should be cut when the pods are just being formed; if cut earlier, the risk of bloat is greater. Palatable but low yielding as it gives only one cutting. Tolerates alkaline soils and can thus be used to reclaim saline areas.



Melilotus indica

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, India	21.6	15.3	29.4	13.1	1.7	40.5			282
Pods, India		25.3	14.9	8.5	1.9	49.4	1.34	0.35	436
Seeds, Chile	95.3	29.0	16.9	4.5	3.2	46.4			315

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Aerial part	Cattle	82.0	58.0	43.0	76.0	2.33	282

B91 *Millettia auriculata* Baker *ex* Brand.

Woody climbing shrub whose leaves are sometimes used as fodder. The powdered root has been used to kill vermin in cattle.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, India		22.7	32.5	9.3	4.6	30.9	1.92	0.29	436

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Leaves	Cattle	69.0	32.0	36.0	49.0	1.73	436

B92 *Mimosa invisa* Mart.

Vigorous winding plant with a spiny stem. of which there are strains with and without thorns. One of the best plants for suppressing the grass *Imperata cylindrica*.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh, late bloom, Kenya		16.5	21.8	7.3	2.5	51.9	1.10	0.32	134

B93 *Mucuna deeringiana* (Bort.) Merr. (*Stizolobium deeringianum* Bort.)

Velvet bean or Mauritius bean

Vigorous-growing annuals of a number of species and hybrids, usually as long vines (3-15 m), although bushy types also exist.
Among the more important species are: *Stizolobium deeringianum* Bort. (*Mucuna utilis*, Woll.), or Florida or Deering velvet bean (with black pods); *S. aterrimum* Piper & Tracy, or Bengal bean, and *S. cochinchinensis* (Lour.) Burk, or Chinese velvet bean (both with white pods). Little difference in chemical composition between species. Grown mostly with maize, pearl millet, sorghum or Japanese cane for support.

Pasture. This is the most important use of velvet bean. Pigs should be allowed to graze the pasture after cattle to consume the beans that have been left behind. It is never well grazed by stock until it is well matured or frosted.

Hay. Velvet bean makes rather poor hay, especially if cut when mature, as the leaves easily fall off; also, the long vines are difficult to handle.

Silage. Good silage can be made from velvet bean together with its supporting crop. It usually turns black after a time, but without impairing its quality.

Pods. In making a concentrate for cattle it is more economical to grind the whole pods rather than to separate the pods and the seeds.

Seeds. Seed meal can be used in compound rations for all classes of livestock. Chickens tolerate up to 15% in the ration without a loss in productivity.

Pigs should not be allowed to consume large amounts of velvet bean, either as forage or seeds; usually they cannot tolerate more than 25% in the diet unless the seeds are cooked. The therapeutic component of velvet bean can be extracted with water and acetic acid.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh aerial part, 3 months after planting, Trinidad	19.6	15.3	36.2	12.2	1.5	34.8			117
Fresh aerial part, 9 months after planting, Trinidad	24.2	16.5	40.5	8.3	1.6	33.1			117
Fresh, mid-bloom, fertilized, Puerto Rico	19.1	15.5	34.4	5.6	4.3	40.2	1.21	0.13	32
Hay, milk stage, Zimbabwe	90.6	14.8	30.7	8.9	2.6	43.0			499
Pods, USA		21.0	15.6	4.5	2.6	56.3			15
Seeds, white variety, Nigeria	94.7	27.4	6.5	4.0	1.1	61.0			374
Seeds, black variety, Nigeria	94.2	28.6	9.5	4.0	0.7	57.2			374
Seeds, Tanzania	88.5	25.9	9.2	3.0	4.4	57.5			172
Pod husks, Tanzania	89.2	4.3	42.4	5.9	0.7	46.7			355

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Fresh, mid-bloom	Sheep	75.0	57.0	67.0	79.0	2.58	32
Hay, milk stage	Cattle	63.9	72.8	79.1	78.6	2.60	499
Seeds	Sheep	81.0	72.0	64.0	97.0	3.39	172

B94 *Ornithopus sativus* Brot.

Serradella

Small semi-viny annual herb adapted to moist sandy soils and cooler climates. Used for forage.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh, early bloom, Kenya		24.4	18.7	11.5	3.7	41.7	1.21	0.24	128

B95 *Parkia filicoidea* Welw. *ex* Oliv.

African locust bean or nitta tree

Spreading tree of medium size with compound leaves and numerous leaflets. The pods grow in bunches, are 12-25 cm long, and contain a dry powdery yellow pulp embedded in dark-brown seeds. The tree is sometimes planted not only for animal feed but also for soil improvement as it extracts nutrients from deep layers of soil. All parts of the pods can be used for animal feed and are free from glucosides. Its usefulness is increased by the fact that the pods can be harvested during the dry season when feed is scarce.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Whole pods, Nigeria	93.0	13.7	19.4	6.7	7.3	52.9			374
Pulp of pod, Ghana		4.9	14.6	4.6	2.3	73.6	1.32	1.76	18
Seeds, Ghana		31.8	9.4	4.4	17.4	37.0			18
Pod husk, Nigeria	93.6	4.7	24.0	8.9	1.2	61.2			374

B96 *Phaseolus lunatus* L.

Lima bean, Madagascar bean, butter bean or Java bean

A perennial that is often grown as an annual. There are two distinct forms of lima bean, small-seeded and large-seeded, both native to South America. Normally a twining herb, although bushy varieties also exist. Adapted to warm humid climates and grown under those conditions mainly for human consumption. The ripe seeds contain prussic acid and should first be soaked and then cooked in new water before eating. Pods from varieties with uncoloured seeds can be fed to goats and sheep. The plant is useful for fodder and hay. Once established, it can endure considerable drought.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Pods, Nigeria	95.4	18.8	17.5	4.0	0.6	59.1			374
Seeds, Nigeria	95.6	27.2	5.2	5.5	0.9	61.2			374

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Seeds	Sheep	66.1	62.2	63.3	92.9	3.00	512

B97 *Phaseolus vulgaris* L.

Haricot bean, kidney bean, snap bean, French bean, dwarf bean, navy bean or string bean

Climbing or erect annual herb with white to purple flowers and seeds having a small elliptical hilum. Important in many countries for its edible beans and pods; of minor importance as fodder. Artificially dried and ground vines can be used as a substitute for lucerne leaf meal in poultry rations.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Haulm, Chile	88.9	6.3	43.4	7.2	0.7	42.4	1.15	0.09	315
Seeds, Chile	87.2	24.2	6.7	4.7	2.4	61.9	0.26	0.43	315
Seeds, Congo	92.4	25.5	2.8	4.9	2.0	64.8			499

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Seeds	Goats	87.2	63.4	67.3	95.7	3.38	499

B98 *Piliostigma thonningii* (Schum.) Milne-Redhead (*Bauhinia thonningii* Schum.; *B. reticulata* G. & P.; *B. abyssinica* A. Rich.)

Bauhinia

Small tree with large two-lobed simple leaves and without thorns or spines. Found on sandy soils. Bears very heavy crops of large dark-brown pods. Browsed avidly by game and cattle.

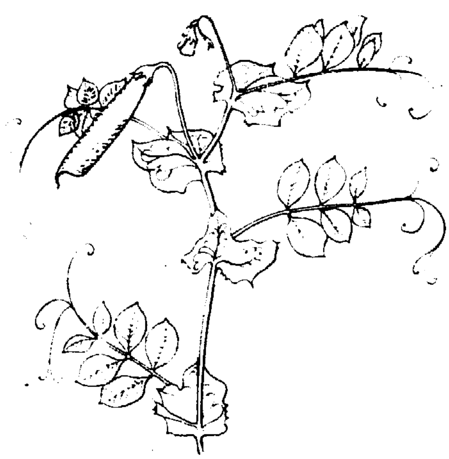
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
		As % of dry matter							
Fresh leaves, mid-bloom, Niger		11.7	26.9	5.0	3.3	53.1	0.91	0.13	45
Pods, Zimbabwe	95.0	10.1	23.7	5.6	3.2	57.4			499
Pods, Nigeria	90.2	7.0	26.2	4.3	2.0	60.5	0.40	1.49	234

	Animal	Digestibility (%) CP	CF	EE	NFE	ME	Ref.
Pods	Cattle	59.2	56.8	60.3	60.4	2.15	499

B99 ***Pisum sativum* L. (*sens. lat.*)**

Pea or field pea

All cultivated types of peas are now included in this species of viny herbaceous plant with white or pink flowers and leaves consisting of two or three pairs of broad oval leaflets. Usually cannot be successfully cultivated in hot tropical climates. Often grown together with cereals. The ripe dried seeds used as concentrates for animals or for human consumption. The vines used for hay, silage and green fodder; also cultivated as pasture for fattening lambs by direct grazing when the crop has completed growth and dried out. The seeds have been included in poultry and pig rations as the sole source of protein with good results. Pea-vine silage has a strong odour, but it is an excellent feed for ruminants.



Pisum sativum

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh, late vegetative, Israel	13.4	17.2	26.9	12.7	3.0	40.2	1.87	0.37	365
Fresh, mid-bloom, Israel	15.2	14.5	28.3	13.2	2.6	41.4	1.84	0.40	365
Haulm, Israel	88.4	8.4	42.5	8.1	1.4	39.6	1.18	0.34	365
Hay, Israel	89.3	14.9	31.5	8.3	2.7	42.7			365
Seeds, Uganda	88.6	25.3	6.2	4.7	1.1	62.7			70
Silage of pods	27.5	12.7	30.5	6.5	3.6	46.7			70
Silage of haulm	23.6	14.8	25.4	17.4	5.9	36.5			70

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, pre-bloom	Sheep	72.0	59.0	59.0	85.0	2.48	365
Fresh, mid-bloom	Sheep	82.0	53.0	61.0	83.0	2.42	365
Haulm	Sheep	49.0	45.0	46.0	59.0	1.76	365
Hay	Sheep	71.0	51.0	50.0	73.0	2.27	365
Seeds	Sheep	86.2	46.3	62.5	92.9	3.21	512
Silage of pods	Sheep	67.5	65.5	90.0	76.6	2.64	70
Silage of haulm	Sheep	57.1	56.7	92.9	68.6	2.21	70

B100 *Pithecolobium dulce* (Roxb.) Benth. (*Mimosa dulcis* Roxb.)

Manila tamarind

Large rapid-growing tree up to 18 m high with pinnate leaves and spiral-twisted reddish pods containing black seeds. Cultivated as hedge and as a shade tree. Used for lopping and browsing. The pods are very palatable.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, Sudan	31.1	29.0	17.5	5.6	4.4	43.5	1.14	0.35	64
Fresh leaves and twigs, Sudan	30.6	23.5	23.1	5.0	3.0	45.4			64

B101 *Prosopis chilensis* (Mol.) Stuntz

Algaroba

Drought-resistant tree up to 10 m high, native to South America and introduced to dry areas in many other parts of the world. Cultivated as a shade and fodder tree. In some countries the seeds are ground into a concentrate for all classes of livestock. The ripe pods are relished by animals, while the green ones are bitter and have little value. Kiln-dried pods ground into a meal are far superior to air-dried chopped pods. The tree easily becomes a troublesome weed.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh young leaves, USA		23.5	24.7	4.7	2.9	44.2	0.86	0.25	165
Pods, Chile	91.5	11.0	11.9	7.3	2.2	67.6	0.44	0.16	315
Pods, Sudan	94.4	11.5	26.9	5.4	2.2	54.0			105
Dried pod meal, Hawaii	89.2	9.5	23.2	7.9	1.5	57.9			20
Seeds, Hawaii		35.2	9.1	5.1	5.2	45.4			245
Pod husks, Hawaii		5.6	27.3	3.8	0.2	63.1			245

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Pod meal	Cattle	70.0	54.0	75.0	70.0	2.30	20

B102 *Prosopis juliflora* (Sw.) DC.

Mesquite or southwest thorn

Shrub or tree up to 20 m high with dark-grey bark, found in drier areas. Leaves bipinnate with two pinnate branches 10-15 cm long having pairs of straight white or brown thorns at their base. Spikes with small cream-coloured flowers, 5-10 cm long. Pods straight or slightly twisted, light brown, sometimes with darker markings, 10-15 cm long and about 1 cm broad, eagerly eaten by stock and known to have a high sugar and protein content. Stock poisonings recorded from pods eaten after exposure to rain. Only ripe pods should be fed, as the green pods are bitter and have little feed value. The leaves are not palatable.

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Fresh flowers, Sudan	30.0	21.0	15.5	10.0	3.2	50.3	1.31	0.40		64
Fresh leaves, Sudan	41.2	19.0	21.6	8.5	2.9	48.0	2.08	0.22		64
Pods, South Africa	93.7	13.9	27.7	4.8	3.0	50.6				193
Fruit pulp		7.7	12.0	2.3	0.6	77.4				234
Seeds, Sudan		65.2	2.8	5.2	7.8	19.0				234
Pod husks		4.3	54.3	3.4	0.6	37.4				234

B103 *Prosopis spicigera* L.

Drought-resistant shrub found on light soils in warm and dry regions, especially in overgrazed pastures. The pods and loppings provide valuable fodder during the dry season.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, India		15.3	17.5	10.0	3.2	54.0	2.65	0.24	436

B104 *Prosopis stephaniana* Kunth *ex* Spreng.

Thorny shrub useful as browse. Grows in poor soils. Withstands drought, thus providing fresh fodder throughout the dry season.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Pods, Cyprus		14.5	15.7	3.8	2.9	63.1			17
Seeds, Cyprus		20.1	9.3	3.4	3.1	64.1			17
Pod husks, Cyprus		11.6	19.0	3.9	2.8	62.7			17

B105 *Prosopis tamarugo* Phil.

Tamarugo

Dense thorny bush up to 12 m high with fine feathery leaves and edible fruits. Slightly curved pods, 12-18 cm long and 1.5 cm in diameter, which fall to the ground when ripe. Remarkably drought resistant. Less thorny, semiprostrate ecotypes have been planted on a large scale in Norte Grande, Chile, one of the most arid and agriculturally barren regions of the world.

A good browse for sheep and goats, but it should not be grazed until it is five years old. The carrying capacity is estimated as one ewe per hectare in the sixth year and ten ewes per hectare after twenty-five years. The dry-matter digestibility of leaves and seeds is only 45-50%, but still sufficient to satisfy maintenance requirements when sheep have free access to it. Animals feeding on tamarugo require supplementary rations of cobalt, iron, magnesium and vitamin A.

		As % of dry matter								
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Browse, Chile	89.3	10.7	32.1	5.0	2.7	49.5	3.98	0.12	315
Leaves, Chile	88.5	9.9	15.8	20.3	2.0	52.0	6.21	0.11	315
Pods, Chile	91.1	11.7	41.5	4.6	1.6	40.6	0.33	0.13	315
Seeds, Chile	92.5	10.1	38.4	7.5	0.7	43.3	0.36	1.50	315

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Browse	Sheep	55.0	25.0	47.0	38.0	1.32	283
Pods	Sheep	55.0	50.0	50.0	74.0	2.18	283

B106 *Prosopis velutina* Woot.

Velvet mesquite

Large shrub or small tree, native to Mexico, which can produce an abundant crop of pods that are eaten by stock when they fall to the ground. The seeds must be crushed for digestibility. The plant is valuable for browsing but can become a pest.

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Dry leaves, USA	90.0	8.3	32.1	9.6	5.4	44.6				91
Pods, USA	94.6	13.6	29.1	5.1	2.0	50.2				162
Seeds, USA		55.3	4.5	4.4	8.9	28.7				91
Pod husks, USA		6.2	32.5	5.3	1.5	54.5				91

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Pods	Cattle	90.4	58.8	95.3	81.3	2.77	162

B107 *Psoralea candicans* Exkl. & Zeyh.

Shrub 1-1.5 m high, often with spinescent branches and with elliptic leaves and white flowers hidden among the leaves. The cylindrical pods, about 1 cm long, are enclosed in the calyx. Found mainly in dry areas.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Twigs, South Africa	92.4	14.7	39.3	4.9	5.4	35.7	0.78	0.15	193

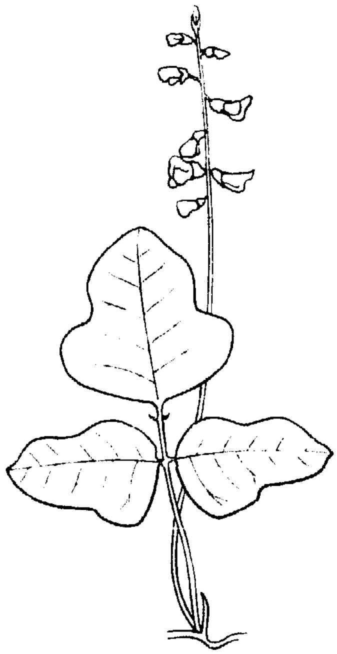
B108 *Pueraria lobata* (Willd.) Chwi [*P. thunbergiana* (Sieb. & Zucc.) Benth.]

Kudzu

Woody perennial vine with leaves resembling those of grapes. Grows vigorously, in one summer, producing shoots 10 m long. Mainly propagated from cuttings or rooted cuttings as the plant seldom gives any seeds. Cannot easily be cut and cured for hay because of its long stems. Newly established plants tolerate little trampling and must be grazed with care during the first two years. Adapted to subtropical and warm temperate climates and able to withstand winter frost. Grows in moderately humid climates on fertile well-drained soils, but can also withstand protracted drought. A good stand takes a long time to establish but is very long-lived. Highly palatable and can be used as a substitute for lucerne. Excellent for silage, especially if mixed with grass.

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Fresh leaves, Zimbabwe		19.6	21.5	7.8	3.9	47.2				19
Fresh stems, Zimbabwe		5.7	46.2	5.6	1.0	41.5				19
Hay, South Africa		13.3	40.3	9.3	2.5	34.6	1.83	0.10		489
Silage, Zimbabwe		13.3	31.1	11.6	4.2	39.8				19

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Hay	Sheep	65.6	43.9	26.3	63.7	1.86	489



Pueraria phaseoloides

B109 *Pueraria phaseoloides* (Roxb.) Benth.

Tropical kudzu or puero

Vigorous, dense-growing vine cultivated in tropical countries as both pasture and fodder. Prefers high rainfall and fertile clay soils but may succeed on sandy loams. Has deep roots and is unaffected by short dry spells; also thrives in shade. Young plants intolerant of trampling or close grazing. Palatable and high yielding. Combines well with molasses grass.

In a humid tropical climate with annual rainfall of 1 200-1 500 mm, tropical kudzu is preferred over kudzu (see B108), yields less, takes longer to establish and produces herbage of lower quality. Kudzu hay has been fed to pigs with good results.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Pasture, early vegetative, Trinidad	22.6	20.5	37.9	6.7	2.0	32.9			82
Pasture, mature, Trinidad	32.7	18.0	42.9	6.1	2.4	30.6	0.71	0.18	117
Fresh aerial part, Puerto Rico	22.5	17.3	34.2	8.1	2.0	38.4			411
Artificially dried, Suriname	89.4	18.0	41.3	6.0					124

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Pasture, early vegetative	Sheep	80.0	60.3	51.9	61.8	2.35	82

B110 ***Samanea saman* (Jacq.) Merr. (*Enterolobium saman* Prain; *Pithecolobium saman* Benth.)**

Saman, rain tree, monkey pod or cow tamarind

Lofty canopied tree with a large symmetrical crown. An advantageous shade tree as the fernlike leaflets close up at night, permitting rain to fall through to the grass beneath. The long black pods and the leaves relished for fodder. Rich in tannins. Withstands lopping and can be maintained at any desired height by judicious pruning. The foliage esteemed as livestock fodder.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh twigs, late vegetative, Malaysia	38.9	24.7	22.1	4.4	2.8	46.0	0.55	0.26	292
Fresh leaves, Thailand	39.1	22.1	29.4	6.0	7.0	35.5	1.42	0.21	56
Fresh leaves, Trinidad	34.4	30.0	29.0	3.5	3.5	34.0			117
Pods, Jamaica	79.5	12.8	14.5	2.4	0.7	69.6	0.29	0.32	43
Pods, fallen, Trinidad	85.0	18.0	10.9	4.6	1.4	65.1			117
Seeds, Jamaica	86.5	31.6	14.0	4.3	6.0	44.1	0.16	0.34	43

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Dried pods	Goats	41.0	38.7	38.6	66.6	2.9	551

B111 ***Sesbania bispinosa* (Jacq.) W.F. Wight (*S. aculeata* Poir.)**

Erect annual 1-1.5 m high, common in low country, especially in dry regions. Often occurs as a weed in rice fields. Cultivated in Central America for its durable fibre. The seeds are excellent poultry feed.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Seeds, South Africa	90.4	36.4	12.1	1.5	6.9	43.1			16
Seeds, India		32.7	10.7	5.0	2.9	48.7	0.37	0.59	436

B112 *Sesbania grandiflora* (L.) Poir.

Sesbania

Small fast-growing tree with few branches and long pods, adapted to humid tropical regions. Cultivated on the low dikes between rice fields. The large white flowers usually used for human food as a salad; the leaves and young shoots relished by poultry, cattle and goats. If the trees are cut back to a suitable height, a large supply of fresh fodder can be obtained for most of the dry season, when only rice straw and dry grass are otherwise available.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh flowers, Sri Lanka	11.1	15.1	13.2	6.5	1.8	63.4			252
Fresh leaves, Sri Lanka	21.0	33.4	5.7	11.6	2.6	46.7	2.33	0.34	252
Fresh leaves, wet season, 4 weeks, 95 cm, Thailand	16.3	25.2	17.8	9.2	4.3	43.5	1.41	0.43	219
Fresh leaves, wet season, 6 weeks, 125 cm, Thailand	17.1	25.1	17.5	7.6	4.7	45.1	1.29	0.47	219
Fresh leaves, wet season, 8 weeks, 130 cm, Thailand	14.5	23.4	22.8	9.7	5.5	38.6	1.59	0.55	219
Fresh leaves, dry season, 4 weeks, 95 cm, Thailand	16.2	29.6	15.4	8.0	4.9	42.1	1.36	0.43	219
Fresh leaves, dry season, 6 weeks, 120 cm, Thailand	17.1	25.1	15.8	7.0	5.3	46.8	0.99	0.47	219
Fresh leaves, dry season, 8 weeks, 125 cm, Thailand	16.7	27.5	16.8	10.2	4.8	40.7	1.26	0.48	219
Pods, Thailand	91.4	1.6	32.7	6.5	4.8	54.4			56

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Leaves, 6 weeks	Sheep	74.0	37.0	34.0	78.0	2.44	219

B113 *Sesbania sesban* (L.) Merrill (*S. aegyptiaca* Poir.)

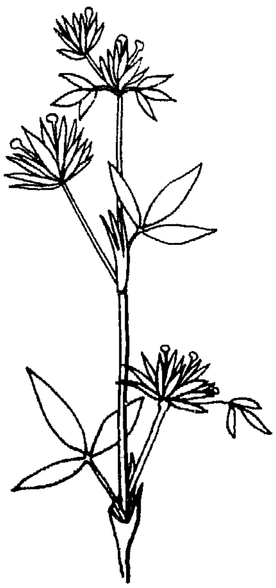
Fast-growing shrub or small tree with pinnate leaves that grows on stream banks and swamp edges. Because of its shallow root system, it can compete with other crops when interplanted. Both the leaves, about 15 cm long, and the young branches are lopped for fodder, which is readily eaten by cattle. Decoction of leaves is used by the natives of Hausa for washing animals as a prevention against tsetse-fly bites.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, mature, Kenya		26.0	14.4	7.6	2.6	49.4	1.11	0.27	129
Fresh leaves, India	31.8	26.5	12.2	10.0	0.9	50.4	2.78	0.43	379
Pods, India		7.8	10.0	6.2	0.5	75.5	1.37	0.37	379
Seeds, India		21.2	8.5	7.2	2.6	60.5	0.44	0.68	379

B114 *Stylosanthes bojeri* Vog. (*S. fruticosa* Alston)

Prostrate perennial, native to the African tropics, which can be used as a pasture plant. Rather resistant to frost and drought, requiring only 300-500 mm of rainfall. Valued by nomadic pastoralists.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, India		10.1	38.4	8.6	1.2	41.7	1.23	0.43	436



Stylosanthes guianensis

B115 *Stylosanthes guianensis* (Aubl.) Sw. (*S. gracilis* H.B.K.)

Stylo, Brazilian lucerne

Erect many-branched perennial herb up to 1 m high with trifoliate leaves. Native to South America, where it takes the place of lucerne, and now introduced in other areas throughout the tropics. Adaptable to a wide range of soil conditions and very resistant to various weather conditions. Can be used to oversow natural grasslands so as to extend grazing into the dry season and increase carrying capacity. Mixes with many grasses, and bacteria inoculation is not always necessary. Fertilization with phosphorus required on poor soils, especially in the early stages of growth. Low palatability during the rain, but readily eaten during the dry season. Mowing usually encourages growth, wheareas cattle grazing suppresses it; grazing by sheep is less harmful. If kept short, it will not become woody but remains leafy and palatable. Seldom used for hay or silage. It has become one of the most popular pasture legumes, and several commercial cultivars are available.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh, late vegetative, Congo		18.1	26.8	8.3	2.1	44.7			428
Hay, 2-month-old cuttings, Malaysia	24.0	16.7	31.7	10.0	1.7	39.9	1.55	0.56	292

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, late vegetative	Sheep	65.9	42.8	38.9	79.7	2.28	428

B116 *Stylosanthes humilis* H.B.K.

Townsville stylo, Townsville lucerne, annual stylo

Erect annual herb up to 1 m high with narrow trifoliate leaves. Introduced on natural grasslands with great success, and considered an outstanding pasture legume because of its high yield of nutritious fodder, obtainable year after year, by applying only phosphatic fertilizer. It has in many instances almost doubled the stocking capacity of natural pastures in Australia, mainly because of the drastically reduced weight loss in the dry season. Mixes with many grasses, most importantly with *Heteropogon contortus*. Before sowing the land should be grazed heavily or burned to reduce grass competition. Direct oversowing gives a lower stand density than sowing on disked land. Also, heavy grazing of newly established swards reduces grass competition as the young legume is less palatable than the grass. Inoculation of the seeds usually not necessary. Also grown alone for both grazing and hay.

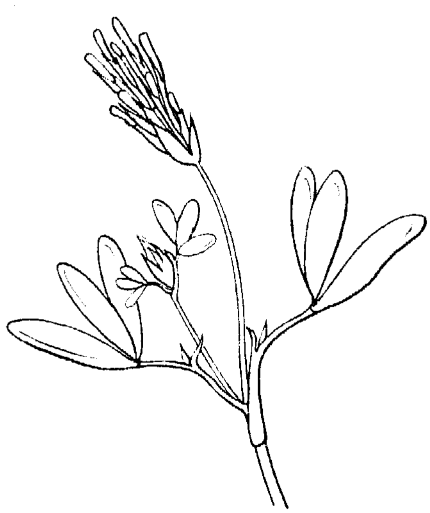
		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh aerial part, Thailand	29.2	19.8	20.9	27.7	3.6	28.0	1.64	0.33	56
Fresh, late vegetative, Burma		22.0	21.0	8.0	3.0	46.0	0.80	0.22	454

B117 *Tamarindus indica* L.

Tamarind

Medium-sized stately tree up to 12 m high with a dense rounded crown of feathery leaves. The pale-yellow flowers with dark-red buds are succeeded by pods 3 cm broad and 15 cm long containing a dark-brown edible sour pulp. To make the seeds palatable to cattle, they should be ground and soaked in water for an hour before feeding.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, Pakistan	25.2	15.8	23.7	7.9	9.6	43.0	2.86	0.26	308
Fresh leaves, India		13.4	17.7	9.5	7.0	52.4	2.39	0.25	436
Seeds, India		18.3	26.4	3.5	7.4	44.4	0.14	0.30	436



Trifolium alexandrinum

B118 *Trifolium alexandrinum* L.

Berseem or Egyptian clover

A vigorous true clover, resistant to alkaline soils, usually cultivated under irrigation for pasture, green fodder and silage. One of the most important legumes of the Near East and the Mediterranean. Very palatable. May be cut several times a season and produces heavy yields under favourable conditions. The succulent stems are, however, difficult to dry because of their high water content, and the leaves drop off very easily in the dry state. The highest yield of protein with a relatively low yield of fibre obtained by cutting the plant at a height of about 40 cm.

Valued for its rapid growth in the cooler winter season in the subtropics and for its good recovery after cutting. Up to six cuttings can be taken from the Miscari variety under irrigation; one or two cuttings can be taken from the Fahl variety on dry land. The herbage quality is good, and cultivation improves the soil nitrogen status. Tolerant of soil alkalinity and salinity.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh, 9 weeks, India		26.7	14.9	15.6	3.0	39.8	1.48	0.31	436
Fresh, 12 weeks, India		21.5	20.6	14.3	2.6	41.0	1.54	0.24	436
Fresh, 15 weeks, India		17.3	24.2	12.9	1.8	43.8			436
Fresh, 18 weeks, India		16.9	22.7	14.9	1.8	43.7	2.58	0.18	436
Fresh, 24 weeks, India		15.8	28.5	16.0	1.4	38.3	2.01	0.20	436
Fresh, first cutting, irrigated, 4 weeks, Israel	10.9	22.0	22.9	19.3	2.8	33.0	2.39	0.37	365
Fresh, second cutting, irrigated, 4 weeks, Israel	12.2	22.1	22.1	19.7	3.3	32.8	2.38	0.25	365
Fresh, third cutting, irrigated, 4 weeks, Israel	9.1	22.0	20.9	17.6	4.4	35.1	2.31	0.33	365
Fresh, fourth cutting, irrigated, 4 weeks, Israel	11.9	20.2	23.5	18.5	3.4	34.4	2.18	0.25	365
Fresh, fifth cutting, irrigated, 4 weeks, Israel	13.6	20.6	26.5	16.2	2.9	33.8	1.99	0.29	365
Fresh, aerial part, Chile	17.4	22.6	20.3	18.9	4.0	34.2	1.62	0.33	315
Hay, good quality, Israel	90.4	16.6	26.2	11.1	2.4	43.7	1.31	0.21	365
Hay, medium quality, Israel	89.5	12.4	36.1	8.6	2.5	40.4			365

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, first cutting	Sheep	79.0	72.0	61.0	82.0	2.46	365
Fresn, second cutting	Sheep	80.0	60.0	63.0	83.0	2.39	365
Fresh, fourth cutting	Sheep	75.0	64.0	64.0	72.0	2.26	365
Fresh, fifth cutting	Sheep	76.0	50.0	49.0	78.0	2.22	365
Hay, good quality	Sheep	73.0	61.0	51.0	70.0	2.30	365
Hay, medium quality	Sheep	60.0	47.0	53.0	65.0	1.99	365

B119 *Trifolium incarnatum* L.

Crimson clover

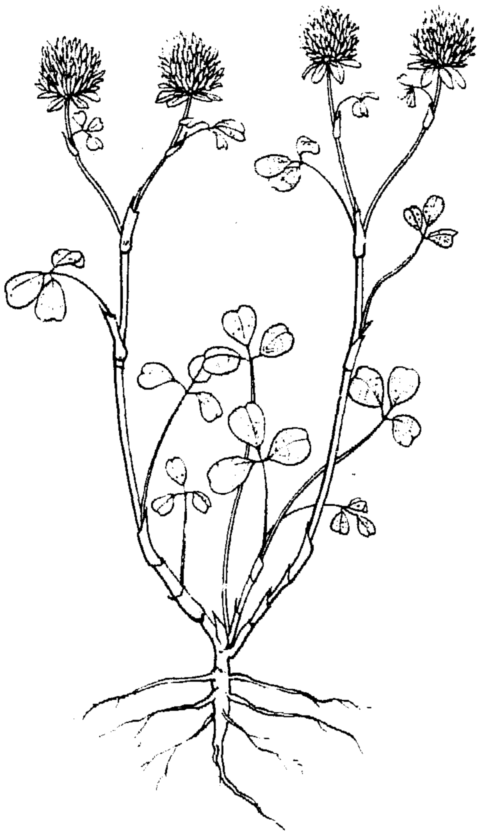
Upright annual with large bright-red conical flower heads. It is not hardy and grows only in subtropical climates, being used in cooler climates as a summer annual and in warmer climates as a winter annual. It is adapted to light, sandy and clay soils but is not very drought resistant. Though it produces an abundance of seeds in permanent pasture, a stand of ordinary crimson clover cannot be maintained without reseeding because the seeds germinate after a light rain and are killed by a subsequent dry spell. To overcome this, the Dixie variety, which has harder seeds that germinate over a longer period, has been developed. It should not be cut for hay after the flowers at the base of the most advanced heads have faded, as the barbed hairs on the heads and stems become hard and wiry and may injure the animals eating them. It makes excellent silage.

		As % of dry matter								
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh, early bloom, Kenya		18.9	14.8	11.5	3.2	51.6	1.32	0.20	315
Fresh aerial part, Chile	17.4	18.6	26.4	11.0	2.9	41.1	1.50	0.32	132

B120 *Trifolium pratense* L.

Red clover or cow grass

Upright red-flowered perennial existing in many varieties. Of great importance in temperate climates, but can also be grown in subtropical regions at high altitudes. Can be used together with grass for pasture and silage.



Trifolium pratense

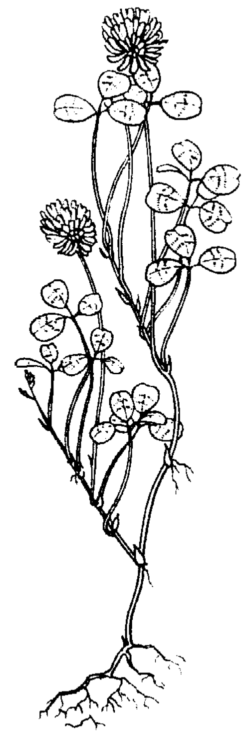
	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh, average values, Chile	17.4	20.7	22.5	11.0	5.3	40.5	1.42	0.32	315
Fresh, early vegetative, USSR	20.0	31.5	10.0	7.5	4.5	46.5			483
Fresh, late vegetative, USSR	22.0	25.0	15.9	7.7	2.7	48.7			483
Fresh, early bloom, USSR	24.0	19.2	23.8	9.2	3.3	44.5			483
Fresh, mid-bloom, USSR	24.9	16.1	25.7	8.0	3.2	47.0			483
Fresh, milk stage, USSR	40.0	9.8	36.5	7.3	2.8	43.6			483
Hay, average, Chile	90.2	9.8	33.8	5.6	2.9	47.9	0.98	0.13	315
Silage, Chile	22.8	14.2	28.9	14.6	5.8	36.5			315

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, immature	Cattle	73.0	61.0	67.0	81.0	2.81	483
Fresh, mid-bloom	Cattle	74.0	58.0	71.0	78.0	2.56	483
Fresh, post-bloom	Cattle	73.0	50.0	56.0	75.0	2.27	483

B121 *Trifolium repens* L.

White clover, Ladino clover

Creeping white-flowered perennial with prostrate stems rooting at the nodes. An excellent pasture plant in cool and moist climates. Stops growing and nearly disappears when warm weather sets in, but reappears when conditions become favourable. Small-leaved varieties used for pasture and large-leaved varieties (Ladino types) for haymaking.



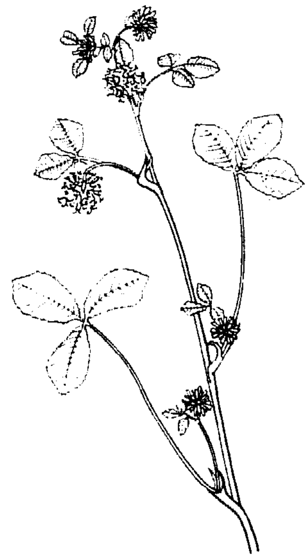
Trifolium repens

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, Malaysia	21.0	21.0	23.8	9.5	1.4	44.3	0.51	0.35	292
Fresh, average values, Chile	17.4	18.9	26.8	10.9	4.4	39.0	1.29	0.34	315
Ladino type, Chile	17.4	19.0	27.8	10.7	4.4	38.1	1.24	0.31	315

B122 *Trifolium resupinatum* L. (*T. suaveolens* Willd.)

Persian clover

Resembles berseem (*Trifolium alexandrinum* L.) but is not so tall and has only a single stem. Grown as a winter annual in the Near East and the cooler parts of the tropics and subtropics. Prefers heavy moist soils, and reseeds once it is established with grasses and fertilized. Hardier and more tolerant to drought but lower yielding than berseem. When used as green feed, usually mixed with some dry roughage to prevent bloat, which it is more likely to cause than berseem.



Trifolium resupinatum

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Fresh, late bloom, Kenya		16.2	14.0	23.6	2.0	44.2	0.84	0.19		132
Fresh aerial part, India		21.5	16.9	17.7	1.9	42.0	1.99	0.23		436
Fresh aerial part, Chile	17.4	27.8	15.6	16.1	4.0	36.5	1.83	0.43		315

B123 *Trifolium subterraneum* L.

Subterranean clover

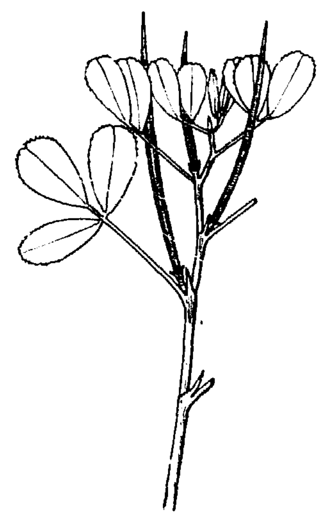
An important pasture crop in some countries. Thrives in temperate climates on acid or neutral soils. Unpalatable before flowering, but grazed heavily after the flowering stage. If this clover constitutes a high proportion of the diet for sheep, breeding troubles may develop owing to the oestrogenic hormone in the plant.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, Chile	17.4	12.5	28.7	9.8	4.4	44.6	1.49	0.33	315
Hay, Chile	90.2	8.0	36.9	8.3	2.2	44.6	0.73	0.23	315
Silage, Chile	22.8	18.5	23.3	16.6	8.5	33.1			315

B124 *Trigonella foenum-graecum* L.

Fenugreek

Annual herb suitable for areas with insufficient moisture for berseem. Sometimes used as a short-rotation catch crop after sugar cane or cotton. Apart from its palatable green fodder, the seeds are used as a condiment. Reported to impart a disagreeable taste to milk.



Trigonella foenum-graecum

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, India		15.7	31.1	8.8	2.1	42.3	1.47	0.22	436
Seeds, India		27.2	1.0	4.0	7.8	60.0	0.88	0.30	379
Pod husks, India		11.3	4.2	3.0	2.9	78.6	0.66	0.14	379
Hay, Spain	82.3	10.0	35.1	10.8	2.2	41.9			533

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Hay	Sheep	59.3	42.6	32.9	69.9	1.21	533

B125 *Vicia benghalensis* L. (*V. atropurpurea* Desf.)

Purple vetch

Climbing vetch with purple-red flowers, not particularly vigorous, forming rather loose stands. Originates from the Mediterranean area, where it is cultivated in fodder mixtures with winter cereals.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh, early bloom, Kenya		23.6	28.8	8.1	3.0	36.5	8.50	0.35	134

B126 *Vicia narbonensis* L.

Narbonne vetch

A plant with thick erect stems that can grow without support. Cultivated as a fodder plant in cooler areas of the subtropics and tropics.

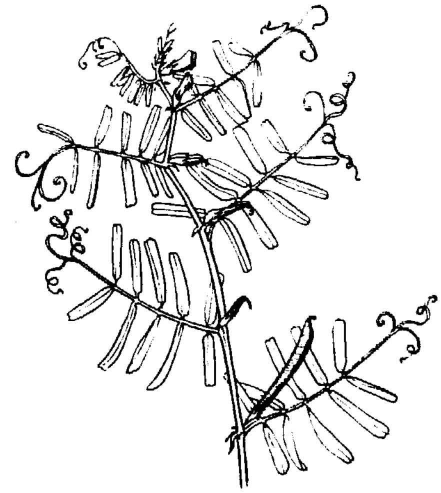
		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh, full bloom, Kenya		24.7	22.7	12.2	3.2	37.2	0.59	0.36	134
Fresh, 3 months, Israel	12.2	23.0	25.4	15.6	4.1	31.9			365

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Fresh, 3 months	Sheep	80.0	58.0	74.0	74.0	2.42	365

B127 *Vicia sativa* L.

Common vetch or tares

Twining herb up to 2 m long, of great importance in temperate climates and producing a reasonable bulk of forage in cooler areas of the tropics. Can either be cut for fodder or grazed. Usually sown with a cereal to support the weak vines.



Vicia sativa

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Fresh, early vegetative, Kenya		35.9	21.3	9.2	2.8	30.8	0.49	0.61		134
Fresh, early bloom, Kenya		26.5	24.3	11.2	3.1	34.9	0.97	0.42		134
Fresh, full bloom, Kenya		18.6	31.9	9.3	2.4	37.8	1.28	0.26		134
Fresh, 10 weeks, Israel	16.6	22.9	25.3	12.0	3.0	36.8	0.96	0.30		365
Hay, Israel	89.1	19.0	28.5	9.1	2.4	41.0	1.11	0.30		365

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, 10 weeks	Sheep	81.0	53.0	51.0	74.0	2.39	365
Hay	Sheep	81.0	49.0	48.0	70.0	2.30	365

B128 *Vicia villosa* Roth (*sens. lat.*) (*V. dasycarpa* Ten.)

Woolly pod vetch

Climbing vetch with violet-purple flowers that forms strong leafy herbage. Stays green longer than common vetch, flowers and seeds late in the season and often survives the dry season, regenerating to almost full strength during the next rainy season.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh, early bloom, Kenya		30.5	24.2	13.3	2.4	29.6	0.64	0.46	134
Fresh, full boom, Kenya		25.6	26.7	11.5	3.8	32.4	0.80	0.40	134

B129 *Vigna aconitifolia* (Jacq.) Marechal (*Phaseolus aconitifolius* Jacq.)

Indian moth bean, pillipesara or mat bean

Herbaceous creeping annual, native to India and Pakistan. A drought-resistant, hot-season fodder plant yielding palatable pasture and hay. Useful in mixtures with lablab, pigeon pea and Sudan grass. Relished by livestock and can be grown on all types of soils. Although it is an annual of only five months' duration, it can serve as a pasture legume as it reseeds itself if allowed to become well established before being grazed.

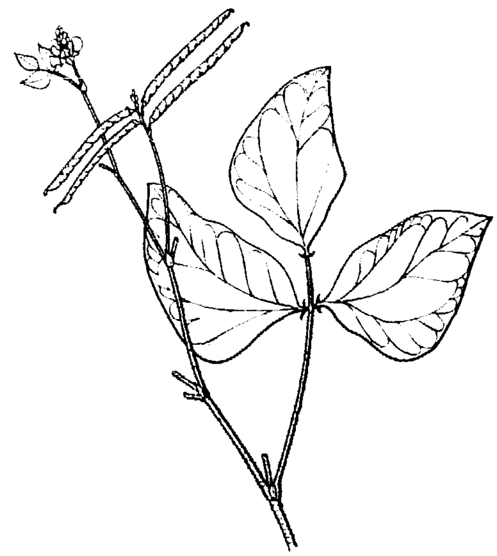
	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, India		15.5	19.7	12.6	1.9	50.3	2.37	0.54	378
Haulm, India		9.6	19.4	14.1	2.9	54.0	3.01	0.24	378
Hay, USA	86.2	17.2	29.4	12.0	1.7	39.7			161
Hay, India		10.6	26.8	13.8	1.9	46.9	2.34	0.18	436
Pods, India		9.6	19.4	14.4	2.9	53.7	2.01	0.25	436
Seeds, India		26.6	5.3	5.6	0.6	61.9	0.35	0.38	436

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Hay	Sheep	67.0	52.0	10.0	65.0	2.00	161

B130 ***Vigna mungo*** **(L.) Hepper (*Phaseolus mungo* L.)**

Mung bean, black gram or urd

Erect spreading annual plant, native to central Asia. Resembles *V. radiata* but is somewhat more hairy; the white hilum also protrudes from the seed. Green gram is sown on lighter soils and black gram on heavier soils. It is grown for forage, silage, hay and chicken pasture. The seeds are free from glucosides.



Vigna mungo

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Fresh aerial part, Trinidad	16.0	19.4	26.8	16.0	2.5	35.3	1.97	0.24		203
Haulm, India		8.9	28.6	12.6	2.8	47.1	1.74	0.16		379
Silage, dough stage	27.3	13.9	19.1	26.4	4.6	36.0				186
Pods, India		9.0	29.9	12.2	2.3	46.6	2.71	0.19		436
Seeds, India		26.8	5.3	5.6	0.9	61.4	0.22	0.39		436
Seeds, Thailand		26.1	5.6	3.7	1.0	63.6				56
Pod husks, India		16.6	24.6	11.0	0.7	47.1	0.78	0.21		436

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Aerial part	Cattle	82.0	72.0	51.0	71.0	2.39	203
Silage, dough stage	Cattle	54.0	48.0	72.0	58.0	1.67	186
Seeds	Cattle	57.0	82.0	52.0	67.0	2.35	436

B131 *Vigna radiata* (L.) Wilczek var. *radiata* (*Phaseolus aureus* Roxb.)

Mung bean, green gram or golden gram

Tall erect herb with yellow flowers, thin cylindrical pods and small, often cylindrical seeds covered with a white rough layer. Drought resistant. Grown for forage, silage, hay and chicken pasture. The seeds are free from glucosides. Can be grown with a number of perennial and annual fodder grasses.

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Fresh aerial part, India		13.0	21.0	11.4	3.7	50.9	2.47	0.34		378
Haulm, India		9.0	29.9	12.1	2.3	46.7	2.71	0.20		378
Pods, India		8.9	28.1	13.1	2.8	47.1	2.49	0.15		436
Seeds, Iraq	90.8	23.3	6.7	5.3	1.0	63.7	0.08			182
Seeds, Malaysia	88.1	24.4	5.1	3.7	1.0	65.8	0.12	0.40		292
Pod husk, Nigeria	90.3	8.2	35.8	7.7	0.6	47.7	2.18	0.20		374

B132 *Vigna umbellata* (Thunb.) Ohwi & Ohashi

Red bean or rice bean

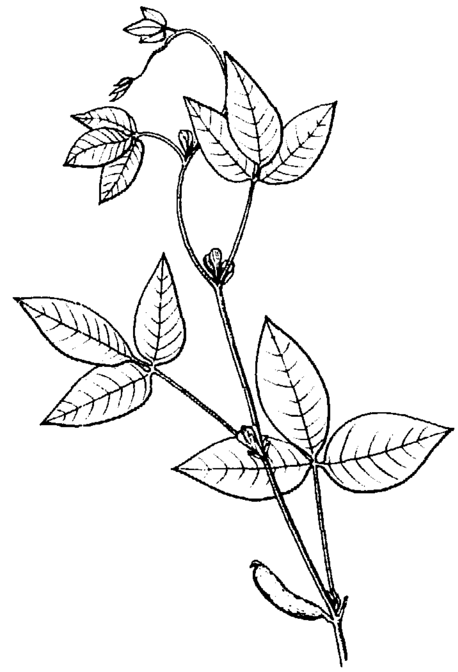
Short-lived, very hairy twining weed with yellow flowers and cylindrical pods. Native to India. The seeds used mainly for human consumption. It may be cut for hay when the pods are half-grown, but the hay should be handled as little as possible because the leaves drop off easily. The straw from seed-harvested vines may be dried, cut and fed to cattle. Though poor in digestible nutrients, it is relished by cattle. Before feeding, the woody portions and soiled or mildewed parts should be removed.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh, mid-bloom, Malaysia	32.0	16.9	30.6	7.8	1.9	42.8	1.03	0.26	292
Seeds, Malaysia	81.0	23.3	6.0	4.6	0.6	65.5	0.67	0.39	292

B133 *Vigna unguiculata* (L.) Walp. subsp. *unguiculata* (*Dolichos biflorus* L.)

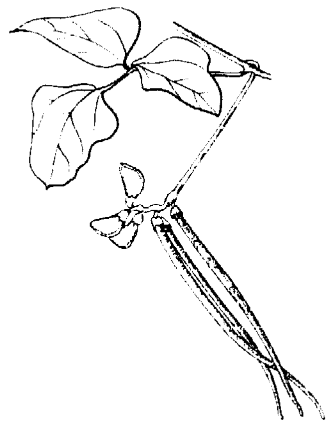
Horse gram

Twining succulent annual herb about 40 cm high. Grown as a dry crop in moderate-rainfall areas. Very drought resistant and suited to sandy and shallow soils. Often cultivated for forage or pasture, sometimes mixed with sorghum. The seeds are used as concentrate feed for cattle. On heavy soils the yield is inferior to *Dolichos lablab* and cowpea.



Vigna unguiculata

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Fresh aerial part, Malaysia	18.2	17.6	21.4	7.1	2.2	51.7	0.55	0.29		292
Hay, India		10.6	16.2	13.1	1.8	58.3	1.81	1.18		436
Pods, India		7.2	37.7	11.5	1.2	42.4	1.66	0.13		436
Seeds only, India		23.8	6.4	6.7	1.1	62.0	0.40	0.29		436



Vigna unguiculata

B134 ***Vigna unguiculata*** **(L.) Walp. subsp.** ***unguiculata*** **(*****V. sinensis*** **(L.) Savi;** ***V. catjang*** **Walp.;** ***V. unguiculata*** **Walp.)**

Cowpea, black-eyed pea, cherry bean, southern pea or wonder pea

Trailing or bushy vigorous-growing annual with large seeds, blue-purple to white flowers, oval to heart-shaped leaves and flattened pods 10-20 cm long. Medium to late maturity (70-140 days).

An excellent crop to grow with maize for silage (one part cowpea vines and two parts maize). Also cultivated as a pasture, hay or silage crop. The straw and seed-harvested vines used for all kinds of livestock. The vines should be cut for hay when most of the pods are full grown and a considerable number of them are mature. If cured by much exposure to the sun, the leaves fall off. Cowpea hay is an excellent roughage for all kinds of livestock; if chopped and moistened, it is suitable for poultry as well. Mixed with ground maize it has proved quite satisfactory for brood sows. There is much waste from trampling if stock is allowed into cowpea fields before the plants are full-grown. To avoid this, cowpeas can be used for zero grazing or can be grazed by pigs before cattle or sheep.

Yields of fresh fodder can be increased by cutting the plants twice in a season. Cowpea can be grown with Sudan grass for hay and with maize for silage.

The seeds are usually too expensive for animal feed, but are used to some extent for poultry. The harvesting of seed is costly because of the uneven ripening of the pods. Culled peas are sometimes used for pigs. Although there is no evidence of toxicity, the gain in weight usually decreases as the percentage of raw beans increases in the ration. This effect can largely be eliminated by autoclaving the beans (at 121°C for 15 minutes) before feeding.

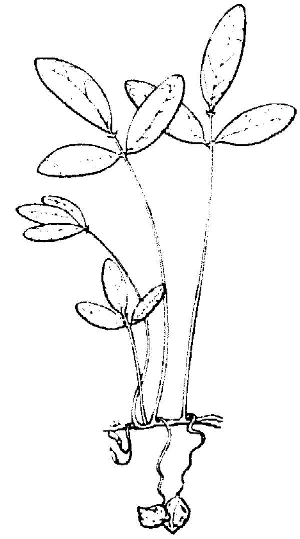
		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh aerial part, Malaysia	11.1	30.6	24.3	14.4	1.8	28.9	2.06	0.31	292
Fresh, mid-bloom, Tanzania		27.5	17.7	12.7	3.9	38.2			487
Haulm, Nigeria		17.5	24.9	7.8	1.6	48.2			58
Hay, South Africa		14.4	22.3	9.9	2.3	51.1	1.33	0.18	489
Seed, Malaysia	92.6	24.9	5.2	4.0	1.5	64.4	0.27	0.42	292
Seed, Trinidad	88.0	22.5	3.5	3.3	1.4	69.3			117
Pod husks, Nigeria	92.6	13.0	33.4	7.2	0.7	45.7			374

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Haulm	Cattle	73.1	48.2	31.3	69.7	2.24	58
Hay	Sheep	64.1	52.7	34.5	80.5	2.38	489

B135 *Voandzeia subterranea* (L.) Thouars

Bambarra groundnut, Congo goober, earth pea, kaffir pea, Madagascar groundnut or stone groundnut

Low short-lived creeping herb with branched stems and hairless trifoliate leaves, native to Africa. The pods are pushed into the soil, like those of groundnut, and usually contain only one hard round seed. It grows well in poor soils. The nuts are not used for oil extraction, as they contain only about 6% fat, but are successfully fed to pigs and poultry; the haulms are a valuable cattle feed.



Voandzeia subterranea

		As % of dry matter								
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Hay, dough stage, Zimbabwe	90.2	15.9	31.7	7.5	1.8	43.1			499
Pods, Nigeria	96.6	18.2	14.2	5.4	5.5	56.7			374
Seeds, Ghana	92.7	21.3	6.7	3.3	7.5	61.2	0.01	0.30	372

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Hay, dough stage	Cattle	65.9	67.1	53.0	70.9	2.40	499

C. Miscellaneous fodder plants

In many parts of the world shrubs, trees and other plants that are not cultivated for fodder constitute an important part of animal diets. Shrub feeding is the only way for stock to survive in semiarid areas when the grass is exhausted. In general, the crude protein content of many edible trees and shrubs is quite high, but its digestibility is low. In addition, many of these plants are deficient in phosphorus, and the response to block licks containing phosphorus is usually good.

C1 *Acalypha fruticosa* Forsk.

Clump-forming shrub 15-25 m high, often forming a pure stand. Widely distributed along river banks and floodplains in riparian woodland. Leaves and young twigs readily eaten by cattle.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh browse, Kenya		14.1	18.1	12.8	3.8	51.2			506

C2 *Acanthus mollis* L.

A perennial wild ornamental plant that grows in warm dry climates and has long been used in Sicily for feeding goats and cattle. Owing to its high nutritive value, cultivation has been attempted. The plant has a vegetative rest period in summer and grows quickly in spring and autumn.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh, spring crop, Italy	17.4	17.2	11.2	11.1	3.0	57.5	0.84	0.26	331
Fresh, autumn crop, Italy	10.2	25.3	11.2	15.7	2.3	45.5	0.83	0.34	331
Seeds, Italy	86.7	26.1	2.8	2.8	1.4	66.9			331

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Spring crop	Sheep	80.5	82.6	47.3	88.3	2.88	331
Autumn crop	Sheep	86.8	85.5	46.5	89.5	2.85	331

C3 *Achyranthes aspera* L.

Heat-loving perennial plant, 60-80 cm high, Grows in sandy soils, especially in the shade of trees and bushes. Palatable in its juvenile stages. Leaves and branches readily browsed throughout the year.

	DM	As % of dry matter							Ref.
		CP	CF	Asli	EE	NFE	Ca	P	
Fresh browse, mid-bloom, Niger		12.9	25.0	12.4	1.4	48.3	0.96	0.34	45
Fresh browse, mid-bloom, East Africa		26.4	20.2	18.6	1.4	33.4	1.79	0.31	129

C4 *Aerva persica* (Burm. f.) Merr. [*A. javanica* (Burm. f.) Juss *ex* Schult.]

Perennial semishrubby plant that prefers sandy soils. Eaten mostly by sheep and goats.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh browse, mid-bloom, Niger		10.3	41.7	8.4	0.8	31.3	0.90	0.15	45

C5 *Agave americana* L.

Century plant

The leaves grow next to the ground in a massive rosette and are up to 2 m long, upturned and prickly on the edges. The plant has a large candelabralike stalk that can be as tall as 10 m. Native to Mexico, it is now found in hot dry areas of the Mediterranean and in Africa. Young plants contain a sugar-rich sap used in Mexico to make mescal and pulque. It is used for feed in the same way as *A. atrovirens,* but should not be fed in large amounts because it contains saponins that may cause illness.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, USA	14.4	7.4	16.0	12.3	1.3	63.0			164
Dried leaves, Zimbabwe	84.9	6.1	15.6	12.4	1.3	64.6			21

C6 *Agave atrovirens* Karw. *ex* Salm Dyck

Maguey

Tall herbaceous plant cultivated in some areas on the dry plains of Mexico as a forage for the dry season. For use as forage, the skin is taken off the leaves, and the remainder cut into pieces and mixed with hay. During an initial period this feed may irritate the mouths of cattle. This agave is also a source of pulque.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, Mexico	9.2	2.3	32.4	8.9	2.8	53.6			88

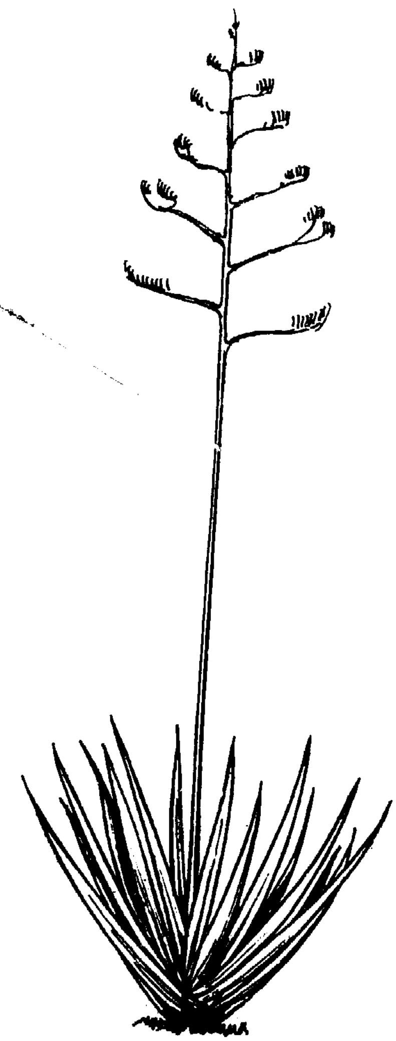
C7 *Agave sisalana* Perr. *ex* Engelm.

Sisal hemp or henequen

Useful reference: 17

Stemless perennial with thick succulent leaves 1-1.5 m long having smooth edges and a sharp dark-brown terminal spine. The plant produces a central spike up to 6 m high after seven or eight years. The leaves are threshed for the durable white fibres used in the manufacture of rope and twine. The leaf waste, or pulp, left as a by-product accumulates in large amounts at processing sites. Sisal leaf waste has been used profitably for cattle and rabbit feed. Up to 27 kg of fresh sisal waste have been fed daily to dairy cows, but the average intake of sisal waste when used as a supplement for grazing cattle is about 10 kg per day. Undesirable side-effects have not been observed even after heavy feeding of sisal waste for long periods. The succulence of fresh sisal waste makes it a useful feed during dry periods. Once accustomed to it, cattle find sisal waste quite palatable. Sisal waste ferments rapidly and should be used within forty-eight hours or be either sun-dried or ensiled.

It takes about one month for "untrained" cattle to reach the maximum intake of fresh waste, whereas a cow which has received sisal waste the previous season attains the same level in a week. Cattle accustomed to sisal waste attack it avidly. The main limitation of utilizing sisal waste for feed is its high moisture content. Besides, it is perishable and low in nutritive value, mostly because of its lack of digestible protein and phosphorus.



Agave sisalana

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Fresh waste, Kenya	11.0	7.6	22.7	15.6	3.7	50.4				275
Washed waste, Kenya	11.0	5.2	35.6	15.5	2.7	41.0	5.72	0.11		275
Washed waste, fermented 5 days, Kenya	12.0	15.1	43.7	21.6	4.9	14.7				275

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh waste	Sheep	8.0	54.0	86.0	66.0	1.87	275

C8 *Alocasia macrorrhiza* (L.) Schott

Alocasia, giant alocasia or giant taro

Herbaceous plant with large heart-shaped leaves up to 1.5 m long that contain a milky juice. The wild variety has a pungent taste caused by oxalate crystals which also cause the mouth to itch. Cultivated forms do not have this property, and the leaves, stalks and black rhizome can be fed to animals.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, Malaysia	9.6	24.0	12.5	17.7	6.3	39.5	1.57	0.14	292

C9 ***Alternanthera philoxeroides*** **(Mart.) Griseb. (*Achyranthes philoxeroides* Standley)**

Alligator weed

A troublesome water weed that can completely choke streams. Usually free floating with 25-40 cm of the plant above the water and intertwined stems 2-3 m long forming dense mats under the surface. Both the aerial part and the underwater stems are readily eaten by cattle, which sometimes learn to wade in the water to graze even the underwater part. The floating plants are easily harvested for fodder by using a cutlass to divide the floating mass into sections, which are then hauled ashore by rope with a grappling hook.

		As % of dry matter								
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Dried whole plant, USA	88.0	7.3	8.5	13.6	1.6	69.0	0.14		10

Amaranthus graecizans

C10 ***Amaranthus graecizans*** **L.**

Annual plant 40-50 cm high that grows in sandy soil. The leaves are used as both feed for animals and food for humans.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh browse, mid-bloom, Niger		19.9	21.0	17.0	1.5	40.6	1.81	0.54	45

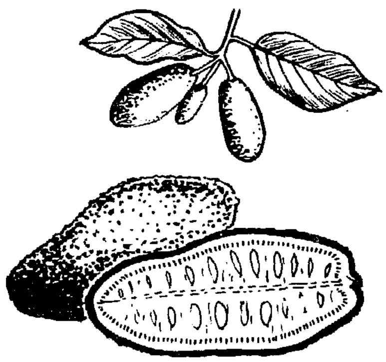
C11 ***Anogeissus latifolia* (Roxb. *ex* DC.) Wall *ex* Bedd.**

Gum ghatti

Deciduous tree found in drier areas. The leaves contain tannin but are nevertheless browsed by cattle.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, India		7.5	24.2	9.5	3.6	55.2	3.03	0.34	436

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Leaves	Cattle	8.0	32.0	53.0	64.0	1.73	436



Artocarpus heterophyllus

C12 *Artocarpus heterophyllus* Lam. (*A. integrifolius* L. f.)

Jackfruit or jakfruit

A tree up to 15 m high with stiff trilobed leaves on the young shoots. The most unusual fruits are green and clump-formed with a papillate surface, weigh up to 25 kg each and can be 1 m long. They grow all along the trunk of the tree. Despite their unpleasant odour the fruits are an important food in the eastern tropics.

Jack leaf is a staple roughage for goats in Kerala, India. Its crude protein digestibility is fairly low because of its high content of tannins. Cattle also relish the rind of the ripe fruit.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, Malaysia	33.1	16.0	16.3	11.8	3.6	52.3	1.47	0.18	292
Fresh leaves, Bangladesh	53.0	18.5	26.2	10.2	5.0	40.1	2.00	0.11	308

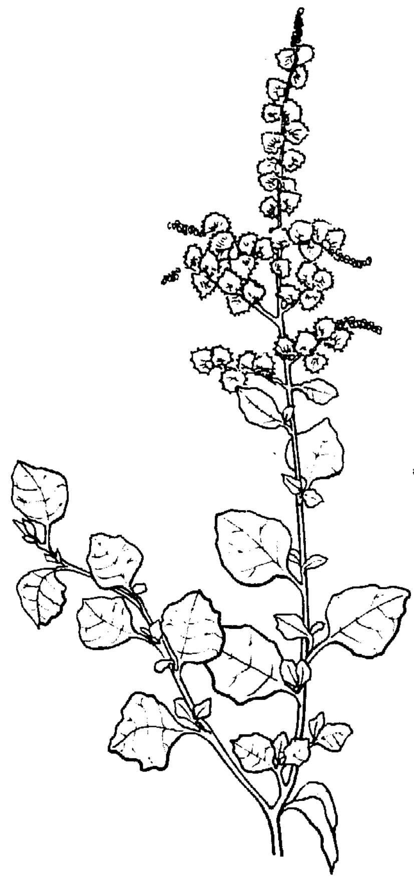
		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Leaves	Goats	46.3	45.6	44.1	56.4	1.78	525

C13 *Atriplex nummularia* Lindl.

Old man saltbush

Erect shrub up to 2 m high with white branches, oval to almost round grey leaves up to 2 cm long, small green terminal flowers, and triangular, laterally compressed fruits 1-2 cm long. Often grown as a fodder plant in drier areas because of its great resistance to drought.

Grows well in deep soil with only 150-200 mm of rainfall annually, but can survive for a year with only 50 mm of rainfall. Resists temperatures as low as – 10°C. Withstands heavily textured soils and tolerates salinity in soil or water. Propagated by cuttings in a nursery for three to six months before planting in the field (1 m × 5 m apart) after the rains. May be grazed when 1.5 m high (second or third year). Now cultivated on a large scale in Tunisia as a fodder crop. Palatable except when grown on very saline soils as the plant accumulates salt.



Atriplex nummularia

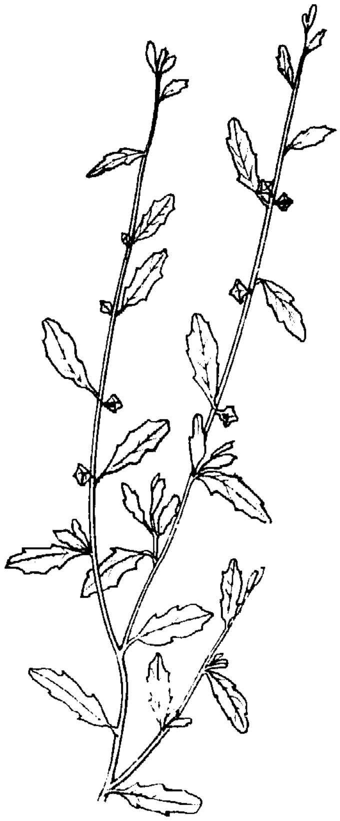
	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh browse, Queensland, Australia	32.2	15.5	20.5	15.8	2.2	46.0			77
Fresh aerial part, South Africa	33.8	21.3	10.3	22.2	2.6	43.6	1.22	0.17	210

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Browse	Cattle	52.0	39.4	42.9	66.3	1.82	77

C14 *Atriplex semibaccata* R. Br.

Creeping saltbush

Prostrate perennial with whitish branches. The grey leaves are narrow and 1-2 cm long. The somewhat fleshy, diamond-shaped red fruits form in clusters in the axis between the branch and the leaves. A common weed in gardens. Used in reclaiming salt land. Readily eaten by goats and sheep; birds are fond of the fruits.



Atriplex semibaccata

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh browse, South Africa	32.6	16.6	18.7	23.6	1.6	39.5	1.81	0.14	210
Fresh browse, Chile	21.9	13.2	20.7	18.3	3.2	44.6			315
Browse, dried, USA	96.4	21.4	17.0	19.3	1.4	40.9			206

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Browse	Sheep	83.0	27.0	16.0	61.0	1.86	206

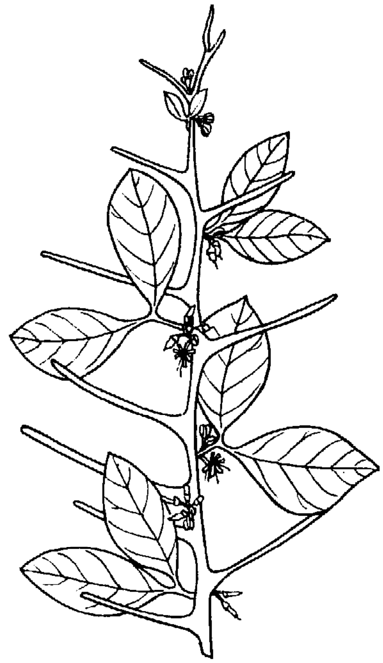
C15 *Azadirachta indica* A. Juss. (*Melia azadirachta* L.)

Margosa or neem tree

Large evergreen tree with edible fruits and aromatic leaves found throughout southern Asia. A mature tree can produce 350 kg of leaves a year, which may be used for feeding cattle during famines. After the oil has been pressed from the seeds, the cake is used as fertilizer, but it can also be used as feed. Up to 10% neem cake may be included in concentrates for cattle and up to 5% for poultry. The oilcake has a very bitter taste.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, India		15.4	12.7	11.2	4.2	56.5	2.65	0.24	436
Fresh leaves, Pakistan	35.8	13.4	14.7	10.3	6.2	55.5	1.94	0.17	308
Neem cake, India	43.1	17.1	28.2	15.4	2.3	37.3	1.38	0.12	538

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Leaves	Cattle	52.0	23.0	58.0	68.0	2.03	436



Balanites aegyptiaca

C16 *Balanites aegyptiaca* (L.) Del.

Desert date

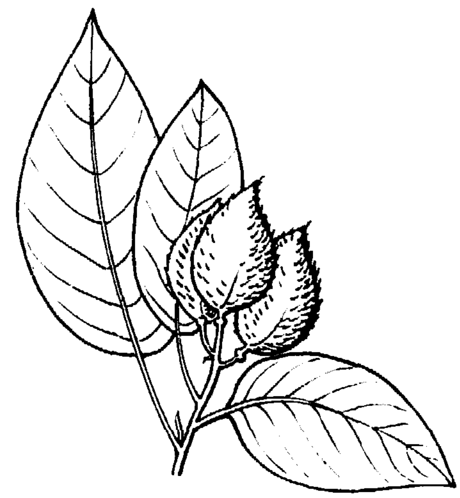
Small or medium-sized tree 3.5-5.5 m high with recurved spiny branches and fleshy succulent leaves. Found mostly on flat land with slightly impeded drainage. As it is drought resistant, it is common in the Sahel. Goats eat the leaves avidly and also pick up the datelike fruits when they fall to the ground. The young spines are soft, and cattle eat young branches when other browse is scarce.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, Nigeria		11.6	13.6	12.7	4.2	57.9			58
Fresh browse, early vegetative, Kenya		27.5	23.3	6.6	1.5	41.1	0.48	0.38	129
Fruit, Zaire	66.3	11.1	10.2	8.1	1.7	68.9	0.16	0.4	537

C17 *Bixa orellana* L.

Annatto

Shrub or small tree usually up to 3 m high with large pink flowers, native to Central America. The seeds are surrounded with a thin coating of waxy pulp that is used for the production of bixin, a common colouring matter added to foods and drugs. The seed meal is seldom used as a protein feed, but it is an effective substance for giving colour to poultry meat and eggs when mixed with poultry feeds.



Bixa orellana

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Pulp	15.6	0.0	3.2	6.4	1.9	88.5	0.05	0.06	235
Dried seeds	94.4	7.0	15.4	5.3	4.9	67.4	0.01	0.01	235

C18 *Boehmeria nivea* (L.) Gaudich.

White ramie

The ramie plant, grown mainly as a fibre crop, is also a source of nutritious green feed. The leaves and tops, unlike the stems, have a low fibre content and are rich in protein, minerals, lysine and carotene. The nutritive value of ramie has been described as similar to that of lucerne, which it can, however, greatly outyield. When ramie is grown for fodder, up to fourteen cuttings a year can be taken from established crops, yielding as much as 300 tons of fresh material (42 tons dry matter) per hectare per year. The foliage is palatable and has proved to be of value not only to stock but also to pigs and poultry. Ramie can be grazed, used as soilage, ensiled together with molasses, or artificially dried for leaf meal. Ramie is palatable to all classes of domestic livestock and is an excellent feed for cattle. As long as satisfactory *ad lib* mineral levels are achieved, ramie can be fed *ad lib* to pigs of all ages and acceptable production obtained. Ramie meal has proved valuable to poultry as a source of carotenoids and riboflavin. In poultry rations 5% leaf meal will normally supply sufficient vitamin A and riboflavin. The only problem associated with feeding ramie is its high mineral uptake, especially molybdenum on soils rich in this element; this can be corrected by adding appropriate levels of copper sulphate to the diet.

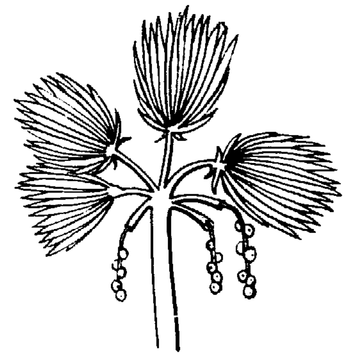
	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Leaf and top meal, USA	91.7	21.0	16.6	14.8	4.0	43.6	4.90	0.27	537
Fresh forage, 25 cm, Colombia		30.1	13.1	18.2	4.4	34.2			537
Dried forage, 40 cm, Guatemala	96.1	22.4	11.9	17.7	3.2	44.8	4.5	0.14	537
Forage, 4 weeks, 95 cm, Thailand	13.9	15.1	26.6	16.5	3.6	38.2			219
Forage, 6 weeks, 115 cm, Thailand	16.2	11.1	29.0	15.4	4.3	40.2	3.70	0.31	219
Leaf meal, Sudan	90.3	22.7	11.3	18.8	8.6	38.6	4.90	0.41	98

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, 4 weeks	Sheep	56.0	45.0	48.0	39.0	1.47	219
Fresh, 6 weeks	Sheep	46.0	49.0	23.0	53.0	1.58	219
Leaf meal	Goats	56.2	32.6	40.0	47.2	1.61	98

C19 *Borassus flabellifer* L.

Palmyra palm or African fan palm

Tall erect palm with fan-shaped leaves and a black stem, usually 15-20 m but sometimes 30 m tall. Cultivated for its edible fruits and for its sap, which can be fermented into palm wine (toddy). The sap, which has a sugar content of about 14%, is also collected and converted into syrup by boiling. After cooling, the syrup hardens into lumps of sugar.



Borassus flabellifer

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, Sri Lanka		13.3	38.0	7.4	4.6	36.7			244
Fruit, Africa	12.4	6.5	16.1	4.8	0.8	71.8	0.21	0.24	154

C20 *Boscia albitrunca* (Burch.) Gilg. & Ben.

Witgatboom

A tree up to 5 m high, in appearance often very variable. Trunk and branches yellowish. Grey-green leaves, elongated, rounded at the ends with a very short petiole. Small yellowish green flowers in dense clusters on woody branches. Yellow berries, more or less spherical with a large hard stone. The softer branches and the leaves often browsed by game and stock, leaving the plants conspicuously trimmed. When cattle eat large quantities of leaves and shoots, milk and meat acquire a very unpleasant taste.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, South Africa		15.8	30.3	7.4			1.44	0.12	193

C21 *Boscia angustifolia* A. Rich.

Medium-sized tree 4-6 m high with white bark, growing in semiarid areas. The branches are very leafy with rather small leaves which are thick, fleshy and hard. Extensively used in the dry season for feeding cattle, goats and sheep, which eat the leaves and young twigs from lopped branches.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh browse, early vegetative, Kenya		19.3	39.2	7.1	1.3	33.1	0.61	0.18	129

C22 *Brosimum alicastrum* Sw.

Breadnut tree or ramon

Evergreen tree up to 30 m high, native to tropical America. Used in some countries as a fodder tree during the dry season. The leaves, seeds and entire fruits are eaten by animals. One tree can produce about 40 kg of seeds, which are relished by pigs.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, Jamaica	38.9	13.9	26.5	7.9	3.4	48.3			43
Pulp, Cuba	15.5	20.1	11.6	6.6	5.3	56.4			88
Seeds, Cuba	42.5	14.0	5.6	3.3	2.9	74.2			88

C23 *Cadaba farinosa* Forsk.

A shrub 1-2 m high with many branches bearing numerous small greyish green leaves. Grows in semiarid and arid areas in the desert grass-bush zone. Cattle and goats eat the leaves and young branches throughout the year, although not excessively. During the dry season it is often the only source of green palatable roughage.

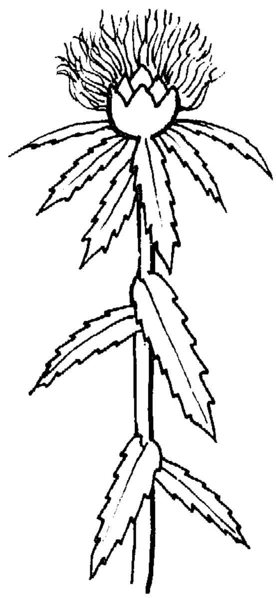
	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Browse, with pods, milk stage, Kenya		18.2	27.3	7.0	1.8	45.7	0.39	0.17	129
Fresh leaves, mid-bloom, Niger		30.6	9.3	15.4	1.8	42.9	0.92	0.16	45

C24 *Carica papaya* L.

Papaya, pawpaw, papay or papaw

Fast-growing tree with deeply lobed leaves that cluster at the top of the trunk. It is widespread in the tropics, and its large fruits are one of the world's most popular tropical fruits. Most parts of the tree contain pepsin, a proteolytic enzyme used as a meat tenderizer. In some areas the leaves are stripped and fed to livestock.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, Pakistan	19.5	20.9	14.5	15.4	13.6	35.6	2.38	0.22	308
Fresh leaves, Nigeria	24.6	32.6	7.3	11.0	0.8	48.3			374
Leaves, dried, Zimbabwe	92.5	23.5	10.6	12.3	4.2	49.4			499



Carthamus tinctorius

C25 *Carthamus tinctorius* L.

Safflower or false saffron

An annual plant 0.3-1 m high with an extensive root system, light-coloured stems and branches, white, yellow, orange or red flowers and small light-coloured seeds. As a grazing crop safflower produces roughly the same amount of green feed per hectare as oats. Succulent safflower is grazed by livestock, and sheep especially seem to relish safflower stubble after harvest. Hay of good quality can be made from safflower, and it is readily eaten by sheep despite the spines.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh, 45 cm, India		17.0	10.9	12.2	1.6	58.3	1.70	0.34	436
Fresh, 75 cm, India		15.1	16.4	11.5	1.7	55.3	1.50	0.29	436
Fresh, 105 cm, India		15.6	23.6	11.2	1.9	47.7	1.30	0.34	436
Fresh, 135 cm, India		12.2	25.0	10.3	2.1	50.4	1.10	0.38	436
Hay, Germany (F.R.)	92.0	12.2	31.1	8.5	2.4	45.8			429
Silage, Germany (F.R.)	16.6	12.6	31.4	8.9	4.4	42.7			429

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Fresh, 135 cm	Cattle	75.0	46.0	46.0	73.0	2.22	436
Silage	Sheep	76.0	61.0	82.0	74.0	2.53	429

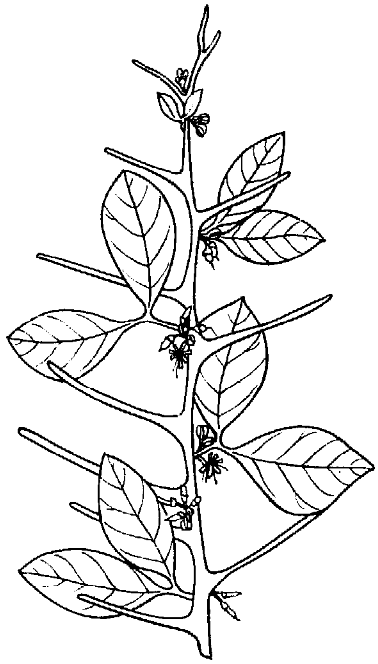
C15 *Azadirachta indica* A. Juss. (*Melia azadirachta* L.)

Margosa or neem tree

Large evergreen tree with edible fruits and aromatic leaves found throughout southern Asia. A mature tree can produce 350 kg of leaves a year, which may be used for feeding cattle during famines. After the oil has been pressed from the seeds, the cake is used as fertilizer, but it can also be used as feed. Up to 10% neem cake may be included in concentrates for cattle and up to 5% for poultry. The oilcake has a very bitter taste.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, India		15.4	12.7	11.2	4.2	56.5	2.65	0.24	436
Fresh leaves, Pakistan	35.8	13.4	14.7	10.3	6.2	55.5	1.94	0.17	308
Neem cake, India	43.1	17.1	28.2	15.4	2.3	37.3	1.38	0.12	538

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Leaves	Cattle	52.0	23.0	58.0	68.0	2.03	436



Balanites aegyptiaca

C16 *Balanites aegyptiaca* (L.) Del.

Desert date

Small or medium-sized tree 3.5-5.5 m high with recurved spiny branches and fleshy succulent leaves. Found mostly on flat land with slightly impeded drainage. As it is drought resistant, it is common in the Sahel. Goats eat the leaves avidly and also pick up the datelike fruits when they fall to the ground. The young spines are soft, and cattle eat young branches when other browse is scarce.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, Nigeria		11.6	13.6	12.7	4.2	57.9			58
Fresh browse, early vegetative, Kenya		27.5	23.3	6.6	1.5	41.1	0.48	0.38	129
Fruit, Zaire	66.3	11.1	10.2	8.1	1.7	68.9	0.16	0.4	537

C17 *Bixa orellana* L.

Annatto

Shrub or small tree usually up to 3 m high with large pink flowers, native to Central America. The seeds are surrounded with a thin coating of waxy pulp that is used for the production of bixin, a common colouring matter added to foods and drugs. The seed meal is seldom used as a protein feed, but it is an effective substance for giving colour to poultry meat and eggs when mixed with poultry feeds.

Bixa orellana

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Pulp	15.6	0.0	3.2	6.4	1.9	88.5	0.05	0.06	235
Dried seeds	94.4	7.0	15.4	5.3	4.9	67.4	0.01	0.01	235

C18 *Boehmeria nivea* (L.) Gaudich.

White ramie

The ramie plant, grown mainly as a fibre crop, is also a source of nutritious green feed. The leaves and tops, unlike the stems, have a low fibre content and are rich in protein, minerals, lysine and carotene. The nutritive value of ramie has been described as similar to that of lucerne, which it can, however, greatly outyield. When ramie is grown for fodder, up to fourteen cuttings a year can be taken from established crops, yielding as much as 300 tons of fresh material (42 tons dry matter) per hectare per year. The foliage is palatable and has proved to be of value not only to stock but also to pigs and poultry. Ramie can be grazed, used as soilage, ensiled together with molasses, or artificially dried for leaf meal. Ramie is palatable to all classes of domestic livestock and is an excellent feed for cattle. As long as satisfactory *ad lib* mineral levels are achieved, ramie can be fed *ad lib* to pigs of all ages and acceptable production obtained. Ramie meal has proved valuable to poultry as a source of carotenoids and riboflavin. In poultry rations 5% leaf meal will normally supply sufficient vitamin A and riboflavin. The only problem associated with feeding ramie is its high mineral uptake, especially molybdenum on soils rich in this element; this can be corrected by adding appropriate levels of copper sulphate to the diet.

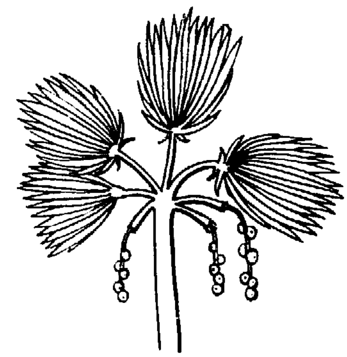
	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Leaf and top meal, USA	91.7	21.0	16.6	14.8	4.0	43.6	4.90	0.27	537
Fresh forage, 25 cm, Colombia		30.1	13.1	18.2	4.4	34.2			537
Dried forage, 40 cm, Guatemala	96.1	22.4	11.9	17.7	3.2	44.8	4.5	0.14	537
Forage, 4 weeks, 95 cm, Thailand	13.9	15.1	26.6	16.5	3.6	38.2			219
Forage, 6 weeks, 115 cm, Thailand	16.2	11.1	29.0	15.4	4.3	40.2	3.70	0.31	219
Leaf meal, Sudan	90.3	22.7	11.3	18.8	8.6	38.6	4.90	0.41	98

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh, 4 weeks	Sheep	56.0	45.0	48.0	39.0	1.47	219
Fresh, 6 weeks	Sheep	46.0	49.0	23.0	53.0	1.58	219
Leaf meal	Goats	56.2	32.6	40.0	47.2	1.61	98

C19 ***Borassus flabellifer* L.**

Palmyra palm or African fan palm

Tall erect palm with fan-shaped leaves and a black stem, usually 15-20 m but sometimes 30 m tall. Cultivated for its edible fruits and for its sap, which can be fermented into palm wine (toddy). The sap, which has a sugar content of about 14%, is also collected and converted into syrup by boiling. After cooling, the syrup hardens into lumps of sugar.



Borassus flabellifer

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, Sri Lanka		13.3	38.0	7.4	4.6	36.7			244
Fruit, Africa	12.4	6.5	16.1	4.8	0.8	71.8	0.21	0.24	154

C20 ***Boscia albitrunca* (Burch.) Gilg. & Ben.**

Witgatboom

A tree up to 5 m high, in appearance often very variable. Trunk and branches yellowish. Grey-green leaves, elongated, rounded at the ends with a very short petiole. Small yellowish green flowers in dense clusters on woody branches. Yellow berries, more or less spherical with a large hard stone. The softer branches and the leaves often browsed by game and stock, leaving the plants conspicuously trimmed. When cattle eat large quantities of leaves and shoots, milk and meat acquire a very unpleasant taste.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, South Africa		15.8	30.3	7.4			1.44	0.12	193

C21 *Boscia angustifolia* A. Rich.

Medium-sized tree 4-6 m high with white bark, growing in semiarid areas. The branches are very leafy with rather small leaves which are thick, fleshy and hard. Extensively used in the dry season for feeding cattle, goats and sheep, which eat the leaves and young twigs from lopped branches.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh browse, early vegetative, Kenya		19.3	39.2	7.1	1.3	33.1	0.61	0.18	129

C22 *Brosimum alicastrum* Sw.

Breadnut tree or ramon

Evergreen tree up to 30 m high, native to tropical America. Used in some countries as a fodder tree during the dry season. The leaves, seeds and entire fruits are eaten by animals. One tree can produce about 40 kg of seeds, which are relished by pigs.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, Jamaica	38.9	13.9	26.5	7.9	3.4	48.3			43
Pulp, Cuba	15.5	20.1	11.6	6.6	5.3	56.4			88
Seeds, Cuba	42.5	14.0	5.6	3.3	2.9	74.2			88

C23 *Cadaba farinosa* Forsk.

A shrub 1-2 m high with many branches bearing numerous small greyish green leaves. Grows in semiarid and arid areas in the desert grass-bush zone. Cattle and goats eat the leaves and young branches throughout the year, although not excessively. During the dry season it is often the only source of green palatable roughage.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Browse, with pods, milk stage, Kenya		18.2	27.3	7.0	1.8	45.7	0.39	0.17	129
Fresh leaves, mid-bloom, Niger		30.6	9.3	15.4	1.8	42.9	0.92	0.16	45

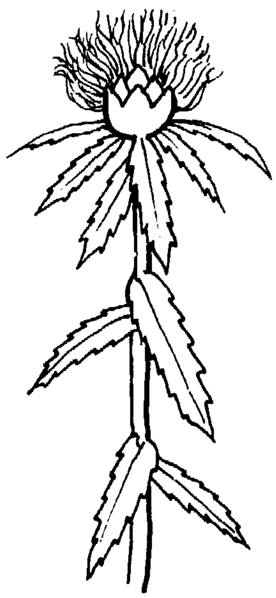
C24 *Carica papaya* L.

Papaya, pawpaw, papay or papaw

Fast-growing tree with deeply lobed leaves that cluster at the top of the trunk. It is widespread in the tropics, and its large fruits are one of the world's most popular tropical fruits. Most parts of the tree contain pepsin, a proteolytic enzyme used as a meat tenderizer. In some areas the leaves are stripped and fed to livestock.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, Pakistan	19.5	20.9	14.5	15.4	13.6	35.6	2.38	0.22	308
Fresh leaves, Nigeria	24.6	32.6	7.3	11.0	0.8	48.3			374
Leaves, dried, Zimbabwe	92.5	23.5	10.6	12.3	4.2	49.4			499

C25 *Carthamus tinctorius* L.



Carthamus tinctorius

Safflower or false saffron

An annual plant 0.3-1 m high with an extensive root system, light-coloured stems and branches, white, yellow, orange or red flowers and small light-coloured seeds. As a grazing crop safflower produces roughly the same amount of green feed per hectare as oats. Succulent safflower is grazed by livestock, and sheep especially seem to relish safflower stubble after harvest. Hay of good quality can be made from safflower, and it is readily eaten by sheep despite the spines.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh, 45 cm, India		17.0	10.9	12.2	1.6	58.3	1.70	0.34	436
Fresh, 75 cm, India		15.1	16.4	11.5	1.7	55.3	1.50	0.29	436
Fresh, 105 cm, India		15.6	23.6	11.2	1.9	47.7	1.30	0.34	436
Fresh, 135 cm, India		12.2	25.0	10.3	2.1	50.4	1.10	0.38	436
Hay, Germany (F.R.)	92.0	12.2	31.1	8.5	2.4	45.8			429
Silage, Germany (F.R.)	16.6	12.6	31.4	8.9	4.4	42.7			429

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Fresh, 135 cm	Cattle	75.0	46.0	46.0	73.0	2.22	436
Silage	Sheep	76.0	61.0	82.0	74.0	2.53	429

C26 *Celosia anthelmintica* Aschers

Large trailing or climbing herb with long spikes. All parts of this plant are eaten by cattle, sheep and goats.

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Fresh aerial part, full bloom, Kenya		15.0	32.9	6.5	2.1	43.5	0.56	0.18		129

C27 *Celtis australis* L.

European hackberry

A tree of heavy hardwood (used for walking sticks, ship rods, etc.). The young leaves are palatable to cattle; the mature leaves are rather unpalatable.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, early vegetative, India	42.3	15.5	22.0	10.1	4.6	47.8	2.83	0.11	444
Fresh mature leaves, India		12.0	16.6	15.8	8.6	47.0	4.47	0.14	444

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Leaves, young	Sheep	62.7	43.5	45.9	74.0	2.21	444
Leaves, mature	Sheep	42.8	29.8	20.9	57.6	1.52	444

C28 *Chascanum caripense* E. Mey.

Shrub up to 1.5 m high with slightly woody branches. The leaves are elongated, deeply lobed or cut, 1-3 cm long and 0.5-1 cm broad. The white flowers grow in terminal spikes about 2 cm long. Rarely browsed by stock.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Pods, South Africa	89.0	14.3	27.3	8.8	2.4	47.2	1.91	0.11	193

C29 *Chenopodium album* L.

Pigweed

Weedy herb with alternate leaves which are sometimes collected and cooked for human consumption. A potential fodder plant, it is rich in protein and can be high yielding.

Chenopodium album

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Leaf meal, India	95.6	21.7	8.3	32.8	3.7	33.5			96

C30 *Chrysanthemum cinerariifolium* (Trev.) Boccone

Pyrethrum

A flower cultivated mainly in East Africa for its content of pyrethrins, which are used in insecticides. Pyrethrum marc is the waste product of pyrethrum flowers that have been ground and extracted with petroleum ether. Before the marc can be used as feed it has to be steamed to remove the residual solvents and destroy the remaining pyrethrins, which are poisonous to stock. The marc is readily accepted by stock and has a high feed value; however, it should not be used for more than 50% of the roughage portion as it depresses productivity. It does not produce off-flavour in milk.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Pyrethrum marc, Kenya	78.3	13.0	23.6	7.1	0.5	55.8	0.53	0.24	552

C31 *Cissus striata* Ruiz & Par.

Low and shrubby small-leaved evergreen with climbing branches, found only in South America. Browsed by cattle.

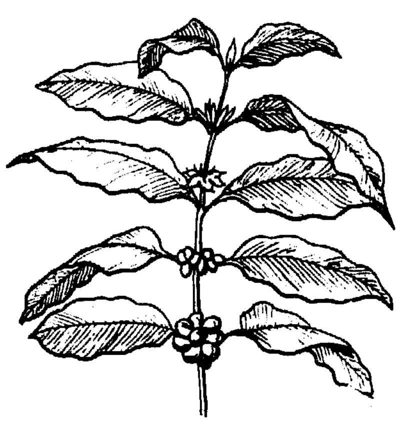
		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh browse, Chile	23.9	20.8	14.2	8.1	2.5	54.4	2.50	0.35	315

C32 *Citrullus lanatus* (Thunb.) Matsum & Nakai (*C. vulgaris* Schrad.)

Watermelon or cocorico

Annual creeping plant with deeply incised leaves and circular fleshy fruits. Grows in sandy soils and persists long into the dry season. The fruits are used for their water content in dry areas. Very palatable to both cattle and pigs.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh aerial part, mid-bloom, Niger		20.0	17.1	18.4	2.2	42.3	1.96	0.46	45
Fruits, Niger	8.4	10.0	25.7	7.8	8.9	47.6	0.34	0.29	537



Coffea arabica

C33 *Coffea arabica* L.

Coffee

The dark glossy green leaves of the coffee bush are sometimes dried and included in concentrates for cattle. They are reported to be palatable and can be fed without any unfavourable side-effects. It has been claimed that the feeding of coffee leaves extends the lactation period (see also D8).

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Dried leaves	93.6	9.9	18.7	13.0	5.9	52.5			154

C34 *Combretum apiculatum* Sond.

Red bush willow

Shrub or tree up to 6 m high with yellow leathery oval leaves 5-10 cm long and 3-4 cm broad. The insignificant flowers are clustered in short spikes. The four-winged fruits are reddish brown and about 2 cm long and broad.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Leaves, South Africa	88.0	12.2	21.6	10.0	3.8	52.4	2.84	0.19	193

C35 *Cordia myxa* L.

Deciduous tree up to 15 m high with rough leaves 15-20 cm long, having either a smooth or ridged edge. Common in Southeast Asia, where the leaves are used as cattle fodder.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, early vegetative, Pakistan	46.0	15.8	14.7	13.1	6.8	49.6	2.56	0.22	308
Fresh mature leaves, Pakistan	36.8	10.1	19.2	16.5	7.4	46.8	2.53	0.18	308
Fresh leaves, India	31.2	14.5	26.7	12.6	2.9	43.3	2.37	0.24	441

C36 *Cordyline terminalis* (L.) Kunth

Boundary marsh, land marsh or dragon's blood

A plant existing in several varieties with leaves varying from green to red-striped. In the Caribbean and South America it is used to mark boundaries and cultivated for fibre, medicine and perfume. (The leaves of the green variety are used in Hawaii for hula skirts.)

	DM	As % of dry matter CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, Hawaii	20.6	13.9	30.9	9.1	3.1	43.0			245

C37 *Croton dichogamus* Pax

A shrub 1.5-2.5 m high with many branches, thin twigs and numerous leaves, which are silvery underneath and brownish on the upper surface. Grows mostly on rocky ground. The leaves that fall to the ground are eaten by goats and are also browsed to a lesser extent.

	DM	As % of dry matter CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh browse, early vegetative, Kenya		25.1	20.1	10.5	2.0	42.3	1.86	0.49	129

C38 *Eichhornia crassipes* (Mart.) Solms (*E. speciosa* Kunth)

Water hyacinth or million dollar weed

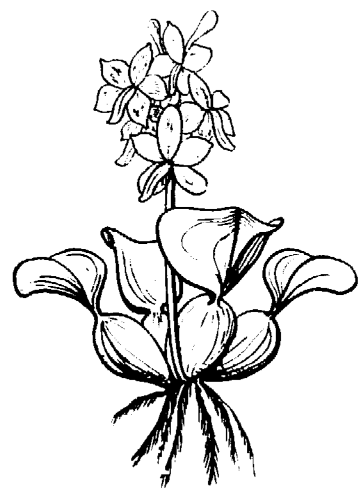
A free-floating water plant whose leaves are above the water surface. A most troublesome weed as it multiplies rapidly, clogging lakes, rivers and ponds and seriously obstructing traffic on waterways. Extremely difficult to eradicate. Much research has been devoted to its use in animal feeding; the plant has been the subject of an FAO study (ref. 153).

Being a floating plant it is easily harvested with nets. The fresh plant contains prickly crystals which make it unpalatable. The fresh leaves are sometimes eaten when other feeds are scarce, but normally more than 25% fresh water hyacinth in the feed reduces intake. Furthermore, the high water content of the plant imposes a limitation on the amount of dry matter an animal is capable of ingesting, and the danger of spreading the weed through seeds in the faeces is great. Usually 2:4-D is used to control the plant. The feeding of sprayed plants should be avoided. Although 2:4-D is not toxic to livestock, sprayed plants may accumulate lethal doses of nitrates.

Boiled water hyacinth is used in Southeast Asia as a feed for pigs. The plants are chopped and sometimes mixed with other vegetable wastes, such as banana stems, and boiled slowly for a few hours until the ingredients turn into a paste, to which oil cake, rice bran and sometimes maize and salt are added. The cooked mixture is good for only three days, after which it turns sour. A common formula is 40 kg of water hyacinth, 15 kg of rice bran, 2.5 kg of fish meal and 5 kg of coconut meal. The physical structure of the plant makes it unsuitable for the normal methods of making hay and silage. The plants dry rather quickly in the sun, but the neck between the petiole and the lamina is very brittle. The lamina shrinks and breaks off with handling, leaving only the petiole which remains round and full of air. The hay is therefore very bulky, and it is not palatable to cattle unless mixed with at least 20% molasses. Urea may be included to increase the content of crude protein. The nutritive value per unit of dry matter is too low to warrant the cost of artificial drying.

Because of the high moisture content of water hyacinth it should be wilted in the shade for forty-eight hours and lacerated before ensiling. Molasses should be added, and sodium chloride and urea are reported to increase the nutritive value and quality of the silage. It has also been ensiled with rice straw (4:1 water hyacinth to rice straw) with good results. These silages have been accepted when gradually included in the ration.

The plant juice has also been used for the production of leaf protein concentrate and as a substrate for yeast production.



Eichhornia crassipes

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh, green part, India	5.9	13.1	18.2	15.3	1.3	52.1	2.16	0.41	436
Fresh, green part, Philippines	7.8	12.8	24.6	11.9	3.3	47.4			299
Hay, India		11.6	24.2	17.8	0.7	45.7	2.19	0.64	357
Silage, Philippines	10.1	9.9	19.7	19.0	1.5	49.9			299
Haylage, India	33.5	11.4	24.5	20.1	1.4	42.6	2.02	0.23	357
Haylage with 2% salt, India	46.8	13.9	17.4	18.9	1.5	48.3	1.70	0.21	357
Dried root, Sudan	92.7	5.8	20.5	3.7	0.9	69.1			93

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Hay	Zebu	37.9	62.1	53.4	60.4	1.76	357
Silage	Sheep	56.1	57.1	76.2	78.5	2.15	299

C39 *Erodium botrys* (Cav.) Bert.

Prostrate white pubescent annual or biennial plant, sometimes used for forage and pasture. Adapted to a subtropical climate.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh, aerial part, Chile	19.5	17.0	22.0	12.5	4.8	43.7	2.40	0.54	315
Silage, Chile	25.0	7.7	33.4	6.6	4.0	48.3			315

C40 *Erodium moschatum* (L.) L'Hér.

White-stem filaree or musk clover

A many-branched annual 15-50 cm high with soft-haired white stems. Used for pasture and hay in semitropical regions.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, Chile	19.5	16.9	22.1	12.8	5.1	43.1	2.49	0.53	315

C41 *Euphorbia coerulescens* Haw.

Thorny leafless shrub 0.5-1.5 m high with numerous erect succulent stems. The branches are ridged longitudinally and constricted at intervals of 4-8 cm. One to three yellow flowers develop on the thorny ridges. When cut or bruised, milky latex is exuded. Although not normally browsed by stock, the plant is eaten when cut into sections and left to wilt for a few days. Apparently the burning taste of the latex disappears, so that the plant becomes palatable to stock. Especially in times of drought it is often used as supplementary fodder.

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Fresh mature browse, South Africa		15.1	15.3	11.8	22.6	35.2	0.17	0.24		193

C42 *Fagara chalybea* Engl.

A tree 6-9 m high with a broad dense crown that grows in moderately dry areas. The leaves and fruits eaten by goats throughout the year. The branches sometimes lopped for feed.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh mature leaves, Kenya		10.3	19.3	6.8	3.3	60.3	1.70	0.47	129

C43 *Ficus benghalensis* L.

Banyan, vada tree or Indian laurel

A large tree with a crown of horizontal branches covering up to 200 m^2 and supported by aerial roots. Often cultivated as a shade tree. The leaves can be used as fodder.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, India		9.7	22.6	14.4	2.9	50.4	2.56	0.19	436

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Leaves	Cattle	21.0	26.0	29.0	65.0	1.55	436

C44 *Ficus carica* L.

Fig or common fig

Small spreading shrubby tree with large leaves, native to Asia and now cultivated in subtropical countries. The leaves can be used as fodder for cattle, but should be collected as soon as the fruit has been harvested and before yellowing begins.

		As % of dry matter								
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, Italy	34.2	14.2	17.1	16.7	5.9	46.1	3.16	0.16	320

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Leaves	Sheep	71.8	32.7	67.8	81.3	2.31	320

C45 *Ficus elastica* Roxb.

Rubber tree or Indian rubber fig

A rubber plant cultivated in greenhouses and living rooms in temperate climates. In its native country, India, it is a large spreading evergreen tree up to 30 m high. It has large threadlike roots and large leathery handsome leaves, each covered with a long pointed reddish sheath when new. It is a source of rubber of lower value than that obtained from the Para rubber tree. The young leaves are poisonous to most animals, causing profuse sweating, paralysis and ultimately death.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, India		13.0	32.2	7.3	4.4	43.1	1.11	0.13	436

C46 *Ficus glomerata* Roxb. (*F. goolereea* Roxb.)

Cluster fig

A large tree that provides dense shade. The edible fruits and the leaves commonly used as fodder.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, Pakistan	48.0	10.1	15.0	13.4	12.5	49.0	4.16	0.16	308
Fresh leaves, India		11.2	12.3	15.1	2.4	59.0	2.68	0.31	436

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Leaves	Cattle	60.0	63.0	48.0	62.0	1.99	436

C47 *Ficus infectoria* Roxb. (*F. lacor* Buch.-Ham.)

A large expansive fast-growing tree with leaves about 10 cm long, commonly grown alongside avenues. The leaves make good cattle fodder.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, early vegetative, India		11.2	27.7	7.7	2.2	51.2	1.07	0.25	436
Fresh mature leaves, India		12.5	20.0	13.1	3.5	50.9	2.21	0.29	436
Shed leaves, India		7.3	25.5	14.2	2.7	50.3	2.36	0.14	436

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Young leaves	Cattle	56.0	62.0	53.0	68.0	2.24	436
Mature leaves	Cattle	32.0	40.0	24.0	53.0	1.50	436
Shed leaves	Cattle	6.0	33.0	30.0	43.0	1.17	436

C48 *Ficus religiosa* L.

Peepul or bo tree

Large glabrous tree with leathery, shining, broad-based, pointed leaves. Commonly grown as an avenue tree. The leaves and branches are extensively lopped for fodder.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, India		9.0	15.9	20.0	2.7	52.4	2.97	0.21	436
Fresh leaves and twigs, Pakistan	50.5	11.7	26.1	15.3	2.9	44.0	3.69	0.27	230

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Leaves	Cattle	59.0	22.0	36.0	52.0	1.42	436
Browse	Oxen	55.0	19.0	46.0	37.0	1.15	230

C49 *Galenia africana* L.

Yellowish green shrublet up to 1 m high with little wood. Linear leaves abruptly tapering to a normally recurved apex, often folded longitudinally, 1-3 cm long. Numerous small flowers growing in terminal clusters. Found in drier areas. Normally not eaten by goats and sheep.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Twigs, South Africa	92.5	10.2	34.2	9.9	4.9	40.8	1.54	0.06	193

C50 *Grewia bicolor* Juss.

A many-branched shrub 2-4 m high, often growing on rocky ground. The leaves and young branches are palatable to cattle.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh browse, early vegetative, Kenya		12.7	23.0	6.0	3.5	54.8	1.60	0.30	129
Fallen leaves, Uganda	88.9	5.8	17.5	13.5	7.4	55.8	3.02	0.14	537

C51 *Grewia kakothamnos* K. Schum.

A shrub 2-3 m high with rather harsh leaves that grows in moderately dry areas. Only goats eat the dry fallen leaves during the dry season.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh browse, early vegetative, Kenya		8.7	32.6	7.7	2.5	48.5	1.53	0.36	129

C52 *Grewia oppositifolia* Buch.-Ham. *ex* Roxb.

Biul

Small tree with edible fruits that grows widely scattered in hill ranges. The leaves and young twigs are lopped for fodder. Regarded by local farmers as a valuable fodder for milch cows and usually preserved for feeding during the winter.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, early vegetative, India		16.4	16.6	14.9	8.4	43.7	3.57	0.25	344
Fresh mature leaves, India		10.1	14.1	14.2	6.8	54.8	4.18	0.25	344

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Young leaves	Sheep	72.4	45.4	38.8	73.3	2.20	440

Guizotia abyssinica

C53 *Guizotia abyssinica* (L. f.) Cass.

Niger plant

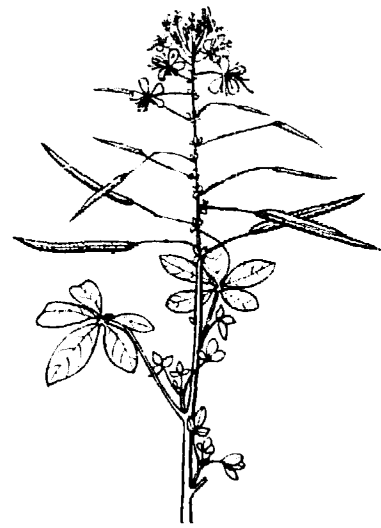
A herb native to tropical Africa, cultivated for its important oilseeds. At the flowering stage the crop may be cut and fed as green fodder, particularly to sheep. Silage may be made from the chopped plant material.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Silage, India	30.4	12.8	24.0	11.5	10.9	40.8			94

C54 *Gynandropsis gynandra* (L.) Briq.

African spiderflower

Annual plant about 70 cm high that grows in sandy and clay soils in dry tropical areas. Sheep and goats relish the plant. The leaves are sometimes used as a vegetable.



Gynandropsis gynandra

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, mid-bloom, Niger		25.7	18.6	19.1	2.7	33.9	1.69	0.59	45

C55 *Helianthus annuus* L.

Sunflower

Native to Central America but now grown all over the world, mostly for its oilseeds. The leaves are usually used as fodder. Sunflower can also be grown as a fodder plant where the season is too short and cool for maize. If grown for silage, it should be cut when approximately half of the heads are in bloom. The later the plant is cut the less palatable it is.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, 7 weeks, Israel	10.8	13.0	20.4	14.8	1.9	49.9	1.67	0.37	365
Fresh aerial part, 10 weeks, Israel	14.6	10.3	25.3	13.7	2.1	48.6			365
Fresh leaves, Zimbabwe	21.2	19.4	9.3	18.6	3.3	49.4			227
Mature heads with 15-cm stem, Kenya		14.6	24.1	8.6	7.2	45.5			412
Silage, mid-bloom, Canada	24.3	14.1	25.6	13.3	5.1	41.9			412
Silage, mature, Canada	47.7	10.6	21.3	11.1	5.1	51.9			412

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Aerial part, 7 weeks	Sheep	70.0	51.0	68.0	82.0	2.35	365
Aerial part, mature	Sheep	74.3	43.0	90.2	65.5	2.42	412
Silage, mid-bloom	Sheep	52.3	48.5	70.0	66.0	2.04	512

C56 *Hibiscus asper* Hook. f.

Perennial plant up to 120 cm tall that grows in sandy soils and is very well liked by camels. Also used as a vegetable for human consumption.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, mid-bloom, Nigeria		31.1	13.5	9.8	3.5	42.1	1.04	0.09	45

C57 · *Hibiscus cannabinus* L.

Wild stockrose, Deccan hemp, kenaf or ambari hemp

Erect shrub 1-1.5 m high, with many branches and leaves covered with hair. Leaves palmately cut, 10-15 cm long. Flowers 5-8 cm in diameter, light yellow with dark-purple centre. Fruit conical, 1-2 cm long containing numerous hairy seeds. Sometimes cultivated for fibre, which is used in bag manufacturing. New varieties used as a raw material in the paper industry may become important as cattle feeds. The stem is largely cellulose which can be digested by ruminants and contains relatively large amounts of ether extract which can serve as a source of energy. The leafy parts of the new varieties often contain as much as 30% protein. Young plants ensile easily.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh stem, India		15.0	19.9	8.2	5.8	51.1	2.08	0.50	379
Leaves, dried, India		13.1	11.6	11.8	2.1	61.4	3.31	0.35	359
Seeds, South Africa	91.5	27.2	25.1	6.1	15.4	26.2	0.60	0.63	193

C58 *Hibiscus lunarifolius* Willd.

Erect perennial herb with medium to large leaves that usually grows near stream banks. The young branches and leaves eaten by goats.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh browse, early vegetative, Kenya		17.8	37.4	9.2	1.6	34.0	1.93	0.33	129

C59 Hibiscus rosa-sinensis L.

Rose of China or Chinese hibiscus

Usually a shrub but sometimes a tree up to 10 m high. Very common in the tropics and subtropics where it is grown — often as hedge — for its profuse, large and very spectacular flowers. Sometimes browsed by cattle.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh browse, Trinidad	13.1	15.4	15.5	11.4	3.5	54.2	1.67	0.52	117

C60 *Hibiscus sabdariffa* L.

(a) var. *sabdariffa*

Jamaican sorrel or roselle

A bushlike annual up to 2 m high that is extensively cultivated in tropical countries for the dark-red calyces surrounding the fruit. This material is the basis of a red nonalcoholic drink that is very popular in many countries. The leaves and seeds can be used as feeds, but they are not very palatable owing to their acid taste.

(b) var. *altissima*

Greenstem kenaf

A rigorous high-yielding annual 3-5 m tall and practically unbranched. Cultivated for its fibres which are similar to those of jute and can be used for paper pulping. The leaves and tops accumulate as by-products. The young leaves, rich in digestible protein, can either be fed fresh or be dried and used as a substitute for lucerne leaf meal. This variety is palatable and has been used as the sole protein feed for ruminants and as a carotene source for layers.

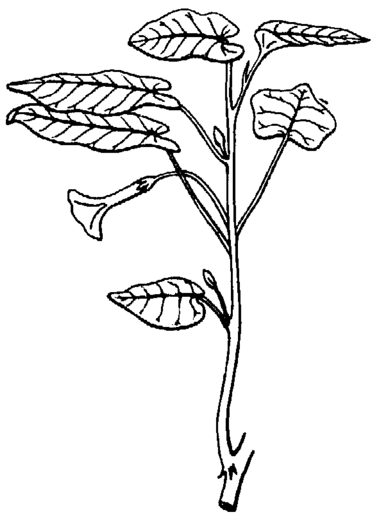
	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Sorrel leaves, India	13.8	12.3	7.8	7.4	7.8	64.7	1.31	0.28	407
Sorrel seeds, Jamaica	91.5	21.4	12.0	5.4	17.5	43.7	0.61	0.32	154
Kenaf tops, Thailand		30.1	10.9	9.1	1.9	48.0			537
Kenaf leaves, Thailand		25.7	11.4	10.6	3.3	49.0			537

C61 *Hibiscus schizopetalus* (Mast.) Hook.

Fringed hibiscus, coral hibiscus or Chinese lantern

A hibiscus with red flowers that can be recognized by the fringed and lacy petals which are bent backward. It has slender and gracefully curved stems. Palatable to grazing animals.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Dried leaves, Thailand	88.6	17.4	14.9	11.3	8.5	47.9			56



Ipomoea aquatica

C62 *Ipomoea aquatica* Forsk. [*I. reptans* (L.) Poir.]

Kangkong or swamp cabbage

A variable water and marsh plant with creeping hollow water-filled stems and shiny green leaves. The big funnel-shaped flowers, 2-5 cm long, are purple or white. Sometimes cultivated for food, and used for pig and cattle feed in Southeast Asia, where it is grown in ponds fertilized with sewage. Very palatable and high yielding. Heavy feeding may cause watery faeces.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh whole plant, mid-bloom, Niger		18.8	20.9	18.2	2.1	40.0	0.71	0.32	45
Fresh leaves, Africa	15.0	24.0	12.7	13.3	2.7	47.3	1.20	0.28	154
Fresh leaves and stems, Malaysia	7.5	28.0	12.0	18.7	2.7	38.6	1.24	0.41	292
Fresh leaves and shoots, Fiji	9.2	34.3	10.2	12.9	3.9	38.7			380

C63 *Justicia exigua* S. Moore

Perennial .herb up to 60 cm high that grows in moderately dry areas. Highly palatable to all classes of livestock and eaten as soon as the fresh shoots appear.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh browse, mid-bloom, Kenya		14.0	21.9	18.9	3.2	42.0	1.67	0.45	129

C64 *Leucas microphylla* Vatke

Perennial herb up to 75 cm high that grows in bush, often on rocky slopes. Very palatable in every season to all classes of livestock and readily eaten.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh browse, mid-bloom, Kenya		11.4	34.1	8.8	3.3	42.4	0.91	0.62	129

C65 *Leucospaera bainesii* C.B. CL.

Grey shrublet up to 0.3 m high with woody gnarled branches. The young leaves and branches are densely hairy. The leaves are smooth, narrowly oval and 1-2 cm long. The flower heads are woody and spherical. Occurs especially in soils with surface lime. Readily eaten by cattle and sheep, and often very stunted by heavy browsing.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Dried leaves, South Africa	91.5	11.7	29.0	10.2	2.0	47.1	1.75	0.07	193

C66 *Linum usitatissimum* L.

Flax

An annual 0.3-1 m high that is grown for its fibre and oil. The straw is sometimes fed to livestock. If mature and of good quality, it has about the same feed value as oat or barley straw. It can be used safely as the only roughage for cattle. The fibres are digested like other fibrous materials and do not form indigestible balls in the stomach.

Green flax straw should be fed with caution because it may contain poisonous amounts of prussic acid. The danger is greater if the immature flax is frozen. Regrowth after harvest can be unsafe as pasture because it may contain toxic quantities of prussic acid.

Flax feed is the residue of the plant after separation of the bast fibre and flax shives. It consists of the leaves, corticle tissues, flaxseed bolls and broken immature seeds of flax.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Straw, Israel	92.3	7.6	36.5	6.2	6.1	43.6		0.03	365
Flax, plant feed, USA	92.1	10.1	36.3	6.6	3.1	43.9			349

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Straw	Sheep	20.0	31.0	40.0	52.0	1.48	365

C67 *Madhuca indica* Gmel. (*Bassia latifolia* Roxb.)

Mowra or mowrah

Large deciduous tree with short trunk, spreading branches and large rounded crown. The flowers are used as a vegetable and as a source of alcohol. The cake from the oil seeds is used as fertilizer. The leaves, flowers and fruit are eaten by cattle.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, India		9.1	18.7	7.8	4.1	60.3	1.53	0.22	436

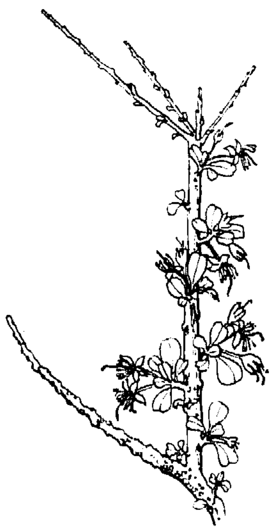
	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Leaves	Cattle	71.0	30.0	62.0	73.0	2.27	436

C68 *Madhuca longifolia* (L.) Macbr. (*Bassia longifolia* L.)

Illipi, mee or mahua

Large evergreen or semi-evergreen tree with a dense spreading crown, cultivated in warm climates for its oil-containing seeds. The oilcake is not commonly used for feed.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh flowers, India		5.0	1.6	4.2	1.8	87.4	0.13	0.12	379
Fresh leaves, India		9.1	19.0	7.6	3.9	60.4	1.46	0.21	379



Maerua crassifolia

C69 *Maerua crassifolia* Forsk.

Atil

Evergreen tree found in drier areas in both sandy and clay soils. The leaves and fruits are palatable to all animals but horses and asses. The sweet fruits are also used for human consumption.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Dried leaves, Sudan	89.9	15.5	6.1	23.8	1.3	53.3		0.13	64
Fresh leaves, mid-bloom, Niger		28.8	10.4	13.4	2.7	44.7	2.06	0.17	45
Dried browse, Sudan	77.7	11.3	33.7	10.1	1.5	43.4	2.09	0.13	64

C70 *Mangifera indica* L.

Mango

Large spreading evergreen planted throughout the tropics as a shade and fruit tree. The leaves of some varieties may smell like turpentine when crushed. The profuse foliage of dark-green lanceolate leaves is relished by cattle.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, India	44.0	8.1	28.0	10.0	2.7	51.2	2.29	0.14	344
Fresh leaves, Pakistan	41.6	9.5	22.6	13.1	4.8	50.0	3.14	0.16	308

C71 *Melia azedarach* L.

Chinaberry, pride of India, Indian lilac or bead tree

Fast-growing tree up to 10 m high that blooms with giant clusters of fragrant flowers. Each pink or blue lilac-like blossom has a dark-purple staminal tube protruding from the middle. The slightly poisonous fruits are about the size of a cherry. Each contains a single five-cornered stone, often used as a bead. The leaves are palatable to goats.

		As % of dry matter								
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, Pakistan	30.1	21.8	11.6	10.8	8.8	47.0	2.31	0.22	308
Fresh leaves, India	39.4	12.4	15.3	11.6	6.2	54.5	2.50	0.24	378

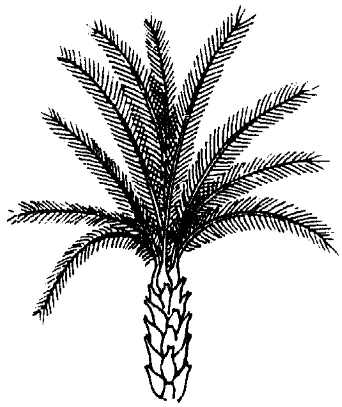
		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Leaves	Cattle	49.9	51.2	65.0	53.9	1.93	378

C72 *Melicoccus bijugatus* Jacq. (*Melicocca bijuga* L.)

Spanish lime or mamoncillo

Slow-growing medium-sized tree. The leaves consist of two pairs of elliptic leaflets; the flowers are greenish white and fragrant; and the fruits contain yellowish translucent pulp and large round seeds. The seeds are sometimes roasted for human consumption.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Whole fruit, Jamaica		10.1	10.8	2.7	1.3	75.1			43
Seeds, Jamaica		11.6	11.2	2.7	1.2	73.3			43



Metroxylon sagu

C73 *Metroxylon sagu* Rottb. [*M. rumphii* (Willd.) Mart]

Sago palm

A palm tree up to 15 m high with large pinnate leaves and stout creeping or ascending stems. It is often cultivated and grows well in freshwater swamps. Sago meal is produced from the trunk when the tree is about twelve years old. The trunk is cut into sections, which are split lengthwise, and the soft material in the centre is scooped out. From this material starch is extracted by washing and straining. The starch is dried to yield sago meal or granulated to "pearl" sago.

A single sago palm yields about 150-300 kg of sago. A normal freshwater swamp can produce fifty palms suitable for felling per hectare each year. The energy production per hectare is thus very high. The sago can be used for feeding either as flour or as "rasp," obtained by mechanical rasping of the barked sago trunks. Sun-dried rasp gives a similar performance to that of sago flour when it is fed to cattle and older pigs.

The meal is very digestible and can be fed to all classes of livestock. It has been included up to 50% in pig diets and up to 25% in poultry diets. High levels of sago meal in rations tend to decrease production and impair feed conversion.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Sago meal, Malaysia	85.1	2.2	5.5	4.5	1.4	86.4	0.04	0.02	292
Refuse after starch extraction, Malaysia	77.3	2.7	10.1	21.0	0.3	65.9	0.38	0.03	292

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Sago meal	Pigs	neg.	neg.	46.0	86.0	3.09	510

C74 *Momordica balsamina* L.

Balsam apple or wonder apple

High slender climbing annual with thin glabrous leaves and orange oval fruit 5-10 cm long. Common in dry regions of the tropics all over the world. Relished by camels.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh aerial part, mid-bloom, Niger		24.8	21.1	15.7	1.0	37.4	1.44	0.29	45

C75 *Moringa oleifera* Lam. (*M. pterygosperma* Gaertn.)

Drumstick tree or horseradish tree

Small tree with thick grey bark, fragrant white flowers and long green pods, which give the tree its name. The seeds are extracted for oil or used in curry powders. The branches are lopped for fodder and are well liked by domestic animals, especially camels.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, Bangladesh	42.7	29.0	19.1	9.1	5.2	37.6	2.06	0.24	308
Fresh leaves, India		15.6	17.9	13.4	4.4	48.7	3.22	0.27	436
Fruit, Sri Lanka	10.7	20.7	27.0	8.9	1.0	42.4			252

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Leaves	Cattle	71.0	58.0	30.0	76.0	2.30	436

C76 *Morus alba* L.

White mulberry

Wide-spreading round-headed tree up to 15 m high with grey or greyish yellow branches bearing thin, rather small light-green leaves. The leaves are palatable to cattle. In North Africa the coppice shoots are harvested for animal fodder.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, India		15.0	15.3	14.3	7.4	48.0	2.42	0.24	436

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Leaves	Cattle	71.0	54.0	4.0	83.0	2.23	436

C77 *Morus nigra* L.

Black mulberry or small-fruited mulberry

Rather small spreading tree up to 10 m high with dark heavy foliage, dark-coloured twigs and rather thick leaves. The leaves are used as cattle fodder.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, Pakistan	38.3	17.6	7.4	20.4	11.5	43.1	2.15	0.13	308

C78 *Olea europaea* L.

Olive

Low spreading tree cultivated extensively in the Mediterranean region of Europe and North Africa as well as in the Americas for its edible fruit from which olive oil can be extracted. The leaves and twigs are useful cattle fodder, and considerable amounts of pruning residue are available.

Olive leaves should be fed green as far as possible; the remainder can be left on the branches to be stripped off later or ensiled. Old dry leaves are palatable to cattle if they are soaked overnight in 2.5 times the volume of water containing 0.2% salt. Cattle or sheep accept daily 1-1.5 kg of green leaves and 0.8-1 kg of dried leaves per 100 kg of liveweight.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, Italy	57.9	13.1	17.7	6.1	7.3	55.8	1.18	0.09	322
Dry leaves, Italy	92.1	10.6	22.9	8.7	8.2	49.6			322
Twigs, Italy	86.8	8.9	28.9	8.5	6.1	47.6			323
Silage of leaves, Italy	77.0	12.2	20.2	8.4	7.9	50.6			322

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Fresh leaves	Sheep	44.3	28.9	24.7	80.1	2.20	322
Dry leaves	Sheep	23.8	24.9	29.3	60.8	1.59	322
Twigs	Sheep	5.8	43.4	30.4	38.6	1.28	323
Silage of leaves	Sheep	16.8	39.0	41.8	59.7	1.72	322

C79 *Opuntia* spp.

Prickly-pear cactus

One of the largest genera of cactus, comprising at least three hundred species which are highly variable in habit and size. The stems and branches have flat, cylindrical or globular joints, usually very fleshy. Some species are almost spineless. The opuntias are commonly large and rampant. They are sometimes cultivated as hedge or for the edible fruits, but they are more commonly regarded as a weed in arid and semiarid areas.

The prickly pears are sometimes used as an emergency feed for animals during droughts, but the spines must first be destroyed with a gasoline torch by passing a flame over the surface of the plant. The spines are dry and burn easily, especially if they are abundant and close. If large quantities are used, the material can be chopped so that the spines are thoroughly broken up. If they can still cause harm, the broken spines should be winnowed out. Other methods of making the spines harmless are soaking in water, steaming or washing with soda.

Because of its high water content and high average salt content, prickly-pear cactus is laxative when fed in large quantities. The opuntias are fairly palatable and when fed in liberal amounts can replace drinking water; however, the nutritive value is not sufficient to maintain weight in animals receiving only cactus. Sheep in good condition are known to survive up to eight months on a diet consisting entirely of opuntia. Preferably the feed should be supplemented by other less succulent dry feeds, such as 1-2 kg of straw or dry grass and 0.5 kg of cottonseed daily. Prickly-pear cactus is sometimes combined with poor quality straw or hay in silage.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
O. amyclaea, fresh branchlets, 1-2 years, Italy	12.3	4.0	12.0	24.4	2.7	56.9			2
O. brasiliensis, fresh aerial part, Australia	13.8	6.5	10.9	17.6	3.3	61.7			270
O. cholla, fresh aerial part, USA	21.1	5.5	13.8	14.0	4.1	62.6			77
O. elatior, fresh aerial part, Australia	10.2	6.3	13.5	18.8	3.3	58.1			270
O. ficus indica, fresh branches, Italy	6.7	9.6	13.4	25.9	1.3	49.8	2.81	0.28	330
O maxima, fresh leaves, South Africa	6.2	6.5	11.3	17.7	1.6	62.9			193

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Aerial part	Cattle	69.4	62.3	72.9	67.2	2.23	77
Leaves	Sheep	68.1	53.2	31.1	73.9	1.91	330

C80 *Osteospermum spinescens* Thunb. (*Tripteris pachypteris* Harv.)

Shrublet up to 0.5 m high with woody branches, lanceolate leaves, 1-2 cm long, light-yellow flower heads about 1 cm in diameter on long pedicels, and three-winged fruit. Readily eaten by goats and sheep.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Dry twigs, South Africa	67.4	9.2	26.4	15.3	3.2	45.9	1.04	0.24	193

C81 *Pentzia incana* Ktze.

Australian sheepbush

Shrublet up to 0.3 m high with woody creepers that produce roots where they touch the soil. The leaves are strongly pinnate and 1-2 cm long. The yellow flower heads are almost spherical and about 0.5 cm in diameter. Because this plant is heavily browsed, it is sometimes difficult to recognize.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh browse, early bloom, South Africa		13.9	25.5	12.9	2.6	45.1			63

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Young browse	Sheep	74.3	24.6	66.5	71.1	1.97	63

C82 *Phoenix sylvestris* (L.) Roxb.

Wild date or toddy palm

Fast-growing palm tree with a stout trunk up to 15 m high. The greyish green arched leaves divide into numerous leaflets and emerge as a tuft from the summit. The tree is valued for its sap, which is extracted and distilled into a potent spirit. The leaves can be used as roughage.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, India		11.0	38.7	6.4	2.8	41.1	0.38	0.14	379
Fresh leaves, India		11.6	27.7	8.0	1.6	51.1	0.60	0.18	436

C83 *Phyllanthus guineensis* Pax

Shrub 1-3 m high with numerous thin branches and small leaves. Very palatable. Cattle and goats eat the fresh leaves and the branches. In the dry season the dry fallen leaves are picked up by goats from the ground.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh browse (with fruits), Kenya		5.3	49.0	4.6	1.8	39.3	0.72	0.31	129

C84 ***Phymaspermum parvifolium*** **(DC.) Benth. & Hook.**

Good karoo

Shrublet up to 20 cm high with erect woody branches and linear leaves 0.5-1 cm long. The large flower heads consist of small white blossoms with a purplish centre. A valuable fodder plant especially because of its extreme resistance to drought.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh twigs, mid-bloom, South Africa	46.0	10.8	33.3	10.6	5.9	39.4			63

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Twigs	Sheep	60.2	13.0	48.7	49.8	1.37	63

C85 ***Plantago lanceolata*** **L.**

Rib grass

Perennial herb that grows in temperate climates. The young leaves are sometimes used as a vegetable but are also of value as animal feed.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, early vegetative, Kenya		15.9	13.3	12.9	2.2	55.7	1.54	0.29	129
Fresh mature leaves, Kenya		12.2	11.4	10.7	2.7	63.0	1.53	0.21	129
Fresh aerial part, Chile	15.7	22.8	16.1	14.7	3.8	42.6	2.46	0.43	315

C86 *Plantago ovata* Forsk.

Plantain

Annual herb cultivated especially in India for its seeds, which are used in medicine and to an extent for animal feed.

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Grain, India		20.9	31.9	8.0	2.4	36.8	0.65	0.57		378

C87 *Portulacaria afra* (L.) Jacq.

Elephant's food or elephant bush

Shrub up to 3 m high with fleshy branches. The fleshy leaves are oval to round, 1-2 cm long, with practically no stalk. The terminal spikes bear numerous small pink flowers. Two morphologically indistinguishable forms occur: one heavily browsed by goats and sheep and one which is not.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, South Africa	17.8	11.8	14.6	11.8	3.9	57.9	2.87	0.35	193
Fresh aerial part. 30 cm high, Kenya		10.7	11.9	19.1	3.8	54.5	1.40	0.12	129
Hay, Zimbabwe		8.5	20.9	9.8	3.8	57.0			19

C88 *Psidium guajava* L.

Guava

Small evergreen commonly cultivated as a fruit tree throughout the tropics. The prominently veined 10- to 20-cm oblong leaves make good cattle feed.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, Pakistan	35.1	11.7	16.1	7.7	8.7	55.8	1.34	0.16	308

C89 *Quercus dilatata* Lindl.

A tree found only in the Himalayas. The leaves and shoots are so extensively lopped for fodder for sheep and goats that unlopped forests of this species are rare.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, India		9.6	29.1	5.1	4.5	51.7	1.61	0.30	436

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Leaves	Cattle	44.0	25.0	4.0	61.0	1.60	436

C90 *Quercus glauca* Thunb.

Blue Japanese oak

A tree found mainly in the temperate zone of central and eastern Asia, where the acorns are often used as human food. The value of the leaves for animal feed is rather poor.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, India		9.6	29.0	7.6	4.1	49.7	1.87	0.23	436

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Leaves	Cattle	48.0	25.0	15.0	54.0	1.48	436

C91 *Quercus incana* Roxb.

A tree with hard reddish brown wood that is used to make agricultural implements. The leaves are palatable but should not be used for heavy feeding over long periods as they may cause constipation.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, India		10.2	31.3	5.2	4.8	48.5	0.99	0.15	436

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Leaves	Cattle	57.0	27.0	29.0	54.0	1.61	436

C92 *Quercus virginiana* Mill.

Live oak

Evergreen tree up to 20 m high with a very spreading head and almost horizontal branches, native to Central America. If live-oak leaves form a large portion of the diet, it is advisable to provide a molasses supplement so as to avoid impaction, which may cause loss of appetite and even death.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Dried leaves, USA	93.8	9.9	31.9	7.1	2.8	48.3	0.71	0.23	162

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Leaves	Sheep	0.0	10.4	29.7	26.9	0.76	162

C93 *Rhigozum obovatum* Burch.

Shrub up to 1.5 m high with spreading branches. Oval leaves 0.5-1.5 cm long. Funnel-shaped bright-yellow flowers 2-4 cm long. Oval capsule 2-4 cm long with a beak about 1 cm long that splits into valves and scatters numerous winged seeds. Usually only the fruit and the leaves are eaten by stock.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh browse, South Africa	47.2	11.3	15.5	6.0	4.1	63.1	0.92	0.13	211

C94 *Rhus lancea* L.f.

Karoo tree

Shrub or tree up to 10 m high with grey bark. Tripartite leaves with three yellowish green lanceolate leaflets 3-7 cm long. Yellowish green flowers in loose sprays. Berries spherical and laterally flattened, fleshy around the hard pip, about 0.5 cm broad. Found mainly along rivers. Seldom browsed by stock.

		As % of dry matter								
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh browse, East Africa		12.7	22.3	7.3	7.3	50.4	0.80	0.19	212

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Foliage	Cattle	36.3	0.0	82.5	70.8	1.96	212

C95 *Rhus natalensis* Bernh. *ex* Krauss

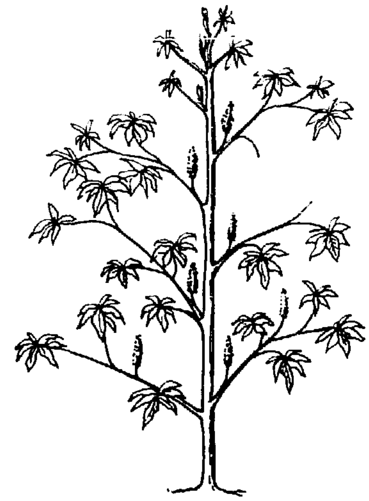
Large shrub or a small tree with leafy branches. The leaves of the lower branches are eaten in all seasons by goats and occasionally by cattle. The numerous small fruits are succulent, have a sour taste when young and are readily eaten.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh browse, early vegetative, Kenya		9.0	19.6	8.8	3.5	59.1	1.43	0.10	129
Fruits, almost ripe, Kenya		11.1	25.3	4.0	5.8	53.8	0.27	0.19	129

C96 *Ricinus communis* L.

Castor

Variable species: commonly an annual herb in temperate climates and a perennial tree in tropical climates. Cultivated for its oilseeds and also for ornamental purposes as some varieties have beautifully coloured leaves.



Ricinus communis

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, India		24.8	10.3	12.4	5.4	47.1	2.67	0.46	436

C97 *Salamalia malabarica* (DC.) Schott & Endl. (*Bombax malabaricum* DC.)

Red silk cotton tree or Indian kapok

A tree, native to India, cultivated for the fine lustrous material (kapok) obtained from the seed hairs. The flowers are collected for human consumption. The leaves, 5-8 cm long and felted with star-shaped hairs, are lopped together with the twigs for fodder.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, India	28.2	12.6	22.3	9.3	6.4	49.4	2.70	0.19	441

C98 *Salix babylonica* L.

Weeping willow

Moisture-loving large deciduous tree, used for shade in pastures. Provides a good reserve of feed for stock when pastures are dry and other green feed is scarce. Can stand frequent severe lopping. For poultry the chaffed green leaves are as nutritious as lucerne.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Dried leaves, Zimbabwe	86.1	16.7	18.0	10.2	2.9	52.2	1.60	0.26	19

C99 *Salsola aphylla* L.f.

Shrub up to 2 m high with thin straight branches bearing very small but distinctly succulent leaves that are about as long as they are broad. The fruit is spherical with a crown of translucent wings. Occurs on saline soils, often along rivers, and seldom reaches maximum height because it is so heavily grazed.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh browse, South Africa	28.1	20.0	14.9	28.6	2.0	34.5	1.55	0.16	210

C100 *Salsola glabrescens* Burtt Davy

Shrublet up to 1 m high, but usually smaller, with small grey-green leaves that are oblong, often pointed, and with fruits that are spherical and have a crown of translucent wings. Usually found along rivers. Readily eaten by sheep and goats.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh browse, South Africa		16.5	25.2	13.2	2.1	43.0	1.95	0.15	212

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Foliage	Cattle	69.8	67.6	97.5	78.4	2.49	212

C101 *Salsola rabiana* Verdoorn

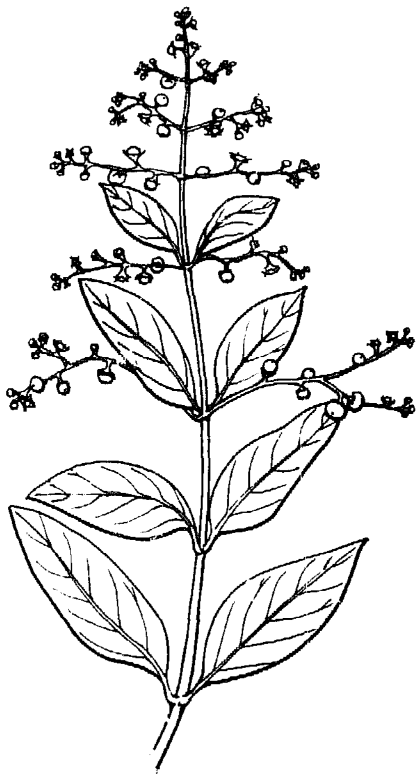
Shrub up to 0.7 m high, but usually smaller, with woody branches laterally flattened and often covered with tubercles from old branches. The broad leaves are very succulent. The fruit is spherical with a crown of semitranslucent wings. Occurs often on soils with surface lime. Readily browsed by goats and sheep.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh twigs, South Africa		11.9	37.1	10.3	1.2	39.5	1.33	0.05	193

C102 *Salvadora persica* Garc.

Saltbush, mustard tree or toothbrush tree

Short evergreen tree suitable for arid regions and sandy soils. Browsed by sheep and goats.



Salvadora persica

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, mid-bloom, Niger		16.1	14.1	20.3	2.3	47.2	2.44	0.15	45
Fresh leaves, Sudan	30.4	13.8	7.9	23.1	1.5	53.7			64

C103 *Sapium sebiferum* (L.) Roxb. (*Stillingia sebifera* Michx.)

Chinese vegetable tallow, tallowberry or tallow tree

Deciduous tree 4-5 m high, sometimes up to 10 m tall, which may assume the habits of a shrub. Cultivated for the fruit, which between the outer husk and seed has a white tallowy mesocarp used in the manufacture of soap and candles. The liquid oil extracted from the seed is used for technical purposes. The oilcake is seldom used in animal feed.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, India	31.5	17.8	12.4	6.0	5.3	58.5	1.36	0.22	441

C104 *Sida schimperiana* Hochst. *ex* A. Rich.

Dwarf shrub 15-60 cm high with short hard branches and small leaves. Provides additional grazing for goats and sheep in denuded areas where graze is scarce.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh browse, Kenya		13.7	29.9	11.3	1.3	43.8	1.00	0.24	129

C105 *Solanum incanum* L.

Sodom apple

Small shrub or perennial herb, usually 60-150 cm high. Cattle and sheep do not touch this plant, but goats eat the leaves when no better browse is available.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh mature leaves, Kenya		30.3	21.0	12.8	2.0	33.9	1.56	0.32	129

C106 *Solanum verbascifolium* L.

Big-leafed plant up to 1.5 m high, sometimes used as a forage plant during the dry season. Very palatable.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh browse, Cuba	31.0	26.5	17.7	12.9	3.9	39.0			88

C107 *Symphytum peregrinum* Lebed.

Russian comfrey

A comfrey characterized by magenta-pink flowers and the absence of wings on the flower stem. Certain strains of this species give good yields on land unsuited to lucerne. It has a low fibre content and has been used not only for cattle but also for pigs and poultry, to which the fresh leaves are palatable. Usually not relished by grazing stock because of its hairy leaves and stems.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, late vegetative, Kenya		19.0	14.0	33.7	2.9	30.4			487
Fresh aerial part, Kenya		20.1	11.3	20.9	3.3	44.4	1.46	0.41	470

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Aerial part	Cattle	82.2	93.0	51.6	79.9	2.51	378

C108 *Syzygium cumini* (L.) Skeels (*Eugenia jambolana* Lam.)

Jambolum, jambolum plum or Java plum

Glabrous tree 15-20 m high with white branchlets, white flowers and purplish red oval edible berries. The leaves and seeds are popular livestock feed in India and Malaysia.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, India	37.1	7.9	20.7	7.0	2.6	61.8	1.38	0.12	344

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Leaves	Cattle	1.0	70.0	35.0	45.0	1.60	344

C109 *Tagetes erecta* L.

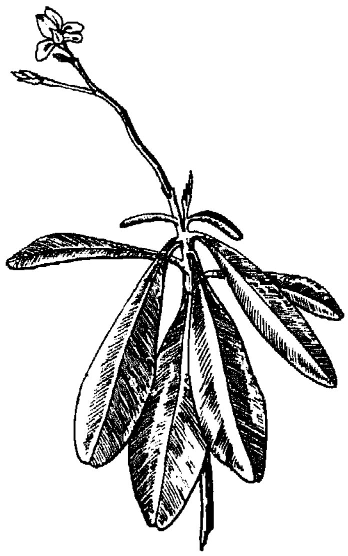
Aztec marigold or African marigold

A flower cultivated especially in Mexico for the production of "zempa" meal from the dried petals. Zempa meal is included in chick diets deficient in xanthophylls. The inclusion of 0.25% zempa meal gives both skin and egg yolks a good pigmentation.

C110 *Talinum triangulare* (Jacq.) Willd.

Waterleaf

Fleshy herb up to 30 cm high used mainly as a vegetable for human consumption. Highly palatable to stock, it has been suggested as a palatability improver in pasture.



Talinum triangulare

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, Nigeria	9.7	21.1	10.3	34.6	1.5	32.5			374

C111 *Tarchonanthus camphoratus* L.

Hottentot tobacco

Tree or large shrub up to 4.5 m high. Goats eat the dry leaves from the ground as well as the young fresh leaves on the trees. In dry seasons the branches are lopped and fed to animals from the ground.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh browse, Kenya		11.4	26.8	5.8	6.7	49.3	0.37	0.10	129

C112 *Tarchonanthus minor* Less.

Camphor bush

Shrub up to 2 m high in which the young branches and lower surface of the leaves are woody and whitish grey. Leaves oval and leathery, 1-2 cm long. Flower heads cream-coloured, about 0.5 cm in diameter, clustered at the end of the branches and half hidden by the leaves. Fruits densely hairy. Occurs especially on soils containing surface lime.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh browse, South Africa	48.7	12.1	25.6	6.7	11.6	44.0	1.42	0.13	211

C113 *Telfairia occidentalis* Hook. f.

Fluted pumpkin, telfairia or oysternut

The leaves, used mainly as a vegetable for human consumption, are relished by sheep and goats.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, Nigeria	13.6	21.2	12.8	13.9	12.9	39.2			374

C114 *Terminalia bellirica* (Gaertn.) Roxb. (*Myrobalanus bellirica* Gaertn.)

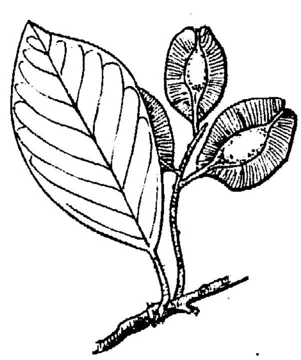
Bastard myrobalan

Large deciduous tree common on plains and lower hills in Southeast Asia, where it is also grown as an avenue tree. The leaves are about 15 cm long and crowded toward the ends of the branches. Considered a good fodder for cattle.

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Fresh leaves, India		8.6	18.6	8.0	4.7	60.1	2.08	0.27		436

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Leaves	Cattle	10.0	56.0	22.0	68.0	1.97	436

C115 *Terminalia brownei* Fres.



Terminalia brownei

Tree 5-10 m high with a broad crown. Stock pick up fallen leaves from the ground, and sometimes the branches are lopped to make fresh leaves available. Young pods are also fed to the animals.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh browse, Kenya		5.7	16.2	6.1	3.6	68.4	1.24	0.11	129
Fresh browse with pods, Kenya		10.3	16.7	5.6	2.9	64.5	0.82	0.13	129

C116 *Terminalia tomentosa* Wight & Arn.

Laurel or sain

Large deciduous tree which can attain a height of 20-30 m. Grows in most soils and is one of the last trees to shed its leaves. The leaves are about 15 cm long, smooth above and woolly beneath; generally they are lopped for fodder.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, India		8.9	21.8	10.3	4.9	54.1	3.20	0.25	436

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Leaves	Cattle	0.0	27.0	35.0	47.0	1.44	436

C117 *Trianthema pentandra* L.

Perennial semiprostrate or prostrate herb 20-50 cm high with slightly succulent leaves. Liked by stock in all seasons.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, late bloom, Kenya		16.5	23.1	17.9	2.5	40.0	1.04	0.27	129

C118 *Ziziphus jujuba* Lam. non Mill. (*Z. mauritiana* Lam.)

Chinese date or jujube

Shrub or small spring tree with edible fruits that is common in southern Asia. The leaf is a popular fodder.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, Nigeria		11.8	14.3	8.6	4.3	61.0	1.97	0.20	58
Fresh browse, India		8.6	30.1	10.8	1.7	48.8	2.16	0.23	403

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Foliage	Cattle	36.0	27.0	62.0	34.0	1.11	403

C119 *Ziziphus mucronata* Willd.

Buffalo thorn

Tree 5-10 m high, with pendant branches that are covered with small recurrent spines. Grows on stream banks. Stock eat the fallen leaves, and the branches are sometimes lopped and fed to cattle. The red berries are readily eaten from the ground by goats.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh browse, early vegetative, Kenya		14.3	8.4	9.4	2.6	65.3	4.68	0.17	129

C120 ***Ziziphus nummularia*** **(Burm. f.) Wight & Arn. (*Z. rotundifolia* Lam.; *Rhamnus nummularia* Burm. f.)**

Pala

Prickly shrub with sweet small round fruits. The small leaves are dark green and velvety above, pale and densely woolly beneath. They are a valuable fodder for camels and livestock. Highly valued in desertlike areas, they are usually stored for winter use by beating them off dried cut branches and gathering them into heaps.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, India		11.5	33.8	6.2	1.6	46.9	1.90	0.31	436

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Leaves	Cattle	47.0	54.0	28.0	69.0	2.10	436

D. Fruits and vegetables

Few fruits are grown specifically for animals. Nevertheless, fruits are important in the feeding of animals in many countries. Culled fruits and fruits from glutted markets as well as vegetable wastes and by-products from processing industries are often available to farmers. Several of these wastes have become standard ingredients in animal feeds. The processing methods for the more important fruit wastes are explained in the feed information summaries. Where large amounts of vegetable residues accumulate during a short season, it may be economical to preserve them. Ensiling or dehydration are the most common methods, but in some cases fractional drying can be more profitable for residues consisting of both stems and leaves. The stems are low in protein fat and vitamins and usually high in fibre, while the leaves contain more protein and vitamins. If the fresh material is dried in a high-velocity current of air at approximately 120°C, the thin leaf blades dry more rapidly than the thicker stems. The dry leaf blade is brittle and easily separated from the tough stem by pounding and screening. The final product is a suitable ingredient in concentrates for pigs and poultry as a source of vitamins A, D and E as well as xanthophyll and protein.

D1 *Adansonia digitata* L.

Baobab, dead-rat tree, monkey-bread tree or bottle tree

One of the world's largest and longest living trees, with a thick trunk that grows up to 30 m round, often becoming hollow, and with dark-green foliage and large white flowers. Both the young leaves and the fruit pulp are used for human consumption. The leaves are rich in calcium, but it is questionable to what extent it is available to monogastric animals, as the leaves also contain gums which may impede its absorption. The white fruit pulp has an acid taste (tartaric acids) and surrounds the seeds, which account for about 65% of the weight of the fruit. Seeds from which the lignified skin has been removed are together with the pulp useful as feed. They are fed mainly to goats and sheep.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fruit pulp with seeds, Tanzania		11.2	26.4	4.6	7.8	50.0	0.31	0.54	177
Seeds, Nigeria	87.9	12.7	25.6	4.0	13.2	44.5	0.25	0.59	14
Young leaves, Upper Volta		9.6	14.4	7.8	1.8	66.4	1.08	0.40	540

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fruit pulp and seeds	Sheep	48.4	34.5	88.4	62.0	2.22	177

Ananas comosus

D2 *Ananas comosus* (L.) Merr. (*A. sativus* Schult. f.)

Pineapple

Perennial stemless plant with long, narrow, fibrous and usually spiny leaves. Native to tropical America, but now cultivated in many warm countries. The fruit grows on an erect stout stalk at the centre of the plant.

Up to 80 tons of leaves per hectare are available annually after harvesting of the fruits. The leaves are a good feed for ruminants and can be used fresh, artificially dried or ensiled. In all cases they must be chopped before use. If ensiled, they should be combined with molasses. Ruminants can be fed 15-20 kg of fresh or ensiled plants daily. No harmful effects have been recorded. The leaf meal cannot be used for pigs or poultry. The dried leaves can advantageously be pelleted.

When the fruits are canned, the outer peel and the central core are discarded. The waste, called pineapple bran, accounts for about 50% of the total pineapple weight, corresponding to about 10 tons of fresh bran or one ton of dry bran per hectare. The bran can be used fresh for feeding, but it is usually artificially dried with approximately 9% molasses and ground into a meal. It can also be dried in the sun by itself in about three days. If the waste is pressed before drying, the process takes less than a day; however, soluble nutrients are lost in the pressing. The bran is difficult to ensile because of its high moisture content and corrosive nature. It is best ensiled with hay or wilted grass. Molasses or a source of starch usually has to be added to ensure satisfactory fermentation.

The bran, either fresh or dried, is a good feed for ruminants and is usually mixed with grass as the roughage portion of the diet. It has also been used at levels as high as 50% in diets for older pigs, but at high levels the rate of weight gain decreases and feed conversion is lowered. It is not beneficial to poultry. Sometimes citric acid is commercially extracted from pineapple juice. The extracted juice can be concentrated to pineapple syrup, which has given very satisfactory gains in older pigs fed 80% syrup and 20% protein supplements.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, Hawaii	20.6	9.1	23.6	4.9	1.6	60.8			371
Silage of leaves, Hawaii	19.1	6.0	22.8	10.0	2.9	58.3			371
Dried bran (cannery residue), Kenya	87.6	3.5	16.2	5.2	0.5	74.6	0.29	0.11	418

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Leaves	Sheep	77.1	81.8	60.2	76.0	2.75	371
Bran	Sheep	0.0	76.7	0.0	79.2	2.59	418

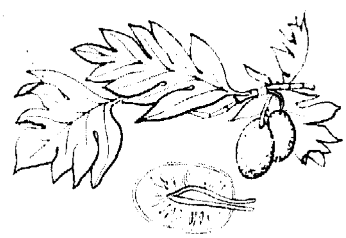
D3 *Apium graveolens* L.

Celery

A vegetable only recently introduced in the tropics for cultivation at higher altitudes. The leaves, which are rich in protein and carotene, have constituted up to 10% of chick rations, effectively replacing lucerne meal.

Apium graveolens

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, Africa	11.0	27.2	3.5	19.0	6.9	43.4	2.70	1.70	154



Artocarpus altilis

D4 *Artocarpus altilis* Fosb. (*A. communis* J.R. Forst.)

Breadfruit

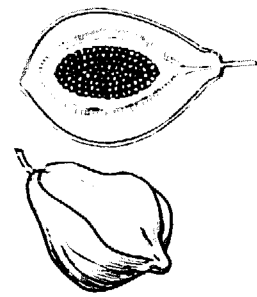
A broad tree up to 20 m high with leaves 30-50 cm long that are thick, leathery, and lobed. The greenish seedless fruits are round, mealy and about 20 cm in diameter. They are cooked or baked and used in the same way as potatoes. The trees yield heavily during the harvest season, and the excess is usually fed to pigs. The fruits can easily be dried and used for off-season feeding. The fruits are divided in the middle, and the pulp is cut into slices about 2 mm thick and sun-dried before grinding. The meal, which has a pleasant odour, is a good energy feed for all classes of livestock.

A seed-bearing variety of this species is known as breadnut. Both the seeds and the pulp are edible. The breadnut tree is distinguished from the breadfruit tree by the rougher surface of the fruits. Breadnut fruits have greenish conical spinelike projections, whereas whole breadfruits are covered with small nipplelike protuberances.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Breadfruit, ripe, Trinidad	29.8	5.7	4.9	6.8	1.0	81.6	0.12	0.15	117
Breadfruit, cooked and peeled, Trinidad	31.8	4.6	4.4	3.2	1.0	86.8			117
Breadfruit, meal, Trinidad	84.9	3.2	5.5	3.1	0.9	87.3	0.08	0.16	117
Breadnut, fibre and skin, Trinidad	13.4	6.5	18.1	11.2	4.5	59.7			117
Breadnut, seeds with shells, Trinidad	31.4	11.1	14.3	4.0	6.0	64.6			117

D5 *Carica papaya* L.

Papaya, pawpaw, papay or papaw



Carica papaya

Fast-growing branchless tree up to 8 m high, native to Central America, which has a crown of very large palmate leaves, at the base of which the large green or yellowish green fruits are clustered. The fruits somewhat resemble melons in shape and can weigh up to 3 kg each. The succulent flesh of the fruit is pink or orange and has a very pleasant taste and aroma. The fruits, supplemented with concentrates, have been fed to pigs with good results.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Whole fruit, early vegetative, Nigeria	7.2	11.4	12.5	7.4	0.8	67.9			374
Whole fruit, mature, Trinidad	9.1	11.1	11.7	9.4	1.2	66.6	0.23	0.16	117

D6 *Citrus aurantiifolia* Swingle

Lime fruit

The green or yellow lime fruit, which resembles a small orange with thin skin, is cultivated for its aromatic taste and processed into lime oil and juice. After the juice and oil have been squeezed out of the fruits, the skins are discarded. The processing plants are usually too small to justify drying facilities. The skins are a good feed when fresh, sun-dried or ensiled. The seeds, usually collected separately in the factory, are rich in fat and should be mixed with the skins for feeding to cattle. Because of the toxic factors in the seeds, they should not be fed to poultry and should be fed to pigs with care as they tend to produce soft fat. Ruminants can tolerate them. If lime skins are fed in large quantities to dairy cows, the morning milk may have a slight off-flavour and be opalescent. According to farmers who use them as feed, lime seeds give animal fur a glossy shine and rid cattle of ticks.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Whole fruit	31.9	11.3	42.3	6.6	9.4	30.4			512
Skin and rags, Trinidad	18.3	7.8	16.9	3.6	5.0	66.7			117
Seeds, Grenada, W.I.	29.1	21.9	13.2	2.1	12.5	50.3	0.18	0.30	117
Silage of skins, Dominica, W.I.	23.0	10.6	21.0	9.5	6.4	52.5			117

D7 *Citrus paradisi* Macf.

Grapefruit

***Citrus sinensis* (L.) Osb.**

Sweet orange

Useful reference: 22

Both are small trees or shrubs about 3 m high that grow in the same habitat. The orange has long been cultivated in all warm climates, especially in the subtropics but also in many tropical countries. The grapefruit has not been cultivated commercially as long as the orange. The grass in citrus orchards can be grazed by calves and sheep.

Fresh citrus

Useful reference: 497

Oranges and grapefruits, as well as lemons, sometimes go to waste if they are not marketed. Cattle can consume large amounts of these fruits (up to 40 kg a day have been reported) with no apparent harmful effects. Cows with access to fresh oranges have produced more on this feed than on clover pasture. Fresh oranges should be offered to dairy cows only after milking so as to avoid flavoured milk. When feeding fresh citrus, protein and mineral supplements should be provided as fresh citrus contains little protein, calcium or phosphorus. Pigs prefer oranges and tangerines to grapefruit. Free-choice feeding of citrus fruits together with a protein supplement has given good results. To avoid the danger of whole citrus fruits getting stuck in the gullet, they should be sliced. This can easily be done by throwing the fruits through a frame in which saw blades are mounted parallel with a few centimetres of space between them.

Citrus pulp

Useful reference: 50

When oranges or grapefruits are processed into juice or sections, 45-60% of their weight remains in the form of peel, rag and seeds. This waste is palatable to cattle. Mature cattle accustomed to this feed will consume 6-10 kg a day. Intakes of up to 120 kg a day have been reported for mature cows in hot climates. Because of the high water content and perishable nature of the waste, it can only be used economically close to the processing plant. The feed is rather difficult to handle, ferments and sours quickly, and can be a fly-breeding nuisance if allowed to spoil. Large amounts are available in the harvest season, and the material can be ensiled for year-round feeding. As citrus pulp is rather moist, a firmer silage is obtained if the pulp is pressed before ensiling or mixed with grass or hay. The ensiling process takes less than fifty days, and the silage is eaten readily by cattle.

Fresh citrus pulp is useful as an ensiling additive to tropical grasses that do not ferment easily by themselves. The addition of 20% fresh citrus pulp to a tropical grass silage will lower the pH and increase lactic and acetic acid fermentation. Pure citrus-pulp silage has a much higher weight per volume than grass or maize silage; therefore, silos in which it is to be placed should be more strongly reinforced than average. This problem does not apply to trench silos. Citrus pulp can easily be ammoniated by direct contact with ammonia at atmospheric pressure. The citrus pulp is loaded into a long polyethylene sleeve, and ammonia gas from a bomb is let into one of the ends. The progress of the ammonia is easily followed because ammoniation turns the pulp brown and heats it up. When the ammonia reaches the open end of the sleeve, the gas is turned off and the excess ammonia is aired off from the pulp before feeding.

Dried citrus pulp (citrus meal)

Useful reference: 51

To increase the use of citrus pulp, it can be preserved by drying. Direct drying cannot be used, however, because of the slimy consistency of the waste. It has been found that the hydrophilic nature of the pectin in the waste can be destroyed by adding lime. The dried pulp can be stored for year-round feeding and deteriorates less in storage than many other feeds. Rodents and birds are not so attracted to dried citrus pulp as they are to other feeds. Dried citrus pulp is slightly hygroscopic and should therefore be stored dry. The machinery for drying is expensive, and the process is economical only where large amounts of waste accumulate. The first step in processing is the addition of 0.5% calcium in the form of limestone or calcium hydroxide to the shredded skins to neutralize the free acids and combine with the fruit pectin. Following this, there are two ways of further processing the citrus pulp:

1. The excess moisture is removed in a press before drying the pulp. The press liquor may then be discarded or concentrated under reduced pressure to 60-70% dry matter and used as animal feed, known as citrus molasses.

2. All the wet material is dried directly in a rotary drier. This method is practical in areas with access to natural gas where fuel costs are low.

Dried citrus pulp that has been pressed before drying is some 10% lower in nitrogen-free extract. Only the contents of ash, fibre and water are consistent, whereas protein and nitrogen-free extract vary according to the season, the proportion of oranges and grapefruits, and the quantity of seeds in the fruits.

No distinction is made between dried pulp from oranges and dried pulp from grapefruits. The dried material is sometimes screened into citrus meal, citrus pulp and fines, but often the whole mixture is ground and sold as citrus meal.

Dried citrus pulp has been used as the main energy source for beef cattle and pregnant heifers and has constituted up to 45% of calf rations; however, the results have indicated that the pulp should not be used at high levels for milking cows as milk production tends to decrease. Urinary calculi have been observed in steers fattened with rations of more than 30% citrus meal.

Because of the processing method, citrus pulp is a good source of calcium, but it contains little phosphorus. Owing to this imbalance there is a very real need to ensure that calcium and phosphorus levels are adequate and in the right ratio. As citrus pulp has a low content of vitamin A, green leafy roughage is an important ingredient in rations with high levels of citrus pulp.

Substances toxic to swine and especially to poultry are present in dried citrus pulp that includes seeds; also, the high fibre content restricts its use in pig and poultry rations. Dried citrus pulp at the level of 10% in chicken diets reduces growth and at about 30% may be toxic. When added to the diets of layers, even at a level of 2.5% dried citrus pulp adversely affects yolk colour.

Dried citrus pulp has been used as deep litter for poultry and subsequently as livestock feed (see 121). Citrus pulp has been ammoniated to increase its nitrogen content, but the method seems to offer little advantage over the separate feeding of a source of nonprotein nitrogen.

Citrus molasses

Useful reference: 209

The liquid obtained from pressing citrus waste contains 10-15% soluble solids, of which 50-70% are sugars. This material, which may amount to more than half the total weight of the waste, can be concentrated into citrus molasses. Citrus molasses is normally a thick viscous liquid, dark brown to almost black, with a very bitter taste. This bitter taste does not diminish its usefulness in cattle feeding, and citrus molasses can be used in the same way as sugar-cane molasses. It may be mixed with pressed pulp prior to drying, thus increasing the ratio of total digestible nutrients (TDN) to crude fibre in the dried product without lessening the keeping quality of the pulp. When fed free-choice to cattle, they consume up to 3 kg per day. It is less readily accepted by pigs. It has been found that citrus molasses can replace 10-40% of the maize in the pig ration, depending on the age of the pig.

CITRUS SEED MEAL

Useful reference: 136

Citrus seeds are sometimes collected separately at the canning plants for oil extraction. The resulting oilcake, called citrus seed meal, compares favourably with many sources of vegetable protein. However, it contains limonin, which is toxic to pigs and especially to poultry. Citrus seed meal is therefore unsatisfactory for these animals. At 5% inclusion it reduces growth and at 20% causes mortality in growing chickens. It is acceptable to ruminants and is comparable to cottonseed oil cake, having the same percentage of crude protein. There is no restriction on its inclusion in diets for ruminants. The toxic factor can be extracted under laboratory conditions, but the process is too expensive for application on a commercial scale.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh whole grapefruits, Israel	12.7	7.0	8.7	3.9	2.4	78.0	0.79	0.16	365
Fresh whole oranges, Israel	12.8	7.8	9.4	4.7	1.6	76.5	0.47	0.23	365
Grapefruit pulp, Cyprus	20.3	6.4	10.5	4.1	0.4	78.6	0.61		369
Grapefruit peels, Israel	17.9	6.7	10.6	3.9	1.7	77.1			365
Orange peels, Israel	16.1	6.8	6.2	3.7	1.9	81.4	1.30	0.12	365
Silage of grapefruit peels, Israel	19.2	7.3	13.0	4.2	2.0	73.5			365
Silage of orange peels, Israel	19.6	7.7	14.3	5.1	2.6	70.3	1.38	0.10	365
Dried citrus pulp, Trinidad	91.8	6.9	13.1	7.1	2.8	70.1			117
Citrus fruit meal, USA		8.1	11.4	5.5	3.9	71.1	4.27	0.09	201
Citrus molasses, USA	71.0	5.8	0.0	6.6	0.3	87.3	1.13	0.08	209
Citrus seed meal, USA	85.0	40.0	8.8	7.0	6.7	37.5	1.65	0.10	136

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Whole oranges	Sheep	64.0	82.0	44.0	99.0	3.30	365
Orange peels	Sheep	53.0	76.0	65.0	94.0	3.20	365
Citrus fruit meal	Sheep	41.1	79.7	99.9	87.7	3.03	201

Coffea arabica

D8 *Coffea arabica* L.

Coffee

A shrub up to 5 m high with white fragrant starlike flowers and dark glossy leaves. The two-seeded deep-crimson fruit is about 1 cm in diameter. The fruit, or "cherry," can be processed by the simpler dry method or by the more advanced wet method to free the seeds, or "beans," from the pulp. With the dry method the cherries are left on the tree until the pulp is dry; after harvesting, the pulp is mechanically separated from the beans.

With the wet method *(café lavado)* the coffee cherries are dumped into a tank to be washed with running water, which transports the cherries to the pulping machines. These remove the pulp from the beans, which remain covered by mucilage and skin (parchment and silverskin). The beans are then allowed to ferment for about three days, after which the loose mucilage is washed off. The beans are dried before they are threshed to remove the skin.

By weight the fresh cherries consist of 45% pulp, 10% mucilage, 5% skin and 40% bean (calculated as 50% moisture in the fresh bean). The high moisture content of the pulp from the wet process causes problems in handling and transport. The pulp should be dried as quickly as possible to avoid spoilage.

Coffee pulp accumulates in large quantities and is used in some areas as a roughage for cattle. The pulp from the dry method is fibrous and rather poor roughage, whereas that from wet processing has much greater feed value. For lactating cows coffee pulp can be fed at levels below 20% of the diet without affecting milk production. Beef animals show a decrease in feed intake and weight gain directly related to the level of pulp in the diet. Up to 16% dried coffee pulp from the wet process has been included in diets for swine with good results. Coffee pulp cannot be included in poultry feeds. Attempts to ensile coffee pulp have not been very successful as the silage becomes dark and unpalatable upon exposure to air.

As there are occasionally large surpluses of coffee in coffee-growing countries, the possibility of using oil-extracted seeds for animal feed has been investigated. The oil cake is unpalatable to all farm animals, and if more than 35% is included in concentrates for cattle, the intake decreases. It cannot be fed to poultry as it likewise tends to depress the daily gain. The residue of the roasted seeds in the production of instant coffee is unpalatable and depresses weight gains in all classes of livestock. At levels exceeding 10% in poultry diets it produces toxic symptoms.

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Pulp, wet method, Colombia	23.0	12.8	24.1	9.5	2.8	50.8	0.58	0.13		537
Pulp, dry method, Kenya	90.0	9.7	32.6	7.3	1.8	48.6	0.29	0.03		415
Skins, Colombia	90.0	2.4	95.2	0.4	0.6	21.4				537
Coffee grounds, Trinidad	19.7	13.3	62.4	0.5	19.6	4.2				191
Coffee oil meal, Colombia	89.8	17.4	27.0	5.5	1.8	48.3				405

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Pulp, dry method	Sheep	10.3	27.9	53.2	50.2	1.33	415

D9 *Cucumis melo* L.

Musk-melon or cantaloupe

Round to oval fleshy fruit about 10-15 cm in diameter produced by a creeping annual with large leaves. There are many varieties in cultivation. They are sometimes given as a relish to cattle and pigs, but furnish few nutrients because of their high water content.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, Niger		27.4	16.9	4.5	2.8	48.4	2.98	0.68	45
Fresh fruit, Israel	6.6	21.2	21.2	9.0	3.0	45.6	0.45	0.30	365

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fruit	Sheep	70.0	80.0	83.0	95.0	3.01	365

D10 *Cucurbita* spp.

Pumpkin, squash, gourd

Pumpkin and squash are sometimes planted as a relish for cattle and pigs. Because the fruits are very low in dry matter and accordingly in nutrients, they are of little value for animal feeding. They have a softening effect on the fat in pigs and should not be fed too freely. Pigs have difficulty digesting the kernels. The kernels can be removed from the fruit and used for feed after shelling.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh fruit, Israel	7.6	14.5	13.2	7.9	2.6	61.8	0.39	0.26	365

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Fruit	Sheep	90.0	80.0	83.0	95.0	3.24	365

D11 *Hibiscus esculentus* L.

Okra or gumbo (often called Lady's finger after the most popular commercial variety)

Stout annual, of which there are several cultivated varieties, grown as a garden vegetable for its long green pods, which contain a slimy substance when they are immature. The seeds of mature pods are sometimes collected for chicken feed and have been used on a small scale for the production of oil. The quality of the seed protein is very good; it can supplement the dietary protein needed by monogastric animals. The seeds are reported to contain gossypol.

Hibiscus esculentus

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, Africa	18.5	23.8	11.4	11.9	3.2	49.7	2.88	0.38	154
Fresh fruit, Nigeria	11.3	15.8	9.8	11.0	1.0	62.4			374
Fruit, dry, Nigeria	87.5	14.6	36.9	8.1	9.8	30.6			374
Seeds, USA	90.5	22.1	28.8	5.1	17.7	26.3			164
Oilcake, India		22.3	19.8	7.4	7.1	43.4	0.29	0.85	379

D12 *Hyphaene* spp.

Doum or dum palm

Useful reference: 333

One of the few branching palms, 10-15 m high, with a very hard and fibrous kernel once used in the manufacture of buttons (see also *Phytelephas macrocarpa*) and cultivated for that purpose in North Africa. The kernel consists mainly of the carbohydrate mannan.

As the nutritive value is increased so much by shelling the nuts, only the kernels should be used. Mature nuts and kernels should be ground into meal as they are very hard. If used together with protein supplement, doum kernel meal is an excellent feed for all animals that is comparable to maize. The carcasses of animals fattened on doum kernel meal tend to have less back fat than those fattened on maize and will therefore be graded higher.

D15 *Musa* × *paradisiaca* L.

Banana, plantain or cooking banana

A fast-growing plant 3-5 m high with herbaceous stem. The fruits grow in bunches of up to 200 banana fingers each. The banana is picked green and ripened in sheds. Large quantities of rejected bananas are available for animal feed in exporting countries. Normally about 4% of the crop is rejected, but up to 50% of the harvest is wasted in some countries. When the bunch has been harvested, the pseudostem (trunk) of the plant is cut down to allow the emergence of new shoots.

The dry matter of the green immature banana consists mainly of starch (72%), which with ripening changes into simple sugars (sucrose, glucose, etc.). Bananas contain tannins which may affect the digestibility of protein in the diet. Ripe bananas are of interest as a source of easily available energy in the feeding of urea.

Uses. Cattle relish bananas, which are usually fed green, chopped and sprinkled with salt as they contain very little sodium. Bananas are less palatable to sheep and goats. They are low in fibre, protein and mineral content and should therefore be fed together with grass or some other roughage as well as a protein supplement and mineral mix. A good silage can be made from equal parts of chopped green bananas and grass or from chopped green bananas mixed with 1.5% molasses.

Bananas are mainly used in feeding pigs, which eat them with relish when they are ripe. The organic matter digestibility of green bananas in pig diets is 70% for the whole green fruit, 90% for the peeled green fruit and even higher for ripe fruit. Bananas should therefore be allowed to ripen before they are fed to pigs; however, ripe bananas fed in large amounts may cause diarrhoea. Bananas are usually fed to pigs *ad lib* with about 1.2 kg of concentrate (10-22% crude protein). There seems to be no advantage in cooking the bananas prior to feeding. Pigs fed bananas tend to have less carcass fat. Mature plantains can be fed in the same way as bananas.

Only the unripe banana and plantain can easily be dried. The meal can be used as a substitute for 70-80% of the grain in pig and dairy diets with little change in performance. Banana meal has been used in poultry diets, but high levels depress growth and reduce feed efficiency. Not more than 5% or 10% of the grain portion of chick and poultry diets should be replaced by banana meal.

Banana leaves can be used as an emergency feed for ruminants; however, owing to the presence of tannins the digestibility progres-

D11 *Hibiscus esculentus* L.

Okra or gumbo (often called Lady's finger after the most popular commercial variety)

Stout annual, of which there are several cultivated varieties, grown as a garden vegetable for its long green pods, which contain a slimy substance when they are immature. The seeds of mature pods are sometimes collected for chicken feed and have been used on a small scale for the production of oil. The quality of the seed protein is very good; it can supplement the dietary protein needed by monogastric animals. The seeds are reported to contain gossypol.

Hibiscus esculentus

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, Africa	18.5	23.8	11.4	11.9	3.2	49.7	2.88	0.38	154
Fresh fruit, Nigeria	11.3	15.8	9.8	11.0	1.0	62.4			374
Fruit, dry, Nigeria	87.5	14.6	36.9	8.1	9.8	30.6			374
Seeds, USA	90.5	22.1	28.8	5.1	17.7	26.3			164
Oilcake, India		22.3	19.8	7.4	7.1	43.4	0.29	0.85	379

D12 *Hyphaene* spp.

Doum or dum palm

Useful reference: 333

One of the few branching palms, 10-15 m high, with a very hard and fibrous kernel once used in the manufacture of buttons (see also *Phytelephas macrocarpa*) and cultivated for that purpose in North Africa. The kernel consists mainly of the carbohydrate mannan.

As the nutritive value is increased so much by shelling the nuts, only the kernels should be used. Mature nuts and kernels should be ground into meal as they are very hard. If used together with protein supplement, doum kernel meal is an excellent feed for all animals that is comparable to maize. The carcasses of animals fattened on doum kernel meal tend to have less back fat than those fattened on maize and will therefore be graded higher.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Whole nut, ground, Somalia	91.4	4.5	24.7	3.6	2.6	64.6			333
Kernel, ground, Somalia	90.4	9.0	7.3	2.8	7.0	73.9			333

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Whole nut	Sheep	0.0	24.6	81.2	50.8	1.74	333
Kernel	Sheep	36.4	57.2	83.4	82.2	2.95	333

D13 *Kigelia pinnata* (Jacq.) DC.

Sausage tree

Lofty wide-spreading tree up to 15 m high, often cultivated as an ornament for its cylindrical fruits, which weigh up to 6 kg. The fruits, very similar to large sausages, are eaten by baboons.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh fruit, Zimbabwe	14.6	5.8	29.4	4.5	6.0	54.3			19

D14 *Mangifera indica* L.

Mango

Large spreading tree that is native to tropical Asia but cultivated in most tropical countries. The round or oval fruit is somewhat flattened and can weigh up to 0.5 kg. The flesh of good fruit has a pleasant aromatic flavour, but inferior varieties have a turpentine flavour and can be rather fibrous. In the centre is the large fibrous flat seed containing a kernel.

The kernels constitute about 15% of the weight of the fruit and may well be used for livestock. Ruminants can tolerate concentrates with up to 50% mango kernels without adverse effects. The kernels are fairly rich in tannins, which progressively lead to reduced growth rates and less efficient feed utilization when included in diets for pigs and poultry.

The fruits are relished by both cattle and pigs. Gluts can be preserved in the following way. Mangoes that are not fully mature are sliced and ensiled in pits 1.5 m^3 dug in the ground and lined with large leaves. One percent salt should be added. The pits are tightly covered with leaves and soil. The silage can be used for off-season pig feeding.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fruit pulp, early vegetative, Nigeria	17.7	35.0	2.8	1.8	0.3	60.1	0.21	0.10	374
Fruit pulp, mature, Nigeria	17.3	5.6	2.3	2.2	0.5	89.4			374
Kernels, India	50.0	8.5	2.8	5.4	8.9	74.4			253
Silage, Mali	16.0	5.0	16.6	9.2	6.2	63.0	0.18	0.09	537

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Kernel	Oxen	72.1	0.0	56.3	70.6	2.56	253

D15 *Musa* × *paradisiaca* L.

Banana, plantain or cooking banana

A fast-growing plant 3-5 m high with herbaceous stem. The fruits grow in bunches of up to 200 banana fingers each. The banana is picked green and ripened in sheds. Large quantities of rejected bananas are available for animal feed in exporting countries. Normally about 4% of the crop is rejected, but up to 50% of the harvest is wasted in some countries. When the bunch has been harvested, the pseudostem (trunk) of the plant is cut down to allow the emergence of new shoots.

The dry matter of the green immature banana consists mainly of starch (72%), which with ripening changes into simple sugars (sucrose, glucose, etc.). Bananas contain tannins which may affect the digestibility of protein in the diet. Ripe bananas are of interest as a source of easily available energy in the feeding of urea.

Uses. Cattle relish bananas, which are usually fed green, chopped and sprinkled with salt as they contain very little sodium. Bananas are less palatable to sheep and goats. They are low in fibre, protein and mineral content and should therefore be fed together with grass or some other roughage as well as a protein supplement and mineral mix. A good silage can be made from equal parts of chopped green bananas and grass or from chopped green bananas mixed with 1.5% molasses.

Bananas are mainly used in feeding pigs, which eat them with relish when they are ripe. The organic matter digestibility of green bananas in pig diets is 70% for the whole green fruit, 90% for the peeled green fruit and even higher for ripe fruit. Bananas should therefore be allowed to ripen before they are fed to pigs; however, ripe bananas fed in large amounts may cause diarrhoea. Bananas are usually fed to pigs *ad lib* with about 1.2 kg of concentrate (10-22% crude protein). There seems to be no advantage in cooking the bananas prior to feeding. Pigs fed bananas tend to have less carcass fat. Mature plantains can be fed in the same way as bananas.

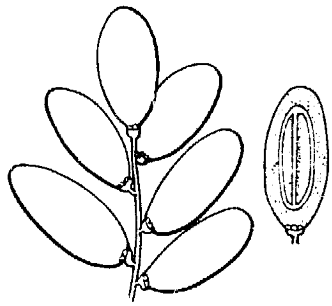
Only the unripe banana and plantain can easily be dried. The meal can be used as a substitute for 70-80% of the grain in pig and dairy diets with little change in performance. Banana meal has been used in poultry diets, but high levels depress growth and reduce feed efficiency. Not more than 5% or 10% of the grain portion of chick and poultry diets should be replaced by banana meal.

Banana leaves can be used as an emergency feed for ruminants; however, owing to the presence of tannins the digestibility progressively decreases as the level of banana leaves is increased in the ration. Banana pseudostems (trunks) are used as animal feed in many countries. Pseudostems can be fed fresh or chopped and ensiled to cattle and pigs. They are easily ensiled if chopped and mixed with an easily fermentable carbohydrate — for instance, molasses or rice bran (4-8%); the silage is of good quality.

Banana peels are very rich in active tannins when green and thus cannot be fed until they are completely yellow, when the tannins are bound in an inactive form.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Dried banana leaves, Thailand	94.1	9.9	24.0	8.8	11.8	45.5	0.75	0.24	56
Fresh banana pseudostems, India	5.1	2.4	20.5	14.3	2.3	60.5	1.16	0.22	436
Fresh banana shoots, India		7.7	48.2	16.2	5.8	22.1	0.81	0.26	436
Fresh banana, whole plant	16.0	6.4	23.7	13.1	0.8	56.0			155
Banana fruit, immature, Trinidad	20.9	4.8	3.3	4.8	1.9	85.2			191
Banana fruit, ripe, Trinidad	31.0	5.4	2.2	3.3	0.9	88.2			191
Banana, peeled fruit, immature, Nigeria	25.1	3.6	0.8	3.4	1.6	90.6			374
Banana, peeled fruit, ripe, Nigeria	30.5	4.2	0.1	4.5	0.5	90.7			374
Banana peels, ripe, Nigeria	14.1	7.9	7.7	13.4	11.6	59.4			374
Banana peels, immature, Somalia		7.7	13.0	16.5	6.0	56.8			326
Banana, silage of immature fruits, 1.5% molasses	25.6	4.7	3.5	5.1	3.5	83.2			181
Fresh plantain leaves, India		9.5	23.1	13.3	5.6	48.5	1.43	0.17	436
Fresh plantain stems, India		2.8	13.8	15.6	1.2	66.6	0.92	0.26	436
Fresh plantain shoots, India		8.7	47.2	17.1	2.8	24.2			379
Plantain fruit, mature, Trinidad	29.4	4.0	1.1	3.6	0.8	90.5	0.75	0.29	117
Plantain peels, mature, Nigeria	18.4	9.1	6.4	17.2	5.6	61.7			374
Plantain fruit, peeled and cooked, Trinidad	42.8	2.6	0.5	1.3	0.1	95.5			117

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Whole plant	Sheep	54.7	53.6	62.5	85.0	2.37	155
Peels, ripe	Sheep	34.1	22.1	40.4	80.1	2.27	222
Peels, immature	Sheep	22.0	74.0	28.0	79.0	2.18	326
Banana, green, raw	Pigs	46.9	46.6	55.9	94.7	3.05	543
Banana, green, cooked	Pigs	43.8	49.5	56.0	94.9	3.06	543
Banana, ripe, raw	Pigs	53.6	58.7	66.9	94.6	2.97	543
Banana, ripe, cooked	Pigs	51.8	62.6	69.2	95.4	3.00	543



Phoenix dactylifera

D16 *Phoenix dactylifera* L.

Date palm

Useful reference: 6

A strong palm tree, sometimes over 30 m high. The upward-arching leaves are very long and stiff with glaucous leaflets. The cylindrical fruits, 2-4 cm long, grow profusely on long hanging strands. The flat seeds account for about 20% of the weight of the fruit and are sometimes removed from the edible flesh before the fruit is dried for export. The seeds are extremely hard and must be crushed in a disc crusher before they can be powdered in a hammer-mill. Ground date seeds can be used in rations for ruminants if a good protein supplement or urea is added. They have constituted up to 20% of the total ruminant ration with good results. Ground seeds have also been used for pigs and as a substitute for barley in chick rations in proportions up to 10% of the total ration without depressing weight gains or feed efficiency. Both dried and sugar-extracted fruit pulp are good carbohydrate feeds for all farm animals and can compose at least 20% of the rations for growing poultry and pigs.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Dried whole dates, Iraq	74.3	2.9	6.5	5.7	1.0	83.9			148
Seeds, Iraq	85.3	5.8	30.0	1.8	7.1	55.3			148
Seeds, hammer-milled, Egypt	90.3	6.6	15.7	3.2	9.0	65.5			145
Sugar-extracted fruit pulp, Iraq	88.2	5.5	11.8	2.7	0.4	79.6			148

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Seeds, milled	Sheep	0.0	52.5	91.4	73.2	2.67	145

D17 *Phytelephas macrocarpa* Ruiz & Pav.

Ivory palm, corozo nut or tagua palm

Slow-growing palm, native to South America but subsequently introduced in other tropical countries. The large white seeds, contained in large round clusters of spiky fruits at the base of the palm, become very hard as they ripen and furnish what is known as vegetable ivory. The seeds were used for making buttons and other ornamental articles, but with the use of new synthetic resins this manufacture has almost ceased. Other palm nuts were also used as a source of vegetable ivory — for instance, doum palm nuts (see *Hyphaene* spp.).

The kernels can be ground into ivory nut meal, which serves mainly as an energy source, as the nuts are largely composed of the carbohydrate mannan. The meal can be used for all classes of livestock in mixed rations without any particular restrictions.

		As % of dry matter								
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Seeds (vegetable ivory)	87.9	5.3	9.3	1.5	1.6	82.3			325

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Seeds	Sheep	25.2	84.6	91.0	82.8	2.93	325

D18 *Roystonea regia* (H.B.K.) Cook

Royal palm

A tall palm grown in Central America. The fresh fruits are sometimes fed to pigs, which first eat the fleshy outer part and leave the kernel until it has dried.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fruits, Cuba	57.3	6.1	23.6	4.3	26.6	39.4			88

D19 *Solanum lycopersicum* L.

Tomato or love apple

Useful reference: 141

The tomato, which originated in South America on the slopes of the Andes, is now widely cultivated in both temperate and tropical countries. Tomatoes serve as the basis of two general classes of products: in one the fresh whole tomatoes are used; in the other only the pulp is used, as in the making of ketchup and soups, from which the seeds and skins are by-products. Because of the semiliquid state of the seeds and skins, it is necessary to obtain a high fraction of solids by passing them through a cyclone. The solids are then pressed into cakes and dried. The waste ferments readily and should be dried immediately. The dried waste is rich in oil, which can be extracted; the resulting oilcake can be used as an animal feed. Skin and seeds account for about 13% of the weight of the whole tomato.

Uses. Dried skin and seeds are sometimes included in pet foods at the 2-3% level to prevent diarrhoea. They can also be used to replace lucerne in poultry feeds at a 5% level. They are reported to be rich in tannins, which limits their use for monogastrics. Dried skin and seeds have constitued 25% of a concentrate for dairy animals with good results. To render the small seeds digestible to ruminants, they must be ground.

The oilcake has a somewhat bitter taste and should be used with better-liked feedstuffs. Because of its high content of fibre, it is used mostly in feed for ruminants with no particular limitations. When first introduced, it should be sprinkled with salt and given in small proportions.

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Skin and seeds, dried	93.3	24.8	27.6	6.6	22.0	19.0	0.18	0.26		512
Oilcake, Italy		37.0	28.3	7.4	6.8	20.5	0.16	0.59		321

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Oilcake	Sheep	72.0	22.0	54.0	71.0	2.19	321

D20 *Vitis vinifera* L.

Grape or wine grape

Useful reference: 318

A strong vine of medium height, but often trained to a short stout trunk. The oval or round berries grow in clusters. The juice of the berries is fermented into wine. After the juice has been pressed out of the berries, the residue — grape pomace or winery pomace — is about 10% by weight of the total grape input. If the grapes are stripped from the stalks before processing, the residue consists of about 40% seeds and 60% skin and pulp. Winery waste pressed with the stalks is composed of about 30% stalks, 30% seeds and 40% skin and pulp. Winery pomace can be stored for a time by heaping and pressing, but dust formation may become a problem owing to disintegration of the pulp. It is easy to make silage of winery pomace as the initial acidity is already high. The pomace may also be separated into skin and seeds by loosening the pulp from the seeds in a breaker, after which a vibrating sieve separates the seed from the skin. Both fractions are then dried; the marc (skin and pulp) is ground in a mill and bagged; and the dried seeds are removed from the dust and stored in silos. The seeds contain 8-22% edible oil and can be either pressed or extracted with solvents.

Uses. The seed oilcake has no feed value as it is not only too fibrous but also contains tannic acid; however, it has been used as a carrier for molasses in cattle feed. Winery pomace including stalks has little value in animal feeding. Its chemical composition is similar to other types of winery pomace, but the digestibility of fibre is much lower and its nutritive value is comparable to that of straw. Winery pomace from stalked grapes has been fed to dairy cows in amounts up to 6.5 kg a day. When supplemented with concentrates and legume hay, it proved to be a good feed. At this level of inclusion the milk yield tends to drop and the butterfat content increases. Larger amounts cause inflammation of the mucosa in the digestive system. Grape marc has a lower fibre content than pomace and has been used for horses in proportions of up to 10% of the ration. The digestibility can be increased by soaking the marc in hot (90°C) water for about twenty minutes to remove the tartrates.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, Pakistan	30.0	15.8	9.2	8.6	13.4	53.0	2.25	0.16	308
Winery pomace (stalk, skin, seed), Italy	40.6	11.7	25.5	7.7	9.9	45.2			318
Winery pomace (skin, seed), Italy	46.5	13.7	23.6	12.8	7.0	42.9	0.82	0.20	318
Winery pomace (stalk, skin), Germany (F.R.)	88.8	14.9	35.8	8.9	5.0	35.4			78
Winery pomace (skin), Italy		14.4	22.3	6.3	8.3	48.7	0.79	0.27	318
Winery pomace (skin), Chile	88.9	18.3	32.0	8.0	6.4	35.3	1.63	0.33	315
Seeds, Chile	93.0	9.6	45.7	4.2	15.2	25.3	0.62	0.22	315
Oilcake (hydraulic press)	88.5	13.6	44.0	5.2	8.5	28.7			512

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Stalk, skin, seed	Sheep	18.4	8.5	77.8	40.9	1.44	318
Skin and seed	Sheep	9.2	34.5	45.3	41.0	1.23	318
Stalk and skin	Cattle	14.0	27.0	55.0	36.0	1.11	78
Skin	Sheep	5.5	5.0	58.9	42.2	1.20	318

E. Root crops

Useful reference: 104

Fresh roots and tubers contain 80-90% water and are succulent feedstuffs. The value of the roots lies in their starch and sugar content and their appetizing properties. The dry matter of roots and tubers is low in fibre and highly digestible. The low crude-protein content consists largely of nonprotein nitrogen, especially in immature and fresh roots. The calcium and phosphorus content is low. Roots and tubers are low in vitamins, with the exception of the carrot, an excellent source of vitamin A. Many root crops give high yields in tropical areas where grain is difficult to grow. The substitution of roots for grain is an economic question; in many parts of the world roots could become a major supplier of energy for animals. Fresh roots are laxative and therefore useful when the rest of the ration consists largely of dry feeds. If cattle rations are low in crude protein, starchy feeds like roots may depress the digestibility of cellulose because the crude protein will be consumed by the rumen flora in the fermentation of the more easily digested starch rather than in the fermentation of cellulose. Roots and tubers are excellent sources of energy to combine with the feeding of urea. The feed value of roots and tubers, which are deficient in crude protein, can in this way be greatly increased.

Tropical root crops have received far less attention from researchers than other crops, and the available information is scanty.

E1 *Amorphophallus campanulatus* (Roxb.) Blm.

Whitespot giant arum, elephant's foot, pongapong

The tuber is a rather flattened rough and knobby sphere weighing as much as 5-15 kg. The single leaf grows to 120 cm in length, and the blade is divided into numerous leaflets and may be 2 m wide. Tubers and leaves of wild plants contain sharp crystals of calcium oxalate that puncture the mouth and tongue, causing intense irritation. Cultivated forms can be used either fresh or cooked for pig feed.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, India		15.3	14.2	16.3	3.3	50.9	1.52	0.81	378
Fresh tubers, Philippines	25.8	19.8	2.3	6.6	1.6	69.7			3T8

E2 *Beta vulgaris* L.

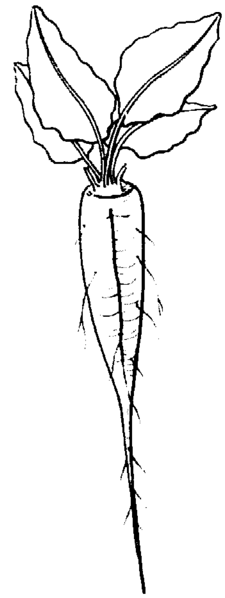
(*a*) Mangold or mangel

Biennial plant with thick roots of different sizes, forms and colours. In the second year a stem up to 1 m high is produced from the top of the tuber. Mangold is cultivated in cooler climates, but it cannot withstand frost and must be harvested before the beginning of cold weather. It can be stored in large outdoor clamps covered with straw. Fresh mangold should not be given to animals as it may cause scouring. Cows are usually given up to 20 kg per day of either whole or pulped mangold. The beets do not taint milk. The tops of mangold can be fed green, but they should first be allowed to wilt for at least a week. If they are clean and free from soil, they may be ensiled. Rams and wethers fed on mangolds for extended periods are apt to develop urinary calculi. In cooler parts of the tropics the roots can be stored in the ground for use during the dry season.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, India		17.0	7.6	29.2	6.2	40.0	0.23	0.34	378
Fresh tubers, India	7.9	13.0	6.1	9.6	2.8	60.6	0.24	0.42	378
Fresh tubers, Chile	12.6	6.4	7.4	4.2	0.6	81.4			315

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Tubers	Sheep	80.6	73.3	53.2	88.6	2.68	378

(*b*) Sugar beet



Beta vulgaris

A variety widely cultivated in cooler climates for the production of sugar. Although fresh sugar beets are not often fed to animals, they are well liked by cattle and pigs and may be included in their diets. Pig diets can beneficially include up to 20% sugar beet. The feed value of sugar beet is about twice that of mangold. It has a reputation for adversely affecting breeding capacity if fed to male stock. When sugar beet is harvested for sugar production, the leaves and the crown are cut off. The crown is rich in sugar but contains substances which interfere with the recovery of sugar from the juice. Wilted leaves and crowns can be fed to cattle and sheep, which relish them. Caution is necessary, however, as they may cause scouring because of their oxalic acid content and contamination by soil. No more than 10 kg per day should be fed to cattle, and they should be mixed with hay. The danger is even greater with pigs. As oxalic acid binds the calcium in the diet, extra calcium has to be supplied. The laxative effect of beet tops is not so pronounced in beet-top silage. Beet tops are easily ensiled both in trench silos and in stacks above the ground. No more than 15 kg should be fed each day to cattle, and no more than 2 kg to sheep. The best results are obtained if the beet-top silage is fed together with legume hay. The ensiling of beet tops produces large amounts of seepage water (about 200 litres/ton) during the first few weeks; therefore, good drainage has to be provided.

In sugar production the beets are first shredded into cossettes, from which the juice is extracted. The juice is then processed like that of sugar cane, yielding sugar and beet molasses. The residue after juice extraction, known as wet sugar beet pulp, is 10-15% dry matter. Its high water content, both from the point of view of transport and storage, limits its use to the vicinity of the sugar mill. Dairy cows can be given up to 12 kg per day and bullocks twice that amount. The wet pulp can be pressed to remove the excess water, thereby raising the dry matter content to 20%. Pressed pulp, though easier to transport, has the same poor keeping qualities. If heaped and covered to exclude air, it can be stored up to two weeks. For longer storage it should be ensiled. Most beet pulp is dried and sold as dried sugar beet pulp or mixed with molasses to form dried molasses beet pulp. As these feeds readily absorb water and swell, they should be soaked in two or three times their weight of water, especially if large amounts are to be fed or if they are to be given to horses or calves. The feeds are palatable, bulky and slightly laxative and have good keeping qualities. Dried beet pulp and molasses beet pulp are fed mostly to dairy cattle, for which they are very suitable. The crude fibre content is well digested by cattle. Up to 3.5 kg a day of dried beet pulp can be given to milking animals, and fattening cattle can make good use of up to 5.5 kg of dried pulp daily. Dried beet pulp may be fed in moderate amounts to calves from the age of about four months, a common daily allowance being 0.5 kg per head. Pigs digest the fibre well, but the pulp is so bulky that total food consumption and weight gain will decrease if more than 0.5 kg a day is fed to fattening pigs. Sows can consume up to 1 kg daily without adverse effects, and the moist soaked pulp is relished once the pigs acquire a taste for it. Young pigs do not thrive on pulp, and it has proved to be unsatisfactory for poultry.

Beet molasses is used like sugar-cane molasses. It has the same feed value but tends to be more laxative; the amounts of beet molasses fed should be less than those recommended for sugar-cane molasses.

There is an intermediate range of fodder beets between mangolds and sugar beets; these are mainly used in northern Europe.

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh [illegible], Chile	13.4	17.9	14.6	17.9	2.8	46.8	1.96	0.40	315
Fresh [illegible] and crowns (tops), Chile	11.5	17.7	15.5	16.0	3.0	47.8	1.48	0.19	315
Fresh tops, Israel	25.3	9.1	10.3	5.1	1.6	73.9			365
Dried tops, Israel	80.1	16.4	9.2	6.9	1.1	66.4			365
Silage of tops, Chile	21.9	10.6	14.2	22.8	5.8	46.6			315
Fresh tubers, Chile	16.7	7.4	6.2	3.5	0.6	82.3	0.26	0.21	315
Fresh pulp, sugar extracted, Chile	16.3	7.6	22.9	3.6	0.7	65.2			315
Dried pulp, sugar extracted, Iraq	92.9	8.0	18.6	5.5	0.0	67.9			182
Pulp with molasses	90.0	12.0	16.8	6.1	0.4	64.7			512
Beet molasses, Chile	81.7	14.7	0.0	10.3	0.3	74.7	0.55	0.08	315
Silage of pulp, Chile	13.9	9.4	24.3	4.0	1.0	61.3			315

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Fresh tops	Sheep	64.0	67.0	35.0	80.0	2.69	365
Dried tops	Sheep	48.0	71.0	25.0	84.0	2.62	365
Silage of tops	Sheep	62.5	73.5	42.9	79.1	2.19	512
Tubers	Sheep	92.0	33.0	0.0	95.0	3.21	315
Dried pulp	Sheep	59.6	89.1	0.0	91.4	3.05	512
Pulp with molasses	Sheep	58.3	89.4	0.0	91.1	2.98	512
Beet molasses	Sheep	34.3	0.0	0.0	89.7	2.65	512
Silage of pulp	Sheep	50.0	52.2	50.0	75.0	2.37	512
Dried pulp	Pigs	34.8	84.2	0.0	87.1	3.09	512
Molasses pulp	Pigs	24.1	84.1	0.0	89.2	2.99	512

E3 *Canna edulis* Ker-Gwal.

Canna, Queensland arrowroot or edible canna

Perennial herb with a purple stem up to 3.5 m high and leaf blades that are dark green tinged with reddish veins. Cultivated in the tropics for its tubers, which are used for human consumption when young. The tubers and leaves are good fodder for cattle and pigs; it is grown for this purpose in Hawaii, where it is harvested 4-8 months after planting.

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Fresh leaves, Uganda		14.1	24.6	12.3	2.5	46.5				70
Fresh aerial part, early vegetative, Tanzania	16.5	10.2	19.6	16.5	5.1	48.6				171
Fresh tubers, Tanzania	30.7	3.6	3.4	7.4	0.8	84.8				171

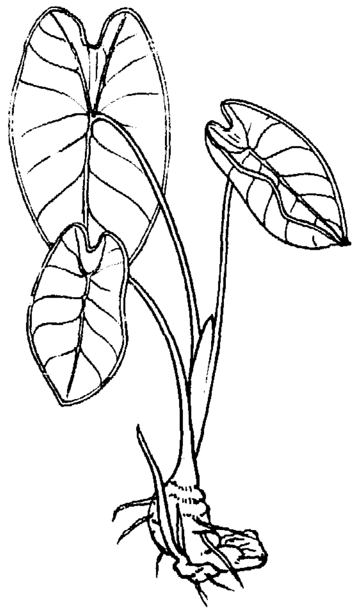
	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Tops	Sheep	44.0	35.0	27.0	66.0	1.71	171
Tubers	Sheep	44.0	89.0	63.0	90.0	2.99	171

E4 *Canna indica* L.

Indian shot

Slender plant up to 1 m high with green stem, also grown in tropical America in gardens for its decorative foliage.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh tubers, Chile	27.5	3.6	4.0	5.3	0.7	86.2	0.13	0.22	315



Colocasia esculenta

E5 *Colocasia esculenta* (L.) Schott

Taro, old cocoyam, eddoe or dasheen

Large coarse herb with crowns of large oblong-oval leaves and an abundance of large spherical underground tubers, which are important sources of food. The tubers should be cooked before being fed to livestock, particularly pigs. Uncooked taro contains substances which irritate the digestive tract and may cause poisoning if fed in large quantities. The leaves are relished by cattle and sheep. Dasheen, which is a variety of this species, is used in the same way. Very high calorific and protein production per hectare can be achieved with this plant. Ground-dried taro root has been tried as a feed for poultry; no toxic effects have been observed, but at higher levels of inclusion growth is poor.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Eddoe, fresh leaves, Nigeria	8.2	25.0	12.1	12.4	10.7	39.8	1.74	0.58	374
Eddoe, fresh tubers, Trinidad	26.2	8.7	1.7	4.0	0.4	85.2			117
Eddoe, peeled tubers, Trinidad	28.3	9.5	1.7	4.1	0.1	84.6			117
Dasheen, fresh aerial part, Trinidad	16.7	22.3	11.4	14.0	7.4	44.9	0.05	0.04	117
Dasheen, fresh tubers, Trinidad	23.7	3.4	3.3	3.2	0.7	89.4	0.38	0.44	117
Dasheen, peeled tubers, Trinidad	36.4	3.2	1.8	2.4	0.5	92.1			117
Dasheen, fresh peelings, Trinidad	18.8	4.7	9.3	6.7	1.2	78.1			117

E6 *Cynara cardunculus* L.

Cardoon

A robust plant up to 2 m high with thick stalks and very large, extremely spiny leaves, greyish green above and white beneath. Cultivated for its edible roots and stalks; the aerial part used as feed for cattle.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, Chile	14.4	16.9	26.9	14.6	6.2	35.4	1.45	0.33	315
Silage of aerial part, Chile	24.4	12.3	22.4	11.2	7.5	46.6			315

E7 *Daucus carota* subsp. *sativus* (Hoffm.) Arcang.

Carrot or cultivated carrot

Useful reference: 503

Annual or biennial herb of European origin with a thick orange or yellow root that has long been used as food. Some varieties can be grown at all altitudes in the tropics. Longer maturing, longer rooted varieties are best suited to high altitudes, while those with quick-maturing smaller roots do best at lower altitudes.

Carrots have a high vitamin A activity, which makes them valuable when hay and straw are the only other feeds. Cattle may be fed up to 20 kg a day when available, whereas pigs can utilize up to 1.5 kg a day. Whole raw carrots are sometimes used to feed sick horses when they refuse other feeds. Carrots may also be dried and ground to a meal for inclusion in compound supplements.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part	16.4	12.1	16.7	18.2	2.3	50.7			484
Fresh tuber	13.4	12.7	10.4	8.2	1.5	67.2			484

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Aerial part	Sheep	62.0	75.0	81.0	82.0	2.43	484
Tubers	Sheep	77.0	82.0	93.0	95.0	3.15	484

Dioscorea alata

E8 *Dioscorea alata* L.

Winged yam, water yam or greater yam

The most important of the cultivated varieties of yam. The white, brown or brownish red root tubers are very large, sometimes over 2 m in length, penetrating deep into the soil. The water content of the tubers is high. The stem is a climbing type with leaves 10-20 cm long.

Growing yam for animal feed is seldom economic, but yam can be used where surpluses are available. The peels are a valuable cattle feed. The tubers of all other types are more palatable cooked than raw, because cooking destroys the poisonous bitter alkaloid dioscorene.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh aerial part, Malaysia	24.1	12.0	25.3	7.9	2.3	52.5	0.95	0.16	292
Fresh tubers, Nigeria	34.2	8.1	2.6	5.2	0.8	83.3	0.12	0.18	374
Fresh tubers, peeled, Nigeria	26.2	7.3	2.3	5.2	0.6	84.6			374
Fresh peelings, Nigeria	25.9	11.7	6.6	9.5	1.0	71.2			374

E9 *Dioscorea cayenensis* Lam.

Yellow yam

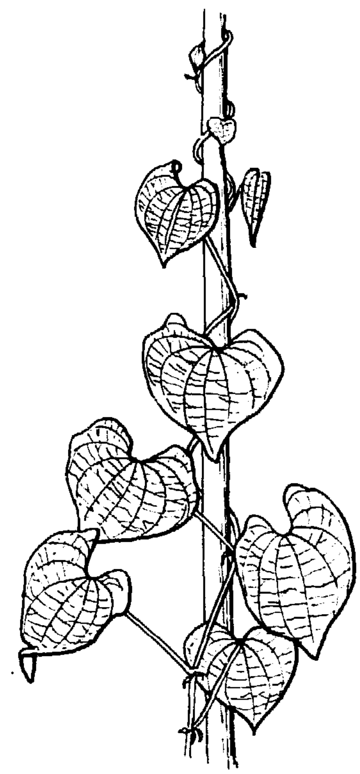
A yam with angular glabrous stem, usually prickly toward the base, and leaves that are deeply cordate at the base and 8-13 cm long. The flesh of the tubers is yellow. The tubers take about a year to mature. The yellow yam does not store well. Peelings can be used as pig feed.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh tubers, Nigeria	16.6	6.2	2.4	3.2	0.4	87.8			374
Fresh tubers, peeled, Nigeria	16.1	5.4	0.8	3.0	0.2	90.6			374
Fresh peelings, Nigeria	21.7	7.4	7.6	7.5	0.7	76.8			374

E10 *Dioscorea esculenta* (Lour.) Burk.

Chinese yam or lesser yam

A variety of yam that produces small egg-shaped tubers which lie shallow in the soil. The tubers are very sweet and white in colour, and the peel is very thin. This species is most suitable for garden planting. At lower altitudes in the tropics it can be grown in place of the Irish potato. The peelings are used for pig feed.



Dioscorea esculenta

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh tubers, Nigeria	18.6	8.7	3.5	4.2	0.5	83.1	0.15	0.15	374
Fresh tubers, peeled, Nigeria	18.6	7.7	1.0	2.7	0.1	88.5			374
Fresh peelings, Nigeria	7.0	10.0	7.6	6.3	0.9	75.2			374

E11 *Dioscorea rotundata* Poir.

White yam

The most popular yam in West Africa. The stem of this variety is round without wings and prickly at the base. The white flesh of the tubers produces a mealy starch. The tubers store well. The peelings are fed to pigs.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh tubers, Nigeria	26.2	5.9	2.4	4.3	0.5	86.9			374
Fresh tubers, peeled, Nigeria	24.1	4.4	1.5	2.8	0.3	91.0			374
Fresh peelings, Nigeria	17.7	11.2	9.5	9.8	1.2	68.3			374

E12 *Helianthus tuberosus* L.

Jerusalem artichoke or girasole

Useful reference: 287

Perennial herb cultivated in tropical and subtropical countries for its tubers. In improved strains the terminal tubers are club-shaped, 10 cm long and weigh up to 100 g. The stem can reach a height of 3.5 m. The fresh tops are used as fodder, but the mature tops are low in digestibility and unpalatable. The thin-skinned tubers are often used as pig feed. The pigs are allowed to gather the tubers, as they are small and difficult to gather by hand and cannot be kept more than a few days without spoiling.

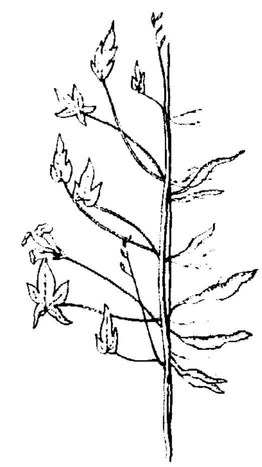
	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, Malaysia	21.7	20.7	12.4	16.1	2.3	48.5	2.04	0.36	292
Fresh aerial part	32.3	10.5	16.7	15.5	3.4	53.9			512
Fresh tubers, Malaysia	16.8	8.3	4.8	6.0	0.6	80.3	0.21	0.35	292
Fresh tubers, Israel	19.6	7.7	6.6	6.1	0.5	79.1			365

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Tops	Sheep	58.8	40.7	45.5	75.3	2.10	513
Tubers	Sheep	67.0	29.0	50.0	93.0	2.98	365

E13 *Ipomoea batatas* (L.) Lam.

Sweet potato

Useful reference: 114



Ipomoea batatas

Creeping plant with perennial vines and adventitious roots, some of which produce swollen tubers. Widely distributed in the tropics and in warm temperate regions, it requires at least four months of warm weather and cannot resist frost. The variation in leaf shape, skin colour and tuber form between varieties is marked.

The tubers are highly digestible and an excellent source of energy. Surplus and cull sweet potatoes can be used fresh or dehydrated in rations for livestock. The fresh tubers are relished by cattle. Up to 50% dehydrated sweet potato chips with 25% maize and 25% molasses, plus urea, has been used in supplements for dairy cows. Fresh sweet potatoes can replace 30-50% of the grain in pig diets. Cooking increases the value of sweet potatoes. Because of the bulkiness of fresh sweet potatoes, they are better utilized by mature pigs. Dehydrated sweet potatoes have approximately 90% of the feed value of maize when they constitute up to 60% of the ration. Strip grazing of sweet potatoes can be used to great advantage with sows. The sows should be given 0.5 kg of high-protein meal supplement in addition to grazing. Care must be taken not to graze overconditioned sows or those on a sweet potato diet because of the risk of becoming too fat. Sweet potatoes produce a hard pork. Sweet potato root meal can be included up to 50% in poultry feeds with good results if properly supplemented with protein.

The young leaves of sweet potatoes are highly relished by stock and are a valuable source of protein. The foliage can be cut regularly but not too frequently without reducing the yield of tubers. The foliage lasts throughout the dry season and is a valuable source of fodder. The foliage is difficult to cure into hay, but wilted vines make a good silage. Sweet potato vine meal can be added at about a 3% level to broiler and layer feeds to heighten the pigmentation of eggs and meat.

	DM	As % of dry matter CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, Israel	10.8	19.4	10.2	25.9	3.7	40.8			365
Fresh vines, Trinidad	8.7	21.9	15.0	18.0	3.4	41.7	1.79	0.24	117
Vines, hay, Zimbabwe	86.6	16.4	27.4	12.6	5.2	38.4			499
Fresh tubers, Kenya	59.0	5.1	2.3	3.5	1.1	88.0			179
Fresh tubers, Nigeria	28.1	5.4	0.3	3.2	0.5	90.6			374
Fresh tubers, peeled, Nigeria	28.7	5.2	0.1	2.7	0.5	91.5			374
Fresh peelings, Nigeria	11.7	6.3	0.3	4.6	1.3	87.5			374
Fresh tubers, red skin type, Trinidad	39.4	8.8	2.4	2.1	0.6	86.1	0.23	0.20	117
Fresh tubers, white skin type, Trinidad	30.0	10.9	3.0	3.9	0.3	81.9			117
Tubers, dried and ground, Israel	87.1	4.6	13.3	6.1	0.8	75.2			365

	Animal	Digestibility (%) CP	CF	EE	NFE	ME	Ref.
Leaves	Sheep	80.0	55.0	84.0	86.0	2.39	365
Hay	Cattle	64.5	35.7	72.8	74.1	2.13	499
Fresh tubers	Sheep	37.5	79.3	51.6	95.5	3.24	179
Tuber meal	Sheep	14.0	37.0	74.0	90.0	2.71	365

Manihot esculenta

E14 *Manihot esculenta* Crantz (*M. utilissima* Pohl)

Cassava, manioc, tapioca, Brazilian arrowroot or yuca

Useful reference: 90

Herbaceous shrub or small tree up to 4 m high with fingerlike leaves. Cultivated widely in the tropics and subtropics for its edible roots. One of the highest yielders of starch found in the tropics.

Toxicity. Cassava roots must be processed very carefully as they contain a glucoside, linimarin, which is acted upon by an enzyme to liberate prussic acid. The peeled roots contain much less prussic acid than unpeeled roots because most of the prussic acid is in the skin.

Varieties can be divided into two groups:

1. *Bitter varieties* with roots containing 0.02-0.03% prussic acid. These have to be processed before being used as feed.
2. *Sweet varieties* with roots containing less than 0.01% prussic acid. These can be used raw for feeding. Most commercial varieties belong to this group.

The prussic acid content depends not only on the variety, but also, and possibly even more, on soil conditions. Usually the bitter varieties have longer and thicker roots than the sweet varieties, but there is no simple safe method to judge the level of prussic acid in the roots.

The Indians of South America place the ground cassava roots intended for human consumption in nets, and wash and squeeze them until the toxic substance is eliminated. The toxic elements can also be removed by cooking or by drying slices of the roots for about two weeks. Cassava root meal is not attacked by insects; the same is true of feed concentrates to which 15% cassava root meal has been added.

Use of roots. Both fresh and dried cassava roots are consumed by ruminants in different forms (sliced, chopped, ground). Dried cassava roots have given satisfactory results as the principal energy source for dairy cattle, intensive beef fattening and lamb growth. Cassava can replace almost all of the grain in the diets with little reduction in performance. Inclusion levels of up to 65%, preferably pelleted, do not seem to affect health, carcass quality or overall performance when the diets are carefully balanced. Palatability can be enhanced by the addition of molasses if pelleting is not possible.

Complete replacement of grain by cassava root meal in layer feed has yielded similar egg production, although egg weight was significantly reduced (a sign of methionine deficiency). Supplementation with methionine has yielded similar results to grain controls. It should be noted that, besides methionine supplementation, careful control of energy-protein ratios is necessary for satisfactory results. The effect of methionine may be attributable to improvement of the protein quality as well as to the utilization of the methionine sulphur in the detoxification process.

For unknown reasons cassava meal seems to cause health problems when included in turkey rations.

Leaves. It is possible to obtain from cassava more than 6 tons of crude protein per hectare a year with the proper agronomic practices directed toward foliage harvesting. Cassava leaf and stem meal has been used at the 35% level in dairy cow concentrates to advantage. Cassava bushes can be harvested as forage when they are three to four months old. They are cut about 40 cm from the ground and chopped in small pieces by hand or in a stationary forage chopper. The forage has been used to provide by-pass protein to ruminants fed urea and molasses. The intake of cassava forage was about 5 kg per day, and about two months of adaptation was required before full production was obtained. In poultry rations the replacement of as little as 5% of the lucerne meal with cassava leaf meal significantly reduced broiler weight gains; however, the inclusion of methionine and vegetable oil additives in rations consisting of up to 20% cassava leaf meal practically eliminated the depression in response.

Silage. The whole cassava plant (including root and aerial part) can be chopped and ensiled in simple pit silos for dry-season feeding at the village level. Simple equipment is required both for harvest and preparation of the silage. The silage is fairly well balanced for ruminants.

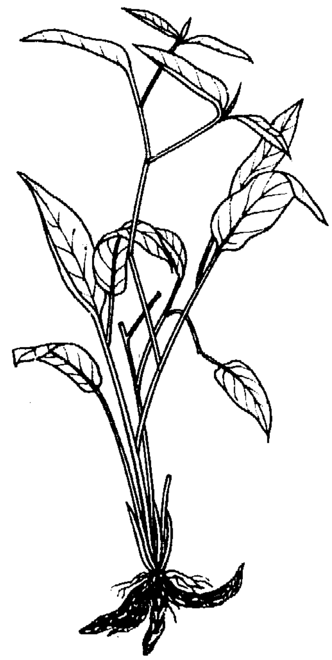
Cassava pomace. Often called cassava meal, pomace is the residue from the extraction of starch from cassava roots. Cassava roots yield approximately equal amounts of starch and pomace, which have less feed value than cassava root meal but can be included in rations for cattle. Starch and pomace are extensively used for pigs in Southeast Asia, where they are regarded as a valuable feed. Up to 10% has been used in poultry rations.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, wet season, 4 weeks, 70 cm, Thailand	15.3	24.8	18.3	8.5	5.2	43.2	0.98	0.52	219
Fresh leaves, wet season, 6 weeks, 100 cm, Thailand	14.5	22.8	22.8	7.6	6.2	40.6	1.03	0.55	219
Fresh leaves, wet season, 8 weeks, 135 cm, Thailand	16.1	24.1	26.0	8.0	5.0	39.9	0.99	0.56	219
Fresh leaves, dry season, 4 weeks, 50 cm Thailand	17.8	25.8	15.2	8.4	5.6	45.0	1.18	0.73	219
Fresh leaves, dry season, 6 weeks, 60 cm, Thailand	16.2	29.0	16.7	8.6	6.2	39.5	1.17	0.62	219
Fresh leaves, dry season, 8 weeks, 65 cm, Thailand	18.5	25.4	18.4	8.6	7.0	40.6	1.41	0.59	219
Fresh tubers, Colombia	36.2	2.8	3.0	2.5	0.8	90.9			310
Fresh tubers, Tanzania	32.1	3.9	4.9	4.8	1.0	85.4			170
Fresh tubers, sweet variety, Nigeria	31.9	2.4	2.0	2.9	0.7	92.0	0.14	0.02	374
Fresh tubers, sweet variety, peeled, Nigeria	28.5	1.7	1.6	5.2	0.7	90.8	0.10	0.04	374
Fresh peelings, sweet variety, Nigeria	27.9	5.6	10.3	4.4	1.4	78.3			374
Fresh tubers, bitter variety, Nigeria	31.9	2.7	3.1	2.7	0.5	91.0			374
Fresh tubers, bitter variety, peeled, Nigeria	28.5	2.6	0.4	2.4	0.5	94.1			374
Fresh peelings, bitter variety, Nigeria	27.9	5.3	21.0	5.9	1.2	66.6			374
Cassava pomace (pulp), sun-dried, Cuba	83.5	2.2	26.9	3.4	0.6	66.9	0.68	0.05	494
Cassava, seed-oil meal, Congo	89.1	2.5	5.5	2.6	0.3	89.1			499

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Leaves	Sheep	57.0	39.0	54.0	71.0	2.19	219
Tubers	Sheep	0.0	53.0	51.0	90.0	2.92	170
Seed-oil meal	Pigs	67.5	74.2	27.6	98.7	3.82	499

E15 *Maranta arundinacea* L.

Herb with slender many-branched stems up to 1.5 m high and with leaves up to 25 cm long and 7-8 cm broad. Native to South America, it is grown in the tropics for its roots, from which a high-quality starch is extracted. The residue after the starch has been washed out from the crushed rhizomes is called bittie. In the process two fractions of bittie are obtained — coarse and fine. Fine bittie can be used as pig feed, and coarse bittie is more suitable for cattle.



Maranta arundinacea

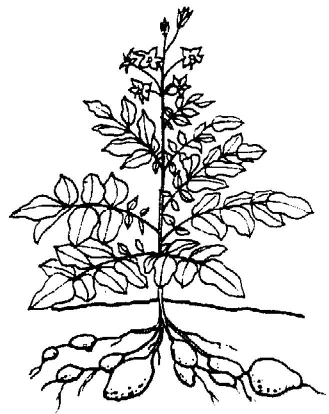
	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Coarse bittie, St. Vincent, W.I.	87.6	5.3	3.8	3.3	1.8	85.8			191
Fine bittie, St. Vincent, W.I.	87.9	2.9	13.4	3.1	0.8	79.8	0.36	0.19	191

E16 *Polymnia edulis* Wedd.

Yacon strawberry

Annual herbaceous plant, native to South America, cultivated for its tubers. The aerial part remains green for a long time. The tubers can be kept for only a few days, but they can be ensiled.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, Italy	16.8	17.1	10.0	16.0	7.4	49.5			88
Fresh stems, Italy	18.3	11.4	26.9	10.2	2.3	49.2			88
Fresh tubers, peeled, Italy	30.5	7.3	5.7	6.7	0.4	79.9			88



Solanum tuberosum

E17 *Solanum tuberosum* L.

Potato oı Irish potato

Useful reference: 511

Herbaceous plant with underground tubers and a weak pubescent or glabrate stem that can be 1 m high. Originated in the Andes, but is now cultivated all over the world except in the humid tropics.

Surplus and cull potatoes, either raw or after cooking (the water should be discarded), are suitable for most classes of livestock. Raw potatoes are not very palatable and have a laxative effect. They should therefore be introduced gradually. To get the most value from the starch, the potatoes should be boiled or steamed. Potatoes may get stuck in the gullet, but this risk can be minimized if the potatoes are fed from low troughs or mashed. Potato sprouts contain an alkaloid, solanine, so it is advisable to remove the sprouts before the potatoes are fed to pigs or poultry. Frozen or dirty potatoes should never be used as feed. Dairy cows can receive up to 15 kg of raw potato a day and beef animals up to 20 kg a day. Pigs are usually given only cooked potatoes, which are efficiently used by fattening and breeding animals; they can be fed up to 6 kg a day. Potatoes produce a firm pork. Cooked potatoes can be used for poultry, to which they have been fed successfully in proportions of up to 40% of the total ration. Potato tubers can be chopped with forage and ensiled. The heat generated during the fermentation is sufficient to cook the potatoes.

The haulm can be ensiled for feeding to cattle. If cattle are given no more than 20 kg a day, it is a good feed that will in no way impair health.

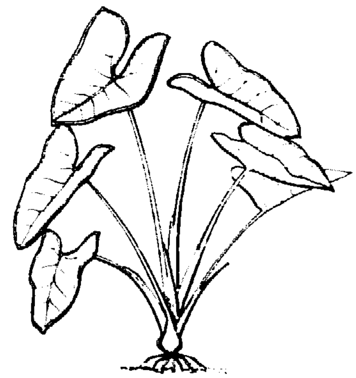
		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Leaf meal, India	91.2	17.5	39.1	10.8	6.4	26.2	1.39	0.14	96
Haulm	23.0	10.9	27.0	13.5	4.3	44.3			512
Silage of haulm	25.0	12.8	17.6	22.4	10.8	36.4			512
Fresh tubers, Israel	20.4	10.3	2.0	5.4	0.5	81.8	0.10	0.25	365
Fresh tubers, Chile	24.1	12.1	3.9	5.0	0.9	78.1	0.10	0.20	315
Fresh peelings	21.2	9.9	3.3	6.1	0.5	80.2			512

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Haulm	Sheep	44.0	35.5	20.0	59.8	1.58	512
Silage of haulm	Sheep	37.5	38.6	44.4	54.9	1.55	512
Fresh tubers	Sheep	51.0	50.0	50.0	90.0	2.95	365
Peelings	Pigs	76.2	71.4	0.0	96.4	3.61	512

E18 *Xanthosoma sagittifolium* Schott

Tannia or new cocoyam

The New World analogue of *Colocasia* (see E5), from which it can be distinguished by its darker leaves and its unjoined basal lobes. The trunk can be up to 1.5 m high and the leaves are large. It produces solid bulbs in the form of an underground stem. The roots can be fed cooked to animals, particularly pigs. Cattle, sheep and goats like the leaves, which are unusually nutritious for leaves of a root crop and compare favourably with good pasture.



Xanthosoma sagittifolium

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Fresh leaves, Trinidad	16.0	22.9	10.0	14.6	7.2	45.3	1.78	0.64	117
Fresh stems, Trinidad	5.8	13.0	15.6	21.4	2.4	47.6			117
Fresh tubers, Trinidad	31.5	6.9	2.6	4.2	0.2	86.1	0.19	0.20	117
Fresh tubers, peeled, Trinidad	24.1	5.9	1.3	4.9	0.1	87.8			117
Fresh peelings, Trinidad	29.5	8.2	11.4	8.5	1.3	70.6			117

F. Cereals

Cereal grains are less important in tropical areas than in temperate areas, as few cereals are suited to tropical climates and the limited production is largely used for human consumption. However, the introduction of high-energy feeding systems is gradually changing the picture, and the new high-yielding varieties are creating in some cases a surplus of grain that is being used to feed animals. Cereal grains are essentially energy concentrates and natural supplements to protein-rich feeds. Their protein is mostly deficient in lysine and of low or moderate biological value. This is of no importance when they are fed to ruminants, but necessitates careful formulation of rations for monogastric animals. The relative feeding value of different cereal grains depends on a variety of factors. The most important are digestibility, fibre content and lysine content, which depend on the type of grain, as well as the content of tannin (cultivar influence) and of hydrocolloids (maturity influence), which affects the rate of gain.

F1 Millets

Millet is the name applied to annual warm-season grasses with small edible seeds which botanically are widely different. The more important are listed below, and all are described in Chapter A.

1. *Echinochloa crusgalli* var. *crusgalli* (L.) Beauv. (*E. frumentacea*)
   Japanese millet, barnyard millet, chiwaga
2. *Eleusine coracana* (L.) Gaertn.
   Finger millet, African millet, Indian millet, rupuko, ragi
3. *Panicum miliaceum* L.
   Proso, broomcorn millet, hog millet, Indian buffalo grass
4. *Paspalum scrobiculatum* L. (*P. scrobiculatum* var. *frumentaceum* Stapf)
   Scrobic, koda, ditch millet
5. *Pennisetum americanum* (L.) Leeke [*P. glaucum* (L.) R. Br. *sens. Amer. auct.*]
   Bulrush millet, cattail millet, pearl millet, Indian millet, horse millet, bajra

6. *Setaria italica* (L.) Beauv.
Foxtail millet, Boer millet, Nunbank setaria

It should be noted that sorghum is sometimes erroneously referred to as millet.

The heads of bulrush millet and foxtail millet are rather dense cylindrical spikes, those of finger millet and scrobic are racemes, and the other millets bear panicles. The seeds, except for those of bulrush millet, remain enclosed in the hulls after threshing.

Use. Although the chemical composition varies, all millets are used similarly. As the seeds are hard, they should be ground or crushed before being fed to cattle and hogs; however, whole seeds or unthreshed bundles can be fed to poultry, although whole seeds are about 5% less digestible for poultry than ground seeds are. Millets are relished by all kinds of livestock. If maize is available, a mixture of millet and maize generally performs better in pigs and poultry diets than either alone. Millet not merely improves weight gains and feed conversion, but also tends to produce a whiter, firmer fat in pigs than is obtained with maize alone. Bulrush millet, which retains the hulls after threshing, should be finely ground as the hard hulls will otherwise splinter into sharp fibres, which can cause internal irritation. When millet is the only grain used for feeding, the performance is generally somewhat lower than with maize, for instance.

Scrobic seeds are reported to cause poisoning; it seems that the husk and testa of the small-seeded varieties as well as unripe seeds can be toxic.

Finger millet is inferior in feeding value and therefore should not constitute more than 50% of the grain content of the ration. An excellent simple ration for the self-feeding of pigs is the following: 40% maize, 40% bulrush millet and 20% wheat pollards. Caution should be taken in feeding bulrush millet to breeding sows in the wet season, for the ergot content of bulrush millet may be dangerously high and cause lack of milk in sows.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Japanese millet, grain, Chile	90.7	8.4	5.9	6.0	3.6	76.1	0.11	0.45	315
Finger millet, grain, Zimbabwe	90.5	12.6	1.8	2.4	4.8	78.4			499
Finger millet, grain, India		10.3	3.7	3.8	1.2	81.0	0.61	0.45	379
Finger millet, hulls, India		7.1	20.8	17.6	1.9	52.6	0.86	0.46	378
Proso, grain, Chile	88.0	10.6	7.6	4.4	4.5	72.9	0.17	0.30	315
Scrobic, whole grain, India	88.4	12.0	11.3	5.0	4.8	66.9	0.57	3.21	250
Scrobic, hulled grain, India	88.3	13.1	0.5	1.1	1.5	83.1	0.40	1.37	250
Bulrush millet, grain, Ghana	90.0	8.3	1.5	1.5	5.2	83.5	0.02	0.30	372
Bulrush millet, grain, India	94.6	10.8	1.0	2.7	5.4	80.1			378
Bulrush millet, husk, India	94.2	4.9	32.7	6.8	1.2	54.4		0.15	378
Foxtail millet, grain, USA	90.0	13.4	10.0	3.6	4.6	68.4			107

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Finger millet, grain	Pigs	86.1	67.0	61.0	95.0	3.89	499
Bulrush millet, grain	Cattle	43.3	0.0	88.3	69.4	2.59	378
Bulrush millet, husk	Cattle	52.2	75.8	70.5	48.3	2.02	378

F2 *Avena sativa* L.

Oats

All of the many varieties of oats are grown in cooler, moister regions. The chemical composition may vary widely with variety, climate and fertilization. Threshed oats remain enclosed in the hulls, leaving the chaffs (glumes) on the straw. A by-product of the milling of oats for human consumption is oat-mill feed, which contains mainly hulls and fragments of the endosperm.

The feeding value is inversely related to the hull content, which can be approximated from the thousand-kernel weight. There is a great variation in the proportion of hulls in oats and consequently in their feeding value. The hulls are of limited value in animal feed and have practically no value for cattle. Oat-mill feed is also a low-protein roughage and can to an extent replace hay in the ration. Coarsely ground oat hulls and oat feed have been reported to prevent gastric ulcers in swine. Oat grain should not be used as feed for three or four months after harvest as it needs to be properly dried. Oats can be fed to all farm animals. For pigs and poultry, ground oats have a considerably higher feed value than whole oats. Hulled oats are more palatable to cattle and older pigs, but it is generally not economical to hull the grain before feeding. The high fibre content limits the use of oats in pig and poultry rations. Usually not more than 25% oats is included in rations for growing pigs, whereas the level in diets for brood sows is generally restricted to about 40%. For poultry the fibre content of oats can be reduced by clipping the awns and pointed tips. Up to 30% ground oats of good quality has been used in rations for growing chickens and up to 50% in rations for laying hens. It is usually advantageous to mix oats with other grains.

The rich magnesium content of oats helps prevent perosis in chickens. Finely ground oats with skim milk make a satisfactory ration for table chickens during the final three or four weeks.

Oats are preferably crushed or rolled before being fed to stock. Crushed oats are excellent for ruminants; they are the standard cereal in horse feeds, but contain too much fibre to be the chief concentrate in pig rations.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Grain with hulls, Chile	86.1	11.7	16.0	2.9	6.6	62.8	0.15	0.23	315
Grain, hulled, Chile	89.3	11.7	11.1	3.5	7.6	66.1	0.13	0.31	315
Hulls, Chile	89.6	3.8	37.0	7.0	1.3	50.9	0.45	0.07	315
Oat-mill feed, United Kingdom	92.0	6.0	30.4	7.0	1.8	54.8			3

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Grain, hulled	Sheep	78.0	37.0	82.0	83.0	3.01	315

F3 *Avena byzantina* K. Koch

Red oat or Algerian oat

Annual grass sometimes cultivated for grain. Adapted to warmer climates than common oats and more resistant to drought.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Grain, Chile	89.3	11.4	13.9	4.0	6.5	64.2	0.09	0.51	315

F4 *Chenopodium quinoa* Willd.

Quinua

Chenopodium pallidicaule **Aellen**

Cañihua

Annual herb 1-2 m tall that matures in five to six months. Important pseudocereals: plants that are not grasses but produce small white, red or black seeds mainly used in making bread and similar food products. Grown in the Andes at altitudes where maize will not grow. The chemical composition of the two species is approximately the same.

In poultry-feeding trials, chicks fed a ration containing cooked quinua made equal gains to those receiving maize and skim milk, whereas rations containing uncooked quinua depressed the growth rate in both chickens and swine owing to the presence of bitter-tasting saponins in the seed coat. Saponins can be removed from the grain by repeated thorough washing, a process that can be shortened by adding lime to the water. Cooking also helps remove both the bitter taste and the toxic effects.

Sajama, a Bolivian variety, is practically free of saponins. The leaves and stalks can be fed to ruminants, and the chaff and gleanings from threshing are generally fed to pigs.

Chenopodium quinoa

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Grain	90.6	16.9	3.9	2.8	8.8	67.6			115

F5 *Digitaria exilis* Stapf

Acha or hungry rice

The grain from this West African cereal cultivated in poor sandy soils is used mostly for human consumption. The grain can also be used efficiently for all classes of livestock. Of interest as a feed for monograstric animals because of its high methionine content.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Grain, Ivory Coast	88.6	7.4	7.2	10.2	3.4	71.8	0.08	0.32	345
Grain, Nigeria	85.3	7.4	0.4	2.7	1.3	88.2			374

F6 *Hordeum vulgare* L. (*H. sativum* Pers.)

Barley

A cereal with about the same distribution as wheat but far less important than wheat in warmer countries because it never enters into international trade to the same extent. Barley is a hard grain that should be crushed or ground for all animals, as it will otherwise pass through the alimentary tract largely undigested. Because of its fibrous hull, it has less value than maize, for example. Barley can, however, be ground and sifted according to particle size. A No. 8 screen divides ground barley into two fractions, the finer containing less than 3% fibre and the coarser about 11%. The finer fraction is more suitable for pigs and poultry than whole ground barley. When fed to poultry, the awns should be removed, as they are hard and may cause irritation.

Barley that is harvested early or matures too rapidly during hot dry weather is rich in viscous substances which may cause sticky droppings and a poor performance in poultry. Ruminants fed large quantities of such barley may become bloated.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Grain, Chile	89.5	10.3	6.2	3.5	2.4	77.6	0.08	0.29	315
Grain, Israel	89.7	12.0	5.2	6.1	2.0	74.7	0.06	0.42	365
Bran, Israel	88.9	13.4	11.2	4.2	3.3	67.9	0.33	0.67	365

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Grain	Sheep	74.0	42.0	66.0	92.0	3.06	365
Bran	Sheep	70.0	35.0	89.0	80.0	2.74	365

F7 *Oryza sativa* L.

Rice

Useful references: 152, 453

Of the many varieties, swamp rice, which requires flooding for two to three months during its growth, is the most important. Mountain, or upland, rice requires less irrigation. After threshing, the rough rice is transported to mills for processing into white rice (polished rice) through a series of operations that free it from the hull, germ and bran. In many countries the processing of rice for local use is still carried out in one-stage mills. The by-product of this simplest form of processing is a mixture of hulls and bran that seldom reaches the market as it is usually returned to the rice grower. In large-scale mills the rough rice undergoes several processes: cleaning, parboiling, hulling, pearling, polishing and grading.

The cleaning process removes all extraneous matter, such as "dead" grains, stones and stalks. For certain varieties it is necessary to parboil (steep) the cleaned rice in hot water for a time to facilitate removal of the hull and improve the keeping quality of the grain. This process also improves the thiamine content of the grain. There are several methods of removing the hull. Hulled rice is commonly called brown rice. After hulling, the germ and outer bran are removed in a set of huller reels and pearling cones in which the waxy cuticle is scoured off by the friction between the high-speed abrasive cone and its casing. The resultant bran meal is propelled through meshes of wirecloth and collected. The milling space between the cone and the casing is adjustable so that the milling rate can be varied by raising or lowering the cone. In most mills the rice passes through several cones, each with a higher milling rate. The brans from the different settings are usually mixed into one product. For a finer appearance, rice from the pearler is passed through polishers. These machines are similar to pearling cones except that they contain a drum covered with strops of hide rather than an abrasive cone. In this process a part of the starchy kernel (endosperm) is removed. If inner bran layers are included, the product is called fine bran, or pollard. The mixture of whole and broken rice from the polishers is separated in sieves and then remixed in proportions corresponding to the standard at which the rice is to be sold. The percentage of by-products depends on milling rate, type of rice and other factors. The following figures give an approximate idea of the proportions: hulls, 20%; bran, 10%; polishings, 3%; broken rice, 1-17%; polished rice, 50-66%.

Uses

Rough rice (paddy or padi). Rice grains in their hulls are very hard and abrasive and must therefore be ground before they are used as animal feed. They are seldom used owing to their high cost. They have been used, however, to replace maize in cattle and pig rations without ill effects, although feed conversion was somewhat depressed in all cases. For pigs, rough rice can be used to best advantage as a replacement for not more than 50% of the maize in the ration. For laying hens, rough rice gives good results when it constitutes 20-30% of the diet. The feeding of mouldy rice should be avoided.

Brown rice (cargo rice). Dehulled rice that retains the bran coating is sometimes used as feed. Usually ground and sold as "rice meal," it can be fed to all types of animals; it is superior to rough rice as it contains less fibre and silica, and it is richer in protein and vitamins than polished rice.

Broken rice (chits, brewer's rice) and polished rice (milled rice). The broken rice separated out after the polishing stage has the same chemical composition as polished rice. There is seldom any surplus of broken rice available for feeding, as much of it is remixed with the whole grains and sold as low-grade rice. It is also sold to the brewing industry for mixing with barley. In some countries it is used for the production of arrak or as the raw material for rice flour.

Broken rice is a palatable, energy-rich and easily used feed. It is used for all classes of livestock, but its high energy value and low fibre content make it especially valuable in rations for growing chickens. Polished rice is seldom used as animal feed because of its high price, but it can be fed in the same way as broken rice.

Rice hulls (husks, chaff). Rice hulls are used in some countries for poultry litter that can later be fed to ruminants (see feed information summary I21). Numerous publications on uses of rice hulls attest to the many attempts to solve the problem of disposing of this by-product. It can be used in animal feeding in the following ways:

1. *As raw rice hulls.* Low-quality roughages like ground rice hulls can be included in small amounts (up to 15%) in high-concentrate diets for feedlot cattle to help furnish bulk, stimulate appetite and decrease incidence of liver abscesses. In areas with a shortage of roughage, ground rice hulls can be used in place of straw or advantageously as a partial replacement for it. The addition of ground rice hulls has been found in some cases to increase the feed intake.

2. *As ammoniated rice hulls.* A process developed for making livestock feed from hulls includes the addition of monocalcium phosphate, removal of silica, ammoniation under pressure and toasting. Ammoniated rice hulls have been used in proportions of up to 40% of the total ration for sheep, without digestive or mastication problems.

3. *Together with bran and polishings.* See the feed information summary for rice mill feed on page 335.

Rice bran. The bran fraction is 14-18% oil. This oil can be extracted from the bran to avoid the problem of rancidity during storage caused by the presence of a lipolytic enzyme that becomes active when the bran is separated from the rice and rapidly increases the free fatty acid content. The free fatty acid content of bran from parboiled rice is below 3% immediately after milling, but increases at the rate of about 1% per hour. Apart from extraction of the oil, the rancidity process can be delayed by heating or drying immediately after milling. Heating to 100°C for four or five minutes with live steam is sufficient to retard the increase in free fatty acids. The rice bran can also be heated dry if spread out on trays at 200°C for ten minutes. The same effect can be obtained by reducing the moisture content to below 4%. Most chemical inhibitors are ineffective.

Rice bran is the most important rice by-product. It is a good source of B-vitamins and is fairly palatable to farm animals. The oil has a marked softening effect on body fat and on the butterfat in milk. With attention to the oil content, rice bran is a valuable feed for all classes of livestock. The maximum amount advisable for cattle is about 40% of the total ration. For pigs, rice bran should not exceed 30-40% of the total ration to avoid soft pork; in the final weeks of fattening, lower levels must be used. Up to 25% can be included in poultry rations; double that amount has been used successfully in experiments. Rice bran that has not been defatted is a useful binder in mixed feeds. De-oiled rice bran can be used at higher levels than ordinary rice bran. Rice bran is often adulterated with rice hulls, as it should have a crude fibre content of 10-15%. The product containing large amounts of hulls should be sold under the name "rice mill feed," which is much inferior to rice bran.

Rice polishings. Polishings present the same storage problems as rice bran. Polishings have a wider use than rice bran because of their lower fibre content. They can be used in poultry and pig rations, but only in small amounts for piglets as they may cause scour. Like rice bran, polishings should be limited in the diet during the final weeks of fattening to avoid oily carcasses. Up to 5 kg per day have been fed to dairy cows without harmful effects or changes in production.

Rice pollards. This mixture of bran and polishing is used in the same way and with the same limitations as rice bran.

Rice mill feed. A mixture of all the by-products obtained in the milling of rice, it contains approximately 60% hulls, 35% bran and 5% polishings. The offal obtained from one-stage mills is of similar composition and is often erroneously called "rice bran." Production of rice mill feed in multistage mills is somewhat cheaper than separate production of the ingredients. The suitability of rice mill feed for animals has been well established. In countries where the use of rice hulls as animal feed is legally allowed, up to 75% of the hay can be replaced by rice mill feed with good results.

	DM	As % of dry matter CP	CF	Ash	EE	NFE	Ca	P	Ref.
Rough rice, Guyana	86.9	11.9	11.8	5.2	1.7	69.4			117
Rough rice, India		7.8	11.9	9.3	1.2	69.8	0.11	0.29	436
Rough rice, USA	89.5	9.3	9.3	4.5	1.5	75.4			161
Brown rice, Philippines		7.6	0.9	1.5	1.6	88.4			218
Brown rice, Viet Nam		10.8	1.5	1.0	1.3	85.4			218
Polished rice, Nigeria	90.1	9.1	0.3	0.6	0.1	89.9			374
Polished rice, Iraq	87.5	7.9	1.8	1.4	1.8	87.1	0.05	0.32	182
Polished rice, parboiled, Malaysia	87.4	7.2	0.2	0.9	0.3	91.4	0.13	0.16	292
Hulls, Malaysia	87.0	4.3	30.0	14.0	0.8	50.9	0.21	0.07	292
Hulls, Egypt	89.9	3.8	43.9	21.6	1.7	29.0			1
Hulls, ammoniated, USA	92.0	11.3	48.6	20.8	1.0	18.3	0.16	0.21	350
Bran, Iraq	91.1	12.4	10.2	12.8	18.3	46.3	0.29		182
Bran, Philippines	88.8	10.6	18.9	13.8	10.6	46.1			300
Bran, Guyana	88.7	13.2	10.1	28.1	5.1	43.5			117
Polishings, USA		10.8	1.1	5.8	9.7	72.6			55
Rice pollards, Tanzania	90.8	15.2	7.2	8.7	19.1	49.8	0.06	1.55	355
Rice pollards, Philippines	87.7	12.5	9.0	11.3	13.3	53.9			300
Rice mill feed, Nigeria	89.0	7.6	36.6	11.3	7.6	36.9	0.09	0.39	374
Rice mill feed, Zimbabwe	94.6	7.7	27.7	15.0	4.2	45.4			499
Rice germ, Spain		24.1	10.5	9.8	19.3	36.3			518
Distiller's spent rice, Malaysia	38.0	8.9	2.1	10.5	3.4	75.1			292
Refuse from starch manufacture	91.7	9.5	2.5	1.6	1.0	85.4			1

	Animal	Digestibility (%) CP	CF	EE	NFE	ME	Ref.
Rough grain	Sheep	76.0	23.0	76.0	91.0	2.96	161
Polished grain	Sheep	86.6	46.7	50.0	97.2	3.47	512
Hulls	Sheep	7.4	21.4	48.0	42.0	0.85	1
Mill feed	Cattle	64.5	12.8	54.7	77.6	1.80	499
Bran	Pigs	68.9	51.6	85.8	79.2	3.00	300
Pollards	Pigs	79.5	50.6	88.9	85.0	3.58	300

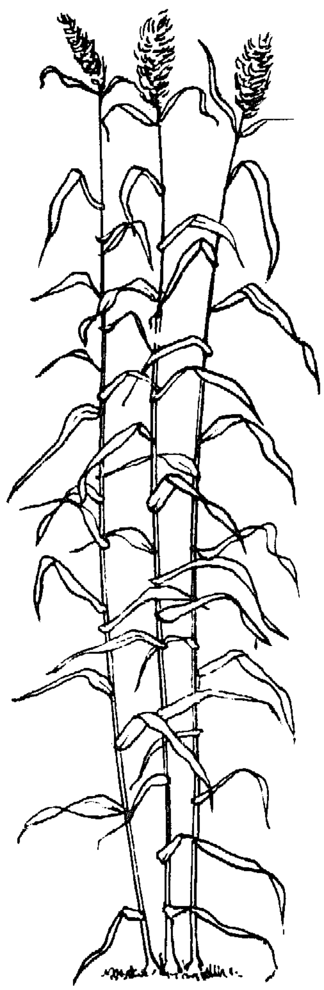
F8 *Secale cereale* L.

Rye

Rye grain is seldom used in tropical and subtropical countries. As it is less palatable than other grains, it should not be fed alone. The level of inclusion in pig rations, for example, is 10-20%. It should not be fed to young animals as it may cause digestive disorders.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Grain, Israel	90.0	13.7	2.6	2.2	1.9	79.6	0.04	0.41	365
Bran, Israel	88.2	17.0	7.7	4.9	3.0	67.4	0.11	0.84	365

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Grain	Sheep	79.0	50.0	65.0	92.0	3.27	365
Bran	Sheep	83.0	33.0	77.0	74.0	2.69	365



Sorghum bicolor

F9 *Sorghum bicolor* (L.) Moench (*S. vulgare* Pers.)

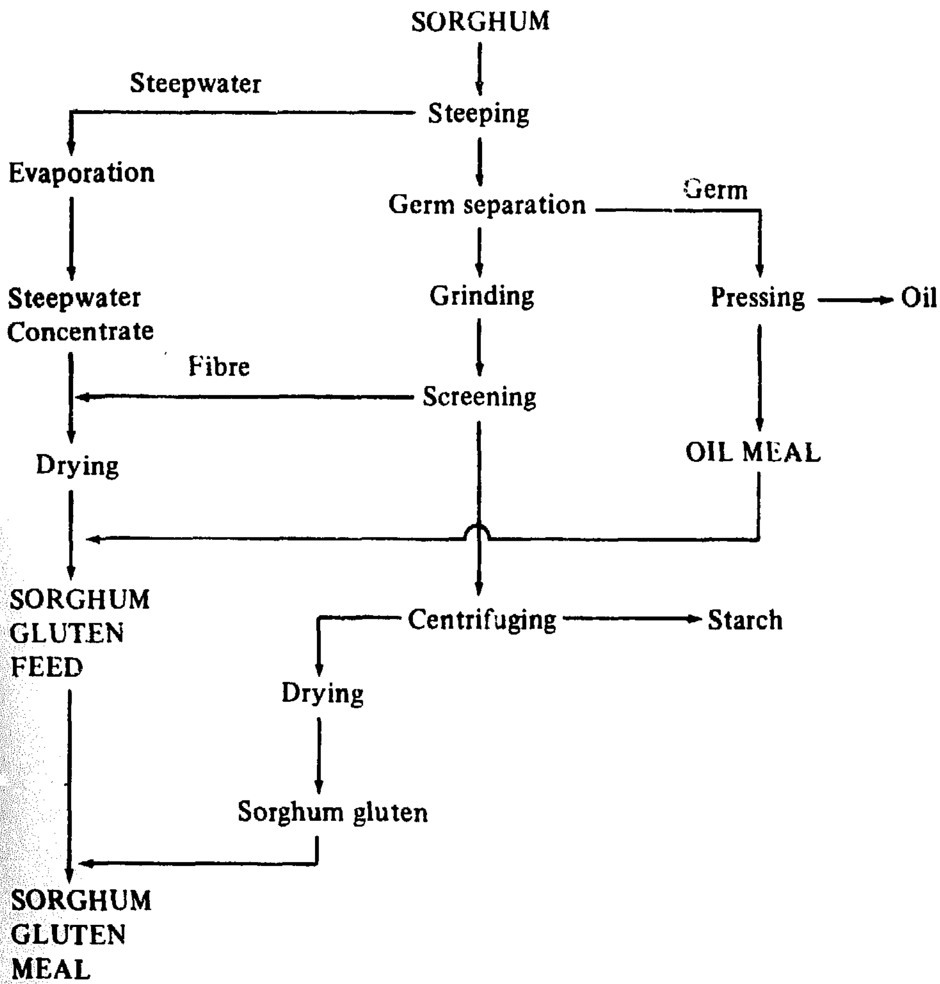
Guinea corn, sorghum, dari, kaffir, feterita, durra, milo or hegari

Useful reference: 460

Sorghums are grown for grain and also for forage in areas with inadequate rainfall for satisfactory maize cropping. There are two general types: the sweet sorghums, which have stems filled with a sweet juice, and the grain sorghums, which usually have pithy stems. Sweet sorghums are grown for forage rather than grain. There are many varieties of grain sorghum, but the composition of their grain does not differ enough to affect significantly their feed qualities. All varieties are annual maizelike grasses more than 2 m high. Sorghum requires similar soil conditions to maize but can grow in drier climates.

Grain. When properly supplemented, sorghum grains are excellent for all classes of livestock. The grains have to be processed before being fed to cattle, else a large proportion of the grains will be swallowed whole and the waxy bran covering the grain will make digestion difficult. Grinding is the simplest, least expensive method of preparing sorghum grain for cattle; other methods include dry-rolling, steam-rolling, flaking and popping. All methods produce end products with different degrees of digestibility. Sheep can be given whole sorghum grains as they masticate them more thoroughly. Whole grain can also be fed to pigs and poultry, but cracked or ground grain gives somewhat better feed efficiency, especially with small-seeded varieties or very dry grains. For best results the grain must be ground only moderately fine, as too finely ground grain decreases consumption. When sorghum grain is replacing maize, it must be borne in mind that sorghum lacks carotene and should therefore be supplemented with about 3% dried green feed. Sorghum has the disadvantage of tending to cause constipation.

Starch-extracted grain. When the starch is extracted from sorghum grain, the by-products from this process, gluten feed and gluten meal, can be used as feeds. The following is a flow chart of the normal process:



Sorghum gluten feed. It has a bitter taste and should be mixed with a more palatable feedstuff such as molasses. In cattle feed it can constitute up to one third of the concentrate portion.

Sorghum gluten meal. Unidentified deficiencies make sorghum gluten meal unsuitable as poultry feed, and it should not exceed 4% of the total ration for pigs. A satisfactory supplement for cattle can be obtained by mixing equal quantities of sorghum gluten meal and cottonseed meal.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Sorghum grain, Israel	89.0	10.9	2.1	3.3	3.9	79.8	0.19	0.20	365
Sorghum grain, USA	90.7	13.9	1.7	1.8	3.5	79.1			39
Hegari grain, Thailand	87.7	11.0	1.8	1.5	0.8	84.9			56
Black kaffir grain, USA	90.4	15.6	1.8	2.0	3.9	76.7			39
Red kaffir grain, USA	90.4	13.3	1.7	1.9	3.5	79.6			39
Feterita grain, USA	90.4	15.5	1.7	1.9	3.2	77.7			39
Dari grain	88.9	10.8	2.1	2.7	4.3	80.1			512
Sorghum bran, USA	88.0	8.9	8.6	2.4	5.5	74.6			198
Sorghum hominy feed, USA	89.0	11.2	3.8	2.7	6.5	75.8			198
Sorghum gluten feed, USA	89.5	24.6	9.5	8.2	4.9	52.8			500
Sorghum gluten meal, USA	89.3	46.9	5.3	3.8	7.2	36.8			500
Sorghum oil meal, USA	98.1	16.6	13.2	1.6	7.8	60.8			500

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Grain	Sheep	54.0	64.0	84.0	83.0	2.96	365
Grain	Pigs	77.0	64.0	62.0	90.0	3.61	499

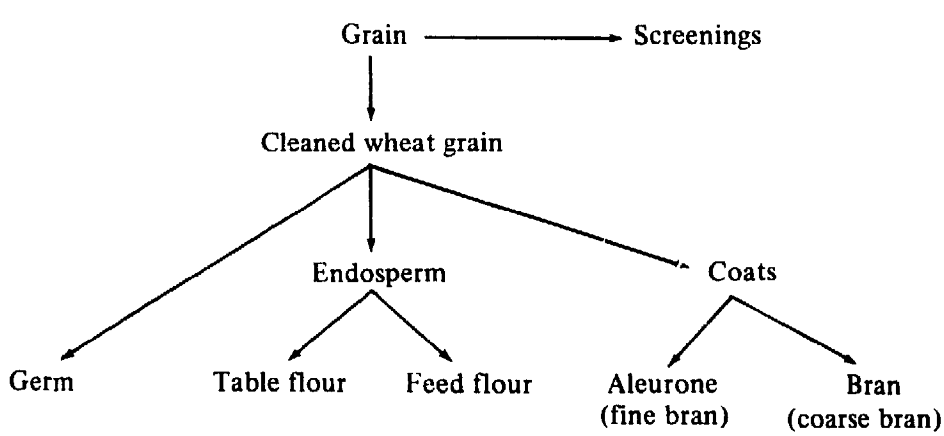
F10 *Triticum aestivum* L. (*T. vulgare* Vill.; *T. sativum* Lam.)

Wheat

Useful reference: 236

A cereal widely cultivated in temperate countries and in cooler parts of tropical countries. Where wheat is not grown, it is usually imported for milling inside the country, as the importing of flour rather than wheat deprives the feed industry of the by-products on which it is based in many countries. The flowering head of wheat consists of a compact arrangement of spikelets around a central stalk. In threshing, the grain — unlike that of barley and oats — comes away naked from the husk. The wheat endosperm is covered with two kinds of fibrous coating: a coarser outer layer, called bran, and under it a less fibrous aleurone layer. The germ is at the base of the kernel. Milling separates the starchy endosperm from the rest of the grain. Whole wheat yields about 70% white flour and 30% offal, consisting of bran, aleurone and germ. In milling, wheat grain passes through about twenty-four processes before it becomes table flour. The more important of these are the breaker rolls, which rupture the bran so that bran and germ separate from the endosperm; the scalpers, which separate aleurone and pieces of the endosperm from the bran; and the flour bolters, which separate fibrous particles from the table flour.

The terms used to designate the various by-products differ from country to country and are often poorly defined. The names also change with the type of wheat used in milling. The following diagram shows how the different by-products are produced.



USES

Wheat grain. Wheat is not usually fed to animals because of its high price; however, unmarketable grain may be used for all classes of livestock. Whole wheat can only be fed to poultry over two months of age; for other animals it should be crushed, especially if it is from varieties with small hard kernels. If wheat is too finely ground, it will form pasty and very indigestible lumps in the mouth; large amounts (over 3 kg per day) can be fatal to horses. In concentrates, wheat can be included up to 25% for cattle, up to 30% for growing pigs, up to 50% for fattening pigs and up to 50% for poultry. Fresh wheat should not be fed to poultry. At these high rates there are definite advantages in including other cereals as well.

Screenings. This product obtained from the initial cleaning of the incoming wheat consists of weak seeds and undersized wheat grains. It is usually finely ground and mixed with other wheat offals rather than used separately.

Wheat-germ meal. This valuable feed is rich in digestible protein and low in fibre, and contains about 10% oil that is rich in vitamin E. If kept for a few days it is likely to become rancid. Sometimes the oil is extracted, yielding wheat-germ oil meal. Usually the wheat germ is mixed with the shorts to give a product called middlings.

Feed flour. This is the residue of the endosperm from the production of fine white table flour with low extraction (60-65%). It contains mainly the starchy portion of the endosperm and also some of the more nutritious aleurone layer. Seldom used alone, it is mixed with other offals to give wheat shorts and middlings (see below).

Bran. There is no sharp difference between fine bran and coarse bran. The bran fractions contain most of the vitamins and protein of the wheat grain. If screenings have been added to the bran, the product is called standard bran. Good bran should have a fair coating of flour and be in the form of large, dry and nonadherent flakes. Bran is a bulky feed that can be used to lighten dense, heavy feed mixtures. It has a slightly laxative effect, partly because the bran fibre is only modestly digested. Coarse bran is excellent for horses and cattle, which can be given up to 2 kg per day. Fine bran can be fed to horses and cattle in amounts up to 2 kg per day, as well as to pigs and poultry. It can constitute up to 35% of the brood sow diet. Young pigs should not be fed bran. To lighten poultry mashes, up to 15% may be included.

Shorts. This is a mixture of fine bran and feed flour in proportions that vary according to the type (extraction rate) of table flour the mill produces. It is used in the same way as wheat middlings.

Wheat middlings. This mixture of shorts and germ is the most common by-product of flour mills. If the proportion of ingredients is retained, middlings are often called mill-run or wheat pollard. Both shorts and middlings can be used for all classes of livestock. They are common — often up to 40% — in concentrates for cattle. Owing to their bulkiness it is difficult to formulate a satisfactory ration based on middlings for growing and fattening pigs. It has sometimes been found economical to include up to 45% middlings, but a more normal level of inclusion is 15-25%. Some middlings can be advantageously included in feed for layers, but practical considerations usually limit the content to less than 10%. Wheat middlings are reported to contain a factor that reduces the incidence and severity of gizzard erosion. Steam pelleting of wheat middlings increases their naturally low metabolizable energy and poor protein utilization in poultry diets as much as 30% and 17%, respectively, by rupturing the aleurone cells and exposing the content of the cells to attack by digestive enzymes.

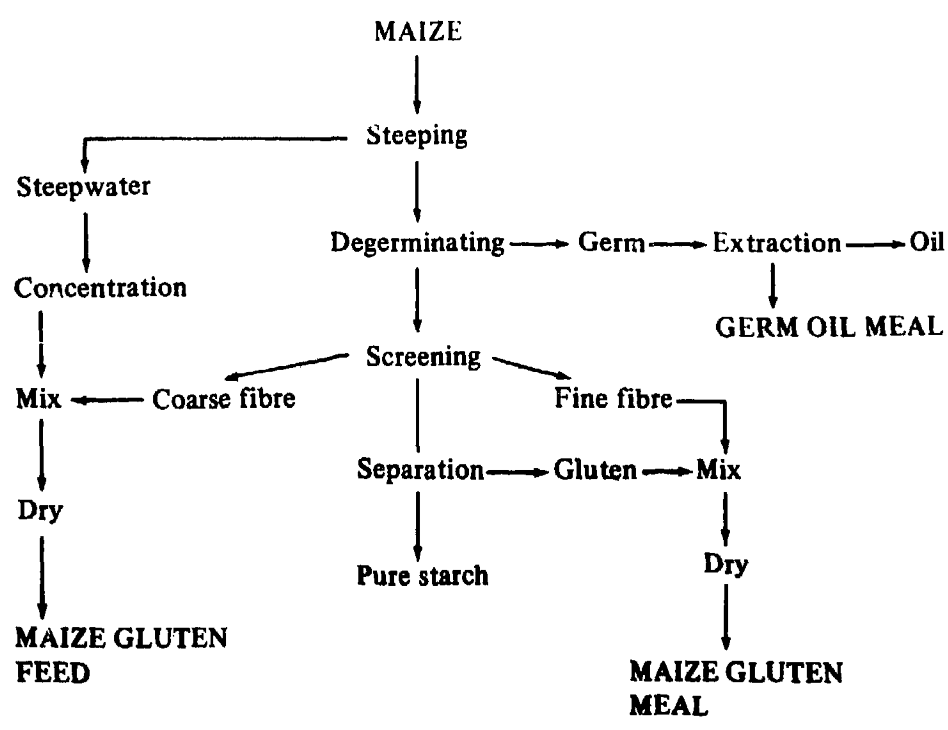
		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Grain, Iraq	87.6	13.9	3.1	1.9	1.7	79.4	0.07		182
Grain, Israel	89.2	13.5	3.3	3.3	2.1	77.8	0.03	0.48	365
Screenings, Iraq	92.7	16.1	4.6	15.0	4.2	60.1			182
Germ, Iraq	91.6	30.2	1.7	4.3	8.1	55.7			182
Feed flour, Iraq	88.9	11.8	0.6	0.5	1.7	85.4			182
Bran, Tanzania	87.6	16.9	11.3	6.4	3.8	61.6			355
Middlings, Kenya		19.4	6.8	4.0	3.3	66.5			417
Middlings (80% extraction)	87.7	16.9	12.2	6.0	5.3	59.6	0.15	1.23	484
Middlings, Trinidad	87.3	20.5	9.0	5.6	5.2	59.7			117

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Grain	Sheep	78.0	40.0	72.0	92.0	3.22	365
Middlings, low extraction	Sheep	73.7	23.3	55.9	82.7	2.81	417
Middlings, high extraction	Sheep	77.0	20.0	79.0	75.0	2.60	484

F11 *Zea mays* L.

Maize, Indian corn or corn

Coarse quick-growing annual cereal grass up to 2.5 m high with long broad strap-shaped leaves, native to South America but now widely cultivated wherever the summer is long and warm enough to permit ripening of the grains. Maize cannot withstand frost. There are many varieties of maize. Flint, or round, maize and dent, or horsetooth, maize are the two varieties most commonly used for animal feed. More recent varieties are hybrid maize and high-lysine (Opaque-2) maize. All types of maize grain should be ground before feeding; even for poultry the grains must be crushed. Maize meal cannot be stored long as it is likely to become rancid, whereas dried grains have a good keeping quality. Maize is stored most economically in a trench silo; the moisture content of the fresh grain should be 30% and it should be crushed before ensiling. When maize is dry-milled to produce flour, the bran and the germ are first separated. Wet milling for the manufacture of starch or starch derivates (e.g., corn syrup) yields a number of by-products. The wet-milling process is usually carried out in accordance with the following flow diagram (ref. 435):



Alternatively, the steepwater can be evaporated and used as feed under the designation maize solubles.

Uses

Maize grain. Maize is palatable and suitable for all classes of livestock. It is rich in energy and low in fibre and minerals. Both the protein level and the biological value of the protein are low. To fully utilize the high productive value of maize, these deficiencies have to be counterbalanced by proper supplementation. Its use should be restricted only in pig feeds, because the highly unsaturated fat in maize may produce a soft fat if maize is included at high levels. The colour pigment in yellow maize, cryptozanthin, can also affect the colour of pig fat; however, this pigment is valuable in poultry diets as it gives the meat and egg yolks a desirable colour. The pigment is partly transformed into vitamin A in the animal.

Maize with a protein of higher biological value was developed in the mid-1960s. Maize contains several different types of proteins with different biological values. In ordinary maize about half of the protein is in the form of zein, a protein almost devoid of lysine. In the new high-lysine strains called Opaque-2 the ratio between the protein fractions is changed, so that zein constitutes less than 30% of the protein. The net result of this altered ratio is a higher content of lysine and tryptophan. Opaque-2 maize can therefore supply a larger part of the protein requirement in pig and poultry diets than ordinary maize can. If carcass quality is a minor consideration and exceptional performance is not required, Opaque-2 maize can be used as the only protein source for pigs, except during early growth, when soybean oil meal should be added to bring the protein level up to about 12%. Although the feed conversion rate is slightly lower, the growth rate is equal to that obtained with the ordinary 16% protein maize-soybean formula.

Another variety of maize with a higher lysine content is Floury-2, which is similar to Opaque-2 in chemical composition and likewise has soft grains.

The digestibility and palatability of maize can be increased by processing: roasting, dry rolling, flaking, etc. Flaking is the most common method. The grains are steam-cooked and then passed between rollers while still hot and soft. Flaked maize passes through the alimentary tract about 25% more rapidly and has about 5% higher digestibility; also, it is more palatable than cracked maize. Flaked maize should not be stored a long time before feeding.

Hominy feed. This by-product of dry milling consists of the bran coating and the maize germ and is palatable to all classes of farm animals. It approaches maize grain in feeding value, but it contains more fat because the germ is included and may produce soft carcasses when fed in large amounts to pigs. The optimum level in pig rations is about 20-25%. In diets for cattle and poultry it has practically the same value as maize grain. Hominy feed is often erroneously called maize bran, a name which should be reserved for bran coating without germ.

Maize-and-cob meal (ground ear-maize). This is the entire maize ear including the cobs, which comprise about 20% of the weight. If the entire maize ear including the husks is ground, the end product is called ground snapped maize. Maize-and-cob meal is valuable for full-grown ruminants, and there is almost no difference in the performance of feedlot animals receiving maize-and-cob meal and animals feeding on shelled maize. For horses, maize-and-cob meal is usually preferred to shelled maize as it is less likely to form a doughy mass in the stomach. The high content of fibre restricts the use of maize-and-cob meal in poultry diets. Pigs can tolerate 25-50% in the diet depending on age. The meal should be well dried; otherwise it is likely to mould in a hot climate.

Maize cobs. This is a low-quality roughage comparable to poor hay. It is unpalatable, and if not dried it becomes mouldy within a few days in a hot climate. Preferably it should not constitute more than half of the roughage except for feedlot cattle.

Maize gluten feed. This by-product of the wet milling of maize is suitable for all farm animals. It is most widely used for dairy cows, but it should not be fed alone as it is not very palatable. The unbalanced amino-acid composition restricts its use in poultry and pig rations. As maize gluten feed contains the colouring pigment of the grain, it is valuable in poultry rations. The maximum recommended level of maize gluten feed is 10% for growing chickens and 16% for layers, 10% for growing pigs and 16% for fattening pigs.

Maize gluten meal. Despite the unbalanced amino-acid composition of this by-product, it gives good results in pigs and poultry when mixed with soybean meal or meat meal. It is not very palatable and is mostly used for cattle.

Maize-germ oil meal (cake or maize oil-meal cake). This product is a valuable feed for all farm animals but pigs. Meal with a high fat content is likely to cause soft back fat if fed in large quantities. It should not be used as the only source of protein for poultry. Maximum recommended daily rations for cattle are 2 kg per day and for pigs 0.5 kg per day.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Maize, grain, Israel	87.0	11.0	4.6	2.0	5.5	76.8	0.01	0.32	365
Hybrid maize, grain, Zimbabwe	90.8	10.2	1.7	1.5	5.2	81.4			499
White maize, grain, Tanzania	89.0	10.6	1.9	1.3	4.8	81.4	0.02	0.36	355
Yellow maize, grain, Tanzania	87.8	12.1	1.4	1.4	5.5	79.6	0.02	0.33	355
White maize, grain, Ghana	87.0	9.1	1.7	1.3	4.2	83.7	0.01	0.30	372
Yellow maize, grain, Ghana	89.2	12.5	2.7	1.6	5.6	77.6	0.02	0.37	372
Maize-and-cob meal, South Africa		9.4	7.8	1.6	2.5	78.7	0.04	0.23	489
Cobs, India		2.1	36.5	2.8	0.8	57.8	0.05	0.06	436
Hominy feed, Israel	88.0	10.9	10.2	3.4	4.8	70.7	0.03	0.27	365
Maize gluten feed, Israel	87.6	26.6	13.2	8.4	2.3	49.5	0.20	0.21	365
Maize gluten meal, USA	91.4	48.0	4.6	2.3	2.0	43.1	0.16	0.43	350
Maize oilcake, India	95.5	19.2	8.6	1.6	9.2	61.4			96

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Grain	Sheep	76.0	57.0	91.0	94.0	3.47	365
Maize-and-cob meal	Sheep	74.0	69.1	78.4	90.3	3.23	489
Cobs	Cattle	55.0	76.0	53.0	79.0	2.74	436
Hominy feed	Sheep	66.0	34.0	81.0	81.0	2.81	365
Gluten feed	Sheep	80.0	55.0	73.0	73.0	2.62	365
Grain	Pigs	69.9	40.7	55.7	92.9	3.64	448

G. Oil-bearing seeds and oilcakes

Many varieties of seeds and fruits are cultivated for their oil content. Some are also used as animal feeds, but more commonly the residue left after removal of the oil is used for that purpose. The protein content of the residue is usually high and the carbohydrate content low. The fat content depends on the method used to remove the oil. Some seeds (e.g., cottonseed and sunflowerseed) are enclosed in a coating that must be removed before processing, else the amount of fibre in the residue will be much higher and the feed value accordingly lower. The final product, sometimes called "decorticated," is referred to as "without hulls" in this publication.

The oil can be removed from the oil-bearing material either with a solvent or by pressing. There are two types of mechanical pressing methods: hydraulic pressing and screw pressing. For hydraulic pressing the seed is ground, heated and wrapped in cloth before being placed in the press. The residual oil in the press cake is slightly higher than when a screw press is used. The screw-press method, usually called the expelling process, is continuous. The seeds are pressed by a screw through a tubular cage with a smaller pitch toward the discharge end. The pressure therefore increases as the seed mass travels through the cage and the temperature increases, causing the oil cells to rupture and thereby increasing the fluidity of the oil, so that it escapes through small openings in the cage wall. Screw pressing is the most drastic of the separation methods for the heat treatment of protein (at about 140°A); this damages the protein to an extent. The press cake usually contains 5-10% oil. If the cake is ground, the end product is called oil meal.

Solvent extraction is more thorough than pressing as it usually leaves less than 2% of the oil in the seed. The ground seed is placed in extraction pots, and the solvent is pumped in and run off. The process is repeated until the amount of residual oil in the seed makes further separation uneconomic. The solvent is recovered by distillation and used again. The residue of ground flakes, called oil meal, is first treated with steam to remove any traces of the solvent and then dried. Oil meals are less palatable than oilseed cakes and have a lower fat content, which reduces their energy value. Oilseed cakes, unlike meals, may turn rancid.

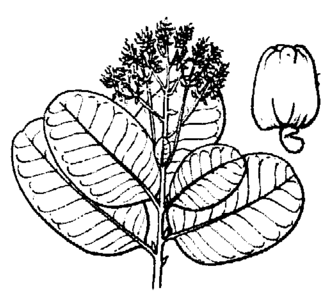
G1 *Aleurites fordii* Hemsl.

Tung tree

Useful references: 61, 286

A small tree native to China but cultivated in other countries with subtropical climates. The kernels yield a valuable drying oil, mainly used in paint and varnish. The foliage and the oilcake are unpalatable and poisonous. As the toxic elements have not been specifically identified, no detoxification process has been developed. However, tung meal has been detoxified experimentally by percolating it in ethyl alcohol for forty-eight hours, after which it is moistened and finally steamed for two hours. Supplemented with lysine, it produced good growth in chickens. The detoxified meal is unpalatable to pigs, and a maximum of 20% tung meal can be included in rations. Untreated meal is toxic and used only as fertilizer.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Oilcake with hulls, mechanically extracted, USA		25.6	42.9	5.4	6.1	20.0			220



Anacardium occidentale

G2 *Anacardium occidentale* L.

Cashew

A spreading evergreen tree that grows to 12 m in height. The cashew nut is attached to the swollen stalk, called the cashew apple, which when mature is 8 cm wide and coloured red and yellow. At harvest the cashew apple is separated from the nut and sold separately as a juicy fruit. The pericarp of the nut consists of two shells, between which there is a resinous layer containing an acrid fluid that has a corrosive effect on the skin, producing blisters on the fingers if the shells are broken manually. Before shelling, this acrid fluid must be eliminated by roasting the unshelled nut. About 30-40% of the cashew nuts produced are discarded either because of broken kernels or scorching during the roasting process. The discarded nuts contain a significant quantity of high-protein material, which is particularly useful for the feeding of monogastric animals. Cashew meal is also very high in protein and can be included without restriction in feeds for pigs; however, it may cause diarrhoea if fed in large amounts to calves and dairy cows.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Kernels, Nigeria		21.5	1.1	3.4	46.1	27.9	0.22	0.15	544
Extracted meal, Nigeria		41.6	1.6	5.5	1.0	50.3	0.51	0.70	544

G3 *Arachis hypogaea* L.

Groundnut, peanut, earthnut, monkey nut, Manila nut, Chinese nut, pindar or goober pea

Useful reference: 420

When the flowering heads of this legume have been fertilized, they turn down into the ground and the fruit matures in the soil. The fruit is a pod commonly bearing two or three kernels. Each kernel consists of two large seed-leaves (cotyledons), between which lies the germ, and the whole is covered by a thin coat (skin). The empty pod is called hull, husk or shell. The fruit can be processed either without the hull (decorticated) or with the hull (undecorticated). The oilcake from undecorticated fruits is richer in fibre and lower in protein than the decorticated cake. It is also richer in residual oil as the hulls obstruct removal. To avoid this loss, the oil is often extracted by the solvent process.

Aflatoxin. Mouldy groundnuts may contain toxic substances, and discoloured nuts with white flesh should be discarded. Aflatoxin, the most important toxin found in mouldy groundnuts, is produced by the fungus *Aspergillus flavus.* This fungus grows when the temperature is between 30° and 35°C and when the moisture content is above 9% in the kernels or above 15% in the oilcake. The attack of this fungus can be prevented, with minimum damage to the hull or kernel, by careful harvesting and by quick drying and storage in low humidity.

Whole groundnuts. "Hogging off" is the practice of allowing swine to feed on groundnuts, which they root out of the soil when turned loose in the field. This practice is not only used for cleaning up waste groundnuts after harvesting, but fields are also planted for this purpose, as it is a very cheap method of fattening pigs. It is necessary to supply the pigs with a mineral mixture that is high in salt and calcium. Ham from groundnut-fed hogs is softer and juicier than normal ham. This can be counteracted, however, by finishing the pigs on a ration containing cottonseed meal, which has the opposite effect from groundnuts. Whole groundnuts are excellent poultry feed and can constitute up to 25% of the diet.

Groundnut cake. The decorticated cake and meal are safe feeds for all classes of livestock because of their good protein balance. For mature ruminants there are no restrictions on the use of groundnut cake. The high fibre content of undecorticated cake makes it a useful corrective for cattle feeding on grass that is low in fibre.

The residual oil in groundnut cake may cause soft fat in bacon pigs; therefore, the extracted decorticated meal is preferable for pig feeding. To avoid soft body fat, the feeding of six parts milo chops or five parts maize meal for each part groundnut cake is recommended. Because of its low fibre and high protein content, decorticated groundnut meal is a valuable ingredient in poultry diets.

Skin. The skin, which constitutes about 3% of the seed weight, is a by-product of the processing of peanuts for human consumption. It has a bitter taste and can only be used in small quantities in ruminant feeds.

Hulls. The hulls amount to 20-30% of the weight of the whole pod. They are often used first as poultry litter and later as feed for ruminants. They have also been used as a carrier for molasses feeds. As they contain over 60% crude fibre, they interfere with digestion, especially of protein, unless they are fed in very small amounts.

Germ. The germ is a by-product of groundnut paste (peanut butter). Although bitter in taste, it can be included in concentrates for ruminants and pigs.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Whole nuts, Nigeria	92.9	21.7	21.1	2.7	39.1	15.4			374
Kernels, Malaysia	92.7	33.2	1.7	2.6	47.8	14.7	0.08	0.42	292
Oilcake with hulls, mechanically extracted, Uganda	90.0	33.5	25.5	6.3	10.1	24.6			69
Oil meal with hulls, solvent extracted, Uganda	92.4	34.4	27.4	4.7	2.0	31.5			512
Oil meal without hulls, solvent extracted, Israel	89.9	57.7	6.8	7.3	1.3	26.9	0.19	0.59	365
Oilcake without hulls, mechanically extracted, Tanzania	92.6	49.5	5.3	4.5	9.2	31.5	0.11	0.74	355
Oilcake without hulls, solvent extracted, Israel	92.0	55.7	8.7	8.2	7.7	19.7	0.20	0.61	365
Skins, India	17.8	12.1	7.1	16.7	46.3		0.24	0.14	436
Germ, USA	95.0	3.0	2.0	3.0	46.0	46.0			420
Hulls, Nigeria	82.3	4.9	68.4	7.4	0.6	18.7			374

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Whole nuts	Sheep	74.0	15.0	90.0	60.0	3.86	365
Kernels	Sheep	89.9	7.7	89.8	84.0	5.06	512
Oilcake, extracted	Sheep	94.0	15.0	90.0	80.0	3.25	365
Oilcake, expeller	Sheep	94.0	15.0	89.0	69.0	3.46	365

G4 *Argania spinosa* (L.) Skeels (*Sideroxylon spinosum* L.)

Useful reference: 248

Medium-sized tree cultivated in North Africa. The seeds yield an oil used for cooking. The leaves and fruit are a valuable feed for stock. The meaty part of the fruit, containing 10% protein and 7% fibre (dry matter basis), surrounds the hard brown nut. The small seeds are crushed and worked into a paste and the oil is pressed out.

Use. The greyish-green oilcake contains saponin, which does not harm ruminants and passes out with the urine; however, when given to dairy cattle, the milk will contain some saponin, which may cause diarrhoea in children. Up to 2 kg per day can be fed to beef cattle without harm.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Seeds, Morocco	94.8	9.0	6.8	2.1	71.7	10.4			49
Oilcake, mechanically extracted, Morocco	73.7	33.4	23.9	5.0	25.0	12.7			49

G5 *Brassica* spp.

Mustard

Useful reference: 97

The name "mustard" is given to various species, the most common being white mustard (*B. hirta* Moench or *Sinapis alba* L.), black mustard (*B. nigra* Koch) and Indian, or leaf, mustard (*B. juncea* Coss.). Mustard is cultivated for its seeds which yield oils and are used to make a condiment. It is occasionally grown (like rape or green manure) as a cover crop for fodder.

Toxicity. Mustard seeds contain a fixed oil (30-35%), which is usually extracted by cold pressing. Though edible, it is used mainly as an industrial oil. A second, very different oil is obtained by grinding the seeds and treating the flour with water to cause a chemical action between an enzyme and a glucoside, thereby producing an oil that is not present as such in the seeds. In black mustard the enzyme myrosinase acts on a glucoside — sinigrin — to produce a volatile, very irritating oil (from which the mustard gas used in the First World War was made). In white mustard the same enzyme acts on a different glucoside — sinalbin — to produce a less irritating oil than that of black mustard. This oil is diluted to make mustard plasters. If the oilcake is used for animal feed, the toxic substances must be evaporated by prolonged steaming (2 hours) or must be extracted. Sinigrin, being water soluble, can be extracted in the following way: the fat-free meal is heated with five parts water to 85°C for one hour and then filtered, after which the residue is washed five times with water.

Mustard meal also contains toxic substances affecting the thyroid.

Use. Detoxified mustard-oil meal has been used for all classes of livestock. Up to 1.5 kg per day can be fed to adult cattle, which also can accept up to 10% untreated mustard meal in the diet. Mustard meal should be mixed with other, more appetizing feeds. Detoxified mustard meal has also been used for poultry (9% of the ration) and pigs (20% of the ration).

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Seeds, Malaysia	91.7	23.4	8.6	5.1	46.7	16.2	0.03	0.60	292
Oilcake, mechanically extracted, Malaysia	89.8	38.5	3.5	9.9	10.7	37.4	0.05	1.11	292
Oil meal, solvent extracted	88.0	26.0	18.2	7.6	2.3	45.9			512

G6 *Brassica rapa* L. Rapifera Group (*B. campestris* L.)

Turnip rape, navette, rubsen or Polish-type rape

Brassica napus L.

Rape, colza or Argentine-type rape

Useful reference: 54

The cultivated varieties of rape are mainly varieties of *B. napus* and *B. campestris*. Both may be grown as annuals or biennials, depending on the variety and time of sowing. The plants are from 0.6 to 1 m high and have thick succulent stems and leaves, although the leaves of *B. campestris* are thinner, less succulent and greener or less glaucous. The seed contains about 40% semi-drying oil. The oil is used as salad and cooking oil or in the manufacture of margarine.

Toxicity. Rapeseed oilcake contains compounds that are potentially toxic to certain age groups or classes of livestock and poultry, but experiments in recent years have indicated numerous ways in which the meal can be used without detriment to animals. The toxic factors derive in part from glucosides, which yield toxic substances when hydrolysed enzymatically. One of these substances inhibits the uptake of iodine by the thyroid and thus causes goitre. Rapeseed may also be contaminated with mustard seed, so that the press cake will contain residual mustard oil that may be harmful. *B. campestris* meals contain a considerably smaller amount of the glucoside than *B. napus* meals.

One detoxification method involves moistening the ground seed and allowing the enzyme to hydrolyse the glucosides. After the oil has been extracted, the cake is steamed. This treatment removes most toxic factors, but the substance causing goitre remains in the cake. Other methods involve extraction of the toxic factors from the cake with hot water or ethyl alcohol. The safest method of avoiding the total effect of the toxic factors is to limit use of the oilcake. An almost glucoside-free variety has been developed (*Brassica napus* L. cv. Bronowski); the growth responses to the oilcake of this variety are reported to be equal to the results from soybean oilcake. The content of toxic constituents differs greatly between varieties and may also depend on the processing method.

Uses. Feeding trials with cattle and sheep have shown that ruminants are less susceptible than other classes of livestock to the toxic effects of rapeseed meal. Adult cattle can be given from 1 to 1.5 kg a day without detrimental effects on feed consumption, growth or milk flavour. Young or pregnant animals should be given less.

Rapeseed meal is not very palatable to sheep and therefore should not exceed 20% of their total ration.

Solvent-extracted meal can constitute up to 4% of the total ration for young pigs (up to 20 kg) and up to 10% of the total ration for market pigs (20-90 kg). It should not be used in rations for breeding stock during reproduction and lactation.

Rapeseed meal should not be used in starter rations for poultry, but it may be used to fatten birds or layers, for which the maximum desirable level is about 10% of the total ration. It should be noted that oilcakes produced by the expeller process may be low in lysine. Poultry fed rapeseed oil meal are likely to have enlarged thyroid glands; however, this condition will usually be of no economic importance if a stabilized iodine is incorporated in the diet. Some strains of layers may produce eggs with a fishy taste when they are fed rapeseed meal.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
B. campestris, seed, India		21.6	6.3	6.0	43.7	22.4	0.49	0.71	436
B. campestris, oilcake, mechanically extracted, India	87.6	36.0	10.4	9.4	12.8	31.4	0.83	1.17	96
B. campestris, oil meal, solvent extracted, Canada	92.0	44.0	10.1	7.8	1.2	36.9			54
B. campestris, oilcake, mechanically extracted, Canada	94.0	37.4	16.4	7.2	7.4	31.6	0.50	0.80	54
B. napus, seeds, Chile	93.1	19.3	27.2	3.5	43.4	6.6	0.32	0.65	315
B. napus, oilcake, mechanically extracted, India	87.2	32.1	12.3	12.9	10.4	32.3	0.50	0.80	96

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Seeds	Cattle	85.0	44.0	93.0	74.0	4.64	436
Oilcake	Cattle	84.0	38.0	91.0	61.0	2.78	436

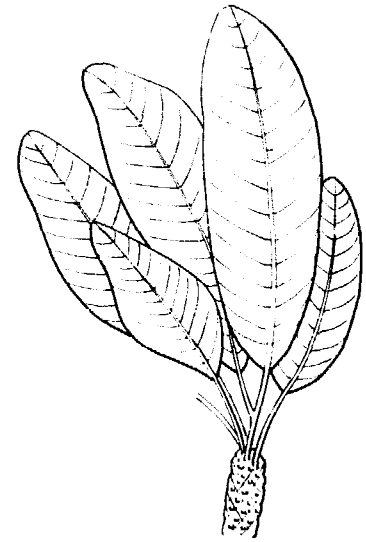
G7 ***Butryospermum paradoxum* (Gaertn. f.) Hepper subsp. *parkii* (G. Don) Hepper (*Bassia parkii* G. Don)**

Butter tree, shea nut, shea butter or karité

Useful reference: 288

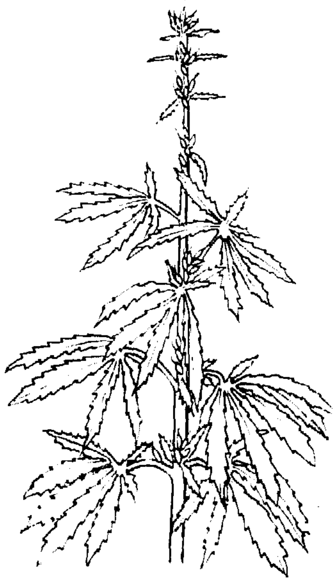
A tree 15-20 m high with a stout trunk bearing leathery oval leaves. The large fleshy nuts (or seeds) yield about 45% edible lardlike fat.

Use. The oilcake, like the seeds, contains saponin, which irritates the digestive tract of animals. Because of its very bitter taste, it is unpalatable. It is especially toxic to pigs, which are poisoned if more than 20% is included in the ration. Ruminants can tolerate more, but a higher than 30% inclusion will affect the digestibility of other feeds in the ration. Because of its very low nutritive value, it is often used as a material in compound cake to provide non-nutritive bulk.



Butryospermum paradoxum

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Oilcake	87.5	17.1	12.0	7.6	4.0	59.3			288



Cannabis sativa

G8 *Cannabis sativa* L.

Hemp

Useful references: 248, 269

There are many varieties of hemp, most of them grown for fibre or in some areas for the oil-rich seed. The seeds are usually pressed twice: first without heat to obtain a clear green cooking oil, and then with heat to obtain a brown industrial oil. As the seeds contain chlorophyll, the press cake is green if the meal has not been overheated in the processing. The cake can be used for feed, but it is mediocre owing to the presence of shell debris.

Use. In countries where hemp is grown, the seeds are used for cattle and poultry as a concentrated energy feed.

The very low digestibility of the fibre component of the oilcake limits its use, especially in pig and poultry feeds. It is therefore used mostly for fattening cattle (up to 3 kg per day) and adult sheep (0.5 kg per day).

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Seeds	91.1	20.0	16.5	4.6	35.8	23.1			512
Oilcake, mechanically extracted		34.5	26.8	8.9	9.6	20.5	0.27	0.47	512
Oil meal, solvent extracted	88.7	39.2	30.0	10.5	1.9	18.4			512

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Seeds	Sheep	75.3	60.0	89.9	79.6	4.16	512
Oilcake, expeller	Sheep	74.0	8.0	89.5	57.4	2.27	512

G9 *Carthamus tinctorius* L.

Safflower or false saffron

Useful reference: 269

The safflower plant, 0.6-1.5 m high, produces many branches with heads at the ends. Each head, as in other thistles, consists of numerous flowers, each normally producing a single seed. A head may produce from 20 to 100 seeds, which are shaped like small sunflowerseeds. The seed is composed of a kernel surrounded by a thick fibrous hull so difficult to remove that much safflower meal is made from unhulled seed. The undecorticated oil meal is also called whole pressed seed meal, whereas the decorticated meal is referred to as safflower meal.

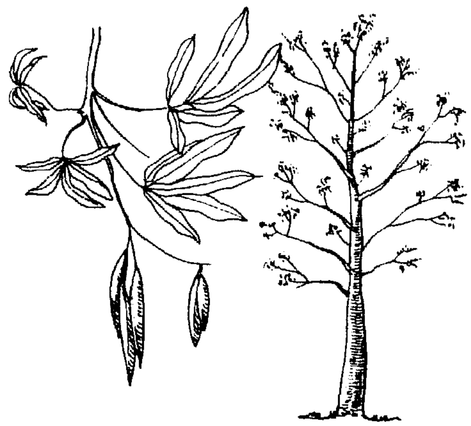
Seeds. The seeds contain about 17% crude protein and 35% crude fat. They have been included in pelleted products as they reduce dust in the hammer-mill and give a product that holds together and will be entirely eaten. Normally the cost of safflower seeds is too high for use as animal feed.

Oilcake. The undecorticated cake or meal is fed only to ruminants. Though not very palatable, it is readily eaten when mixed with other feeds. It gives no off-flavours to milk. Decorticated oilcake can well be utilized in pig and poultry feeds with attention to the balance of amino acids and within the amounts the rather high crude-fibre content allows. It has no negative effect on digestion or on meat or egg quality. It has been included up to 15% in diets for monogastric animals with good results. If the meal is autoclaved, pasting of the beaks in young chicks is prevented.

Hulls. The hulls, forming about 40% of the seed, are unpalatable, reduce gain, and can constitute only a small part of the roughage requirement.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Oilcake with hulls, mechanically extracted, India	92.7	30.5	24.9	6.1	9.0	29.5	0.12	0.59	379
Oilcake with hulls, mechanically extracted, USA	92.0	20.7	35.9	4.3	6.5	32.6			192
Oilcake without hulls, mechanically extracted, India	91.3	49.7	9.0	8.2	11.0	22.1	0.06	1.10	379
Oilcake without hulls, mechanically extracted, USA	92.0	39.1	19.0	8.0	8.3	25.6			192
Hulls, USA	91.3	4.2	58.2	1.5	5.1	31.0			192

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Oilcake with hulls	Cattle	80.0	22.0	82.0	49.0	1.99	192
Oilcake without hulls	Cattle	88.0	23.0	89.0	63.0	2.80	192



Ceiba pentandra

G10 *Ceiba pentandra* (L.) Gaertn. (*Eriodendron anfractuosum* DC.)

Kapok or silk cotton tree

Useful reference: 425

A tree native to tropical America, but now cultivated mostly in Southeast Asia for the production of waterproof down used in lifejackets and rafts. The oil from the seeds is used in edible products and soap. Ground seeds can be included up to about 70% in cattle diets; over this amount the mixture is not very palatable and may be refused.

The oilcake is rather undigestible because of its fibre content and is used in livestock feeding in the same way as hemp cake. Oilcakes that have developed a soapy smell should not be fed to monogastrics as they may be toxic.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Seeds, India		30.4	19.6	8.2	23.1	18.7	0.47	0.97	425
Oilcake, mechanically extracted, Tanzania	89.7	28.8	31.6	7.9	8.8	22.9			355
Oilcake, mechanically extracted, Malaysia	86.4	33.8	22.1	7.9	6.4	29.8			56

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Seeds	Zebu	86.6	2.1	91.5	85.3	3.36	425
Oilcake	Sheep	74.1	19.8	90.1	50.0	2.18	512

G11 *Citrullus lanatus* (Thunb.) Matsum & Nakai (*C. vulgaris* Schrad.)

Watermelon or cocorico

Creeping annual with large round fleshy fruits in which are embedded small flat seeds. It is cultivated in equatorial Africa, where the seeds are used mainly for human consumption; but in some areas they are crushed for oil extraction. The oilcake can profitably be used at levels up to 20% in feeds for ruminants.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Seeds with hulls, Nigeria	88.0	24.4	31.6	4.2	35.4	4.4			374
Seeds without hulls, Nigeria	91.9	34.5	8.2	6.2	46.7	4.4			374
Hulls, Nigeria	92.1	4.5	61.4	5.9	3.2	25.0			374

G12 *Cocos nucifera* L.

Coconut

Useful reference: 110

The ripe fruit of the coconut palm has a hard shell covered by a fibrous outer coat and contains an edible kernel with the coconut in the centre. The nut is split open, and the edible kernel is dried to a moisture content below 6% to prevent deterioration. The dried meat, called copra, is then subjected to pressing or extraction. The residue is known as coconut (oil) meal (or cake), copra meal or poonac. Depending on the milling equipment, the oil residue in the marketed product ranges from 1% to 22%. Hydraulic press residue is usually marketed in flat round cakes, and the other grades are sold in dark-coloured lumps. The product known as sediment meal is quite distinct, however, as it is recovered from the filter pads of the oil-straining presses. On the average 1 000 nuts will produce about 180 kg of copra, and the processing of this amount of copra yields about 110 kg of oil and 55 kg of meal, the remainder being evaporated moisture and unavoidable losses. The fibrous coat (husk) has no feed value. The dust from processing the husks into fibre (coir dust) has been suggested as a carrier for molasses.

Coconut orchards can be grazed when the leaves can no longer be reached by the grazing animals. It is often necessary to apply extra fertilizer to orchards that are being grazed as the coconut leaves tend to become yellow.

Coconut water. Coconut water is usually wasted when the nuts are split open. The dry matter content of coconut water declines as the nut matures and is a meagre source of nutrients when the nuts are harvested for copra. On estates the coconut water is sometimes fed to cattle in place of ordinary drinking water. At first it has a purgative effect, but cattle soon become accustomed to it. It has also been used as a substrate for the microorganism *Rhodotorula pilimanae* and as an ingredient of a semen extender for artificial insemination.

Copra. Copra is usually too expensive to use as an animal feed, though it has been fed to pigs and poultry with good results. As the fat in copra contains only small amounts of unsaturated fatty acids. its consumption leads to firm body fat and good flavour.

Coconut meal. Coconut cake or meal used in feeding must not be old and rancid as it will cause diarrhoea. Because it swells considerably in water, it should be moistened before it is fed in large amounts. Animals which are not used to it are at first somewhat reluctant to feed on this product, but if it is introduced slowly into the ration, they soon acquire a liking for it. It is claimed that it increases the fat content of the milk. It also affects the butterfat in the milk by making it harder and lending it a pleasant flavour. The maximum safe amount for dairy cows seems to be 1.5-2 kg daily; larger quantities may result in tallowy butter. Beef cattle can consume much more without impairment of carcass quality.

Because coconut meal is rather rich in fibre, its inclusion in pig diets is restricted. Depending on the other ingredients it may constitute up to 25% of the total diet. In areas where coconut meal is abundant, and if one is prepared to accept less efficient feed conversion, up to 50% can be used. It produces firm fat in pigs.

Coconut meal is seldom used in poultry rations because of difficulties in formulating a ration that is balanced with respect to amino acids and sufficiently low in fibre and high in energy. Lysine is a special problem as much of this acid is apparently destroyed in the screw press. Poultry rations of up to 40% coconut meal have been formulated and tested, however. In these the energy content is increased by the addition of coconut oil and the amino acids are balanced by the addition of methronsine and lysine or of fish meal. Coconut meal made from mouldy copra is unsuitable for poultry diets.

Paring meal. Paring meal consists of the outside of the shelled coconut, which is trimmed off in the preparation of shredded coconut for human consumption. It contains a protein of higher biological value than that of coconut meal because it is not heat processed.

	DM	As % of dry matter CP	CF	Ash	EE	NFE	Ca	P	Ref.
Coconut water, Nigeria	5.2	4.4	6.5	12.3	6.0	70.8	5.77	3.85	374
Copra, Malaysia	50.0	7.4	3.0	2.0	68.0	19.6	0.03	0.26	292
Copra, Philippines	51.3	9.7	4.3	2.9	64.4	18.7			300
Oil meal, solvent extracted, Iraq	93.4	20.5	26.1	7.0	0.4	46.0			182
Oilcake, single pressing, Malaysia	88.7	19.5	8.5	5.4	18.4	48.2			292
Oilcake, double pressing, Malaysia	88.2	20.0	8.3	5.9	11.7	54.1			292
Oilcake, expeller, Trinidad	88.8	25.2	10.8	6.0	5.2	52.8	0.08	0.67	191
Oilcake, expeller, Philippines	91.7	22.7	10.5	5.5	7.7	53.3			300
Coir dust, Tanzania	87.1	2.3	34.2	7.6	0.7	55.2			355

	Animal	Digestibility (%) CP	CF	EE	NFE	ME	Ref.
Oilcake, expeller	Sheep	91.0	35.0	95.0	80.0	3.14	365
Copra	Pigs	83.8	84.0	95.4	91.4	6.72	300
Oilcake, expeller	Pigs	73.4	49.5	89.6	72.0	3.20	300

G13 *Crambe abyssinica* Hochst. *ex* R.E. Fries

Crambe, Abyssinian kale or Abyssinian cabbage

Erect annual herb 10-90 cm high with large pinnately lobed leaves. As it matures, the leaves drop and the seed pods and stems turn tan. The pods are harvested for the extraction of oil from the seeds. The residual seed meal, though high in protein (40% in decorticated meal and about 30% in other meal), contains glucosinolates which make it unpalatable and limit its use for animal feed. It can be made palatable by treatment with ammonia or sodium carbonate, to neutralize the undesirable components, or by heat treatment. The oilcake can be included up to 50% in supplements for ruminants.

	DM	As % of dry matter CP	CF	Ash	EE	NFE	Ca	P	Ref.
Seeds	88.0	15.5	10.8	3.0	55.0	15.7			364
Oil meal, solvent extracted	88.0	34.0	23.8	6.9	1.3	34.0			364

G14 *Cucurbita* spp.

Pumpkin, squash, gourd

Useful reference: 248

The pumpkin is native to tropical and subtropical climates. Many varieties are cultivated. The seeds are sometimes extracted for their oil or fed to animals.

Use. Too many seeds in the diet may cause indigestion owing to the high fat content. Pigs should be given shelled seeds, as they will have difficulty eating them otherwise. The oilcake is an excellent protein concentrate but turns rancid if not properly defatted. The hulls are of little value because of their high fibre content.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Seeds with hulls	90.0	31.6	19.7	4.0	38.9	5.8			462
Seeds without hulls	92.6	35.7	2.3	4.2	49.9	7.9			183
Oil meal with hulls, solvent extracted	89.5	47.0	34.0	8.5	1.3	9.2			291
Oilcake without hulls, mechanically extracted	88.0	63.2	5.7	9.0	13.0	9.1			248
Hulls	89.8	19.0	72.0	2.8	5.9	0.3			291

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Seeds with hulls	Cattle	84.0	61.0	96.0	68.0	4.61	183
Oil meal, extracted	Sheep	81.0	40.0	48.0	96.0	2.50	291
Hulls	Sheep	38.0	13.0	77.0	40.0	1.00	291

G15 *Elaeis guineensis* Jacq.

African oil palm

Useful reference: 101

A palm tree 20-25 m high native to west tropical Africa. The fruit grows in bunches and consists essentially of a soft outer skin, which is reddish orange when ripe, and a fibrous layer covering the nut, composed of a shell and a kernel containing the palm oil.

The fruit yields two kinds of oil: palm oil from the fleshy covering and palm kernel oil from the nut. During the processing of palm fruits the first residue of empty bunches — 50% of the fresh fruit bunches — is used as fuel in the oil-extraction plant. Then another 20% of the fresh fruit bunches are processed in a mechanical press to obtain viscous crude oil. The nuts from 15% of the fresh fruit bunches are separated from the solid residue, or palm fibre, and sent to plants specializing in the extraction of palm kernel oil. Purification of the oil produces large amounts of sludge.

Palm oil. The oil from the fleshy outer skin of the fruit is customarily included (at about a 5% level) in pig and poultry rations as a source of vitamins A and D and to reduce dustiness in the feed.

Palm press fibre. This by-product is acceptable to ruminants at a low level of inclusion in the diet. Crude protein and crude fibre digestibility decreases when the level of inclusion exceeds 25-30%. The fibre can be dried and pelletized to overcome the problems of poor keeping quality and bulkiness.

Palm oil sludge. The waste from palm oil purification has been used to feed cattle and pigs on estates where it is produced. Cattle seem to accept up to 40% palm oil sludge in their rations without adverse effects. Palm oil sludge and press fibre combined in equal proportions can constitute up to 50% of the ruminant ration; however, this blend can be stored for no more than a day and a half before it becomes unpalatable. Raw or concentrated palm oil sludge can be absorbed on cassava meal or palm kernel cake and dried into feed cakes.

Palm kernel cake. Despite a comparatively high oil content, palm kernel cake is dry and gritty and is not readily accepted by all types of stock. As an ingredient in mixed feeds, its unpalatability is of less importance.

Solvent-extracted meal is particularly unpalatable and must therefore be mixed with well-liked feeds, such as molasses, and fed in gradually increasing proportions. It is, however, a safe and wholesome material, and if reasonable care is taken in the arrangement of the feeding, it is readily eaten.

Palm kernel cake is largely used for feeding cattle. It tends to produce a firm butter when fed to dairy cattle. A ration of 2-3 kg per day has been found satisfactory for adult cattle.

Good results have been obtained from pig rations consisting of 20-30% palm kernel meal. Higher proportions usually cause scouring. It has been claimed, however, that a final pig fattening ration of 62.4% palm kernel meal, 35.1% maize and 2.5% blood meal gives average weekly increases of 4.5 kg per hog. Young pigs do not always like it, and in pig feeding it must always be introduced very gradually. Palm kernel cake or meal tends to produce firm pork of good quality.

Palm kernel cake, though seldom used in poultry rations, seems to be palatable to poultry and can replace wheat middlings in the poultry diet. Up to 20% has been included in the diet with good results.

	DM	As % of dry matter CP	CF	Ash	EE	NFE	Ca	P	Ref.
Kernels, Malaysia	92.0	7.9	3.9	1.7	54.0	32.5	0.09	0.31	292
Pericarp, Malaysia	66.6	7.4	19.0	8.1	12.0	53.5	0.13	0.12	292
Kernel oilcake, hydraulically pressed, Ghana	88.2	15.8	29.7	3.7	23.0	27.8	0.21	0.47	372
Kernel oilcake, expeller, Nigeria	91.6	20.4	9.0	5.7	8.3	56.6			374
Kernel oil meal, solvent extracted, Ghana	90.8	18.6	37.0	4.5	1.7	38.2	0.31	0.85	372
Palm press fibre, Malaysia	86.2	4.0	36.4	9.0	21.0	29.6	0.31	0.13	516
Palm oil sludge, Malaysia		9.6	11.5	11.1	21.3	46.5	0.28	0.26	516

	Animal	Digestibility (%) CP	CF	EE	NFE	ME	Ref.
Kernels	Sheep	95.2	60.3	95.3	84.0	5.38	512
Oilcake, expeller	Sheep	84.9	60.0	96.1	85.3	3.31	512
Oilcake, expeller	Pigs	60.0	36.3	25.0	76.7	2.25	512

G16 *Glycine max* (L.) Merr. (*G. soja* Sieb. & Zucc.)

Soybean, soya bean, soja bean or Manchurian bean

Useful reference: 108

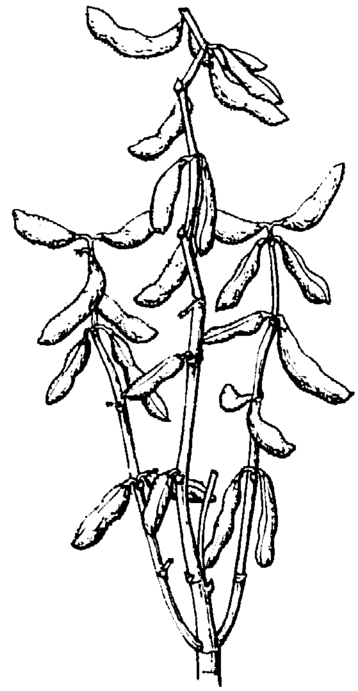
One of the world's most important oilseed crops and a staple food of the Orient. Indigenous to the Far East, it is now cultivated elsewhere, particularly in the United States.

A typical legume, the soybean seed has a smooth, often shiny, thick coat. The soybeans are cleaned, dried (if the moisture content is more than 13%) and fed into cracking rolls. Often the hulls are removed as they contain little oil, thereby increasing the effective capacity of the processing plant. Because of the rather low oil content of the seeds (below 20%), solvent extraction is the most common method. The cracked seeds are prepared for this process by passing them through a flaking machine. The extracted meal is ground in a hammer-mill. The cake or meal is usually classified for marketing by its crude protein content: 41% for undecorticated expeller or hydraulic-process cake, 44% for undecorticated solvent-process meal and 50% for decorticated solvent-process meal. The actual crude protein content is somewhat higher than the guaranteed figure.

Trypsin inhibitor. The nitrogenous constituents of the seed include some inhibitory and toxic factors. The most important of these is the soybean trypsin inhibitor, which blocks the activity of the digestive enzyme trypsin. As it is destroyed by heat and as soybeans are normally heated before or during processing, it is of no concern in the oilcake. Whole seeds, however, should be thoroughly heated before feeding to pigs or poultry. Too high or too prolonged heat will destroy essential amino acids. Soybean also contains urease, an enzyme that releases ammonia from urea, and therefore cannot be fed together with urea.

Seeds. Soybeans are the richest in protein of all the common seeds used for animal feed. They should not be stored until thoroughly dry. At harvest the seeds often contain too much moisture for satisfactory storage and must therefore be dried to a moisture content of less than 15%. For feed they should preferably be cracked or ground (grinding is easier if the beans are mixed with grain). If they are fed in large quantities to cattle, the diet must also contain adequate amounts of vitamin A. Ground soybeans cannot be stored long in a hot climate.

For cattle, soybeans are an excellent feed without processing or specific conditioning by heat; but for monogastric animals, especially young pigs and poultry, the beans have to be heated to destroy factors that lower their nutritive value. This can be done in a heated rotating drum; however, this method is unsatisfactory because some beans are charred and others not heated enough. A safer method is to pressure-cook the crushed beans at 115°C for ten minutes or at atmospheric pressure for two hours. The carcass will lack firmness and be too juicy if the level of whole beans in the diet exceeds 20-25%. For poultry, up to 30% whole, heated soybeans can be included in the diet with no depressing effects.



Glycine max

Soybean meal. Soybean meal or cake is one of the most valuable sources of vegetable protein. The amino-acid composition is comparable to that of milk protein. It is essential, however, to remember the shortcomings of soybean meal as a substitute for animal proteins in compound feeds. Some minerals are present only in small quantities in soybean meal, and although it is a good source of some vitamins, it lacks vitamin B_{12}, which is found instead in animal protein supplements. This vitamin is probably the one most often lacking in practical poultry diets.

From the taste of the meal it is possible to judge whether it has been heated enough during processing to be safe for pigs and poultry. It should have a pleasant nut-like taste and a light brownish colour. If the meal has a "beany" raw taste, it should be used only for ruminants. Properly heated soybean meal is an excellent feed for all classes of animals with no restraints on its use; however, soybean oil meal extracted with trichloroethylene is toxic to some animals and should not be used for feeding.

Hulls. Also called soybean mill feed or mill run, the hulls are the by-product of decorticated soybean meal. Rich in fibre, they are used for ruminants. If mixed with low-fibre ingredients, such as maize and soybean meal, they can be included up to 40% in the concentrate portion of the diet without significantly reducing the milk yield.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Seeds with hulls, Zimbabwe	91.2	26.4	19.0	7.2	11.0	36.4			499
Seeds without hulls, Trinidad	95.8	42.9	4.9	5.2	20.4	26.6			117
Oil meal with hulls, solvent extracted, Israel	89.2	49.9	5.0	6.3	0.7	38.1	0.20	0.74	365
Oil meal without hulls, solvent extracted, USA	89.8	56.7	3.1	6.2	0.9	33.1	0.29	0.69	356
Oilcake with hulls, mechanically extracted, Israel	91.0	44.0	8.1	7.5	7.7	32.7	0.20	0.73	365
Oilcake with hulls, mechanically extracted, Malaysia	84.8	47.5	5.1	6.4	5.4	34.6	0.13	0.69	292
Hulls, Trinidad	89.8	7.8	44.0	7.0	0.8	40.4			117
Hulls, USA		16.2	31.7	4.4	1.8	45.9			464

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Seeds with hulls	Cattle	85.0	72.0	84.3	88.1	3.34	499
Oilcake, extracted	Sheep	92.0	87.0	47.0	94.0	3.46	365
Oilcake, expeller	Sheep	85.0	73.0	86.0	91.0	3.42	365
Hulls	Cattle	64.4	61.1	43.8	78.6	2.52	464

G17 *Gossypium* spp.

Cotton

Useful references: 452, 400

Gossypium

There are many wild varieties of the cotton plant, and the cultivated varieties that have been developed differ widely.

The fruit of the cotton plant is a ball of seed cotton — that is, cottonseed with staple cotton, lint fibres and linters. The cottonseed consists of two parts: the hull, from which the staple cotton lint and linters arise, and the kernel, from which the oil and meal are obtained. The embryo contains innumerable glands filled with a pigment called gossypol.

The husk is sometimes separated from the kernel before crushing, but often the whole seed is extracted for oil. Undecorticated oilcake is much richer in fibre and lower in protein.

The term "Egyptian cotton cake" refers to the undecorticated cake of black seeds, and "Bombay cotton cake" is the term used for the undecorticated cake of white seeds. The cotton fibres of white seeds cover the whole surface and are much more difficult to remove; if the cottonseed cake is broken, the fibres can be seen.

For every ton of lint in seed cotton there are approximately 1.7 tons of cottonseed. One ton of seed yields about 200 kg of oil, 500 kg of cottonseed meal and 300 kg of hulls.

The residual oil in hydraulic-press cake is usually between 4% and 8%, in screw-press cake between 3% and 5%, and in solvent-extracted meal less than 3%.

Gossypol. The pigment gossypol has an inhibiting effect on digestive enzymes. It is also a biological antioxidant, which diminishes appetite and causes constipation. Hens fed on cottonseed meal may produce eggs with mottled yolks owing to the effect of gossypol. If eaten in sufficient quantities, gossypol is toxic to monogastric animals; pigs and rabbits are the most sensitive, whereas poultry are more tolerant. Mature ruminants can ingest gossypol, but young cattle are much more susceptible to its toxic effects.

Only free gossypol (which can be extracted with aqueous acetone) is physiologically active and toxic. In raw seed, free gossypol amounts to 0.4-1.4% of the weight of the kernel. During processing much of this becomes bound gossypol. The remaining free gossypol is 0.05-0.20% in hydraulic-press cake, 0.02-0.06% in screw-press cake, about 0.05% in prepress solvent-extracted meal and 0.1-0.4% in direct solvent-extracted cake. This means that hydraulic-press cake and direct solvent-extracted meal are essentially cattle feeds owing to their higher free-gossypol content.

Another group of substances found in cottonseed meal — cyclopropenoid fatty acids — may alter the structure of egg yolks and give them a pinkish hue in storage; therefore, cottonseed meal is less suitable for laying hens.

The biological effect of gossypol can be prevented by adding iron in the form of ferrous sulphate. The amount of iron to be added is largely empirical. To increase growth, the following proportions of iron to free gossypol have been used: for cattle 1:1, for broilers 2:1, for layers 4:1 and for pigs 1:1.

Uses

Cottonseed. The whole kernel may be used as a feed for mature cattle, as is often done where proper milling equipment is not available. The seeds are usually soaked in water and fed in small quantities as a supplement to green feed. Too large an amount should not be fed as the high oil content may cause scouring. By treating the seeds with 5% ferrous sulphate, they can safely be included in small quantities in pig rations.

Cottonseed meal. Cottonseed meal is an excellent protein supplement for cattle. The limitations on effective utilization of this product in rations for swine and poultry are of minor significance for ruminant animals. Gossypol in normal concentrations has no toxic effects on cattle, but it has been shown that the weight gain in beef cattle decreases as the gossypol content of the diet increases. This effect can be completely neutralized by the addition of ferrous sulphate. As cotton hulls are available at the mills where the meal is produced, mixtures of meal and hulls can be bought. An economical fattening ration for cattle is 20% meal and 80% hulls, together with 3-4 kg of grass daily and a mineral supplement. Both decorticated and undecorticated cottonseed meal have a constipating effect on cattle, which is beneficial in feeds with a high molasses content. Calves are susceptible to the harmful effects of gossypol because of incomplete rumen development; hence it is recommended that concentrates for calves under five months of age contain no more than 10-15% cottonseed meal.

Cottonseed meal can be used safely and profitably in pig rations. Rations containing up to 0.01% free gossypol can be used without the addition of iron salts. On the basis of a typical analysis this means that the safe upper limit for a good screw-press or prepress solvent meal is about 20% and for direct solvent-extracted meal about 5%. Over these levels, iron must be added in a 1:1 weight ratio to free gossypol.

Cottonseed meal can also be used in rations for growing chickens if the free gossypol does not exceed 0.03%. Below this level, iron (2:1 iron to free gossypol) will completely overcome the depressing effect. As cottonseed is low in lysine, it may be necessary to make up for this deficiency by adding lysine. Prepress solvent-extracted meal may be used in layer feed if the gossypol has been inactivated with iron (4:1 iron to free gossypol) and if the free gossypol content is not above 0.4%.

As determination of the amount of free gossypol in a meal requires laboratory facilities, ferrous sulphate may routinely be added to diets containing cottonseed meal. For instance, for layers 0.05% iron (corresponding to 0.25% ferrous sulphate septahydrate) can routinely be included in rations containing up to 10%

cottonseed meal and up to 0.16% iron in rations containing greater amounts. Broilers cannot tolerate more than 0.07% iron in the diet.

Cottonseed hulls and cotton wood. Cottonseed hulls are used in many parts of the world as a roughage for cattle and sheep. In Haiti the hulls are spread out on the ground in feedlots. To increase the nutritive value, it has been suggested that the hulls be finely ground so that approximately 50% will pass through a 50- to 60-mesh screen. The fine fraction used for feeding contains about twice the fat content and 1.7 times the protein content of the original hulls.

Cotton wood is also used in some countries as a cattle fodder. Stems, branches and leaves can be ground, ensiled or hydrolysed with sodium hydroxide for feeding to beef cattle.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Whole seeds, India	94.3	20.6	21.5	4.9	20.1	32.9			378
Whole seeds, Egypt	91.2	21.5	23.2	5.5	26.2	23.6			512
Bombay cotton cake	87.7	23.0	24.7	6.6	5.5	40.2			512
Egyptian cotton cake	87.9	26.4	24.2	6.6	5.7	37.1			512
Oilcake with hulls, mechanically extracted, Israel	91.4	26.9	24.0	5.0	6.8	37.3	0.22	0.63	365
Oilcake with hulls, mechanically extracted, Uganda	88.0	26.2	25.6	6.2	5.7	36.3			69
Oilcake with hulls, mechanically extracted, Zimbabwe	94.5	30.5	7.9	7.0	7.6	47.0			499
Oilcake without hulls, mechanically extracted, Israel	92.3	47.7	12.5	6.6	5.4	27.8	0.22	1.34	365
Oil meal without hulls, solvent extracted, Iraq	94.3	40.3	15.7	6.8	0.6	36.6	0.31	1.11	182
Oil meal without hulls, prepress solvent extracted, USA	89.9	46.1	15.1	7.1	0.7	31.0	0.17	1.36	452
Cottonseed hulls, West Indies	86.2	13.9	30.0	3.6	8.8	43.7			191
Cotton wood, Venezuela		5.3	64.9	8.1	0.9	20.8			537

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Seeds, Indian variety	Cattle	68.4	21.6	91.2	22.2	2.46	378
Seeds, Egyptian variety	Sheep	68.4	75.9	86.6	49.8	3.45	512
Bombay cotton cake	Sheep	77.2	20.3	93.8	53.7	2.13	512
Cake with hulls, expressed	Sheep	75.0	38.0	95.0	66.0	2.59	365
Cake with hulls, expressed	Cattle	72.0	57.0	91.3	80.4	3.02	499
Cake without hulls, expressed	Sheep	83.0	45.0	97.0	74.0	3.06	365
Hulls	Sheep	0.0	49.0	78.0	43.0	1.74	365

G18 *Guizotia abyssinica* (L.) Cass.

Niger seed, inga seed or blackseed

Annual herbaceous plant with softly hairy stems reaching a height of 15 m. Cultivated in India and tropical Africa for the edible oii obtainable from the small black seeds, which are also exported as food for caged birds. The black oilcake is comparable in feeding value to undecorticated groundnut cake and can be included in concentrates for all classes of livestock, which are tolerant of its rather high fibre content. Cattle find it very palatable. Up to 30% oil meal has been used successfully in rations for layers.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Seed	95.0	24.2	16.8	5.3	40.0	13.7			512
Oil meal, solvent extracted, Italy	92.2	34.1	22.3	12.0	1.2	30.4			329
Oilcake, mechanically extracted, Italy	89.6	36.9	18.0	11.4	7.1	26.6	0.09	0.82	499

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Oilcake, extracted	Cattle	86.1	30.1	73.3	67.7	2.32	329
Oilcake, expressed	Cattle	82.4	55.2	83.1	58.7	2.69	499

G19 *Helianthus annuus* L.

Sunflower

Useful reference: 451

Annual or perennial plant up to 6 m high with heads up to 3 dm in diameter. The seeds of the cultivated sunflower species are used as poultry feed or in the manufacture of oil and its by-product, sunflowerseed meal. Undecorticated and decorticated cakes are made. Sunflowerseed oil meal — equivalent in nutrient value to solvent-extracted soybean oil meal — can be produced by lowering the processing temperatures to 93°C in the cooker and 104°C in the conditioner and by opening the choke of the expeller. The seed consists of between 25% and 40% shell. Even if the seeds are decorticated before processing, about one third of the removed shells are usually added back to the decorticated kernels to increase the efficiency of extraction.

Seed. Despite the high percentage of fibre in sunflowerseeds, they can be fed to laying hens in place of a cereal grain. On account of its fat content, the seed has a high energy value. The oil is said to be particularly beneficial during the winter and when the birds are moulting. Sunflowerseed has the highest sulphur amino-acid content of the major oilseeds.

Oil meal. The composition of the oil meal varies with the quality of the original seed and the method of processing. A wide variety of products are available on the market, ranging from low-quality strawlike meals to high-quality flours. The use of high-fibre sunflowerseed oilcakes is restricted to the feeding of adult ruminants, whereas the decorticated cake is a digestible high-protein feed that can be used freely in balanced mixtures for all livestock. As the cakes are hard, they are best fed ground and incorporated in compounds. Meals with a high fat content tend to produce soft pork if fed in large amounts. If limited to about one third of the protein supplement, the meal gives good results in pigs, especially those weighing over 45 kg. The oilcake does not keep well. Supplementary lysine will be necessary if large amounts are to be fed to nonruminants, and for poultry a rich source of energy has to be added.

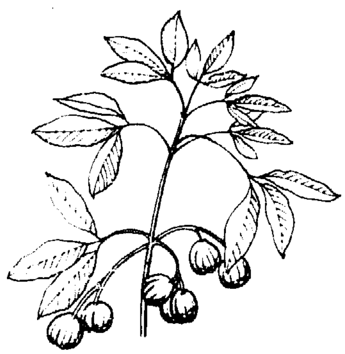
Deseeded heads. When the deseeded heads have a high moisture content, they may be silaged with or without molasses. Very dry heads can be made into a feed meal. The heads must first be shredded and then well dried, preferably in a grass drier, before being reduced to meal in a hammer-mill.

Hulls. Sunflower hulls can be used as a roughage for ruminants. Lambs have been fed 0.5 kg of pelleted hulls daily with good results.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Heads with seeds, mature, South Africa		12.7	23.9	9.3	13.7	40.4	0.63	0.08	489
Seeds with hulls, Chile	93.7	12.3	27.9	3.1	42.0	14.7	0.21	0.59	315
Oilcake without hulls, mechanically extracted, Uganda	91.0	34.1	13.2	6.6	14.3	31.8	0.30	1.30	69
Oil meal with hulls, solvent extracted, Zimbabwe	91.3	26.7	37.8	5.7	4.6	25.2			499
Oil meal without hulls, solvent extracted, average values	90.0	42.7	16.1	7.7	4.0	29.5			289
Heads without seeds, Zimbabwe	88.3	10.1	20.6	13.1	3.6	52.6			227
Hulls, USA	89.9	20.0	32.1	4.9	6.8	36.2			247

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Whole heads	Sheep	72.2	55.2	93.2	72.9	2.93	489
Seeds with hulls	Sheep	90.1	33.5	95.0	71.0	4.28	512
Cake without hulls, mechanically extracted	Sheep	75.0	26.0	90.0	54.0	2.85	365

G20 *Hevea brasiliensis* Muell.-Arg.



Hevea brasiliensis

Para rubber or caoutchouc tree

Useful reference: 147

The rubber tree starts bearing fruit at four years of age. Each fruit contains three or four seeds, which fall to the ground when the fruit ripens and splits. Each tree yields about 800 seeds (1.3 kg) twice a year. The seed consists of a thin hard shell and a kernel. As the shell also contains some oil, the kernel and the shell sometimes are extracted together, yielding an undecorticated oilcake or meal with a very high fibre content. There is a great difference in feeding value between decorticated and undecorticated meal. The oil can either be expressed (hot or cold) or extracted. The press cake contains 8-15% residual oil, whereas the extracted meal has only 2-4%.

Toxicity. Fresh rubber-seed oilcake contains up to 0.09% prussic acid, which is released, as in linseed, from a glucoside by an enzyme. The high temperature of normal processing destroys the enzyme that releases the prussic acid. Boiling — particularly in acid water — also renders the oil harmless. Oilcake that has been stored for at least six months can also be fed to animals without special precautions; however, undetoxified cakes must not be wetted before feeding.

Use. The oilcake has value as a cattle feed, but is not very palatable because it is powdery. It has been fed in amounts of 2-3 kg a day to adult cattle with good results. It is unpalatable to sheep.

Rubber-seed meal can be incorporated into poultry rations at levels between 10% and 15% for chicks and up to 25% for growers, but its use requires supplementation with sulphur amino acids.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Kernels, Malaysia	70.0	18.0	1.9	2.6	52.3	2T.2			292
Oilcake with hulls, mechanically extracted, Thailand	91.9	14.4	46.6	2.7	4.8	31.5			56
Oilcake without hulls, mechanically extracted, Sri Lanka	90.7	26.7	10.8	6.4	3.8	40.0	0.12	0.47	535

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Oilcake without hulls, mechanically extracted	Sheep	91.0	99.0	97.0	95.0	4.34	30

C21 *Juglans regia* L.

Walnut

Useful reference: 269

Medium-sized tree cultivated commercially for the nuts in subtropical countries. An extremely hard shell covers the two-lobed wrinkled kernel. Walnut oilcake is an excellent feed, containing vitamins A, B_1 and B_2. The decorticated cake can be used for all animals with good results. Poorly processed cakes turn rancid and give the meat a bad taste.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Kernels, France	95.4	15.1	9.2	1.9	58.2	15.6		0.28	408
Oilcake with shells, mechanically extracted, USA		23.2	30.9	5.0	9.0	31.9			269
Oilcake without shells, mechanically extracted, Israel	89.3	47.9	10.3	6.7	6.6	28.5			365
Oil meal without shells, solvent extracted, Israel	83.5	47.9	4.0	8.9	1.6	37.6			365
Hulls	92.3	1.8	61.3	1.5	0.8	34.6			512

	Animal	Digestibility (%) CP	CF	EE	NFE	ME	Ref.
Oilcake without shells, mechanically extracted	Sheep	80.9	25.8	59.3	56.9	2.31	360

G22 *Lallemantia iberica* Fisch. & Mey.

Dragon's head

Useful reference: 290

Annual herb with a short vegetative cycle adapted to dry climates, cultivated for its seeds, from which a drying oil is extracted. The oilcake has been used for horses, ruminants and rabbits with no observed ill effects. A cow can be fed up to 2 kg per day.

	DM	As % of dry matter CP	CF	Ash	EE	NFE	Ca	P	Ref.
Oil meal with shells, solvent extracted, Morocco	87.6	35.9	26.5	10.2	1.8	25.6	1.14	1.60	239
Oil meal without shells, solvent extracted, Morocco	90.0	46.0	15.5	14.6	2.4	21.5	0.66	1.79	239

	Animal	Digestibility (%) CP	CF	EE	NFE	ME	Ref.
Oilcake without shells, solvent extracted	Sheep	80.9	25.8	59.3	56.9	2.31	360

G23 *Linum usitatissimum* L.

Flax or linseed

Useful reference: 237

An annual, 0.3-1 m high, grown for the production of fibre and flaxseed or linseed oil — a drying oil used in paints, linoleum and soft soap. From one to ten seeds are found in each of the round balls at the tips of the branches.

The term linseed meal is used for ground unextracted seed, for ground linseed cake and for meal from the extraction process, each having a different oil content (35%, 10% and 3% respectively). As the oil content largely determines the use of linseed meal, it is necessary to know which specific product is meant by the term.

The hull is low in fibre and rich in protein and is therefore included in the oilcake.

Prussic acid. Immature linseed contains the glucoside linamarin. At certain temperatures (optimum 40°-50°C), conditions of acidity (pH 2-8) and in the presence of moisture, an associated enzyme — linase — will release prussic acid from the glucoside. Under normal conditions of manufacture, involving high-temperature treatment, the linease is destroyed so that no prussic acid can subsequently be released. Unprocessed whole seeds and linseed cakes processed under low temperature can be toxic to animals, especially if the seed or the cake is wetted before being used for feed. As the enzyme is destroyed by sufficient heat, boiling for ten minutes will make the feed safe. Extraction with trichloroethylene or carbon tetrachloride destroys the glucoside.

Seed. The whole seed is too hard for animal feeding and must be either crushed or softened by soaking and boiling. Because it is rich in oil it can be used as a concentrated energy feed for ruminants and pigs. Whole seeds can be used as an ingredient in calf meals. As the oil in the seed is unsaturated, it may produce soft pork if too much seed is fed to pigs.

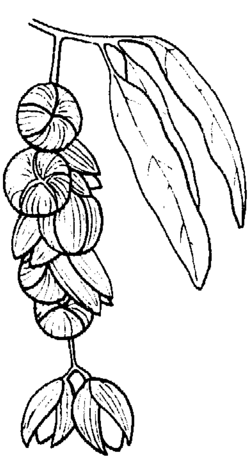
Oilcake. Linseed cake has the reputation of causing "bloom" on the coats of cattle, which is attributed to the oil. The cake in large amounts is laxative, and an excess has an undesirable softening effect on the butterfat and gives the milk a rancid taste. The recommended maximum intake for cattle is 3 kg per day.

Because of this softening property of the oil, linseed cake is unsatisfactory as a main ingredient in pig feeds. Moreover, being deficient in some essential amino acids, it is not suitable as the sole source of proteins for swine. It is, however, a good protein supplement when used together with fish meal, skim milk or other animal by-products. Of course, the extracted meal is not likely to have any softening effects. Up to 1 kg per day has been used with good results, but not more than 8% linseed meal is commonly included in rations. For young pigs and brood sows, a maximum of 5% linseed meal in the ration is usually recommended.

Linseed cake is toxic to poultry except ry small proportions (under 3%). Larger amounts depress g he toxicity can largely be eliminated by soaking the meal for twenty-four hours or by adding pyridoxin, one of the mins, to the diet. The reasons for the antitoxic effect of the in are unknown.

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Seeds, Uganda	92.7	29.2	4.8	4.9	36.0	25.1	0.20	0.60		70
Oil meal, solvent extracted, West Indies	88.0	36.0	9.0	6.4	2.9	45.7				117
Oilcake, mechanically extracted, India		30.5	9.5	10.2	6.6	43.2	0.37	0.96		436
Oilcake, hydraulically pressed, Kenya	84.8	30.1	10.8	4.2	19.5	35.4	0.40	0.80		417

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Seeds	Sheep	80.2	32.7	95.1	79.9	4.44	512
Oilcake, hydraulically pressed	Sheep	86.5	16.9	91.6	73.9	3.52	417



Macadamia integrifolia

G24 *Macadamia integrifolia* Maiden & Betche

Macadamia nut, Queensland nut.

Evergreen tree native to eastern Australia and also extensively cultivated in Hawaii and California. The nuts have a smooth round shell measuring about 2 cm in diameter. The shell splits when the kernel is ripe. The kernels contain 75-80% oil, which would make a good salad oil, but the kernels are too valuable as dessert nuts for commercial milling.

Feed-grade macadamia nuts can be included up to 10% in concentrates for ruminants without adverse effects. Higher levels in ruminant feeds decrease feed intake and digestibility because of the high fat content of the nuts.

	DM	As % of dry matter CP	CF	Ash	EE	NFE	Ca	P	Ref.
Whole nuts, Hawaii	97.4	9.9	9.2	1.4	70.1	9.4	0.10	0.25	547

G25 ***Madhuca indica*** **J.F. Gmel. (*****Bassia latifolia*** **Roxb.)**

Mowra or mowrah

Madhuca longifolia **(Koenig) Macbr. (*****Bassia longifolia*** **L.)**

Illipi or mee

Both trees are native to southern Asia and are cultivated for the edible fat in their fleshy seeds. The oilcakes are rich in saponin and toxic, causing injury to the mucosa of the digestive tract and haemolysis of the blood. Detoxification by heat treatment has been attempted, but the treated cakes are very low in digestibility.

	DM	As % of dry matter CP	CF	Ash	EE	NFE	Ca	P	Ref.
Oilcake, mechanically extracted, India		16.0	3.1	5.7	10.9	64.3	0.12	0.36	379
Oilcake, mechanically extracted, detoxified	92.2	29.0	12.6	10.5	7.7	40.2			257

	Animal	Digestibility (%) CP	CF	EE	NFE	ME	Ref.
Oilcake, detoxified	Sheep	11.9	54.4	83.8	17.1	1.14	257

Nicotiana tabacum

G26 *Nicotiana tabacum* L.

Tobacco

Useful reference: 103

Only the leaf of the tobacco plant is commercially important, and the other parts are usually wasted. The varieties grown for cigarette tobacco are usually allowed to flower and bear seeds. The seeds are very small, and as only a minor fraction of the total production is needed for seeding purposes, they are a by-product which can be put to good use. The seeds are entirely free of the poisonous alkaloid nicotine present in the leaves. They are rich (35-40%) in edible semidrying oil, and the oilcake can be used as feed for ruminants. Up to 2.8 kg per day per head have been fed to dairy cows. Chickens experimentally given 25% whole tobacco seeds and 75% commercial feed in the first ten weeks of life gained as fast and efficiently as those given only commercial feed.

In southern Ethiopia chewed tobacco leaves are spit into the throats of sheep and oxen. The animals like this and seem to grow better as a result, possibly because the nicotine helps kill internal parasites.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Oilcake, solvent extracted, India	86.7	36.9	25.2	15.2	0.4	22.3			324
Oilcake, solvent extracted, Germany (F.R.)	88.5	35.9	28.5	13.8	0.7	21.1			103

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Oilcake, solvent extracted	Sheep	67.4	2.0	99.9	40.2	1.45	324
Oilcake, solvent extracted	Cattle	74.5	27.7	77.4	68.0	2.00	103

G27 *Olea europaea* L.

Olive

Useful references: 248, 317

A tree cultivated for its fruit, from which an edible oil can be extracted. There are numerous varieties with fruits varying from round to oval and from 1 to 3 cm in diameter. Under the thin skin is the fleshy mesocarp containing the oil and in the centre a black hard nut with a kernel.

The fruits can be processed in several ways, each producing a different type of oilcake. Most commonly the whole fruits are crushed and pressed, first under low pressure and after that in another press under greater pressure, to produce a very hard cake consisting of kernels, broken kernels and pulp with a water content of 20-25% and a residual oil content of 8-16%. The cake is sometimes used as animal feed or is processed further by three methods. (*1*) The whole cake is solvent extracted. (*2*) The cake is recrushed, extracted with hot water and pressed. (*3*) The kernels and the pulp are separated either in a specially designed classifier or by flotation in water. The kernels, being heavier, sink to the bottom, while the pulp remains afloat. The floating pulp is 20-25% oil and can be used directly as livestock feed or can be further extracted. The kernels contain so little oil that they are discarded. If separated in a classifier, the skins (epicarp) can be collected separately from the kernels and the pulp.

Another method (the Acapulco method) separates the fruits into kernels and pulp, and the oil is pressed out of the pulp between rubber discs.

Use. Because of the rather low price at which the press cake is sold to factories for further oil extraction, there have been several investigations to assess its value in animal feeding. As the cake turns rancid rather quickly and may become completely unpalatable and even harmful to animals, it must be preserved either by drying or ensiling. Press cake containing kernels has a very low feed value and causes digestive troubles, especially in cattle. Therefore, the cake should be separated into kernels and pulp. The kernels can then be used as fuel to dry the pulp. The main value of the pulp as an animal feed is its high fat content. Owing to a peculiarity of the pulp, its protein is very low in digestibility. Contrary to what might be expected, the high oil content of the pulp has no adverse effect on the fat composition of the carcass. Up to 50% of the ruminant ration can consist of destoned press cake, and up to 15% does not decrease the digestibility of the ration. Calves can be fed 1-2 kg daily, fattening swine 0.8-1.5 kg and sheep 0.2-0.3 kg. Olive cakes extracted with solvents have less feed value because of their lower fat content. (The feed value of olive cakes is comparable to that of wheat straw.) The factor causing the decrease in digestibility seems to be soluble in tetrachloroethylene, as oilcakes extracted with this and subjected to alkaline hydrolysis showed no reduction in digestibility. Oilcakes so processed are comparable to good forage in feed value.

The destoned cake has also been used in feeding pigs in proportions up to 50% of a daily ration consisting of maize, wheat pollards and coconut cake. No digestive trouble or decrease in appetite was observed, and the rate of increase in liveweight was normal; however, the feed efficiency tended to be somewhat lower. Cakes should not be fed to pregnant animals as the birth weight tends to be lower. The cake has a rather low palatability.

Olive kernels are of no value as animal feed.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Kernels, Italy		1.2	74.1	1.2	0.8	22.7			332
Skins, Italy	89.2	13.2	28.3	7.9	14.9	35.7			332
Press cake (kernels and pulp), Israel	85.2	6.3	40.0	4.2	11.9	37.6			365
Press cake (pulp only), Italy		10.5	32.5	5.8	14.5	35.7			332
Pulp, solvent extracted, Cyprus	93.3	10.5	34.8	4.7	2.8	47.2	0.33	0.12	369
Acapulco pulp, Italy	60.7	8.4	15.8	8.8	33.3	33.7			332

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Skins	Cattle	32.8	37.7	76.8	38.1	1.95	332
Pulp	Cattle	17.0	35.0	85.0	32.0	1.85	332
Pulp, solvent extracted	Sheep	14.0	17.9	60.9	29.1	0.92	332
Acapulco pulp	Cattle	21.6	0.0	85.6	38.7	2.76	332
Kernels and pulp	Sheep	0.0	0.0	86.0	20.0	1.06	365

G28 *Orbignya cohune* (Mart.) Dahlgr.

Corozo palm

Useful reference: 461

An oil palm, usually growing wild, bearing relatively large fruit with a thick hard shell containing one or more kernels. The palms are usually tall (up to 20 m), and the fruits grow in bunches measuring about 1 m in length and weighing 20-25 kg. Several species of the genera *Scheelea* and *Attalea* are also called corozo palm because of the difficulty of distinguishing them from the genus *Orbignya*. The corozo palm nuts are processed chiefly by the soap industries. The resulting oilcake is highly palatable. It is chiefly used for livestock, but it has also been included with good results in pig diets at levels up to 30% and in poultry diets at a level of 10%. The proportion of corozo meal in the diet can, however, be increased to 50%.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Oilcake, mechanically extracted, Guatemala	90.8	21.8	24.0	4.7	7.9	41.6	0.24	2.20	461

G29 *Orbignya speciosa* Barb.

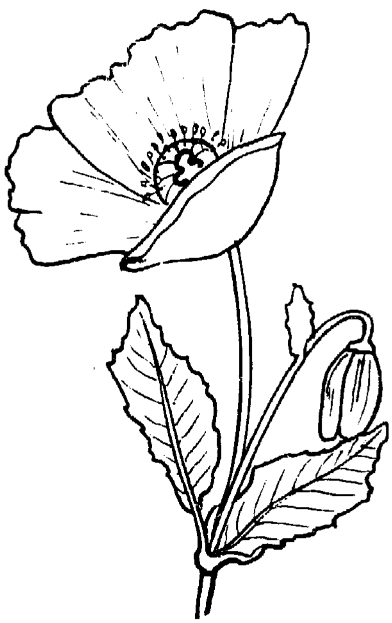
Babassu

Useful reference: 269

A wild fan-shaped palm, native to Brazil, up to 20 m tall with large curved leaves reaching 9 m in length. Its bunches of oblong or conical fruit are often 1 m long. After flowering, the palm bears two to four clusters of about 250 fruits each twice a year. Each nut consists of an extremely hard shell containing two to six kernels held by a hard fibrous layer. The oilcake is palatable but may cause scouring if used in large proportions. This effect has been attributed to its magnesium content (0.97%). It is used in the same way as coconut meal.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Oilcake, mechanically extracted, Brazil		24.9	15.0	5.9	6.8	47.4	0.13	0.49	223

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Oilcake, mechanically extracted	Sheep	85.0	18.0	98.0	71.0	2.75	223



Papaver somniferum

G30 *Papaver somniferum* L.

Poppy

Useful reference: 97

Varieties of poppy grown for their oil, which is used in artists' paints. The seeds of these varieties contain no alkaloids, but the oilcake resulting from extraction should be fed to animals with caution as it may have been contaminated by pieces of the capsule. It is not very palatable and is low in energy, and should therefore be mixed with well-liked carbohydrates like grain or beet pulp when fed to ruminants. One kilogram per day is the recommended maximum daily intake for adult cattle. It can be included up to 10% in poultry feed.

The symptoms of poisoning are excitement, constipation and excessive salivation. Although deaths are rare, the poisoned animals take a long time to recover.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Seeds	92.8	22.5	9.3	8.1	35.0	25.1			512
Oil meal, solvent extracted, Germany (F.R.)	88.5	40.7	19.2	15.3	0.8	24.0			361
Oilcake, mechanically extracted	90.5	40.8	9.2	15.2	10.8	24.0			512

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Oilcake, mechanically extracted	Sheep	79.1	49.4	91.3	64.1	2.88	512

G31 *Prunus dulcis* (Mill.) D.A. Webb (*P. amygdalus* Batsch)

Almond

Useful reference: 502

A tree grown for its nut mainly in the Mediterranean countries and California. The outer portion of the almond fruit is similar to the fleshy portion of the peach. Inside this is the nut, consisting of a shell and a kernel surrounded by a thin skin. Almonds are sometimes extracted for their oil, which is used in cosmetics and pharmaceuticals. The bitter variety (*amara*) is richer in amygdalin than the sweet variety (*dulcis*).

Toxicity. The kernels and the oilcake contain the glucoside amygdalin, which can yield prussic acid. Kernels and cakes must therefore be cooked thoroughly before being used as feed. The detoxified cake can be fed to all domestic animals, but it is usually sold to bakeries at a higher price.

Use. The only important by-product of almond processing is the hull. As the almond ripens on the tree, the hull usually splits open. After the almonds are harvested, the nuts are passed through a machine which removes the hulls. The hulls can be used in cattle and sheep rations. They have been mixed 1:1 with barley and fed together with alfalfa hay with excellent results. Varieties with soft hulls are superior to varieties with hard hulls. The total digestible nutrients (TDN) on a dry matter basis are about 80% in soft hulls and about 60% in hard hulls. The hulls can also be ensiled.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Kernels, USA	95.3	18.6	2.7	3.0	54.1	21.6	0.27	0.52	501
Skin, Cyprus	69.5	9.8	27.7	6.3	7.6	48.6		0.38	369
Oilcake with hulls, mechanically extracted, USA		10.5	23.5	6.5	5.5	54.0			269
Oilcake without hulls, mechanically extracted	89.3	47.9	4.2	6.4	4.3	37.2			347
Hulls, USA	80.0	4.4	16.9	6.9	3.1	68.7			502
Hulls, Cyprus	89.4	1.6	28.5	1.7	0.9	67.3			369

G32 *Ricinus communis* L.

Castor

Useful reference: 75

A plant grown as an annual in temperate zones and as a perennial in the tropics, where it becomes a tree up to 10 m high. Three seeds (also incorrectly called "beans") are encased in a spiny outer hull (or shell). After the seeds have been freed from the hulls by drying or with dehulling machinery, the oil is extracted from them. Castor-oil meal is often called castor pomace. The extracted meal contains about 1% residual oil. Screw-pressed cake has about 6-8% residual oil and double-pressed cake 5-7%.

Toxicity. Castor seeds and hulls contain toxic components. The principal toxic component is ricin, a protein, but a powerful allergen that is more difficult to inactivate than ricin is also present. The allergen may cause hypersensitivity in humans who have contact with the products, but it seems to cause little harm to animals. The ricin can be destroyed by autoclaving the meal for fifteen minutes at 125°C. If no autoclave is available, the meal is boiled in three times the volume of water for ten minutes, after which the water is discarded and the treatment repeated. The cake is then dried in the open air at 70°-80°C.

Use. Apparently fowl have more resistance to the toxic elements than mammals. Up to 40% detoxified meal has been included in poultry rations. High levels of inclusion have also been reported in rations for ruminants; however, it has been recommended that castor pomace be restricted to 5% and hulls to below 10% of the total ration for ruminants. Heifers experimentally trained to consume 0.7 kg of untreated castor meal per day are reported to have shown no ill effects or decrease in appetite.

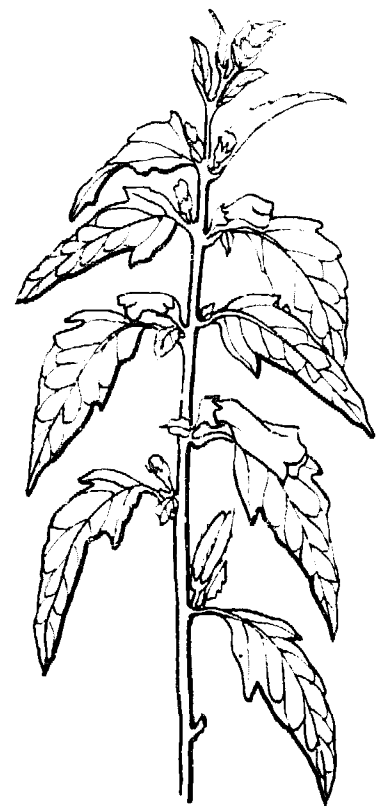
		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Oil meal, prepressed, solvent extracted, USA	92.0	38.5	32.3	7.1	1.0	21.1	0.76	0.87	75
Hulls, USA	91.9	28.8	31.3	7.0	2.2	30.7	0.54	0.65	75

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Oilcake	Sheep	80.8	8.9	92.9	43.4	1.85	512

G33 *Sesamum indicum* L. (*S. orientale* L.)

Sesame, gingelly or benne

Useful reference: 87



Sesamum indicum

An erect annual plant 0.5-2.5 m high which matures in 70-150 days. The fruit consists of an elliptical pod with two to four chambers containing about twenty seeds each. After extraction of the oil from the seeds, the resulting oilcake is a valuable high-protein feed. Combined with groundnut meal it provides a well-balanced protein supplement. Mixed with an equal amount of cottonseed meal, it has been included up to 15% in chick rations. Supplemented with blood meal and energy this feed has been quite successful.

Use. The oilcake is palatable to all classes of livestock and has a mildly laxative effect. If it forms too large a part of the ruminant or swine ration, it will produce soft butter and pork. It is recommended that dairy animals be given no more than 3 kg of sesame cake per day, as larger amounts will give the milk a disagreeable taste. It should not be wetted when fed, as the meat will acquire an unpleasant taste.

Sesame meal is frequently used as the principal protein in both growing and fattening rations for swine, constituting up to 30% when 5% of the ration is a lysine-rich ingredient, such as meat meal. Excessive use of sesame meal may produce soft pork.

As sesame cake is rich in methionine and arginine, it has great potential as a poultry feed when mixed with lysine-rich materials. It has a high content of phytic acid and appears to bind calcium; hence the amount of calcium in diets containing sesame meal should be increased. The cake will become rancid if stored for any length of time.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Seeds, India		19.7	1.7	5.8	51.5	21.3	0.81	0.50	378
Oilcake, hydraulically pressed, Malaysia	83.2	35.6	7.6	11.8	17.2	27.8	2.45	1.11	292
Oilcake, mechanically extracted, Tanzania	92.9	44.0	4.8	12.2	11.9	27.1	2.43	1.32	355
Oilcake, mechanically extracted, Iraq	91.1	43.7	6.9	17.5	6.3	25.6	3.66	1.71	182
Oilcake, mechanically extracted, Israel	90.7	46.4	8.9	13.0	6.6	25.1	2.09	1.10	365
Oil meal, solvent extracted, Iraq	94.0	44.0	8.2	14.9	1.4	31.5			182

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Seeds	Sheep	89.8	22.2	94.9	56.0	4.99	512
Oilcake, mechanically extracted	Sheep	91.0	59.0	88.0	66.0	3.06	365

G34 *Shorea robusta* Gaertn.

Sal tree

A tree cultivated in India for the most important commercial timber used in construction there. The seeds are used for fat extraction. The oilcake, though rich in tannins (5-8%), has been used in proportions of up to 20% in concentrates for cattle without detrimental effects. As the protein remains completely undigested, the oilcake yields energy only. Salseed cake can constitute up to 10% of poultry and pig rations without changes in performance. The leaves can be used as roughage for cattle.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, India		10.1	27.4	3.9	3.2	55.4	0.77	0.12	426
Seeds, India		8.0	5.2	2.4	16.7	67.7			550
Oilcake, India		10.9	2.2	4.2	1.3	81.4	0.26		548

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Leaves	Cattle	11.0	24.0	36.0	58.0	1.54	436

G35 *Shorea stenoptera* Burck.

Borneo tallow nut

A tropical tree 6-15 m high with 5-cm nuts. The kernels are enclosed in a thin, brittle case set in an acornlike cup with winglike attachments that enable the nut to fall clear of the parent tree. The nuts are collected from the ground and dried in the sun until the shells are sufficiently brittle to be separated from the kernels by pounding in rice mortars. The seed is usually solvent extracted. The meal, though nontoxic, contains tannic acid and should therefore be used at low levels. It cannot be fed to chicks, and diets for layers should include not more than 10%, as higher levels will produce eggs with greenish brown yolks. Similar meals are made from other *Shorea* species.

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Solvent-extracted oil meal from black nuts	89.8	17.5	6.8	2.2	3.1	70.4				269
Solvent-extracted oil meal from brown nuts	89.1	11.7	4.6	3.8	2.0	77.9				269

G36 *Theobroma cacao* L.

Cocoa

A tree indigenous to South America, but now cultivated mainly in West Africa within 20° of the equator. A tropical rain-forest crop, cocoa is cultivated for its beans, which are contained in large red or yellow pods growing directly on the stems and branches of the tree. The beans are embedded in a white mucilage (together about one third the total weight of the pod). Both the mucilage and beans are taken out of the pod and fermented. The fermented dried beans are then processed in chocolate factories. First, they are roasted to develop flavour and aroma. After cooling, the beans are cracked and the shell winnowed away, leaving the cracked seed kernel, known as the nib. The nib is ground to give cocoa mass or chocolate liquor, from which the cocoa fat (cocoa butter) is extracted by pressing. The resulting cake is pulverized into cocoa powder.

Toxicity. Cocoa beans and shells contain theobromine, an alkaloid poisonous to animals, which limits their use for feeding. The level of theobromine is very low in the pods.

Cocoa pods. The pods (see ref. 48), being rich in potassium, are left in the field to fertilize the cocoa trees. The pods rot very quickly. Fresh pods are sometimes consumed by livestock, but for efficient use they must be dried and ground. Pod meal has been fed without toxic effects to cattle in quantities of up to 7 kg per day and to pigs in quantities of up to 2 kg per day. For dairy cows, pod meal seems to be comparable in value to corn-on-cob meal. Rations containing cocoa pod meal have a somewhat lower feed efficiency for beef cattle, but this will be compensated by the larger intake. For pigs, cocoa pod meal has replaced maize and can constitute up to 35% of the ration without decreasing weight gains.
To ensure that the animals consume sufficient quantities, the pods must be sun-dried (to 60% moisture content) and then chopped, ground and pelletized.

Cocoa pulp. During fermentation the mucilage, or pulp, decomposes into liquid substances. The sugar in the pulp is converted first into alcohol and subsequently into acetic acid. Much of the pulp runs off in the form of "sweatings." The concentration of alcohol in sweatings is about 2-3% and in acetic acid 2.5%. The total dry matter in sweatings is about 8% with a crude protein content of about 20%. The total volume of sweatings is considerable, but no practical use has been found for them.

Cocoa beans and oilcake. Cocoa shells, beans and oilcake all have high nutritive values and could serve as feedstuffs for livestock except for their theobromine content. The shells are a good source of vitamin D. They are acceptable to ruminants in small amounts (up to 0.8 kg per day have been fed to dairy cows), but they are hazardous for pigs and poultry. Cocoa products can be rendered harmless by being cooked in water for one and a half hours, filtered and dried. Pig rations can include up to 25% of the processed product without reducing weight gains or feed efficiency.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Beans, Nigeria	47.2	14.3	9.0	4.6	42.8	29.3			374
Beans, Ghana	92.1	15.1	5.9	3.3	37.1	38.6	0.08	0.36	372
Shells, Israel	91.2	22.6	13.7	8.7	9.3	45.7	0.15	0.27	365
Oilcake, mechanically extracted, UK	86.5	26.8	10.5	6.9	6.5	49.3			66
Oilcake, mechanically extracted, Ghana	90.6	25.3	9.6	5.2	5.5	54.4	0.15	0.75	372
Fresh pods, Nigeria	11.4	6.5	30.3	13.4	1.1	48.7			374
Dried pods, Trinidad	87.4	6.3	24.0	7.8	0.5	61.4			117

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Shells	Sheep	37.0	0.0	89.0	40.0	1.66	365

H. Feeds of animal origin

The unique value of feeds of animal origin in upgrading the nutritional qualities of diets for monogastric animals is well recognized. In diets based on cereal grains and other plant products it is difficult to avoid a deficiency of essential amino acids and some vitamins. Feeds of animal origin can supply these amino acids and vitamins. Animal products, even when used in small amounts, can vastly improve the nutritional value of the entire diet. They are seldom used in diets for ruminants, as these animals normally have no need of the B vitamins or of high-quality protein.

H1-9 Slaughterhouse by-products

Useful reference: 151

The raw materials of slaughterhouse by-products are animals that have died from disease, carcasses or parts of carcasses that have not passed meat inspection, technical blood, inedible parts of the digestive tract (e.g., bibles), reproductive organs, bones and other trimmings that are not acceptable as food for aesthetic reasons. In many developing countries practically no animal by-products are produced. Often all but the blood, skin, hoofs and stomach contents of slaughtered beef animals is eaten. The slaughterhouse offal from pigs is even less. Also, only a small percentage of animals are condemned in sanitary inspection. However, even under such conditions it is possible to utilize offal for by-products, which owing to the construction of modern slaughterhouses can be processed more efficiently.

H1 Protein supplements of animal origin

Protein supplements are the residues of meat scraps and trimmings after the fat has been extracted. Each of the methods of extracting fat yields a slightly different protein concentrate. To avoid the spread of foot-and-mouth disease, the material should be subjected to a boiling temperature for at least one hour during processing.

1. Wet rendering involves a higher temperature than other methods and therefore yields a concentrate of slightly lower protein value. The tissues are placed in a tank, water is added and steam is injected directly into the bottom of the tank. The fat cells are ruptured by the high temperature and the free fats

float to the surface, where they are skimmed off. The cooking water is drained off into a container, and the wet protein residue is pressed to remove additional fat and then dried. The cooking water which is rich in dissolved protein is evaporated and either used separately for feeding or added to the dried protein residue. Blood may be added to the protein residue to increase its protein content. The protein concentrate obtained by this method is called "digester tankage" or simply "tankage." Generally the conversion rate of raw material to dry meal is 4:1.

2. In dry rendering the meat scraps are heated in an open cooker, usually a horizontal steam-jacketed tank equipped with an agitator. After the tank is loaded, the steam is turned into the jacket to heat the contents. The heat breaks down the fat cells and evaporates the moisture. When all the water has evaporated, the steam is turned off and the content of the tank is dumped into a percolating tank, where the free fat is drained out. The remaining protein residue, called "meat cracklings," is usually further processed to remove more of the fat either with a press or a solvent extractor. The protein concentrate obtained with this method is called "meat meal." If so many bones have been added that the phosphorus content exceeds 4.4%, or if the crude protein content is below 55%, the product is called "meat-and-bone meal," or if made from condemned whole carcasses, it is known as "carcass meal." Generally the conversion rate of raw material to dry meal is 3:1.

3. Where there are no rendering facilities, the meat from condemned animals and offals, including washed intestines, should be cut into small pieces and cooked for at least one hour. This can be done in an oil-drum which has been cut in two along its longitudinal axis. After one hour's cooking the bones are removed, and wheat middlings and rice bran are added in equal weight to the mass and stirred in. This mixture is boiled for a half hour to give the final product a thick consistency. It is fed to pigs the same day or at most the day after it is prepared.

Use. Meat meal and tankage are most widely used in feeds for poultry and pigs. They are usually too expensive to feed to ruminants, which in any case generally find meat products unpalatable. Because of the usual high price of meat meal and tankage, they are used to balance the amino-acid composition of diets rather than as a major source of protein. High levels of meat products in pig diets should be avoided, as an excess of calcium will disturb the zinc balance. Normally less than 5% meat meal and tankage are used in growing and finishing diets for pigs and less than 10% in diets for brood sows and poultry.

Important unidentified growth factors for monogastric animals have been attributed to meat products. There is a wide variation in the composition of meat meal and tankage depending on the ratio of muscle tissue and connective tissue in the raw material. The biological value of connective tissue is much lower than that of muscle tissue.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Tankage, USA	93.7	65.1		22.1	8.6		6.40	3.20	11
Meat cracklings, Trinidad	81.9	54.3	0.8	2.4	15.8	26.7			117
Meat meal, Tanzania	92.9	58.9	2.5	18.0	1.6	19.0			355
Meat meal, Tanzania	96.6	80.5	0.0	5.0	6.8	7M7			355
Meat meal from hippopotamus, Zimbabwe		62.6		2.4	12.8				499
Meat-and-bone meal, USA	95.6	53.3		29.7	12.3		10.50	5.20	11
Carcass meal from game, Zimbabwe	93.9	64.1	2.1	19.6	13.3	0.9			499
Cattle ears, raw	23.7	85.0	0.1	4.0	10.9	0.0	0.10	0.20	369
Cattle tracheas, raw	34.6	59.8	0.0	3.0	37.2	0.0	0.06	0.25	369
Cattle rumen, raw	29.2	68.5	0.0	3.5	28.0	0.0	0.04	0.28	369
Cattle intestines, raw	21.8	65.5	0.0	4.9	29.6	P.0	0.06	0.92	369
Lamb legs, raw	41.7	44.7	0.0	25.1	30.2	0.0	4.20	13.68	369
Lamb tracheas, raw	29.5	54.9	0.0	4.5	40.6	0.0	0.06	0.72	369
Lamb rumen, raw	17.0	74.5	0.0	7.8	17.7	0.0	0.06	1.52	369
Pig stomach, raw	31.1	49.5	0.0	1.9	48.6	0.0	0.03	0.45	369

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Meat meal from hippopotamus	Pigs	92.0	0.0	79.4	0.0	3.79	499
Carcass meal from game	Pigs	89.2	50.0	99.9	53.7	4.11	499

H2 Blood

Only about 6 kg of blood meal can be produced from 1 000 kg liveweight. Modern methods of producing blood meal involve drying in fluidized beds, spray drying at a low temperature or drying on a porous carrier in a stream of hot air. These drying processes yield a water-soluble blood meal, often referred to as blood flour to distinguish it from ordinary blood meal which is less soluble in water. On a semicommercial scale, blood meal is made by steaming or boiling the blood for twenty minutes, collecting the coagulate, drying and milling. Care should be taken not to allow the temperature to exceed 120°C in any phase of the process, or else the meal will be of inferior quality.

For processing smaller amounts, the blood is collected in large pots and boiled over an open fire until it has coagulated and the water has evaporated. The blood should boil very slowly and be stirred continuously. The blood meal may then be spread on a concrete floor in a well-ventilated shed to cool and dry completely. Another way to utilize the blood is to absorb it on wheat middlings, citrus meal or rice bran, after which the material is spread out for drying on trays heated from below or placed in the sun. In this way the low-protein vegetable matter is enriched with blood protein. The process may be repeated several times. Blood can also be coagulated by the addition of 1% unslaked or 3% slaked lime. However, 10-15% of the dry matter and many of the minerals are lost if coagulate rather than whole blood is used for the production of blood meal. Blood meal made from whole blood contains more isoleucine, one of the essential amino acids. Raw blood can be preserved for about one week by the addition of 0.7% formic or sulphuric acid. If 0.5% potassium metabisulphite is added to blood that has been treated with sulphuric acid, the blood may be stored for a few months before feeding.

The keeping qualities of blood meal are good only when the moisture content is approximately 10-12%. If the moisture content is higher, the blood heats and cakes or even ferments in storage; if it is much lower, the blood loses its red colour owing to the lack of moisture and will consequently produce black blood meal.

Use. Blood meal contains only small amounts of minerals, but is very rich in protein, which has, however, a rather biased amino-acid composition. Because of its low palatability, less than 5% is usually included in diets for pigs and poultry. Larger amounts are seldom required nutritionally and may also cause scouring. Higher proportions may be used for cattle and in milk substitutes for calves. For calves it should not constitute more than 50% of the protein in the diet, because of its low palatability. Raw blood mixed 2:1 with minced slaughterhouse offals has been fed successfully to poultry. Up to 0.7 kg per day of raw blood or acid-treated blood has been given to pigs after a few days of becoming accustomed to the feed. The digestibility of raw blood is very high. In pigs the digestibility of crude protein is 88% for blood flour, 72% for blood meal, 90% for raw blood and 95% for acid-treated blood. The digestibility in cattle is somewhat higher.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Blood meal, Nigeria	89.5	88.5	0.4	6.0	1.2	3.9	0.28	0.28	374
Fresh cattle blood, Cyprus	20.2	95.7		4.1	0.2		0.89	0.25	369

H3 Liver meal

Whole livers are dried at a low temperature and ground into meal. Condemned livers may be used for this purpose. Liver meal is generally included in small amounts in poultry and pig feeds as a source of B vitamins.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Liver meal, Uganda	92.1	73.2	0.0	10.4	9.4	7.0	0.02	0.07	70

H4 Bone meals

Bones suitable for processing can come not only from slaughterhouses but also from municipal dumps, hotels and restaurants. With simple equipment the bones can be processed into either raw bone meal or calcinated bone meal; more expensive equipment is required for steamed bone meal.

Green bone meal. This material is made by drying and grinding fresh bones. It should not be used in animal feeding as it is apt to spread diseases.

Raw bone meal. Fresh bones are boiled in open kettles until they are freed of all adhering material. The bones are then dried and ground.

Steamed bone meal. The bones are cooked under steam pressure to remove excess meat and fat. Under steam pressure the bones become more brittle and are easily ground into a meal. Meal of good quality should be free of disagreeable smells.

Special steamed bone meal. This product is made from bones extracted from the bone collagen, the mother substance of gelatin and glue.

Calcinated bone meal (bone ash). The bones are piled on a metal frame and burned to sterilize them and rid them of all organic matter. This is the only recommendable method of utilizing desert bones. The charcoal-like bone ash is friable and can easily be pulverized.

Use. Bone meals are used as a phosphorus and calcium source in animal feeding. They are also good sources of trace elements. They can either be mixed with concentrate supplements or used in cattle licks in the field.

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Raw bone meal	75.0	36.0	3.0	49.0	4.0	8.0	22.0	10.0		191
Steamed bone meal	93.0	10.0	2.0	78.0	3.0	7.0	32.0	15.0		191
Special steamed bone meal	92.0	6.0	0.0	92.0	1.0	1.0	33.0	15.0		183
Calcinated bone meal	94.0	0.0	0.0	99.0	0.0	1.0	34.0	16.0		191

H5 Rumen contents

Undigested feeds in the rumen of cattle at slaughter present a serious disposal problem for slaughterhouses. This material — about 30 kg for a 350-kg animal normally starved before slaughter — is usually washed into rivers or piled and left to rot, thus causing concern beyond the slaughterhouse. The rumen contents can be preserved by adding sulphuric acid to pH 3.0, by ensiling together with molasses or by drying either in the sun or on trays heated from underneath. If used for feeding, it is important that the material be dried immediately. It has been used as a feed for cattle, pigs and poultry. Rumen contents contain not only the vitamins in the feed ingested before slaughter but also B vitamins from the rumen flora. Dried rumen contents have been used to replace up to 100 g by weight of the grain in pig diets without a decrease in weight gains or feed efficiency. Rumen-content silage is palatable to pigs, which can consume up to 0.5 kg per day once they have become accustomed to it. It has also been mixed with blood for use in poultry diets. In large slaughterhouses the rumen content can be more efficiently utilized if the liquid component is separated by pressing. The solid part is dried in a rotary drier for feeding to cattle, and the liquid part can be precipitated or condensed and dried for use in pig diets. Rumen contents, once the liquid is pressed out, can be dried and used first as litter in poultry houses and subsequently as feed for ruminants.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Cattle rumen contents, Cyprus	12.0	16.2	25.4	13.5	2.3	42.6	0.21	0.62	369
Lamb rumen contents, Cyprus	15.2	28.8	25.5	12.3	4.6	28.8	1.00	0.56	369
Liquid part of rumen contents, USA	8.7	24.1	21.8	13.2	31.0	9.9	1.95	1.03	463
Solid part of rumen contents, USA	64.7	10.3	38.0	7.3	1.8	42.6	0.73	0.42	463

H6 Hydrolysed hog and cattle hair

Useful reference: 346

Hog hairs are more difficult to hydrolyse than feathers. The fibres disintegrate when pressure-cooked (3.5 kg/cm^2 or 50 lbf/in^2) at 148°C for thirty minutes. The processed product is a valuable feedstuff because of its high protein content, but it is deficient in methionine, lysine and tryptophan. The amount of the meal which can be used effectively under ordinary conditions is limited. The inclusion of more than 2-2.5% in poultry feed does not seem advisable. Also hydrolysed wool has been used as a replacement for soybean meal at levels of 2-5% with good results. Hydrolysed hair seems to be unsuitable for pigs.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Hydrolysed hog hair, Cyprus	36.8	96.7	0.0	1.0	2.3	0.0	0.34	0.14	369
Hydrolysed wool meal, China (Taiwan province)	80.5	51.6	12.2	26.0	10.2	0.0			539

H7 Horn-and-hoof meal

Useful reference: 402

The horns and hoofs are treated separately. The hoofs are soaked in water until they become spongy and can be freed from the bones, after which they are spread out in the sun to dry. The horns are cured in the sun until the horn pith is completely dried and can be removed by hammering. The horns and hoofs together are put into an autoclave (digester) and steam cooked for seven hours at 110°-112°C. The material is then dried and finely ground. The digestibility of horn-and-hoof meal has been shown to increase progressively with the fineness of the ground material. It has been used at low levels in poultry diets with variable results. It seems to be unpalatable to most classes of livestock.

A high digestibility, about 80% for the crude protein, has been reported for horn-and-hoof meal prepared by steeping the hoofs and horns in 10% sodium carbonate for sixty hours at 20°C, after which the material was boiled in water for one hour and dried at a high temperature until it turned golden yellow.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Lamb hoofs, raw, Cyprus	38.6	69.5	0.0	15.8	14.7	0.0	2.10	8.75	369
Horn-and-hoof meal, Pakistan	89.6	88.6	0.0	5.6	4.7	1.1	0.80	0.73	402

H8 Tannery by-product meal

Before hides are tanned, the flesh and epidermis are removed by either hand or machine scraping. The by-product from this process is usually used as fertilizer, but it can be solvent extracted, dried and ground to a meal for animal feeding. It is very rich in glycine (20.9%) and lysine (8.1%) and has been used to replace up to 25% of the soybean oil meal in poultry feed. It does not affect feed efficiency, but it tends to depress growth.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Tannery by-product meal	79.7	85.1	0.0	5.3	9.6	0.0			508

H9 Hydrolysed leather meal

Tanned leather scraps can be hydrolysed in much the same way as poultry feathers (see H11). Hydrolysed leather meal can be included in broiler diets at levels up to 8% with no adverse effects. Chromium is usually used as the tanning agent, but the metal does not seem to accumulate in the meat or fat of birds fed leather meal. Mixed with meat meal, it has been included up to 3% in pig diets without adverse effects.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Hydrolysed leather meal	91.6	71.4			7.1				498

H10-15 Poultry By-products

Modern poultry industries are growing up in many developing countries. Usually the birds are produced in concentrated areas and processed into ready-to-cook poultry in a central plant. This concentration allows efficient conversion of the by-products into animal feeds. The most important processed by-products are poultry by-products meal, hydrolysed poultry feathers and poultry fat.

H10 Poultry by-products meal

Poultry by-products of slaughter — such as feet, head and undeveloped eggs — can be processed in the same way as other slaughterhouse waste if the quantities are large enough. Gizzards and intestines can be used as well if the contents are removed. The dry-rendering method is usually preferred for processing poultry by-products. Poultry tankage and meat meal are about equal in value to the same by-products from larger animals. They can be used as the only protein component in growing and finishing rations for swine with good results. Poultry by-product meal is remarkably rich in the vitamin choline and is often included up to 5% in poultry diets.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Poultry by-products meal, USA	94.2	59.9	2.1	15.5	17.1	5.4	3.75	1.80	11
Chicken feet, raw, Cyprus	39.7	53.4	0.0	20.3	26.3	0.0	4.00	3.33	369
Chicken viscera, raw, Cyprus	26.3	52.9	0.0	4.7	42.4	0.0	0.22	0.96	369
Chicken heads, raw, Cyprus	32.8	56.7	0.0	20.0	23.3	0.0	2.80	3.30	369
Chicken blood, raw, Cyprus	17.9	91.8	0.0	5.9	2.3	0.0		0.56	369

H11 Hydrolysed poultry feathers

Useful reference: 42

Unprocessed poultry feathers cannot be digested by single-stomach animals; however, feathers hydrolysed by cooking at a high temperature under sufficient pressure are highly digestible. This treatment also gives the feathers a good keeping quality, so that unlike raw feathers the feather meal will not rot. The insolubility of feathers is mainly due to the protein keratin, which contains a high percentage of the amino acid cystine. Autoclaving reduces the cystine content from about 10% to 3.5%, thereby making the feathers more soluble and digestible. The digestibility of the crude protein in hydrolysed feathers is 75-80%. The quality of the product depends largely upon the efficiency of the hydrolysis. Undercooked meal will still contain undigestible raw feathers, while overcooking reduces the digestibility and lowers the yield of crude protein. The feathers can be processed either under low pressure (130°C) for two and a half hours or under high pressure (145°C) for thirty minutes. After cooking, the material is dried at about 60°C and ground to pass a 20-mesh screen. If a pressure cooker is not available, the poultry feathers can be hydrolysed with chemicals. The feathers are cooked in an open kettle with a solution of sodium sulphite in alcohol and water. During cooking about 80% of the feather material dissolves in the liquid. After cooking, the liquid is filtered to remove the undissolved parts and is allowed to cool. During cooling the whole mixture will set, and the solvent can then be expelled by pressing and washing. The solid protein residue is dried for use.

Hydrolysed feather meal can supply part of the protein in the diet of ruminants. Up to 10% has been included in concentrates for dairy cattle. Abrupt introduction of feather meal in the diet may reduce consumption of the concentrate. The gradual addition of hydrolysed feather meal over an extended period seems to minimize this problem. As feather protein is deficient in several essential amino acids, other ingredients must be used to balance these deficiencies. In practice, the proportion of hydrolysed feather meal included in rations for monogastric animals is 5% or less. When low-quality oilcakes make up the protein portion of the diet, 2.5% fish meal or meat meal is added to supplement the feather meal. Provided that satisfactory levels of the essential amino acids are maintained, hydrolysed feather meal is a useful source of protein.

		As % of dry matter								
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Hydrolysed poultry feathers	93.0	91.4	0.4	3.8	3.9	0.5	0.42	0.51	401

H12 Poultry offal meal

Useful reference: 394

This meal is a combination of all poultry by-products processed together in the same proportions as they occur in the processing plant. The product is similar to a mixture of about 45% poultry by-product meal, 40% hydrolysed poultry feathers and 15% poultry fat. It is satisfactory for mixing into poultry diets.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Poultry offal meal	92.4	68.5		7.8	23.1				394

H13 Hatchery by-product meal

Useful reference: 509

Hatchery refuse — infertile eggs, dead embryos, shells of hatched eggs and unsaleable chickens — can be made into a useful feed by cooking, drying and grinding. The high calcium content limits its use as feed, but up to 4% has been included with excellent results in broiler-type diets. The protein component can be precipitated by boiling the hatchery waste in three times its volume of sulphite waste liquor for five minutes. The coagulum, which contains very little calcium, is pressed and dried.

Incubation appears to modify the egg albumen in a way that makes it readily digestible by pigs. Raw incubator eggs can satisfy a major portion of the pigs' daily needs, thereby providing a way to salvage some value from unhatched eggs as well as a convenient method of disposing of the waste. There is a danger of a biotin deficiency in pigs fed 30% or more dried raw eggs. The symptoms of this deficiency are cracked hoofs, dry rough skin and loss of hair. A protein, avidin, in raw egg whites ties up biotin in the gastrointestinal tract and prevents its absorption. Heating destroys the avidin and prevents a biotin deficiency.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Hatchery by-products meal	93.7	37.2	0.0	36.0	21.7	5.1	22.0	0.52	191
Coagulated hatchery waste	98.8	51.0	0.0	2.5	40.3	6.2			336

H14 Eggshells

About 10% of the egg is shell. Considerable amounts accumulate at hatcheries and plants where eggs are frozen or dried to egg powder. About 94% of the eggshell is calcium carbonate, and approximately 4% is organic matter that contains some calcium and magnesium phosphates. Other elements such as boron, copper, chromium and iodine occur in traces. Where sources of calcium are scarce, eggshells may be sterilized, ground and used in poultry mashes. Very finely ground eggshells can be used in pig diets.

H15 Whale products

Useful reference: 67

The muscle of whales is similar in composition to that of other mammals. Whales are processed only on an industrial scale. The whale meat is heated under steam pressure to release the oil, which is the primary product of the industry, and during this process the tissues are broken down into a slurry. After the oil has been centrifuged off, the remainder is separated into solids and liquids. The solid material — 45-50% of the remainder — is dried, ground and sold as whale meal. The black viscous liquid, which contains a high proportion of soluble protein, can be acidified and concentrated to be sold as whale solubles. The composition of whale meal varies with the processing method and with the bone and fat included in it. Whale meal is graded according to percentage composition as follows:

		CP	EE	Ash
Grade A	Meat only	80-85	3- 5	2- 3
Grade B	Meat and bone	45-65	10-16	20-30
Grade C	Bones	18-25	>16	55-65

Whale meal is used in the same way as fish meal, and it is a valuable source of B vitamins, including B_{12}.

There is no danger of an off-flavour in meat or eggs when whale meal is used. Whale solubles are a satisfactory replacement for meat meal or fish meal if the deficiencies in calcium, phosphorus and vitamins are taken into account. Whale oil does not cause taints, but an excess may cause softening of pig fat. Up to 10% whale oil can be included in pig rations without adverse effects.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Whale meal	94.6	92.8	0.0	2.2	3.7	1.3	0.04	0.09	513
Whale meal and bone meal	92.0	58.4	0.0	27.0	13.0	1.6	6.63	3.37	363
Whale solubles, condensed	50.0	84.0			0.4		0.12	0.60	335

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Whale meal	Pigs	87.8	0.0	97.0	0.0	4.40	513

H16-22 Fish Products

Useful reference: 150

Properly processed fish products are among the very best sources of high-quality protein for animals and also contain relatively large quantities of lysine, methionine and tryptophan — the amino acids most often lacking in a cereal-based diet. They are rich in minerals and vitamins and are reported to supply "unidentified growth and hatchability factors." Fish products are mostly used at low levels in pig and poultry diets, especially in starting and breeding rations for poultry.

H16 Raw fish

Useful reference: 34

There are wide variations in chemical composition among the different fish species and also in the same species caught at different times of the year or growing under different conditions. The general categories with examples are shown in the following table (see ref. 465):

Characteristics	Sample species	Prototype			
		DM	CP	EE	Ash
		... *Percent* ...			
A. Low oil (under 5%) - low protein (under 15%)	Butter clams *(Saxidomus nuttal)*	17.0	13.3	1.3	1.9
B. Low oil (under 5%) - high protein (15-20%)	Pacific cod *(Gadus macrocephalus)*	18.5	17.9	0.6	1.6
C. Low oil (under 5%) - very high protein (over 20%)	Skipjack tuna meat *(Katsuwonus pelamis)*	27.6	26.2	0.7	1.5
D. Medium oil (5-15%) - high protein (15-20%)	Mackerel *(Scomber scombrus)*	32.5	18.0	13.0	1.5
E. High oil (over 15%) - low protein (under 15%)	Siscowet lake trout *(Cristivomer namacush)*	47.5	11.3	36.0	0.5

These categories include the following species:

Group A: Oysters and clams

Group B: Carp, cod, flounder, haddock, hake, mullet, ocean perch, pollack, rockfish, whiting, crab, scallop and shrimp

Group C: Halibut and tuna

Group D: Anchovy, herring, mackerel, salmon, sardine

Raw fish are seldom used in everyday diets for other than fur-bearing animals, but they have been fed to pigs and can be used regularly if mixed with other feeds. In Peru it was found economical to feed pigs up to slaughter a ration consisting half and half of raw anchovies and sweet potatoes. To avoid a fishy flavour in the meat, fish was removed from the diet four weeks before slaughter. Washed salted herring have also been used in amounts up to 0.5 kg per day. An excessive use of raw fish may be detrimental because they contain the enzyme thiaminase which destroys the B-vitamin thiamine. Although not all fish contain thiaminase, this can be a problem particularly in the feeding of fur-bearing animals; therefore, it is not advisable, for example, to use more than 25% raw fish in the diet of mink.

H17 Fish meal

Useful references: 392, 68

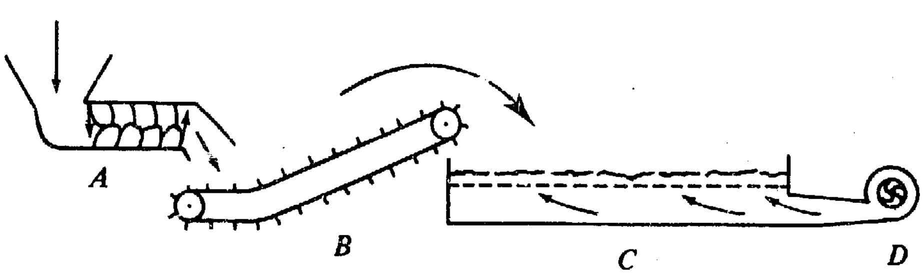
Historically fish meal was a by-product of fish oil production and a way of utilizing surpluses and small fish that could not be sold for human consumption. As the value of fish meal came to be recognized, fishing industries were developed with fish meal production as their primary purpose. The industrial production of fish meal requires highly skilled labour and expensive plants. There are two principal ways of making fish meal: by direct drying (white fish meal) or by cooking before drying (dark fish meal). The oil content of the raw material determines which of these two methods is used. The two processes are diagrammed in the flow chart on page 406.

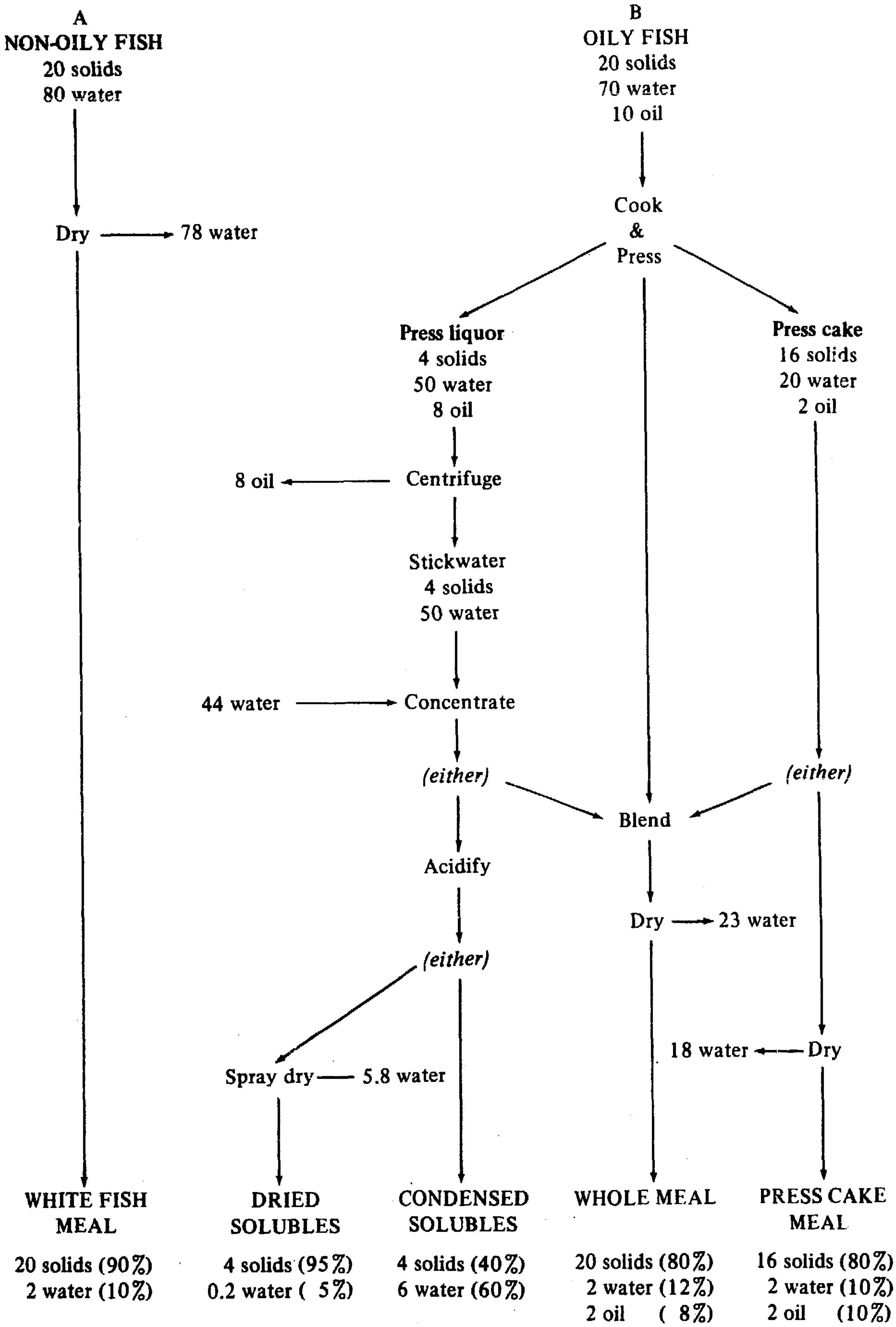
White fish meal is produced from whole fish, partly eviscerated fish and residues after the fillets have been cut off. The level of fat in the meal is usually between 3% and 6%. Dark fish meal is usually made from whole fish. The oil is separated by cooking and pressing, leaving a press cake, which is then dried to make the most common type of fish meal. Alternatively, the press cake may be blended as shown in the flow diagram.

Shark and dogfish should be processed by the cook-and-press method as dried and ground shark meal has little or no value as a supplementary protein, whereas cooked and pressed meal is about equal in value to ordinary fish meal for poultry and pigs.

Fish meal can be produced on a small scale under rural conditions in the following way. The fish or fish waste is ground or chopped, boiled for a short time and squeezed in cloth to eliminate water and oil. The residue is then dried in the sun or in an oven. In an oven it is first dried for two hours at about 45°C and then finished at 65°C. It can subsequently be ground if necessary. The keeping quality of the meal is good.

For the manufacture of fish meal on a medium scale (from 100 to 200 kg per day) a small plant may be constructed as shown in the diagram below. The fish passes through the grinder *(A)* and is transported on a conveyor belt *(B)* to a dehydration tank *(C)*. This tank has a double bottom; the upper one on which the ground fish falls is perforated to permit the passage of hot air from a blower *(D)*. For rapid drying the fresh fish is mixed with the same volume of dried fish meal before grinding. The temperature of the hot air should be 80°-90°C. If occasionally stirred during drying, 500 kg of fish will dry in about six hours with an oil consumption of about 50 litres.





A
NON-OILY FISH
20 solids
80 water
Dry
78 water
WHITE FISH MEAL
20 solids (90%)
2 water (10%)
B
OILY FISH
20 solids
70 water
10 oil
Cook & Press
Press liquor
4 solids
50 water
8 oil
Centrifuge
8 oil
Stickwater
4 solids
50 water
Concentrate
44 water
(either)
Acidify
(either)
Spray dry
5.8 water
DRIED SOLUBLES
4 solids (95%)
0.2 water (5%)
CONDENSED SOLUBLES
4 solids (40%)
6 water (60%)
Press cake
16 solids
20 water
2 oil
(either)
Blend
Dry
23 water
WHOLE MEAL
20 solids (80%)
2 water (12%)
2 oil (8%)
Dry
18 water
PRESS CAKE MEAL
16 solids (80%)
2 water (10%)
2 oil (10%)

Fish meals should be stored dry, and the sacks should not be stacked. Storage facilities for newly manufactured meal should be airy to facilitate the initial oxidation of the residual oil. With this precaution there is no need to add an antioxidant to the fish meal.

Because of its high cost, fish meal is rarely fed to ruminants. Some experiments indicate a better response to fish meal than to other protein sources. Under most conditions, however, it is not economical to feed fish meal to ruminants. Fish meal has become a standard ingredient in pig and poultry rations to make up for deficiencies of essential amino acids.

The amount of fish meal added to the diet depends, of course, on the composition of the other ingredients. For poultry the average levels are 10% for starters, 8% for finishing rations and 5-6% for layers. For pigs a common level is about 7%. The only factor that requires attention when the level of fish meal is high in the ration is the oil, which may lend a fishy flavour to meat or eggs. The safe maximum limit of fish oil in both pig and poultry diets is between 1% and 1.5%, which in most cases means a maximum inclusion of about 10% fish meal. For the latter part of the growing period of pigs and poultry a maximum level of 2.5-5% is recommended.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Tunafish meal	90.0	68.9	1.1	22.2	7.8	0.0	4.44	2.78	225
Whitefish meal	91.0	72.5	1.1	22.0	4.4	0.0	7.89	3.89	392
Pilchard, press cake	88.0	72.7	1.1	18.2	8.0	0.0	4.89	3.41	392
Herring, whole meal	90.0	78.9	1.1	11.1	8.9	0.0	3.00	2.20	392
Fish meal, Chile	92.3	72.6	1.1	15.7	2.7	7.9	3.66	2.41	261
Fish meal, Peru	91.8	70.5	1.1	16.8	5.2	6.4	4.30	2.83	261
Fish meal, Tilapia fish	93.7	66.5	0.0	29.8	3.7	0.0			499
Fish meal, viscera only	90.0	76.7		9.1	5.0				302

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Tunafish meal	Cattle	76.0	0.0	97.0	0.0	2.85	516
Whitefish meal	Sheep	93.0	0.0	90.0	0.0	3.22	224

H18 Alkali-reduction meal

Storage in alkali solutions is an emergency method of holding fish when landings exceed plant capacity. After heating and oil separation the aqueous phase is acidified and dried to yield alkali-reduction meal. The nutritive value of the meal depends on the concentration of sodium hydroxide in the solution. The maximum concentration of sodium hydroxide that should be used in the storage liquor seems to be slightly above 2%. With 3% sodium hydroxide the meal was toxic to poultry and low in nutritive value because of partial destruction of vitamins and essential amino acids. When 2.25% sodium hydroxide solution was used for storage, there was less destruction and the alkali-reduction protein was nutritionally similar to soybean meal protein.

H19 Fish protein concentrate

Useful reference: 459

The product is also called fish flour. It is prepared by solvent extraction of fish meal to remove the oil and thus the fishy taste. It is manufactured mainly for human consumption, and the price is usually higher than that of fish meal. As fish protein concentrate (FPC) is free of oil, its keeping quality is good. Usually the less digestible water-soluble protein is removed, thereby rendering it more digestible than fish meal. Fish protein concentrate can entirely replace skim milk in calf milk replacers and may be used in pig starters. A spray-dried calf milk replacer containing 22% FPC, whey and fat has become very popular in the Scandinavian countries and has proved to be equal to conventional milk replacers.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fish protein concentrate, South Africa	95.4	87.5		11.5	0.2		2.00	2.00	135
Fish protein concentrate, Sweden	91.9	80.0	0.0	11.6	0.3	0.0	3.50	2.50	29

H20 Fish oil

Useful reference: 38

Fish oils are an important source of vitamins A and D. In addition, fish oil supplies unsaturated fatty acids. There is a notable difference in the vitamin content of oil from whole fish and oil from fish livers as shown in the following list (in international units/gram):

	Vitamin A	Vitamin D
Herring oil	30-300	25-160
Pilchard oil	100-500	20-100
Menhaden oil	340-500	50-100
Cod-liver oil	550-30 000	85-500
Halibut-liver oil	4 000-165 000	550-20 000
Tuna-liver oil	50 000-1 000 000	16 000-30 000

It must be remembered that fish oils and their vitamins are easily oxidized and destroyed. They cannot be used as a source of vitamins in commercially manufactured feed concentrates because the vitamin activity ceases upon storage of the feed; besides, it is difficult to mix the oil evenly throughout the mixture. Fish oil should be protected from strong light and stored airtight. Over-enthusiastic use of fish-liver oil can cause nervous disorders in chickens. Owing to the unsaturated nature of fish oils they cannot be used as a source of energy to the same degree as other fats. The maximum amount that can be included in rations for monogastric animals is between 1% and 1.5%.

H21 Fish solubles

Useful reference: 352

The press liquor from the manufacture of brown fish meal retains most of the oil in the original material. The water and the oil are separated by centrifuging. After removal of the oil, the remainder, called press water or lime water (because of its white colour), contains about 10% solids. These can be concentrated in evaporators and either mixed back into the press cake to form whole meal or used separately as condensed fish solubles or as spray-dried meals called dried solubles. The main value of fish solubles is their high content of vitamins of the B complex. It is also claimed that fish solubles contain an unidentified growth factor that is important in poultry feeding. Fish solubles are commonly included at a level of 2-3% in rations for pigs and poultry that are kept in confinement with no access to green feed. They are not normally used as a major source of nutrients, because a large proportion of the nitrogen is in non-protein form and hence cannot be utilized by monogastric animals.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Menhaden fish solubles, USA	51.1	62.1		15.3	17.4		0.12	1.10	456

H22 Fish silage

The manufacture of fish silage is a simple and inexpensive way of utilizing waste and scrap fish in quantities that are insufficient for the economic production of fish meal. Two different methods are used to make fish-carbohydrate silage and acid silage. In both cases, lean fish give better silage and least affect the taste of the meat. In the case of fish-carbohydrate silage, the oil should be removed from the fat by cooking and pressing in cloth before ensiling.

Fish-carbohydrate silage

Useful reference: 367

The principles of making fish silage are the same as those for other types of silage. The material is stored airtight and preserved by acids arising from the anaerobic fermentation of carbohydrates, which must be added as fish products contain no carbohydrates. It is important that the fermentation process start rapidly so that the fish will not spoil. To ensure rapid fermentation, molasses should be added if the ratio of fish in the silage is high. If only starch is used, it can be converted into simple sugars by adding an enzyme, such as the amylase in malt, which is available at breweries. Many types of carbohydrates are used: rice bran, wheat middlings, potatoes, cassava, molasses, maize and citrus meal. Many ratios of carbohydrate and fish have been recommended. The maximum amount of fish that can be included in the silage seems to be 60% with dry sources of carbohydrates (citrus meal or grain by-products) and much lower, about 10%, with fresh sources (such as potatoes). With higher percentages the silage will be moist.

The silages shown in the table on page 411 were made in the following way. The whole fish were disintegrated in a meat grinder and mixed with the carbohydrates; then the mixture was stored in airtight plastic containers. (Oil-drums painted on the inside could have been used, but not unpainted drums as the silage was very corrosive.) The silages could be kept in a hot climate for at least five months and smelled pleasant when opened. The ingredients of the molasses-type silage were whole fish 50%, citrus meal 20%, wheat middlings 20% and molasses 10%; those of the malt-type silage were whole fish 58%, wheat middlings 40% and malt 2%.

Silage should *not* be used before it becomes acid as it may be poisonous. Fish silage can be used either fresh or dried. It is fed mainly to young pigs and poultry and to breeding animals, but feeding should be stopped some weeks before slaughter. Off-flavours can be prevented by following the same rules as for other fish feeds.

ACID SILAGE (LIQUID FISH)

Useful reference: 386

Acid silage is easily made in hot climates by a very reliable process. All types of fish and fish wastes can be used if they have not previously been cooked or dried. The principle is that acid added to the fish lowers the pH and prevents bacterial putrification. The protein-splitting enzymes known as cathepsins, present in the muscles and stomach of the fish, are active only in an acid environment. The optimum level of their activities is between pH 4 and 5 at about 37°C.

Acid silage is easily manufactured with little equipment. The fish are ground as finely as possible and placed in a vessel. An oil-drum, preferably painted inside, will suffice. About 5% concentrated acid is then added. The best acids are phosphoric, formic and acetic acids, as hydrochloric acid renders the silage salty and sulphuric acid precipitates calcium sulphate. After being well mixed, the silage is allowed to stand until the fish is liquified, which will take less than a day in a warm climate. Scales and big bones, which will not liquify, should be filtered off and either discarded or dissolved in concentrated phosphoric acid and mixed back. After the acidity has been controlled and adjusted to below pH 5, the silage can be stored for several months without spoiling. The liquid can be fed directly if neutralized with limestone or chalk, or it can be dried with brewer's grain, wheat middlings and like materials. If yeast is added during the liquification process, the silage can be dried easier to condensed liquid fish or spray dried. If oily fish is used, the oil should be separated by centrifuging. Acid silage has the same composition and dry matter content as the fish it is made from; however, the digestibility of the protein is higher and the availability of amino acids is better in the silage than in the fish from which it is made.

A convenient way of producing an acid silage is the following recipe. About 62 kg of ground fresh fish or fish scraps are first mixed with 2 kg of formic acid and then 4 kg of sulphuric acid. The mixture is blended with 32 kg of lucerne meal or wheat bran. The product is rather dry and easy to handle.

Neutralized liquid fish can constitute up to 35% of pig rations. It has also been used for poultry as the major supplier of protein, in which case 4-5% dried acid silage is the normal level.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fish silage, malt type, Trinidad	49.8	38.0	6.0	10.2	6.2	39.6			191
Fish silage, molasses type, Trinidad	47.6	28.2	6.1	11.3	4.4	50.0			191

H23 Shrimp meal

Shrimp meal can be made either from freezing-plant waste (heads and scales) or from whole shrimps in areas where the quality of the shrimps is not good enough for human consumption. To manufacture shrimp meal, the waste or the shrimps are dried first in the sun or in an oven and then ground.

Shrimp meal is about equal to meat meal in feed value. About 5% is usually mixed with other protein supplements in pig and poultry rations. Because it is extremely rich in choline, its inclusion in poultry diets makes supplementation with synthetic choline unnecessary.

Shrimp meal has long been used by nutritionists in trout and salmon diets for desirable coloration. The inclusion of as much as 15% shrimp meal is not unusual in pond trout formulations. The meal contains large quantities of chitin, a nearly indigestible crude protein. Therefore, the figure for crude protein in the analysis of shrimp meal should be corrected for the fraction contributed by chitin and the nitrogen it contains. About 10% of the crude protein in whole shrimp meal and up to 50% of the nitrogen in scale meal originate from chitin.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Meal from whole shrimps, Madagascar		73.6		18.6	6.6		3.03	1.13	189
Meal from shrimp heads and scales, Trinidad	89.8	48.9	18.3	31.9	0.1	0.8			117

H24 Starfish meal

The oyster industry has attempted to alleviate the serious problem of starfish by collecting them on a large scale for use as feed. Dried and ground starfish are very rich in ash composed mostly of calcium. As the meal also contains thiaminase, which destroys the B-vitamin thiamine, the meal should be used with caution. Up to 20% has been used to supplement grain in pig diets, and up to 5% has been included in poultry diets. At these levels no negative influences have been observed under experimental conditions, although it took some time for the animals to become accustomed to starfish meal. The taste of the meat was not affected.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Starfish meal	85.0	35.3	47.1	9.4					180

H25 Snails

Snails are abundant in many parts of the world. The African giant snail (*Achatina fulica* Bowdich), which can grow to over 30 cm long, has attracted special interest as a feed for farm animals. Snails are cooked, dried and ground for use in poultry and swine rations to replace fish or meat meal. The results compare favourably with fish meal and no adverse symptoms have been observed. Fermented snails which have been salted, placed in jars and allowed to ripen for some months have also been used for swine.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Helix sp., whole, dried, Spain	94.3	66.5		8.3	8.0				339
African giant snail, whole, dried, Malaysia	88.9	51.3		7.9	2.7		0.83	0.54	292

H26 Silkworm pupae

Useful reference: 328

Spent silkworm pupae accumulate in large quantities as a by-product of the silk industry, especially pupae of the mulberry variety *(Bombyx mori)* and the tassar variety *(Antheraea mylitta paphia)*. Small quantities can be included in pig and poultry diets. The pupae can be better utilized if freed from the highly unsaturated fats that affect the taste of the meat. Silkworm pupae meal has been used with good results to replace fish meal in diets for monogastric animals. Pupae contain some chitin because of their high crude protein content, of which only about 75% is true protein. The cocoons have no feed value and should therefore be separated.

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
B. mori, solvent extracted	92.5	77.6	4.3	7.3	1.0	9.8	0.1	1.5		276
B. mori, raw	20.0	54.2	3.9	5.2	30.3	6.4	0.1	1.1		276
A. mylitta paphia, solvent extracted	92.8	74.2	10.2	6.9	1.1	7.6	0.2	0.8		276
A. mylitta paphia, raw	20.0	56.3	7.7	5.3	30.0	0.7	0.2	0.7		276

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Extracted pupae	Sheep	87.7	73.5	94.6	36.2	3.26	276

H27 Locusts

Useful reference: 208

Locusts *(Schistocerca gregaria)* are relished by many African tribes, which also use them as animal feed whenever large amounts of dead locusts are available. Locusts killed with dinitro-ortho-cresol can be fed to animals, but those killed with arsenic should not. Fresh locusts when mashed have an offensive smell, but this odour is absent from sun-dried locusts that have been ground or pounded into a meal. Dried locust meal is palatable to pigs and poultry. If properly supplemented, it is a good feed even though much of the protein is in the form of keratin. It will, however, lend a fishy smell to pig meat and should therefore be fed to breeding animals only. When dried grasshoppers were fed to poultry, this disadvantage was not observed. Up to 20% has been used in pig rations and 16% in poultry rations.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Whole locusts, raw, Kenya	29.4	63.5	13.5	8.7	14.1	0.2			208
Whole locusts, dried, Tanzania	89.5	51.6	14.0		10.9				499

H28 Milk by-products

Milk contains almost all nutrients required by animals. Although milk products are excellent feeds, their cost prohibits extensive use for all but young animals; also, fresh milk products are bulky to handle and deteriorate rapidly in transport. Milk is deficient in iron and copper. If the young animals are suckled too long, they may suffer from anaemia, which accounts for the colourless meat of so-called "white veal," or calves fed entirely on milk.

Skim milk (separated milk). This is milk from which most of the fat has been removed but in which all the protein remains. The protein has a high biological value and is very digestible. Skim milk is a good source of vitamin B, whereas the fat-soluble vitamins (A and D) are removed with the fat. Fresh skim milk is commonly used in calf feeding in place of whole milk. From the fifth day of the calf's life, skim milk is gradually substituted for the whole until it is fully replaced on the forty-fifth day. As skim milk is deficient in fat-soluble vitamins, it is advisable to mix the skim milk with a vitamin concentrate or cod-liver oil (30 g daily per calf) from the thirtieth day. Salt lick should be provided, and concentrates can be given in small amounts from the fifteenth day.

For young pigs skim milk can be used to advantage. It can be given *ad lib* to piglets from three weeks of age up to weaning, but they should also have access to a concentrate with adequate amounts of vitamins A and D. Mature pigs can be fed skim milk with a corresponding reduction of protein in the meal ration.

Skim milk can be given to poultry to drink *ad lib* or can be used in preparing wet mashes. When skim milk is fed *ad lib* to growing birds from six weeks of age or to laying and breeding hens, at a rate of 20 litres per day per 100 birds, roots or protein-deficient cereals will provide a balanced ration with respect to proteins, minerals and some vitamins; but it will still be necessary to include a suitable source of vitamins A and D.

Slightly sour milk can be fed to pigs and poultry, but to prevent digestive troubles they should consistently be fed *either* fresh or sour milk. Containers for milk that are used for feeding must be kept absolutely clean. Small quantities of formalin (1-2 ml of a 40% formalin solution per litre of milk) can be added to skim milk to delay clotting for some weeks. Milk so treated can be fed satisfactorily to fattening pigs without any changes in meat quality. Experiments to find a substitute for the removed butterfat have been conducted, but it is usually not advantageous to make "filled milk" by adding oil to skim milk, as oily and watery carcasses may result. It is better and safer to increase the energy content of skim milk by adding cassava meal or another carbohydrate.

Dried skim milk is commonly included in calf and pig starters at levels of 5-20% and is also used in chicken feed at levels of 2-3%.

Buttermilk. This residue from churned whole milk contains somewhat more fat than skim milk. It is used in the same way as skim milk for pigs and poultry, but it has a laxative effect on young calves.

Whey. This is the residue from the manufacture of cheese, during which most of the protein and fat are removed. Accordingly, the dry matter content of whey is low and consists mostly of milk sugar and minerals. A maximum of 25 kg of fresh whey per day can be fed fresh to pigs at a rate of 7 kg per 1 kg of dry meal. For poultry it can replace drinking water, with the advantage of adding nutrients to the diet; or it can be used to prepare wet mashes. A simple method of feeding whey to pigs is to provide it *ad lib* with a daily supplement of 1 kg of concentrate per pig until the pigs weigh 50 kg, after which the concentrate is changed to 1 kg of barley or a low-protein concentrate.

Liquid whey can be fed *ad lib* to cows if they have free access to water. The average consumption will then be 60 litres of whey and 30 litres of water, although the individual variation is considerable. The feeding of restricted amounts of liquid whey to cows (6% of the liveweight) has also produced good results. Twelve litres of whey with 6% dry matter can replace 1 kg of cereal. Large amounts of whey tend to lower milk production and at the same time increase the butterfat content. If salt is added to the whey, the amount fed should be restricted to less than 25 g of salt per 100 kg of liveweight per day. Fresh water should always be provided.

Whey can be condensed to whey paste (30% DM) or be dried. Dried whey will not cause the animals to consume more dry matter than when they are fed liquid whey. Young animals usually show a considerable response to even small amounts of dried whey in their rations. To avoid digestive troubles in adult animals, it is advisable to introduce the whey gradually.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh whole milk, Uganda	15.0	24.0	0.0	5.3	41.3	29.4	0.80	0.67	69
Fresh skim milk, Trinidad	9.6	37.5	0.0	8.3	1.6	52.6			191
Skim milk powder, Uganda	90.0	36.4	0.0	8.3	1.7	53.6	0.93	0.73	69
Fresh buttermilk, UK	10.0	33.0	0.0	8.0	12.0	47.0	0.80	0.67	3
Fresh whey, Cyprus	5.3	10.8	0.0	9.2	0.4	79.6	0.75	0.64	369

I1 Seaweed

Seaweed has long been used in livestock feeding in temperate climates, but its use in warm climates has not been well investigated. The results of feeding temperate species of seaweed have not been sufficiently encouraging to justify the high production costs, and despite the plentiful supplies, seaweed has never become an important feed. As the digestibility of its protein is usually low, seaweed serves mainly as a source of minerals and, to an extent, of vitamins and energy. The iodine content is so high that prolonged feeding of large amounts of seaweed may produce symptoms of iodine poisoning. High levels of seaweed in the diet may also affect the digestibility of the other ingredients in the feed.

Seaweed is almost always used as dried meal. After harvest, the seaweed is rinsed in fresh water, partially dried in the sun, washed again with fresh water containing 0.2% hydrochloric acid and then dried in a vacuum before grinding. The nutritive value depends on many factors, such as species, time of the year and water temperature. To produce a meal of good quality the seaweed should be dried quickly without overheating.

Seaweed meal of good quality has constituted up to 10% of cattle feeds with good results, and 35 g a day have been fed experimentally to sheep with increased gains as compared to the control animals. Seaweed meal is less suitable for pigs, and in some cases it can give the pork a fishy smell. It can be included at low levels without any decrease in animal production. The optimum level of about 6% in poultry diets has a positive effect on the yolk colour and usually supplies the required vitamin A. Seaweed seems to help combat intestinal parasites.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Seaweed meal[1], Norway	88.7	5.9	10.6	18.4	4.7	60.4	1.29	0.06	409
Pterocladia capillaceae, dried, Egypt	89.6	19.4	9.6	28.2	0.4	42.4			144
Cystoseira sp., Malta		10.2	13.6	20.2	1.0	55.0	3.09	0.05	109
Sargassum longifolium, South Africa	91.4	9.4	7.1	36.3	0.5	46.7	2.20	0.12	193

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Seaweed meal	Sheep	0.0	99.9	0.0	91.0	2.37	409

12 Leaf protein concentrate and grass juice

Useful reference: 272

Protein synthesis is one of the chief activities of the green part of the plant. Some forage crops produce leaf protein in large quantities of up to 5 tons per hectare — three to four times that of grain crops. The basic technology for separating the leaf protein from the fibrous part of the leaf has been known for about fifty years, but a technology for large-scale production was not developed until the 1970s. The basic steps for the production of leaf protein concentrate (LPC) are grinding the plant and separating the juice by pressing. The protein is dissolved in the juice, after which it is coagulated, usually by heating, and then dried. The machinery needed for large-scale production is expensive, the minimum economical output being about 10 tons of leaf protein per hour — which means that about 5 000 hectares are needed for the commercial production of LPC. Smaller machinery has been designed for use at the village level.

Dried LPC contains about 40% crude protein, of which about three quarters is true protein. The amino acid composition is remarkably constant regardless of the green fodder used. The biological value of leaf protein lies between that of soybean and that of milk. The product is green and presents no palatability problems when included in mixed feeds.

The recommended level of LPC in diets depends on both the raw material and the processing method; LPC from green cereal fodder, rye grass and marrowstem kale has been shown to cause fewer problems than that from lucerne. It seems possible to include LPC in the diets of poultry, pigs and calves at levels covering up to 30% of the protein allowances for these species. When using lucerne LPC, this level can under certain conditions create problems, in which case it is advisable to decrease the percentage of inclusion.

Protein concentrate from sugar beet tops has given poor results and cannot be recommended until the processing method is changed. At higher levels of inclusion in poultry diets LPC may depress feed intake and increases the incidence of wet droppings. The carcasses of poultry reared on LPC diets are yellower, which in some countries can create market resistance. The LPC preparations now being manufactured are very dusty, which can cause problems in handling.

A milk replacer for calves based on LPC gave very good results. It contained 20% LPC, 12.3% fish protein concentrate (FPC); 48.7% dried whey, 15% animal fat and 4% minerals and vitamins.

Liquid grass juice can be fed directly to pigs. The juice is readily extracted by mechanical pulping and squeezing on a belt press. The yield of juice is approximately 50% of the weight of the crop. The addition of sodium metabisulphite to the acidified juice at pH 4 permits long-term storage. Grass juice can replace three quarters of the soybean meal in pig rations. It is fed most simply in a ratio of 4:1 liquid to a meal consisting of 93% barley, 5% soybean meal and 2% minerals and vitamins.

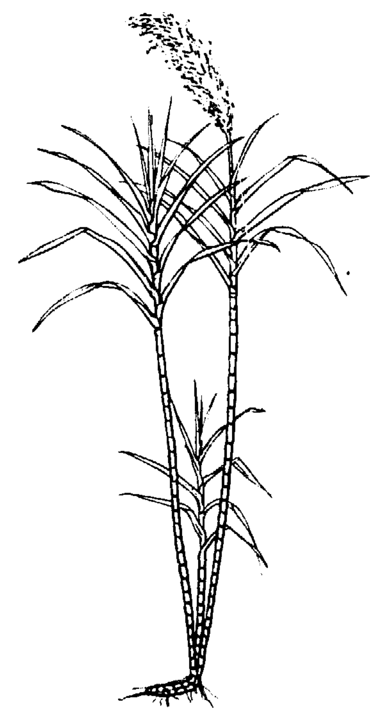
The residue from the extraction of the leaf protein from herbage still contains protein and can be used as roughage for cattle, although its palatability is fairly low. As most of the soluble minerals are also extracted with the protein, it is necessary to provide a mineral mix with the residue.

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Lucerne, aerial part, fresh, USA	94.5	23.0	24.3	8.3	4.8	39.6				205
LPC from lucerne, USA	95.1	36.7	0.7	13.4	6.9	42.3				205
Residue of lucerne, USA	92.6	17.1	35.2	6.9	3.3	37.5				205
LPC from lucerne, Sweden		42.0	3.0	16.0	3.0	36.0				478

13 Sugar cane and its by-products

Sugar cane (*Saccharum officinarum* L.) is widely cultivated in the tropics for the production of cane sugar. It is a perennial grass up to 3 m high; the canes can be 5-6 cm in diameter and the leaves 0.5-1 m long. About eighteen months after planting or after the previous harvest the cane becomes tough and turns pale yellow. At this point it is ready for harvest. Usually the field is burned before harvest to defoliate the cane and facilitate the harvest operation; however, in a dry climate the cane is not burned as the leaves left in the field improve the moisture retention of the soil.

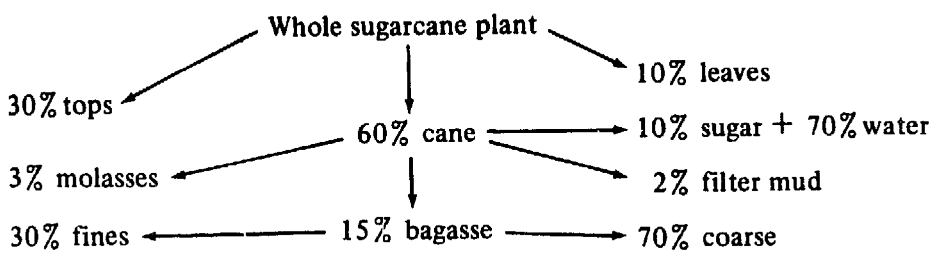
At the factory the chopped cane is pressed and the sugar extracted with water. The almost sugar-free residue is called bagasse or megasse. The extracted juice is clarified by liming, heating, settling and filtration. The residue on the filters is called filter-press mud. The clarified juice is then evaporated to a syrup and crystallized by boiling in vacuum pans. The mixture of crystals and liquid is centrifuged. The crystals are retained on the perforated wall of the centrifuge, and the liquid, called A-molasses, is transferred back to a vacuum pan, boiled and centrifuged again. This step is repeated with the subsequent B-molasses. The final molasses, or C-molasses, from which no more sugar can be crystallized, is called blackstrap molasses. The final product, raw sugar or muscovado, is boiled and clarified to form crystallized white sugar. Refinery molasses is produced as a by-product during this process.



Saccharum officinarum

Sugar cane can be used in a variety of ways in animal feeding: it can be grown for forage; the cane juice can be used in the form of invert molasses; the leaves can be used for fodder; and the bagasse or just the fine portion of it can be used as a roughage or as a carrier for molasses. Sugar-cane tops are an important feed in many sugar-cane-growing countries; the sugar itself is used in livestock feeds when the price is low; and, the A-, B-, C- (final) and refinery molasses are used in livestock feeding or as a substrate for the production of fodder yeast.

On average the cane yields about 10% sugar, but this varies with the variety, time of year, the weather conditions, whether the field has been burned and the time interval between harvesting and processing. Therefore, only approximate figures for the different by-products from sugar cane can be given in the following diagram:



It has been suggested that sugar cane in many tropical countries is a more efficient producer of easily available carbohydrate than other crops, as is illustrated in the following table of average yields per hectare and the corresponding energy yields in total digestible nutrients (TDN). The energy in sugar cane is calculated as the yield of high-test molasses, here assumed to be 18.2 tons per 100 tons of cane.

Country	Maize grain		Sorghum grain		Cassava tubers		Sugar cane (High-test molasses)	
	Ton	TDN (ton)	Ton	TDN (ton)	Ton	TDN (ton)	Ton	TDN (ton)
Mexico	1.2	0.96	2.5	2.00	—	—	11.4	7.48
Jamaica	1.2	0.96	—	—	2.3	0.40	12.6	8.28
Ecuador	0.5	0.40	—	—	7.1	1.24	12.6	8.28
Peru	1.6	1.28	1.7	1.36	11.9	2.07	26.5	17.41
China (Taiwan prov.)	2.4	1.92	1.6	1.28	16.1	2.80	13.4	8.80
India	1.0	0.80	0.5	0.40	13.5	2.35	8.7	5.72
Ethiopia	1.1	0.88	0.7	0.56	—	—	26.1	17.15
Kenya	4.3	3.44	0.8	0.64	6.7	1.17	8.5	5.58
Uganda	1.1	0.88	1.1	0.88	3.8	0.66	16.7	10.97

SOURCE: *FAO production yearbook 1968-69*

Sugar cane grows better than maize in warm humid areas. As a fodder crop, sugar cane has a practical advantage over maize. The latter is almost solely fed as silage, which can be made only at a fairly specific and critical growth stage of the crop, whereas sugar cane can be harvested at any time of year, thereby saving on machinery and simplifying management. Furthermore, the fodder yield may be much higher with sugar cane than with maize. A good crop of maize turned into silage produces about 12 tons of dry matter per hectare, whereas the annual yield of sugar cane in some areas is as high as 60 tons of dry matter per hectare. Sugar-cane production is usually restricted to areas in the vicinity of a sugar factory as it becomes less profitable if the cane has to be transported more than 20 km; thus there is scope for extending the cultivation of sugar cane if the cane can be sold at a competitive price for cattle feeding in areas farther from a factory.

WHOLE SUGAR CANE

Useful reference: 199

Because of its high sugar content and high yield, sugar cane is, in many parts of the world, unequalled in the production of energy per hectare. It is therefore not surprising that sugar cane is also grown for forage. The whole stalk can be given fresh to cattle as an emergency feed, but because of its hard and fibrous rind it is better chopped in a silage cutter. Sugar cane contains very little available protein and must therefore be supplemented with a protein concentrate. In one trial a ration of two parts sugar cane, two parts corn cob, and one part cottonseed meal gave a daily gain of 0.6 kg for fattening bulls.

As soon as the cane is chopped, the sugars begin to ferment into alcohol and organic acids, which tend to have a negative effect on animal performance. Thus it is important that the chopped cane be consumed by animals with a minimum delay. One of the most important advantages of sugar cane over other fodder crops is that it can be left growing in the field until needed with no loss in nutritive value. Ensiling is therefore not a necessity, as it is for conventional forages. Sugar cane is difficult to ensile because the abundance of sugars may give rise to alcoholic fermentation, which can be controlled by the addition of aqueous ammonia.

Sugar cane can provide a valuable dry season fodder. It is preferably established in a compact area (approximately 1 ha per 30 head of mature cattle) and fed off each year, the entire stand being replaced every seven to ten years.

In emergencies, chopped whole sugar cane, supplemented only with salt and phosphorus, can be fed *ad lib.* The results will be slightly better if urea and, as a safeguard, ammonium sulphate are added. To avoid pasture damage from overgrazing and treading, it is recommended that the herd be enclosed in a simple drylot (e.g., with a three-strand fence to form a paddock in one corner of the field, preferably where there is natural shade and water). The sugar cane should be fed in the drylot from troughs to avoid waste, and the animals allowed to graze for some three hours daily where practical.

Whole sugar cane can also be used for semi-intensive feeding of dairy cows. The cows should receive *ad lib* chopped whole sugar cane supplemented with an aqueous solution of urea ammonium sulphate and minerals. They should be kept in a simple drylot, preferably separated into three groups: *(a)* first half of lactation; *(b)* second half of lactation; *(c)* dry cows and in-calf heifers. The ideal supplementation for all three groups is three hours of grazing per day on *Leucaena leucocephala*. Group *(a)* should also receive 500 g daily of rice polishings (or the equivalent of bypass protein and gluconeogenic precursors), and group *(b)* should be given 250 g daily of the same supplement (or equivalent). If *Leucaena* is not available, the daily supplement should be 2 kg for group *(a)*, 1 kg for group *(b)* and 0.5 kg for group *(c)*. Sugar cane is sensitive to trampling, but young cane can be strip grazed if the cattle are not allowed to graze the same area for more than a few days.

A new approach to the utilization of sugar cane as forage has been made in the West Indies (ref. 284), where fresh sugar cane is processed in a cane peeler to remove the rind from the succulent pulp. The pulp is used as a succulent feed and the rind can be used for paper manufacture. The highly digestible pulp contains over 90% of the sugar in the cane. Unfortunately, the results of later trials with the feeding of derinded sugar cane to ruminants have not been as positive as the original findings promised, apparently because of intake problems caused by a low rumen turnover rate.

For fattening swine, derinded sugar cane pith can effectively consitute up to 35% of the ration and supply about 50% of the total energy. Acceptable responses have been obtained with broiler rations of 50% derinded cane pith.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Whole sugar cane, Trinidad	32.4	9.0	30.5	5.3	1.5	53.7			191
Stalks only, Trinidad	15.2	6.9	31.5	8.7	0.8	52.1			191
Stalks only, chopped and ensiled, Puerto Rico	24.8	3.6	36.1	6.3	2.1	51.9			406

14 Sugar-cane tops

Useful reference: 102

The tops are cut off the plant during harvesting and widely used for feeding draught animals or cattle owned by workers on the sugar estates or by the sugar companies. As fodder, fresh sugar-cane tops provide adequate nutrients to meet the maintenance requirement of cattle, but for production it is necessary to add a protein concentrate. Sugar-cane tops can be ensiled for better utilization of the large quantities available during the harvest season. Chopped sugar-cane tops are easy to ensile and provide a palatable silage. The low nitrogen content of sugar-cane tops may be increased by adding urea or a urea-molasses mixture during the ensiling process. Leaves from the cane plant can be included in the silage, but they lower the digestibility.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Cane tops, fresh, mature, Trinidad	25.6	6.3	35.0	6.2	2.2	50.3			82
Cane tops, fresh, post ripe, India	39.9	4.5	31.9	12.5	3.0	48.1			111
Cane tops, stalks only, Trinidad	15.2	6.9	31.5	8.7	0.8	52.1			117
Cane tops, leaves only, Trinidad	30.5	5.9	36.3	9.1	1.7	47.0			191
Dry leaves ("strip cane"), Hawaii	48.0	2.7	42.3	4.8	1.0	49.2			517
Hay of leaves, India		2.6	37.2	6.1	1.4	52.7	0.39	0.06	436

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Tops, mature	Sheep	50.6	64.8	31.7	63.3	2.16	82
Tops, post ripe	Zebu	57.0	74.0	76.0	72.0	2.39	111
Dry leaves	Cattle	0.0	51.0	32.0	57.0	1.82	517

Useful references: 264, 113

An average of 60% of the bagasse produced is used as fuel in sugar mills. The fibres of bagasse are of two kinds: *(1)* fine, strong, flexible fibre that is suitable for the manufacture of high-grade pulp and paper; and *(2)* short fibre or pithy material that yields little or no chemical pulp in papermaking and gives paper undesirable properties if it is not removed. Both types contain about 20% lignin. The easiest method of separating the two fractions is to dry the bagasse and then pass it through a hammer-mill, which loosens the pith clinging to the fibres. The material is then passed over a classifying screen or passed under suction fans to remove the pith. The finer portion is referred to as pith, bagacillo, pulp or bagasse fines.

Most studies of bagasse as a feedstuff show that young ruminants use more energy to digest bagasse than they obtain from it. The dry matter is usua''v only about 25% digestible, but there is a marked variability in bagasse digestion among individual animals. Bagasse pith is usually regarded as containing 20-25% digestible nutrients; however, where there is a shortage of forage, it may be of value. In many such areas, rations employing a high proportion of concentrate feeds are used for beef cattle, but such rations cannot be used for dairy cows as their diets should contain not less than 14% fibre on a dry matter basis. For this purpose, between 10% and 20% coarsely ground bagasse has been included in the ration to maintain the digestive system in good working order. Bagasse pith has been used in proportions of up to 27.5% in beef cattle rations before production decreased markedly. The poor palatability of bagasse will be improved by mixing it with blackstrap molasses. Palatability can be increased up to 55% by adding molasses. Bagasse can also be made more palatable by adding citrus meal.

As animals over two years old seem to utilize bagasse better, it is a more satisfactory feed for these animals. The digestibility of dry matter in old animals is often about 50%. Bagasse is comparable to hay for older animals and has been used in fattening rations for older bullocks with good results. Ammoniation of bagasse can lower palatability. The digestibility of the crude protein in ammoniated bagasse is about 60%, but it does not improve the digestibility of the bagasse itself. Urea seems to be a better source of nonprotein nitrogen because it does not introduce the problems of unpalatability created by molasses.

Bagasse and bagasse pith are good carriers of molasses, and several mixtures of bagasse and molasses exist on the market. The use of bagasse to absorb molasses simplifies the transport and handling of molasses. In a hot humid climate there is, however, the risk of moisture absorption and fermentation. Therefore, the moisture content of the bagasse must be less than 10% and the final product must be stored dry. Camola, one of the more common mixtures, consists of four parts bagasse pith and ten parts cane molasses. Molascuit contains more molasses than any other mixture. It is made by mixing pith with an excess of hot molasses, after which the mixture is centrifuged. The proportion of pith to molasses in molascuit is 1:6.25 by weight.

The feeding value of bagasse can be increased in several ways. Coarse grinding in a hammer-mill (3/16-inch screen) seems to improve the digestibility. Bagasse has also been ensiled in an attempt to break down the fibre by microbial action. The most successful method, however, has been treatment with chemicals so as to partly dissolve the lignin and thus make the cellulose more accessible to the digestive enzymes. The following treatments of crude bagasse have been studied in Puerto Rico (ref. 274):

	IN VITRO DIGESTIBILITY (%)
Before treatment	11
After treatment with:	
$Ca(OH)_2$, 70°C, 24 h	35
KOH, ambient temp., 24 h	37
KOH, 70°C. 24 h	43
7% monoethanolamin, 75°C, 24 h	43
5% Na_2SO_4, 100°C, 4 h	46
2% NaOH, ambient temp., 24 h	50
2% NaOH, 70°C, 24 h	65

The last treatment reduces the lignin content of the bagasse by 50%. The most economical method seems to be treatment with 2% NaOH at ambient temperature. To a batch of 100 kg of crude bagasse are added 1 000 kg of a solution of 2% NaOH, and the mixture is allowed to stand for 24 hours, after which the solution is drained off and filtered. Up to 2% NaOH is then added to the filtered solution, and it is used again for another batch of bagasse. The same solution may be used up to five times. The treated bagasse is washed, dried and coarsely ground.

It has been found safe to mix urea into a complete ration based on bagasse. Up to 3% urea has been used. The cattle eat bagasse feed so slowly that there is no danger of consuming fatal doses of urea.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Bagasse, Hawaii	90.3	1.9	45.0	8.0	1.0	44.1			517
Bagasse, Cuba	99.2	1.0	50.1	2.5	0.3	46.1			142
Bagasse pith, Cuba	87.8	1.7	45.1	2.5	1.5	49.2	0.39	0.04	142
Bagasse pith, ammoniated, USA	91.9	12.7	42.8	3.4	1.0	40.1			264
Camola, USA	78.9	2.2	11.0	13.9	0.5	72.4			264
Molascuit, Trinidad	81.0	2.2	3.7	12.2	0.5	81.4			191

	Animal	Digestibility (%)				ME	Ref.
		CP	CF	EE	NFE		
Bagasse	Cattle	0.0	58.0	54.0	41.0	1.64	517
Molascuit	Cattle	16.7	21.3	0.0	65.1	1.97	191

16 Cane juice

Useful references: 9, 295

Because international trade in sugar is largely based on quotas for each producing country, there arises the question of what to do with the excess of sugar cane in times of overproduction. This excess is often used for feeding in the form of denaturated raw sugar, high-test molasses or dehydrated cane juice. The yields of these three alternative products from 100 tons of cane are as follows (in tons of dry matter):

Raw sugar + molasses	High-test molasses	Dehydrated cane juice
11.2 + 2.5	15.4	14.1

The production of dehydrated cane juice has several advantages: the processing is cheaper than that of raw sugar; it is easier to transport than molasses; and it does not present many of the problems of feeding molasses. To dry the cane juice, it is first limed and then concentrated as close to the crystallization point as possible in the normal equipment of a sugar mill. The hot concentrate with a Brix of about 90° is then sprayed on a back-mix in a continuous mixer and dried to a moisture content of about 3%. A portion of the material is recycled to provide back-mix. About 3% starch is added to the final dark-coloured product to reduce caking during storage, preferably in airtight bags. The dehydrated cane juice is used in the same way as sugar in compound feeds, especially calf starters, pig and poultry feeds, and feeds containing urea. In pig feeds it has been included up to 22.5% in starter rations, 45% in grower rations and up to 75% in fattening rations. The dressing-out percentage was generally higher with cane juice treatments than with grain controls. No scouring was observed, and weight gains were similar to those from rations based on grain. Trials with this material in both broiler and layer rations showed excellent results when it constituted up to 25% of diets balanced in protein, amino acids, minerals and vitamins.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Cane juice, dehydrated, South Africa	96.5	1.0	0.5	3.6	0.0	94.9			9

17 Molasses (or treacle)

Useful references: 383, 396

There are many kinds of molasses, and the terminology is often confusing. Only molasses from sugar cane will be dealt with here. For citrus molasses see D7, for beet molasses see E2 and for wood molasses see I26.

Blackstrap, or final, molasses is the by-product from which the maximum of sugar has been extracted. When the term molasses is used without specification, it usually refers to blackstrap molasses. For feeding, blackstrap molasses is diluted with water to a standard Brix of 79.5°. (The specific gravity of molasses is indicated by the Brix value in degrees.) At 79.5° Brix a litre of molasses weighs 1.39 kg. Undiluted blackstrap molasses is usually 80°-90° Brix.

Integral, or unclarified, molasses is made by partially inverting cane juice to prevent crystallization of the sucrose and concentrating it to 80°-85° Brix.

High-test, or clarified, molasses is the same as integral molasses, but it is made from cane juice that has been clarified by liming and filtration to remove impurities. The sucrose in the cane juice is inverted, during which reducing sugars are produced by the action of sulphuric acid or yeast invertase.

Sugar is only partly extracted from A- and B-molasses. For further explanation see the introduction to the chapter on sugar cane and its by-products.

Refinery molasses is the by-product from the refining of raw sugar into white sugar. The quantities produced are rather small.

The table below shows the average percentage of sugar by types in the different kinds of molasses. The actual amounts vary widely from factory to factory.

	Total sugars	As sucrose	As reducing sugars
Dehydrated cane juice	90	75	25
A-molasses	68	60	40
B-molasses	57	50	50
Blackstrap, or final, molasses	47	40	60
High-test molasses	78	30	70
Raw sugar	99	98	1

For ruminants there is no great difference betwen the various kinds of molasses. For high levels of molasses in pig and poultry diets, high-test molasses and A-molasses are superior, while blackstrap, or final, molasses can be used only if mixed with a minimum of 30% sucrose. The usefulness of B-molasses for pigs lies between that of A-molasses and that of blackstrap molasses. Whether there is a difference in energy content between sucrose and reducing sugars is not clear.

There are four principal ways of utilizing molasses:

1. *In dry feeds.* In addition to increasing palatability, settling dust and serving as a binder, molasses can replace other more expensive carbohydrates in feeds. Its laxative effect is an added advantage in many feeds. The following levels of inclusion are usually not exceeded in commercial mixed feeds: for cattle, 15%; for calves, 8%; for sheep, 8%; for pigs, 15%; and for poultry, 5%. The maximum amount to be used is often determined by the absorbability of molasses by the other ingredients in the diet.

   The following figures show the maximum percentage of molasses absorbed by some feed ingredients:

	Percent
Ground maize cobs	40
Coconut meal	33
Wheat middlings	19
Maize meal	15
Cottonseed meal	15
Brewer's dried grains	9

   There is generally no advantage in adding molasses to poor-quality roughages like straw to increase the feed intake, as in most cases there will be no additional weight gain from the higher consumption. The risk of impaction is smaller, however, when molasses is added to straw.

2. *In silage making.* Molasses ferments quickly and is sometimes added at the level of about 5% to grass during the ensiling process as a preservative, with its nutrient value and palatability factor as a bonus. Molasses can also be used as a sealant for silage mounds. About 50 kg of molasses per square metre is usually sufficient for this purpose. If molasses is mixed into silage with a low protein content, it is desirable to add urea to the molasses. Molasses may also be sprayed on hay during curing to prevent leaf losses.

3. *As a carrier for urea in liquid supplements for ruminants.* In these supplements the concentration of urea is very high, usually about 10% but sometimes much higher. The intake of these supplements is kept low, usually about 0.5 kg daily. Liquid supplements are described in the chapter on urea (see page 465).

4. *At high levels for maximum utilization of molasses.* In many sugar-cane producing areas there is a large surplus of molasses and a scarcity of grain for feeding. Largely owing to the efforts of T.R. Preston and his co-workers in Cuba, it has been demonstrated that molasses can be used as a substitute for grain.

When fed in large amounts, molasses may be toxic. The symptoms of toxicity are reduced body temperature, weakness and rapid breathing. Cattle usually have difficulty standing and try to lean their shoulders against the fence with their forelegs crossed. The remedy is to take the animals off molasses feeding for a few days and immediately give them a solution that is rich in phosphorus and sodium. The cause of toxicity is most often a scarcity of drinking water close to where animals are fed molasses or a too rapid switch to high molasses diets.

As mentioned earlier there is no great difference between high-test molasses and blackstrap, or final, molasses for feeding ruminants; however, it may be necessary to supplement high-test molasses with phosphorus and calcium because of its lower ash content. Caution must be employed in feeding molasses to calves. Young calves weighing 35-40 kg can be given 45 g of molasses per day, and the amount can be increased up to 900 g per day when they are six months old. The protein given to young calves must be true protein (oilcakes, etc.). The use of molasses in the ration for fattening cattle is much more extensive; usually molasses-urea is fed *ad lib* and forage is restricted to increase the consumption of molasses. The system worked out in Cuba involves *ad lib* feeding of a mixture containing 91% molasses and 6.5% water. Urea and salt are dissolved in the water before it is mixed with the molasses. The mixture, fed in open troughs, is top-dressed with 70 g of an insoluble protein supplement per 100 kg of liveweight. In Cuba, Peruvian fish meal is used. The reason for this additive is explained in the section on urea (see page 465). Each animal consumes 8-9 kg of this mixture per day. In addition, a mineral mixture of 50% bone meal or dicalcium phosphate and 50% salt is fed *ad lib*, and each animal is given 10 kg of fresh cut forage. The daily weight gain per head is about 1 kg. Restricted grazing, one and a half hours twice daily, has also been used. Bloat seems to be a problem with this feeding technique, but it can be controlled by adding antifoam agents such as silicones to the molasses or the drinking water. Fresh forage can be replaced by hay, rice straw or bagasse pith fed *ad lib* if vitamins are added.

Molasses can also be used as a supplement for grazing cattle. In the dry-wet tropics molasses supplementation of rainy season pasture will primarily increase carrying capacity rather than improve performance, because in the animal the forage energy is replaced by the more readily fermentable energy from the molasses. Nevertheless, molasses and molasses-urea supplements have had a marked effect on cattle production and reproductive capabilities when forage and nutrient availability is reduced, as it is during the dry season.

The amount of molasses given usually varies between 0.5 and 3 kg a day per head depending on the pasture. Factory-built feeders are available, but a feeder can be home-built quite easily. An ordinary car tire is mounted on a horizontal axle over a trough, which is covered except for a slit through which the wheel passes. Molasses is poured into the trough, and the tire rotated so as to cover it with molasses. The animals will soon learn to lick the tire and make it rotate to expose more molasses. The wheel should be mounted so that it reaches close to the bottom of the trough. If the intake of protein is limiting production, urea can be mixed into the molasses. The addition of 2-3% does not decrease the palatability of the molasses. As the molasses-urea mixture is deficient in phosphorus, it is necessary to add phosphoric acid to the mixture or to give the cattle a mineral mixture containing enough phosphorus. Drinking water must be supplied close to the feeder. Undiluted molasses is not likely to ferment even in hot weather; however, if diluted with rain water, it will rapidly ferment into alcohol and may fatally poison the cattle.

Ammoniated molasses is now seldom used owing to its low palatability. It also seems to affect the nervous system of cattle. Blackstrap, or final, molasses is produced in dehydrated form (spray-dried) in South Africa. By using an additive to decrease the hygroscopic properties a molasses meal is obtained.

A high level of blackstrap molasses in rations causes diarrhoea in monogastric animals; however, the rates of gain and feed conversion may still be acceptable despite scouring. At levels of 6% in creep feed, 12% in the growth ration between weaning and 30 kg, 20% in the growth ration between 30 and 45 kg, 30% in the fattening ration between 45 and 70 kg, and 40% in the fattening ration between 70 and 100 kg liveweight, the feed conversion will be around 4:1 and the daily gain about 0.6 kg if the diet is balanced. The addition of fibre to the diet will stop diarrhoea but depress feed conversion. As the scouring is probably caused by the high mineral content of blackstrap molasses, better results are obtained with high-test molasses, which has a lower mineral content, or with a mixture of blackstrap molasses and at least 30% sucrose. Integral molasses is less suitable. In Cuba a diet of 71% high-test molasses, 24% fish meal and 3% yeast plus minerals and vitamins produced a daily gain of 0.6 kg. Blackstrap molasses with added sugar gave a similar result but a lower feed conversion — 3.6 versus 3.1 for high-test molasses.

The use of blackstrap molasses for poultry creates similar problems as it does in pigs. As the level of inclusion in the diet increases, the faeces become wetter and the feed efficiency decreases. Nevertheless, it might still be economically justifiable to include high levels of blackstrap molasses in poultry diets in many countries despite the drawbacks. It has been used as a substitute for imported maize in several countries, where it has constituted up to 35% of the total ration. More promising results have been obtained in Cuba with liquid poultry feed based on high-test molasses or on a mixture of blackstrap molasses (25%) and raw sugar (75%). A ration containing 54% high-test molasses, 13% fish meal, 27% yeast, 3% alfalfa meal, 1.5% sunflower-seed oil, vitamins and minerals gave a feed conversion of 3:1. The feed was diluted with half the amount of water to give it a fluid consistency.

	DM	As % of dry matter CP	CF	Ash	EE	NFE	Ca	P	Ref.
High-test molasses, Cuba	76.9	1.4	0.0	2.7	0.0	95.9			383
A-molasses, Cuba	66.0	1.2	0.0	5.1	0.0	93.7			383
Blackstrap molasses, Cuba	76.1	4.4	0.0	7.2	0.0	88.4			383
Blackstrap molasses, Uganda	74.0	4.2	0.0	8.6	0.0	87.2	0.71	0.07	69
Blackstrap molasses, Puerto Rico	73.7	4.7	0.0	8.0	0.0	87.3			293

	Animal	Digestibility (%) CP	CF	EE	NFE	ME	Ref.
Molasses	Sheep	0.0	—	—	83.0	2.63	293

18 Sugar

Useful references: 375, 382

When the world market price of sugar is low, the surplus above the quotas is usually imported as feed-grade sugar. Sugar released for feed purposes is either coloured or denatured (e.g., with fish meal) to distinguish it from sugar intended for human consumption. A low percentage (10%) is usually included as a sweetener in creep feeds, especially for pigs. Sugar has been used to replace the cereal portion in poultry feeds, in which the calorific value is maintained by the addition of fats. It has been found that broilers grow as fast on a diet of this type as on a conventional ration based on cereals. For layers the same egg production has been maintained, but the eggs are smaller. In all cases, feed conversion has been somewhat poorer than with cereal diets. Sucrose added to ruminant diets supports growth but not lactation.

	DM	As % of dry matter CP	CF	Ash	EE	NFE	Ca	P	Ref.
Crude sugar, West Indies	97.0	0.0	0.0	1.2	0.0	98.8			7

19 Filter-press mud

Useful reference: 466

Filter-press mud, or scum, contains many of the impurities of the cane juice and includes organic compounds such as proteins, five-carbon sugars, starchy gums, waxes and inorganic compounds, mainly calcium sulphate and calcium phosphate. At present, filter-press mud is used as a fertilizer in sugar-cane cultivation. The composition of filter-press mud varies according to soil type, type of filter and other factors. It has in some countries been included in animal feed, but for this purpose it must be dried immediately or fed absolutely fresh. Fresh mud contains about 80% water, ferments within six to twelve hours and can turn toxic. The drying of the mud at the sugar mills is relatively cheap as the steam supply is usually more than adequate for the drying process. Dried mud can constitute at least 50% of the concentrate portion of the diet for ruminants without affecting food intake.

It has been fed fresh together with molasses to beef cattle on pasture during the dry season. The mixture was consumed without difficulty and the inclusion of filter-press mud did not significantly depress the rate of weight gain. Animals fed the mixture had higher levels of serum phosphorus. The digestibility of the protein is very low (less than 20%), while the dry matter digestibility is approximately 35%.

		As % of dry matter								
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Filter-press mud, Trinidad	26.0	10.4	12.1	23.9	10.9	42.7			191
Rotary-filter mud, Mauritius		15.1	21.4	14.2	7.5	41.8	2.63	1.11	431

110 Molasses distiller's by-products

Sugar-cane molasses is fermented and distilled to make rum. The residue after distillation has a very high content of ash, especially calcium sulphate. If the residue is to be used as animal feed, the calcium must be removed from the molasses prior to fermentation by means of the Reich process. The molasses are diluted with water to 40° Brix and heated to 80°C. Sulphuric acid is added to pH 4, and after one hour the solution is centrifuged, thereby removing about 80% of the calcium. The hot clear molasses is cooled, diluted and transferred to the fermenting vessels, where yeast is added. During fermentation the sugars are converted into alcohol. After about forty hours the yeast dies and settles to the bottom of the fermenting vessel, forming rum vat yeast. The alcoholic liquid (wash) is drawn off at a level of about 20 cm from the bottom, centrifuged and passed into the stills. The solids from the centrifuge, mainly yeast, are placed in settling tanks. Once a day the material at the top of the settling tanks is recycled through the centrifuge and the bottom sediment is dumped. This sediment is similar in composition to the rum vat yeast. The wash contains about 8% alcohol, which is distilled off, leaving a residue that is called spent wash, molasses distiller's solubles, dunder, stillage or distillery slop. The by-products are dried yeast, 1.5% of the weight of the molasses, and spent wash, four times the volume of the molasses or 28% by weight.

The yeast spoils quickly if it is not dried, preferably on roller drums, as it has been shown that rum vat yeast dried at a high temperature (130°C) is nutritionally better than that dried at lower temperatures. Spent wash can be fed to cattle in fresh liquid, in condensed or in dried form, either alone or absorbed in citrus meal, maize cobs, bagasses, and other suitable material. The dried rum vat yeast is used in the same way as brewer's dried yeast, which it resembles in amino acid composition, except that rum vat yeast contains less leucine and lysine. Usually it is included at levels of less than 10% in rations for poultry and pigs. Molasses dried solubles are a good source of vitamins, and it has been claimed that they contain unidentified growth factors. Poultry feeds can contain up to 2.5% dried solubles, and pig and calf concentrates up to 5%. Ammoniated condensed spent wash has been used as a source of protein for beef cattle.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Sediment from settling tanks, Trinidad	10.6	25.7	0.8	12.1	0.3	61.1			117
Rum vat yeast, Trinidad	10.7	30.0	1.1	13.0	1.7	54.2		0.87	117
Spent wash, Trinidad	7.0	16.6	0.6	21.8	0.2	60.8			117

111-14 Brewery By-products

The first step in the production of beer or ale from barley is the production of malt. The barley is soaked for two or three days in warm water, which causes it to germinate and commence growth. During this process the enzyme alpha-amylase is activated in the grain. Another enzyme, beta-amylase, is already active in the unmalted grain. Growth is stopped by kiln-drying the sprouted grain when the young shoots and rootlets are about 2 cm long. The dried shoots and rootlets are screened off and sold under the name malt culms. At the brewery the malt — which in some countries is mixed with rice or other grains — is crushed, and after adding water the mass is kept warm for some days, during which the alpha-amylase and the beta-amylase change the starch in the grain into fermentable malt sugar and dextrines, both of which dissolve in the water. When most of the starch has been converted into sugar, the liquid, called "wort," is filtered off. The wort is boiled with hops and filtered, after which yeast is added and the wort is fermented into beer.

111 Malt culms (malt sprouts or coombs)

Useful reference: 106

The fibres of malt culms, being highly digestible, are a useful feed. Their value is greater for ruminants than for monogastric animals because only about half of the crude protein is digestible true protein. As dried malt culms swell in the stomach, the amount fed daily should be limited to 2.5 kg for horses and 1.5 kg for cattle. It has been used in the rations of growing-finishing pigs up to a level of 16% of the total diet with good results. The quality of malt culms is variable; only those in good condition, free from mould and off-flavours, should be used. Malt culms are bitter and are sometimes refused if fed alone. They can affect the taste of milk if large amounts are given to dairy cattle.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Malt culms, dried, Australia	90.0	27.2	15.6	6.1	2.2	48.9			216

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Dried culms	Cattle	81.6	92.1	85.0	74.0	2.93	216

Useful reference: 53

The extracted malt, or spent grain, contains 75-80% water when filtered off. In large breweries the spent grain is dried to about a 10% moisture content, usually in a steam-tube drier. Wet spent grain spoils rather quickly and should be used fresh or stored out of contact with air. It can be stored up to two weeks quite successfully by heaping it, treading it well and covering it with wet sacks; however, wet grain stored in this way should not be fed in excessive amounts. For longer storage it may be ensiled in a silo with drainage. To ensure proper fermentation, 2-3% molasses can be added. Fermentation takes four to six weeks, after which a good silage results. The wet grains can be preserved for a week or two by adding 0.4% of a mixture of formic and propionic acids.

Spent grain is a safe feed for most stock if the grain left over in the feed bunks is removed, so that it does not become sour and cause scouring or if it is fed in amounts which can be consumed in one meal. Spent grain is a bulky feed, low in energy and is therefore seldom used for intensive fattening of beef cattle. It is, however, used in feedlot rations for beef cattle in countries where it is uneconomical to feed maize or other grains. A commonly used ration for beef cattle has the following composition: dried citrus pulp, 40%; coconut meal, 40%; and dried brewer's grain, 20%. Silage and wet spent grains can also be used for beef cattle. Up to 12 kg per day have been fed to animals weighing under 500 kg, while animals over 500 kg have received up to 20 kg per day. Most of the spent grain produced is used in rations for dairy cattle. A normal level of dried brewer's grain in supplement concentrates for dairy cattle is 10-25%, but higher proportions can be used, depending on the relative prices of alternative sources of protein and energy. Wet grain can be given in large amounts to dairy cows; up to 15 kg per day have been fed, but half that amount seems to result in optimum utilization. Spent brewer's grain is a balanced feed for milk production. A ration of 8 kg of wet grain per day is usually adequate for maintenance plus 4 litres of average-quality milk. It is a common observation that the percentage of butterfat decreases when cows are fed large amounts of spent grains.

To avoid off-flavours, it is recommended that wet brewer's grain be fed to cows after rather than before milking. The wet grain must be fed fresh, as it turns sour after being stored for a few days and may upset the acid-base balance of the cow or even cause poisoning if eaten in large quantities. In most cases, 150 g of sodium bicarbonate given twice daily for two days will cure the disorder. Calves have been given up to 2 kg per day of spent grain silage or fresh wet grain. The amount can be increased to a maximum of 4 kg per day for yearlings. The watery nature of wet grain restricts its use for sheep and horses; however, dried brewer's grain has a good reputation as a feed for these animals.

Brewer's spent grain is not commonly included in commercial poultry feeds. It has been shown, however, that up to 20% dried brewer's grain can be included in poultry rations with excellent results. It has been suggested that an unidentified factor in brewer's grain may account for the improved growth and feed conversion in chickens and for the increased fertility and hatchability of the eggs.

Brewer's grain is not commonly used for pigs, although small quantities can be fed with good results to sows and to pigs after reaching about 35 kg. The amount that can be included in the diet depends on the age of the pig, but a maximum of 50% of the diet protein can be supplied by brewer's grain without a reduction in growth rate and feed efficiency. Silage and wet grain have also been fed to pigs weighing over 35 kg in amounts of 1-3 kg per day, depending on age. It is possible to mechanically separate the fibrous husks from the high-protein portions of dried brewer's grain. The fibre portion has greater value in diets for monogastric animals.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Brewer's grain, wet, Malaysia	22.3	27.8	12.6	4.9	8.0	46.7	0.16	0.65	292
Brewer's grain, dried, Trinidad	91.8	19.5	18.4	4.4	5.1	52.6			117
Brewer's grain, dried, Tanzania	84.3	17.0	13.2	9.3	6.8	53.7	0.08	0.10	355
Brewer's grain, dried, Kenya	90.8	21.4	16.5	7.4	3.8	50.9			417
Brewer's grain, silage, Trinidad	25.1	23.9	18.9	6.4	7.6	43.2			191

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Wet brewer's grain	Sheep	73.0	39.0	88.0	62.0	2.65	365
Dried brewer's grain	Sheep	72.6	70.3	85.7	67.5	2.59	417
Silage of grain	Sheep	78.3	51.0	91.8	57.9	2.60	122
Wet grain	Pigs	58.9	7.8	0.0	59.7	1.99	377

113 Spent hops

Extracted hops are so bitter as to be unpalatable and are very low in digestibility. In smaller breweries they are discarded, but in larger breweries they are sometimes mixed with the spent grain and dried. If spent hops are added to the spent grain in the same proportion they are produced, they will constitute about 5% of the total mixture, which will not affect the palatability or nutritive value of the dried brewer's grain.

	DM	As % of dry matter							Ref.
		CP	CF	Ash	EE	NFE	Ca	P	
Spent hops, dried, UK	89.1	17.2	23.6	7.2	7.6	44.4			512

114 Brewer's yeast

Useful reference: 65

Brewer's yeast is seldom used fresh as it spoils quickly and may cause watery flesh in pigs. An excellent source of protein of high biological value and digestibility, brewer's yeast is a very valuable component of poultry and pig rations, in which it is used, however, mostly for vitamins of the B complex and for unidentified but important growth factors in poultry production. When irradiated with ultraviolet light, it also provides vitamin D. If the yeast contains hop constituents, the bitter taste makes the feed unpalatable if included in large amounts. The bitter taste can be removed by mixing the slurry with a solution of sodium hydroxide and sodium phosphate at pH 10 and 45°-50°C, after which the mixture is concentrated, washed and dried.

Brewer's yeast is usually included at levels of 2-5% in rations for pigs and poultry, but if the price of dried brewer's yeast is low, it can replace up to 80% of the animal protein in pig and poultry diets provided that additional calcium is added. Calves can be given up to 200 g per day of dried brewer's yeast, and in some cases it seems to increase the fat content of milk from cows.

The yeast is usually roller-dried, which requires such expensive machinery that the process is economical only in large breweries. The yeast can, however, be mixed with the brewer's grain and dried as a mixture in a steam-tube drier. This method increases the value of the spent grain.

Fresh yeast can be fed to cattle and pigs, who quickly get used to eating it. When large quantities are fed to swine, a mineral mixture with a high calcium and a low phosphorus content must be chosen, and vitamin B_{12} has to be added as well. Dairy cows may be fed 15 litres of fresh yeast daily, which will provide sufficient protein for 30 litres of milk but enough energy for only 10 litres of milk; therefore, fresh yeast should be fed together with an energy-rich low protein feed such as maize silage or root vegetables. Swine should be fed a litre of cooked or boiled yeast daily at the start of fattening, rising to 2 litres daily at the end. Fresh yeast should *not* be fed to suckling sows because of the danger of diarrhoea in piglets.

	DM	As % of dry matter								Ref.
		CP	CF	Ash	EE	NFE	Ca	P		
Brewer's yeast, Germany (F.R.)	89.1	49.9	1.5	8.5	1.3	38.8	0.13	1.56		183

115 Grain distiller's by-products

Useful reference: 342

Grain is fermented and distilled to yield ethanol or acetone butanol. The by-products from grain distilleries vary in chemical composition according to the type of grain and the process employed. The most commonly used grains are rye, wheat and maize. The two most important processes are outlined below. For explanation of technical terms, see the feed information summary on brewery by-products (pages 435-438).

The British method. The grain is crushed, and the grain starch is converted into sugars by adding malt. The sugars are extracted and the grains are screened off, either to be dried or used as wet feed for animals. Yeast is added to the wort for fermentation. The alcohol is distilled from the fermented liquor, after which the alcohol-free effluent (pot ale or spent wash) containing the yeast may be dried to yield dried distiller's solubles. Alternatively, the spent wash may be centrifuged and the solids dried into distiller's concentrate, which is similar in composition to the solids, or dried dreg, collected from the spent wash by sedimentation.

The American method. The grains are converted by adding malt, and the whole mixture is passed forward to the fermenting vessel, where yeast is added. After fermentation the whole mixture, including the grain, is distilled. The alcohol-free effluent, or whole stillage, from the still is then passed over a screen to separate the grain from the liquid. This liquid, called thin stillage, which contains the yeast, is condensed and may be dried into distiller's solubles. In some plants the thin stillage is centrifuged before being condensed and the solids are added to the grain.

Distiller's spent grain, or draff, is not as palatable as brewer's spent grain, but it contains more crude protein and less fibre. It can be fed fresh, ensiled or dried by the same method and in the same quantities as brewer's grain.

Distiller's grain with distiller's solubles has been included up to 15% in pig diets with no change in performance. The inclusion of 3-7% in chick diets has in some cases increased growth. This has been attributed to an unidentified growth factor found in products of fermentation. The addition of calcium carbonate to the diet (40 g a day for cows and 10 g for sheep) increases the digestibility of distiller's grain.

Distiller's solubles are valued for their growth factors and as a source of B-vitamins. It is doubtful whether distiller's solubles promote growth in cattle, but it has been claimed that they contain a rumen-stimulating factor that increases cellulose digestion. The growth-promoting effects in pigs and poultry have been clearly demonstrated. In most cases the addition of 5-10% dried distiller's solubles increased the productivity of both classes of animals. The use of distiller's solubles as the major source of protein has been less successful owing to their poor palatability. Nevertheless, they have been included up to 20% in calf starters, and a very good protein supplement for pigs was composed of two parts meat meal, one part dried distiller's solubles and one part lucerne meal.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Malt distiller's grain, fresh, UK	23.9	19.8	17.3	3.3	8.2	51.4			342
Maize distiller's grain, dried, USA	94.4	27.6	13.6	2.5	9.4	46.9	0.12	0.51	349
Malt distiller's grain, silage, UK	27.2	21.4	19.8	2.9	8.8	47.1			342
Spent wash, condensed, UK	32.8	18.3	24.3	6.1	0.7	50.6	0.03	0.98	446

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Ensiled grain	Sheep	70.8	63.7	82.3	66.2	2.80	123

116 Bakery waste

Useful reference: 200

Bakery waste, such as stale bread and crumbs, can be dried and mixed for animal feeding. It is rich in fat and carbohydrate, but the protein quality and the vitamin content are low. It has been used as a substitute for grain in rations for all classes of livestock. When bakery waste is fed in large amounts, it must be supplemented with vitamin A, minerals and good-quality protein. It has been included up to 30% in cattle rations without affecting palatability. For pigs it can replace all grain. As the product is rich in salt, more than 15% cannot be used in poultry rations.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Bakery waste, USA	89.8	10.7	0.4	3.8	12.7	72.4			266

117 Fats

Useful references: 12, 13

Throughout the world fats of different origins are being produced in ever greater quantities. At the same time the conventional market for fat has been decreasing, largely because of the introduction of synthetic detergents; hence a surplus of fat is available at a low cost for the feeding of animals.

Fats and oils may be added to feeds with the following effects:

(a) Fat is very rich in energy and increases the energy value of the ration to levels unattainable with other ingredients.

(b) Pure fat is often the cheapest available energy source. The economy of using fat is often enhanced by the increased growth rate and the shorter time required for production; also the addition of fat permits the inclusion of other low-energy, low-cost materials.

(c) Some of the fatty acids are essential to animals. For this reason it may be necessary to add pure fat in some formulas, especially calf rations.

(d) Fats increase palatability.

(e) Fats eliminate dustiness in compounded feeds and reduce wear on pelleting dies.

(f) Experiments indicate that it is possible to decrease the amount of excrement to less than one half by adding about 7% fat to feed for monogastric animals, thereby minimizing waste disposal problems.

Antioxidants. These substances are added to fats to prevent them from becoming rancid. Rancid fats are unpalatable to animals and may even be toxic. This is usually manifested in the form of diarrhoea, liver problems or encephalitis. Vegetable fats and oils are usually extracted with antioxidants which occur naturally in plants. It is necessary to add an antioxidant to animal fats, such as BHA (butylated hydroxyanisole), BHT (butylated hydroxytoluene) or ethoxyquin; the usual amount is 125-200 g per ton of fat.

Antioxidants are effective only in newly extracted fats. These chemicals break the chain reaction of fat oxidation, in which process the antioxidants themselves are consumed. When all of the antioxidant is consumed, the fat turns rancid. It is not possible to increase the keeping quality of fat by adding more of the antioxidant because an excess will, on the contrary, speed up the process. The rapid consumption of antioxidants can be slowed down by adding 50-100 g of citric acid per ton of fat to regenerate the consumed antioxidants and by adding EDTA (ethylene-diamine-tetra-acetic acid) to conjugate mineral traces that initiate oxidative chain reactions. The addition of EDTA is especially recommended if the fat will come into contact with copper, nickel, cobalt, manganese or, to a lesser degree, zinc or iron.

Stabilized animal fat in compounded feeds will keep fresh for at least four months if a mineral mix is not included. In a feed containing a mineral mix the keeping quality of fat is rather poor.

Different kinds of fat. Fat is described by its origin, melting point (titre), amount of free fatty acids, colour and impurities. Animal fats are described as tallows when they are solid above 40°C, as lards when they are solid between 20°C and 40°C, and as oils when they are liquid below 20°C. Generally, tallows come from cattle or sheep, lards from hogs, horses or bones of all kinds, and oils from marine animals or vegetables. The lard from pigs and poultry can be highly variable depending on the diet. The water content of lard should be checked, as it is possible by using certain chemicals to make it take up extra water.

Fish-liver oil, especially cod-liver oil, was formerly widely used as a source of vitamins A and D. It has been found. however, that it oxidizes very quickly in mixed feed and loses its potency within a few days; thus its inclusion in mixed feeds is wasteful. Fish-liver oil is of value in animal nutrition, but to retain its vitamin content it must be kept in a cool. airtight container and away from strong light.

Palm oil is very rich in beta-carotene. The amount varies greatly depending on the method of processing and stage of maturity of the fruit. Unripe fruit contains about 1 mg of beta-carotene per kilogram, while ripe and overripe fruit have about 3 mg and 2.5 mg per kilogram. For cattle this corresponds to 600, 1 900 and 1 600 I.U. of vitamin, respectively.

Soapstock is a by-product of the refining of crude vegetable oil, which contains free fatty acids and traces of protein that must be removed before the oil is sold for eating. After adding sodium hydroxide, the oil is heated. At a certain temperature, the sodium reacts with the free fatty acids and combines with heat-coagulated protein in globules which settle to the bottom of the vessel. The clear refined oil is siphoned off the top. This material is known as soapstock because it is used in the production of soaps. It is rich in free fatty acids, usually containing more than 35%. Soybean soapstock also contains xanthophyll. In one experiment 6% soybean soapstock gave egg yolks a good colouring. Small amounts of soapstock have been included in pig and poultry diets. It has no harmful effects and can be used in the same way as fat.

Use. Much research has been done on the effect of added fat in dairy feeds. The results have varied greatly and have indicated that it is not advisable to allow the total fat content to exceed 8-10%. The brown lard is added to feed for ruminants as they can usually consume low-priced fats, although acceptability may decrease after the first few days. The use of artificial milk containing 14-30% fat in intensive feeding is rapidly spreading. Milk replacer starters (for calves and lambs up to a month old) contain 14-18% fat. Generally these products have a base of skim milk powder, to which homogenized fat is added together with minerals, antibiotics and emulsifiers (usually soya lecithin at a level of 6-9% of the total fat). Milk replacers for finishing beef cattle may contain up to 30% fat. It is advisable to use only stabilized fat in these types of feed.

In pig rations the type of fat is more important than the amount. Rancid fats or fish oils should not be fed to pigs, with the possible exception of breeding animals. The softening effect of fat on pork depends mainly on the degree of saturation of the fatty acids in the fat included in the diet. The following table gives the approximate percentage of polyunsaturated fatty acids in the more common fats:

	Percent		*Percent*
Butter oil	5	Olive oil	8
Cocoa fat	3	Palm oil	10
Coconut oil	1	Rapeseed oil	70
Cod-liver oil	80	Sesame seed oil	40
Cottonseed oil	50	Soybean oil	60
Groundnut oil	30	Sunflower seed oil	65
Herring oil	80	Walnut oil	75
Lard	10	Whale oil	40
Maize germ oil	55	Tallow	3

When the ration is properly balanced in protein and other nutrients, the addition of fat to the pig diet modifies the thickness of the backfat very little. It is advisable as a general rule to increase the protein level 0.5-1% for each percent increase in the amount of fat added. It is also important to increase the supply of minerals and vitamins by the same amount. Generally the feed conversion of a diet with added fat increases by the same percentage as the fat added (up to a maximum depending on species, other ingredients, etc.), and it is necessary to increase the contents of proteins, minerals and vitamins by the same percentage so that the proportion of the dosage received by the animal will not be reduced. Vitamin B, choline, calcium and magnesium should be increased by greater amounts than is usually indicated by the change in feed conversion alone. This applies also to poultry diets.

With the inclusion of fat in poultry diets it is possibile to increase the energy content and at the same time have a high level of other nutrients. In this way the genetic potential for rapid growth is better exploited. Broiler diets with up to 34% fat have been used, and for broilers the fat dosage seems to be limited only by economic considerations. Using fat in broiler diets may also be a method of overcoming the poor performance of broilers in hot environments, as it has been shown that fats have a lower heat increment than carbohydrates and proteins. It is therefore possible to improve the performance of chickens during high temperature stress by replacing carbohydrate calories with fat calories and by reducing the total protein while maintaining appropriate rations of amino acids and energy. As a rule the first 3-4% of fat added will pay with the double advantage of growth stimulation and improved feed utilization; above this level only the advantage of improved feed utilization remains. In practical feed formulations the economic level of fat addition is 5-6%. By increasing the protein, mineral and vitamin contents and adding fat, smaller amounts of the feed need to be eaten and the presence of fat inhibits the heat-producing conversion of carbohydrate to body fat. For layers the addition of fat must be proportional to egg production. When production is less than 30% (30 eggs per day from 100 layers), no more than 3% should be used. When production is over 70%, up to 6% may be used.

The digestibility of animal fat is about 80% for monogastric animals and 85% for ruminants. The energy value on a dry matter basis is 190% TDN for ruminants and 180% TDN for pigs. Homogenized animal fat is about 92% digestible, and the energy value is 207% TDN for ruminants. Animal fat contains no minerals or vitamins.

118-20 Single-cell Protein

Many methods for the production of single-cell protein (protein from microorganisms) have been devised. In the 1960s interest focused on single-cell protein as a means of closing the "protein gap," because microorganisms can, under favourable conditions, produce large amounts of protein in a short time. While 1 000 kg of livestock can produce a maximum of 1 kg of protein in 24 hours, 1 000 kg of yeast may increase in the same period of time to 5 000 kg, of which half is edible protein. The advantage of microorganisms in this respect is illustrated by the following table of the time required to double the biomass:

Yeast and bacteria	20 minutes-2 hours
Algae	1 hour-2 days
Grass	1-2 weeks
Broilers	2-4 weeks
Growing pigs	4-6 weeks
Growing cattle	1-2 months

Initial enthusiasm in this field produced several methods of little practical value. For instance, it is generally uneconomic to produce single-cell protein from inorganic nitrogen and high-grade carbohydrates such as molasses, sugar and starchy roots. It is important to remember that ruminants have the ability to convert inorganic nitrogen to protein; in this respect each ruminant functions like a small fermentation factory. Furthermore, the ruminant can use otherwise worthless plant material, whereas the production of single-cell protein is expensive even if cheap raw materials are used. Expensive equipment often has to be used to prevent contamination with unwanted pathogenic or toxic microorganisms. The nutritive value of fast-growing microorganisms is lower than the chemical analysis indicates because the crude protein includes a large portion of nucleic acids that are nutritionally of little value. The cell walls of some microorganisms are very rigid and difficult for monogastric animals to digest. Yet some methods have great potential, and others have already been applied on a commercial scale.

118 Bacteria

Bacteria are very versatile organisms that can grow on almost everything; however, only one group of bacteria — those which can oxidize methane — has been thoroughly investigated for the production of single-cell protein. These bacteria have not been isolated and clearly defined; usually called *Methanomonas methanica* Söhngen, they are probably not a single species. Methane-oxidizing bacteria need more oxygen for growth than yeast and algae, and this increases the cost of production. There are also problems in obtaining a concentration of bacteria in the medium that is high enough for profitable production. Methane is among the most inexpensive and abundant sources of energy to be found. It is the main component of the gas produced in the anaerobic treatment of sewage and of natural gas, which in some parts of the world is burned off for lack of demand.

The *Methanomonas* bacteria are the only ones that can utilize methane as a source of energy. The risk of contamination is minimal. The bacteria are cultivated as a submerged culture in a water solution of mineral salts and a source of nitrogen (ammonia or urea). Air and methane are bubbled through the liquid and dispersed with an impeller. A batch culture is harvested after three days and yields about 12 g of wet bacteria per litre. The dried biomass of bacteria is pinkish white, odourless, tasteless and non-toxic and consists of about 70-80% protein of balanced amino acid composition. For practical application it has been suggested that natural gas together with air (certain proportions of air and methane are explosive) can be bubbled through a lake or a pond. As a source of mineral and nitrogen, manure will do. As the bacteria produce acid it will probably be necessary to add limestone to maintain a constant pH. The bacterial biomass may either be collected and used for feed or allowed to remain in the water as a food for fish.

I19 Algae

Useful reference: 398

For growth, algae require carbon dioxide, sunlight, nitrogen and minerals. Carbon dioxide can come from the air or be supplied in pure form. Pure carbon dioxide is a waste product of many industries, including breweries. Three species of unicellular algae are important to the production of single-cell protein.

1. *Chlorella vulgaris*. This alga grows in an acid medium. The cells are small and must be separated by centrifugation. The cell walls are fairly rigid, and the digestibility of the dry matter of intact cells is 40-50% for monogastric animals.

2. *Spirulina maxima*. This species belongs to a group known as blue-green algae, which are closely related to bacteria. *Spirulina* grows in a saline and alkaline medium where carbon dioxide is assimilated through bicarbonate and carbonate. The pluricellular *Spirulina* is about one hundred times larger than *Chlorella* and can be separated from the growth medium by filtration. It grows naturally in ponds and lakes in Ethiopia and Chad, where sun-dried

Spirulina has long been used as human food. Under favourable climatic conditions the daily yield is about 14 g dried algae per square metre a day.

3. *Scenedesmus obliquus*. This species grows in a slightly acid medium and must therefore use carbon dioxide dissolved in the growth medium. It has, together with other *Scenedesmus* species, been artificially cultivated for feed. It grows naturally in some lakes in Mexico and was used by the Aztec Indians as human food. The yield is about 0.5 g per litre in shallow ponds. The cells have to be separated by centrifugation. The dry matter digestibility of untreated cells is very low, usually below 30% in monogastric animals.

Cultivation. The risk of infection in algae cultures is rather low if large inoculums are used and optimum conditions for rapid growth are ensured. The algae are often cultivated in open vessels in the form of circular shallow canals in which the liquid is kept in constant motion. The water is enriched with the required nutrients and carbon dioxide is bubbled through it. Often devices are used to prolong the contact between the gas and the liquid. An interesting development is the use of sewage water and waste water from industries (for instance, yeast plants) as the growth medium. For the production of algae from sewage water a mixture of *Scenedesmus* and *Chlorella* is used.

Use. Algae meal is nontoxic and can be used to supply all required protein without any ill effects. The dried material remains stable in storage for at least six months. Because of its high cost, it is not fed to ruminants. Up to 10% algae meal has been used in pig diets with no change in growth rate or feed conversion. It has been concluded that algae meal has at least the same protein value for pigs as meat-and-bone meal. Algae meal is rich in xanthophyll (2.2 g/kg) and gives egg yolks a good colour. It has also been used as a major source of protein in poultry. Algae meal is low in energy and reduces performance when included at high levels. It is readily accepted by both pigs and poultry.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Chlorella vulgaris, dried	95.5	44.8	8.7	14.2	8.3	24.0			60
Spirulina maxima, dried	90.0	65.6			2.8				99
Scenedesmus obliquus, dried	94.0	56.4	6.9	8.5	13.8	14.4	0.17	1.87	458
Sewage-grown algae		53.1	4.7	14.2	6.8	21.2	1.90	2.20	337

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Sewage-grown algae	Pigs	72.1	0.0	28.7	0.0	2.09	217

Torulopsis utilis (Candida utilis)

Useful reference: 467

Whereas brewer's and distiller's yeasts are usually *Saccharomyces cerevisiae* (see 114), the yeast propagated specifically for animal feed is usually *Torulopsis utilis* (Torula yeast or fodder yeast). Torula yeast is used because it grows rapidly and can be cultivated on a variety of materials. Among the materials used as substrate for fodder yeast production are press liquor from the manufacture of dried citrus pulp, molasses, sulphite waste liquor from the paper industry, saccharified wood (both hexoses and pentoses can be used) and fruit wastes (coffee beans, apples, etc.). Torula yeast grows best at pH 4. Nitrogen and phosphorus must be added to the growth medium: about 0.4 kg of ammonium sulphate and 0.13 kg of trisodium phosphate for each kilogram of yeast to be produced. Air has to be supplied generously to promote rapid yeast growth and minimize the production of alcohol. The air is introduced at the bottom of the fermenter and dispersed by an impeller or by a porous ceramic disc.

Use. Dried yeast is valuable as a source of high-quality protein. It lacks the bitter taste of brewer's yeast (which has, however, on the average, a higher biological value). Fodder yeast is well supplied with minerals and B-vitamins, and if irradiated, supplies vitamin D as well. Dried yeast can be included in mixed feeds for all classes of livestock. Normally the high price limits its use, and its inclusion in diets is based chiefly on its value as a supplement to the amino acids and to compensate for the vitamin deficiency in cereal grains. Yeast is rich in purines (8%) and pyridines (4%), which have practically no nutritive value and are included in the crude protein fraction of the proximate analysis. When the cost of dried yeast is low, it may be fed to cattle as a source of protein in amounts of 1-2 kg per day. Cows with a high milk yield have been reported to show an additional increase from feeding with yeast, possibly because the animals' own production of B-vitamins is insufficient for a high milk yield. For calves the B-vitamins of yeast are of value; therefore, 3-5% is sometimes included in calf starters and feeds for growing calves. Pigs can well tolerate up to 5% yeast in the total ration. Sometimes, when other sources of vitamins and protein are cheaper, small amounts of yeast are added to supply unidentified growth factors. The feeding of yeast to sows during gestation and lactation (100-400 g per day) is reported to improve piglet growth and lower mortality. Yeast can be used as a substitute for soybean oil on a weight-for-weight basis in poultry diets up to 9% of the total ration for male chicks and at least 23% for female chicks. For optimum results much smaller amounts should be used — about 3 g daily per bird.

A distinction must be drawn between ordinary dried yeast and yeast which is the by-product of the production of yeast extract, as the latter contains only half the protein of the former and is low in vitamins.

Petroleum yeast

Useful reference: 439

The yeast *Candida lipolytica* can utilize the paraffin fraction of crude petroleum. Yeast grown on crude petroleum or paraffin extracted from it is now commercially produced at several plants close to refineries. The fermentation takes place in a petroleum-water emulsion supplied with ammonia and mineral salts and a generous amount of oxygen. Two different processes are used:

1. *Pure paraffins*. The paraffins extracted from petroleum are fermented under sterile conditions. The paraffins are almost completely consumed by the yeast, which is centrifuged off and dried without refining. The yield of dried yeast is about 1.6 g per litre.
2. *Crude petroleum (gas oil)*. In this process the paraffin, which is about 10% of the petroleum, is consumed by the yeast, and the remaining 90% petroleum is used in the normal refining process. The yeast is centrifuged off after fermentation and then freed from the adhering crude petroleum by solvent extraction.

Use. The yeast cream from the separator is spray-dried into a powder, which is used in calf, poultry and pig rations. If supplemented with methionine, up to 25% can be included with excellent results in calf milk replacers and at least 20% can be included in poultry rations to replace soybean oil meal and fish meal. Up to 10% has been used for sows and 15% for piglets to replace all fish meal and a portion of the soybean meal without significant adverse effects. Petroleum yeast is palatable, and toxic symptoms have not been recorded.

Yeast surface culture

Plant residues can be partly covered with a solution containing sugar. After adding a small quantity of dried yeast, together with nitrogen salts and phosphate, the whole is aerated and allowed to ferment. It is then dried and used as fodder. This method is in most cases uneconomical.

Symba yeast

Useful reference: 241

This yeast is the product of a symbiotic process employing two microorganisms: *Endomycopsis fibuliger,* a yeast that converts starch into simple sugars, and *Torulopsis utilis,* a yeast that grows on the sugars produced from the starch. The method has its greatest value in utilizing starch containing waste water and starchy wastes from primary industries. Symba yeast is a mixture of about 95% Torula and 5% *Endomycopsis.*

Symba yeast has been used successfully in a milk replacer for calves with the following composition: 24.5% yeast, 35% dried skim milk, 20% dried whey, 19% fat, 1% minerals and vitamins and 0.5% methionine.

MOULD

Many species of mycelium-forming fungus produce extracellular enzymes that can degrade complex substrates such as lignocellulose. There has been much research on the possibility of using sawdust and other highly lignified by-products for the production of mycelial protein; however, the growth of these organisms is usually slow. Moulds are also used in submerged cultures on more conventional substrates. *Aspergillus niger* is used to produce microbial protein from carob beans. *Pekilomyces varioti* is cultivated on sulphite waste liquor on a commercial scale in Finland for use in pig and poultry feeds. One of the advantages of using a mycelial fungus is the very simple separation process. The mycelium is easily filtered off and washed directly on the filter, after which most of the water can be removed by pressing.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Torula yeast	93.0	50.0	0.5	8.6	6.5	34.4	0.40	1.30	519
Molasses-grown yeast	85.7	50.9	1.0	9.9	4.8	33.4			191
Wood sugar-grown yeast	89.9	51.9	1.6	8.0	1.6	36.9			191
Sulphite-grown yeast	91.7	47.9	1.2	8.5	3.6	38.8			191
Crude petroleum yeast	94.0	70.2	—	7.8	1.0	21.0			537
Scenedesmus obliquus	91.0	68.7	7.4	7.4	7.2	17.3			537
Aspergillus niger, mould	95.2	30.9	7.6	2.3	1.0	58.2			495
Pekilomyces varioti, mould	95.0	65.0	8.0	6.0	2.2	23.0			

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Torula yeast	Cattle	90.0	90.0	80.0	90.0	3.49	519
Torula yeast	Sheep	89.0	99.0	78.0	95.0	4.03	519

121 Manure

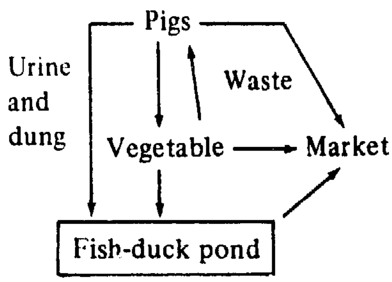
Useful references: 25, 184

Coprophagy, or feeding on manure, is not new in animal nutrition. For example, livestock feeding on a farm has frequently involved a system of beef cattle followed by hogs and subsequently chickens. Under such a programme the nutrition of the hogs and chickens is based on manure. The current interest in manure as a feedstuff is mostly due to the problem of waste disposal from intensive livestock and poultry operations. Apart from this problem it has been recognized that large amounts of nutrients are wasted. The re-use of manure is one way of creating edible protein from waste material which is often disposed of uneconomically and also creates a nuisance. The amount of excreta produced is considerable: a 2-kg hen produces 0.8 kg a week, a 650-kg cow 150 kg, an 80-kg pig 40 kg and a 45-kg pig 22 kg.

Manure has served as a substrate for both yeast and algae used as feedstuffs, and it has been tried as a substrate for maggots used as a poultry feed; however the simplest way to use it is as a direct feed.

Toxicity. Fresh manure seems to contain no toxic products unless it is allowed to putrefy. Some parasites and diseases can be disseminated in manure; there is less risk if the manure is made into a silage. Manure containing nematode eggs was completely free of them four weeks after ensiling. Heating and cooking have the same effect. The transmission of diseases from poultry to cattle via manure is unlikely. Similarly, there appears to be no serious problem with drug residues in poultry manure, except for copper- and arsenic-containing drugs. As cattle and especially sheep are sensitive to copper, manure from animals receiving high levels of copper in their diets should be fed with care.

Pig manure. Pig manure is important in the pig-vegetable-fish-duck chain that is common in Southeast Asia. The integrated system, long profitably used by Chinese farmers, is shown in the diagram (ref. 306).



Swine manure contains over 20% crude protein. Because of this high content of crude protein, dried fresh swine manure has been used in experimental work as poultry feed with no adverse effects on either meat or eggs. The same product has been used to advantage in pig finishing rations at the 15% level. It has also been included in sheep rations at the level of 40% (in pellets) with good results.

Cattle manure. A low digestible energy content and a relatively low crude protein content are the two primary deficiencies which limit the usefulness of ruminant excreta as a supplementary ingredient in feed. The dehydration of cattle excreta for use as an ingredient in cattle feed is clearly uneconomical.

Steer manure has been fed to finishing beef cattle either mixed fresh with other feeds or as wastelage. When fed fresh, the manure is collected daily from the pen and blended with the ration in the ratio of 2:3. The mixture is kept in a closed container overnight and fed the following day. When fed as wastelage, fresh manure is mixed with ground grass hay in the ratio of 57:43 and stored in a silo, where it ferments and acquires a silage odour. Wastelage from Coastal Bermuda hay averages 13% crude protein and 60% digestible nutrients. The product has been combined with concentrates for feeding to finishing cattle and has also been used as the sole feed for ewes and beef cows. A complete ration recommended for feedlot cattle consists of 40% fresh cow manure mixed with 42% cracked maize and 18% maize silage. The mixture is ensiled for ten days before feeding. When wastelage is fed alone for a long period, it may be necessary to add vitamin A and phosphorus or feeds rich in these growth factors. Feeding manure to dairy cows produces no effect on lactation or milk taste. Dried fresh manure smells like mixed feed. The dryness of dehydrated manure seems to lessen its palatability, but manure fermented as silage is well accepted. Once cattle become accustomed to this feed there is no effect on consumption. Wastelage should not be stored in a rusty structure.

Manure from finishing cattle has been fed to pigs to utilize the undigested grain it contains. Besides, manure is a fermented product and contains growth factors, especially the B-complex vitamins and some essential amino acids. Dried fresh cow manure included in rations for growing birds (but not for layers) has produced much faster growth in some cases, possibly because of hormone activity in the manure.

Poultry manure. With the intensification of poultry keeping, not every poultry farm has enough land on which to spread manure. The results of many experiments indicate that dried poultry manure can be successfully included in the feeds of both ruminants and nonruminants.

Fresh poultry manure is about 30% crude protein on a dry matter basis, about half of which derives from uric acid. For ruminants the digestibility of the crude protein is close to 80% and that of the organic matter about 65%. Poultry manure is also rich in minerals, which makes further mineral supplementation of rations containing dried poultry manure unnecessary.

As fresh poultry manure ferments very quickly, it must be dried without delay if it is to be used for feeding. The drying temperature should be no higher than 90°C so as not to damage the protein in the manure and no lower than 70°C so as to sterilize the manure. It should then be ground to facilitate the removal of feathers.

Uric acid can be utilized by rumen microbes for protein production (see feed information summary I 30). As uric acid is not easily dissolved in the rumen fluid and the ammonia is only slowly released, it is therefore more efficiently utilized than other nonprotein nitrogen (NPN) sources. The rumen flora seems to take about three weeks to adapt before it can fully utilize uric acid. For ruminants dried poultry manure can be used like any other protein concentrate. When a dried poultry manure ration is maintained at a normal energy level, the weight gains or the milk production are satisfactory. Its low energy value (about the same as hay) may cause low palatability when it is fed at high levels, but various steps can be taken to improve palatability, such as the addition of molasses or fat. The feeding of dried poultry manure does not affect the flavour of meat or milk.

The feeding of dried poultry manure to pigs has been less successful. Levels of 5-10% do not usually affect the growth rate, but the feed conversion ratio becomes poorer with further additions to the ration. At higher levels, growth rates are depressed as well, probably because dried poultry manure is low in the essential amino acids needed by pigs and because of the excessive amount of calcium. In poultry diets it has been found that dried poultry manure can be included up to 5% for broilers, up to 20% for Leghorns and up to 40% for layers without adversely affecting production; however, feed efficiency was inversely proportional to the amount included in the diet.

Much of the interest in the feeding of poultry manure has been centred on deep litter, which is a mixture of a suitable litter material and poultry droppings developed over a period of six months or more and maintained in a dry, friable condition. The litter is placed in a layer between 3 cm and 25 cm thick on the floor of the poultry house, mainly to absorb the moisture from poultry excreta, which is about 80% water when voided. This moisture is subsequently disposed of by evaporation and is also used in decomposition. Microorganisms thrive on the manure in the litter and break it down. This microflora produces growth factors, notably vitamin B_{12}, and antibiotic substances which help control the level of pathogenic bacteria. Consequently, the growth rate and health are often superior in poultry raised on deep litter. Various types of litter materials are used, such as sawdust, wood shavings, groundnut hulls and bagasse. The litter material must be sufficiently water-absorbent, reasonably coarse so that packing does not occur, and capable of decomposition. The addition of lime helps keep the litter dry, and the addition of superphosphate reduces the escape of ammonia from the litter, thus maintaining the nitrogen content at a higher level.

When used as feed, the litter should be dried immediately after removal from the poultry house and preferably milled and run over a magnet to remove stray metal scraps. Dried litter can be stored for a long time. Poultry litter has also been ensiled to prevent deterioration. For feeding it should be mixed with energy-rich feedstuffs. The following formula has been recommended: litter 65%, citrus meal 25%, molasses 9% and minerals and vitamins 1%. When mixed in the feed, poultry litter does not keep and must be used quickly. The depth of the litter, as well as the material, affects the nutritive value. Poultry litter is a low-cost palatable feed which has given very good results in both dairy cows and beef cattle.

Citrus meal is a good litter producer. The subsequent chicken litter is a very good energy-rich feed. It should be noted, however, that citrus seeds must not be included in citrus meal used for litter as they may cause poultry mortalities.

Litter silage has been produced by packing broiler litter into an upright airtight silo, adding water until the total moisture content was 35-38% and leaving the silo sealed and undisturbed for six weeks. This has proved to be an excellent ingredient for cattle feed, and the process partially destroys harmful microorganisms.

Sewage

Activated sewage sludge is made by a fermentation process, in which the organic matter in sewage is metabolized by a variety of microorganisms under heavy aeration. This process is most common in modern sewage treatment plants for the production of large amounts of activated sludge. This end product is a gelatinous mass of microorganisms, rich in nitrogen and vitamin B_{12}. It can be used as a source of vitamin B_{12} in animal nutrition, for which the inclusion of 2% in rations will in most cases satisfy the requirement. The inclusion of a higher percentage of activated sludge as a source of nitrogen has been less successful, because high levels decrease intake and cause diarrhoea. The maximum amount for pigs is about 5% and for poultry and ruminants 8%. The crude protein digestibility for ruminants is about 55%.

Guano

Droppings from birds or bats contain up to 10% nitrogen and are rich in phosphorus (up to 5% for fish-eating birds). For ruminants it can be used as a nonprotein nitrogen source. It should be used in the same way as urea and usually gives the same response.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Manure from steer on a hay ration, fresh	17.9	8.4	22.5	18.8	3.1	47.2			186
Manure from steer eating silage plus concentrate, fresh	17.4	11.4	22.2	12.0	2.4	52.0			186
Layer manure, dried	92.3	28.3	12.0	16.5	1.8	41.4	5.10	1.60	23
Wood-shaving broiler litter, dried	88.9	30.6	14.6	19.0	2.8	33.0	2.48	2.26	57
Groundnut-hull broiler litter, dried	89.1	32.0	15.1	17.9	2.8	32.2	2.77	2.86	57
Bagasse chicken litter, dried	92.3	2.8	44.9	2.2	0.8	49.3			264
Citrus meal broiler litter		26.5	11.8	9.5	3.0	49.2			201
Wheat-bran broiler litter		27.2	17.1	19.9	1.7	34.1			351
Maize-cob broiler litter		26.5	16.7	13.9	4.3	38.6			351
Sugar-beet pulp broiler litter		31.6	14.1	17.7	1.9	34.7			351
Rabbit manure		20.0	28.5	14.5	1.2	38.5			516
Bat guano, Trinidad	91.9	22.9	41.6	11.2	2.4	21.9			117

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Wood-shaving litter	Sheep	70.4	66.1	62.7	68.6	2.23	57
Groundnut-hull litter	Sheep	73.0	66.8	56.3	69.7	2.31	57
Citrus meal litter	Sheep	82.0	72.8	85.6	81.6	2.90	201

I 22-27 Wood and wood By-products

Useful reference: 388

Wood contains a high percentage of potentially digestible carbohydrates, but when fed in the form of untreated sawdust or chips it is largely indigestible, even by ruminants.

The structural components of wood — lignin, cellulose and hemicellulose — form a close physical and chemical complex called lignocellulose.

Lignin gives plants strength and rigidity. The content of lignin varies from about 2% in immature forages to about 15% in mature forages, whereas in wood the percentage is somewhat higher. It is completely indigestible and also lowers the digestibility of cellulose and hemicellulose by acting as a physical barrier to cellulose-splitting enzymes.

Hemicellulose consists of digestible polysaccharides constructed mainly of 5-carbon sugars. The sugar xylose is the commonest component of hemicellulose in forages. The digestibility of hemicellulose varies from 45-90%, depending on the sugars it is composed of.

Cellulose is usually the most abundant polysaccharide of the lignocellulose complex and consists of 6-carbon sugar glucose. Pure cellulose is fully digestible by ruminants.

The lignocellulose complex accounts for most of the gross energy in common forages and wood. The percentages of the cell wall constituents of various plant materials on a dry matter basis are as follows:

	Hemi-cellulose	Cellulose	Lignin	*Ref.*
Alfalfa (medium maturity)	6.0	25.0	7.2	488
Orchard grass (medium maturity)	40.0	32.0	4.7	
Rye straw	27.2	34.0	14.2	426
Birchwood	25.7	40.0	15.7	
Sprucewood	20.9	46.0	24.1	

The mechanism by which lignin affects digestibility is complex. Rye straw has nearly the same lignin content as birchwood, but rye straw is far more digestible. Hence the lignin content in itself is not a reliable yardstick for measuring digestibility. Wood species differ widely in lignin content, but as a rule the wood of conifers contains more lignin than deciduous or broad-leaf trees.

I 22 Untreated wood

Useful reference: 427

Numerous feeding trials and laboratory experiments have shown that the nutrients in untreated wood are essentially unavailable to farm animals with the exception of a few less lignified hardwood species. The new concept of feeding cattle on high-grain rations has increased the possibility of using wood residues like sawdust and chips as the roughage component. Experiments have shown that sawdust is an effective roughage substitute when it constitutes up to 15% of the total ration. Cattle compensate for the lower energy of sawdust-diluted feed with higher intake. Some sawdusts — poplar is an outstanding example — are partly digestible by cattle. The *in vitro* digestibility of spruce sawdust is nil, of oak sawdust 5% and of poplar sawdust 30%.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Pinewood, Germany (F.R.)		1.0	69.8	0.5	0.4	28.3			359

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Pine sawdust	Sheep	0.0	11.9	42.6	6.7	0.38	268

123 Treated wood

Useful reference: 343

Comparatively mild treatments can markedly increase the digestibility of wood from certain species by exposing the cellulose from the protecting lignin to render it more accessible to attack by cellulose-splitting enzymes. In some woods the cellulose is partly exposed by openings in the lignin which can be widened by swelling. In other woods — for instance, white oak — these openings are plugged and chemical treatments are of little value. The most promising treatments for making wood more digestible are the following:

1. *Ball milling.* This method reduces the wood to microparticles. As particle size decreases, more cellulose is exposed. Carbohydrate digestibility in ball-milled wood approaches that of feed grain (70-80%).

2. *Chemical treatments.* These include treatment in aqueous solutions of alkali and vapour-phase treatment with sulphur dioxide. Red oak has been made 55% digestible by chemical treatment. After steeping in a solution of 15% sodium hydroxide, a poplar species with 5% dry matter digestibility *in vitro* had a digestibility of 50%. Alkali-treated aspen and birch

sawdust have constituted up to 30% of ruminant rations with good results.

3. *Steam.* In some cases steaming has been a very effective method of increasing digestibility. Steamed aspen wood with a dry matter digestibility of 48% was used successfully as a substitute for hay in sheep rations.

4. *Muka.* The needles of conifers and the leaves of deciduous trees can be made suitable for animal feeds with little processing. Basically all that is required is heating at 210°C for a few minutes to drive off moisture and unpalatable essential oils, followed by milling. The major development of this process has taken place in the USSR, where about 100 000 tons of the product, called Muka, are fed to animals each year. Muka is somewhat similar to lucerne, being rich in cellulose, carotene and minerals and containing one half to two thirds as much protein. It is fed as a supplement to poultry, cattle, milking cows and pigs at 5-8% levels. The major impetus to the development of Muka in the USSR appears to have been the large-scale production of essential oils with Muka as a by-product.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Spruce Muka		8.8	46.3	4.4	6.5	34.0	0.72	0.12	537
Birch Muka		8.0	22.8	4.2	8.2	56.8	0.78	0.26	537

5. *Fungal degradation of lignin.* This process is based on the ability of white-rot fungi to utilize lignin with minimum degradation of cellulose and hemicellulose. The product is a high cellulose-hemicellulose fibre which is a potential roughage for ruminants. Fungal degradation is slow compared to steaming or chemical treatment as it requires several weeks, but this is not necessarily a serious drawback. The process has not yet been developed for practical use, but the research in this area is intensive.

Useful reference: 368

Lignocellulose can be freed from lignin and hemicellulose by chemical treatment to yield cellulose. This can be done by two methods:

1. *Sulphite process.* The chopped wood is cooked seven to fifteen hours at 145°C under pressure in an acid solution of calcium bisulphite. After cooking, the chips are free of lignin and hemicellulose and consist of fairly pure cellulose.
2. *Sulphate process.* The wood is cooked three to six hours at 175°C under pressure in a solution of sodium hydroxide, sodium sulphide, sodium carbonate and sodium sulphate. The wood contains some lignin after cooking.

Cellulose has long been known to have a high energy value for ruminants. During the Second World War large amounts were used in the Scandinavian countries. When the war ended and cheap energy-rich feeds became available, the use of cellulose as feed ceased despite attempts to lower the cost by producing cheap fodder cellulose from forest waste. Horses digest cellulose very well, and it is also digestible by adult pigs. The digestibility of the organic matter in average cellulose is 53% for adult pigs and only 37% for small pigs. The physical form of the cellulose is also important. Ground cellulose is 90% digestible by sheep, but cellulose in the form of torn sheets is only 79% digestible.

		As % of dry matter								
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Sulphite cellulose	94.0	0.3	85.5	0.6	0.7	12.9			233
Sulphate cellulose	94.0	0.2	87.8	1.4	0.1	10.5			233
Fodder cellulose	94.0	0.5	75.5	3.8	1.2	19.0			233
Mechanical pulp	94.0	1.1	74.2	0.4	0.3	24.0			233
Cellulose from sawdust	94.0	0.4	86.4	2.5	0.7	10.0			233

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Sulphite cellulose	Sheep	0.0	95.0	71.0	92.0	3.39	233
Sulphate cellulose	Sheep	0.0	96.0	14.0	88.0	3.36	233
Fodder cellulose	Sheep	0.0	84.0	26.0	79.0	2.85	233
Mechanical pulp	Sheep	0.0	4.0	37.0	12.0	0.22	233
Sawdust cellulose	Sheep	0.0	55.3	37.0	53.0	1.93	233

125 Paper

Useful reference: 125

Waste paper varies greatly in digestibility according to the raw material from which it is made. Newsprint (daily newspapers) contains more mechanical pulp of low digestibility than office discard paper. Commonly, newsprint is a blend of 70% mechanical pulp and 30% chemical pulp. Mechanical pulp undergoes no chemical change and therefore has approximately the same digestibility as the original wood, whereas chemical pulp is highly delignified and thus almost completely digestible. Hammer-milled newsprint has been used as roughage for cattle. It seems that high levels of newsprint (12%) or office discard paper (15%) in rations depress food intake. Ground newsprint can absorb three times its weight of blackstrap molasses. Upon drying, it becomes a stable and friable product with fair palatability for cattle. The coloured ink in newsprint contains lead, but it does not seem to accumulate to any noticeable extent in animals. No health disorders have been observed in cattle that have been fed waste paper. The dry matter digestibility of newsprint is about 30% and of brown wrapping paper and cardboard 40-60%, whereas high-quality chemical pulp paper is up to 98% digestible.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Office paper		0.7	83.8	5.5	1.9	8.1	0.1	0.0	537
Newsprint		0.7	68.9	0.9	3.7	25.8	0.1	0.0	537

Useful reference: 202

Processes for converting wood into molasses have been known for more than a century. To change cellulose into glucose, high temperatures and pressures are required when dilute acids are used. With concentrated acids the process can be carried out at room temperature, but the percentage of unrecovered acid makes the cost very high. Hemicellulose is more easily converted into sugars. The hemicellulose from hardwood (e.g., maple and beech) yields a high percentage of 5-carbon sugars, while hemicellulose from softwood (e.g., pine and fir) yields a fifty-fifty mixture of 5-carbon sugars and 6-carbon sugars. Ruminants can assimilate both types of sugars, whereas the 5-carbon sugars are less available to monogastric animals. The Madison wood-sugar process, which consists in hydrolysing cellulose into simple sugars, is one of the more economical of the many methods developed for this purpose. It involves continuous pumping of a spray of hot 0.5-0.6% sulphuric acid on chips or sawdust heated in a digester to 150°C at the start and gradually increased to 185°C. After removal from the digester the sugar solution is cooled to 138°C and neutralized with lime. The resulting sugar solution contains 5-6% simple sugars and is concentrated to a syrup for feeding. One ton of wood will yield about 0.5 ton of sugars. The syrup has a bitter taste, but this does not seem to make the molasses less palatable to cattle. The syrup can be used for cattle in the same way as sugar-cane molasses (see feed information summary 17). Sugars from softwood can constitute up to 20% of poultry rations in substitution for the same percentage of grain.

A newer related procedure is the solubilization of hemicellulose from wood by steam during the manufacture of hardboard. This process is economical as it does not require chemicals. The hemicellulose sugars are concentrated or spray-dried and sold as animal feed under the name wood molasses. For ruminants wood molasses is roughly equal to sugar-cane molasses. It can be included up to 5% in diets for monogastric animals. Above that level the energy value of wood molasses declines as the amount in the diet is increased. High levels of wood molasses in diets for monogastric animals cause digestive disorders.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Wood molasses, acid process	63.6	1.1	0.0	6.0	0.3	92.6	2.80	0.09	350
Wood molasses, steam process	65.0	0.8	1.0	9.2	0.3	88.7	1.23	0.12	350

127 Pulping by-products

The types of by-products vary from one pulp mill to another. Many of these by-products would undoubtedly have value as animal feed, but this aspect has been poorly investigated so far. Screen rejects, which are partially pulped but not bleached, have a dry matter digestibility of 44%. The ray cell and vessel fines, also a partially pulped by-product, have a dry matter digestibility of 72%. Centrifugal cleaner fines are a fully pulped and bleached by-product with the same digestibility as the cellulose. The by-product from mills producing synthetic fibre from wood is rich in digestible hemicellulose and has been used experimentally in sheep rations without any obvious harmful effects in amounts of up to 0.6 kg per day.

Lignin sulphonates are produced by concentrating sulphite pulping liquors until they contain 50-55% solids, after which they are handled like molasses or are spray-dried. Ammonium, calcium, magnesium or sodium sulphonates can be produced, but the ammonium lignin sulphonates are probably the most important as they are a good source of both crude protein and energy. Commercially, they are mixed with molasses for use as a binding and pelleting agent or for feeding as a low-level energy source.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Waste from synthetic fibre mill	84.4	0.4	0.1	7.6	0.1	91.8	0.17	0.02	424

128 Treatment of poor-quality roughage

Useful reference: 393

Various types of crop production (cereals, sugar cane, etc.) result in large quantities of low-digestibility roughages, which are thus eaten far less voluntarily because of their slow passage through the alimentary canal. Only limited use can be made of straws in ruminant nutrition. Animals spend more energy in chewing and digesting such roughages than they gain from them.

Often the digestibility of poor roughage is limited not by the lignification but by the low nitrogen content. The minimum crude protein requirement for efficient lignocellulose breakdown of roughages fed as the sole diet is claimed to be 3.8-5%. In many cases the digestibility and the rate of rumen passage can be increased by supplementing the feed with protein concentrate or urea plus minerals. In some cases it is economical to increase the nutritive value of poor roughages by physical or chemical treatments.

Physical treatments. Roughages can be treated by soaking, boiling, fermenting or grinding. Grinding is the preferred method as the others generally give poor results. However, grinding the roughage deprives the animal of the opportunity to reject the fibrous parts and also reduces the digestibility of the feed, although this disadvantage is usually counterbalanced by a higher voluntary feed intake. If, for instance, wheat straw is ground, even rather coarsely, the intake increases by 20-30% because of faster passage through the rumen. This is illustrated by the results of an experiment with late timothy (ref. 207):

	DIGESTIBILITY OF CRUDE FIBRE	INTAKE OF DIGESTIBLE ENERGY
Long form	46%	90 $kcal/W_{kg}0.75$
Ground and pelleted ...	31%	175 $kcal/W_{kg}0.75$

Such increases in digestible energy intake can produce dramatic changes in beef production of more than 50% increases in daily gains for animals on all-roughage diets. It should be noted that the increased intake of digestible energy raises the protein requirement as well. When ground forage is mixed with concentrates, grinding tends to eliminate the difference in forage quality.

Chemical treatments. Treating straw with alkali can give a product of considerable nutritive value. The usual methods require large quantities of water and are therefore impracticable in areas where water supplies are limited. The process consists of soaking the straw in ten times its weight of 1.3% sodium hydroxide solution at ambient temperature for about twenty-four hours. The liquid is then drained off to be used for another batch of straw. An average of 7-8 kg of caustic soda is consumed by 100 kg of straw. The straw is washed after treatment until it is free of alkali. This treatment increases the organic matter digestibility of wheat straw from 46% to more than 70%. As straw so treated is loose, less energy is lost in chewing and digestion. The straw is palatable and can be consumed in large quantities by livestock. Beef cattle can be fed up to 20 kg of treated straw per day, dairy cows up to 15 kg, young heifers up to 10 kg and sheep up to 3 kg.

Attempts have been made to reduce the amount of water required for the process, so that 100 kg of straw, for example, can be mixed with only 300 litres of water and 6 kg of sodium hydroxide. After treatment the straw is washed according to the principle of chromatography (countercurrent), whereby the stream of water meets the flow of straw. The straw and the water are introduced at opposite ends of a container. The water passes through the straw and vice versa, and each is extruded at a point as far as possible from the point of introduction; thus the dirtiest water meets the dirtiest straw and the cleanest water meets the cleanest straw. With this method a total of 400 litres of water is sufficient to reduce the alkali content to an acceptable level. Chromatographically treated wheat straw has a crude fibre digestibility of about 90%. If higher costs for chemicals are acceptable, the alkali can be neutralized with acetic acid rather than washed out. However, the high level of sodium in such materials may cause problems if fed in large amounts. Neutralization through ensiling also seems promising.

A recent approach is to spray low concentrations of alkali on the feed (4 kg of sodium hydroxide per 160 kg of chopped straw) and to allow it to slake before feeding. The sprayed straw is pelletized so that the alkali comes in close contact with the fibre. The pellets are not neutralized before feeding. Another modern method is that of treating the straw for fifteen minutes in a hot (80°-90°C) solution of sodium hydroxide. The liquid is then pressed out of the treated straw before it is dried in a grass drier. The acid hot gases (carbon dioxide and sulphur dioxide) in the drier neutralize the straw.

Treatment with gaseous ammonia also increases the digestibility of straw and enriches it with nitrogen. In a simple application of this method the straw is baled loosely and placed on a plastic sheet, after which the straw is tightly covered with plastic and gaseous ammonia (3-4% of the weight of the straw) is let in through a hose. The straw can be used after three to eight weeks, when the plastic is removed and the ammonia aired off.

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Wheat straw, alkali treatment	18.9	2.9	53.5	5.0	1.5	37.1			221

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref.
Alkali-treated straw	Sheep	0.0	77.0	39.0	57.0	2.29	221

For bone meals, see food information summary H4, and for eggshells, feed information summary H14.

Limestone. This is the most common source of calcium used in livestock feeding. It is almost pure calcium carbonate. Calcitic limestone contains 36-38% calcium and can safely be fed free choice *(ad lib)* mixed with salt. Dolomitic limestone contains at least 5% magnesium carbonate and should not be used for poultry, but it is as good as calcitic limestone for other animals. Portland and natural cement can be used instead of limestone.

Seashells and coral. Seashells are almost pure calcium carbonate (95-99%) and are good sources of calcium for all classes of animals. Clam shells, oyster shells, conch shells, coral and coral sand can all be used for feeding. Shells that have been ground to a coarse grit seem to be more palatable to laying hens; for other animals the shells should be finely ground. Seashells and coral contain about 37% calcium and no phosphorus.

Rock phosphate. This contains about 75% tricalcium phosphate. It should not be used unless it is guaranteed to contain less than 0.5% fluorine. Rock phosphates from some areas (e.g., Curaçao) are low in fluorine, whereas those from other areas must be defluorinated before they can be used. Defluorination of rock phosphate is an industrial process that is suitable only for large-scale production. Rock phosphate contains about 17% phosphorus and 34% calcium.

Fertilizer superphosphate. This can also be used as a mineral supplement if no other sources of phosphorus are available. It is necessary to extract the soluble phosphorus by thoroughly mixing the superphosphate with water and allowing the slurry to stand for some time. The fluid containing the phosphorus is then poured off and can either be evaporated or included in liquid mixtures. One kilogram of superphosphate yields about 70 g of phosphorus.

Insoluble grit. Hens store small fragments of stone in their gizzards to grind the food they eat. Poultry on open range can pick up the grit required, but when they are housed intensively indoors it is essential to supply them with a source of insoluble grit. Limestone or crushed seashells are not useful for this purpose as they have no sharp edges for grinding feed. The feeding of insoluble grit to growing chickens up to six weeks of age is not necessary.

Edible earth. Earth eating is common among range cattle and wild animals, especially in Africa. The patches of soil that attract animals have been chemically analysed, but no specific mineral that entirely explains this behaviour has so far been found. Some patches have a salty taste which attracts animals; however, even in those patches the sodium is not always in the form of sodium chloride and may occur as sulphate or carbonate. Below are some analyses of edible earth (ref. 499).

LOCATIONS	Ca	P	Fe	K	Na	Cu	I
			Percent				
[1] Masuku, Zambia	4.77	0.65		10.08	16.23		0.8 ppm
[2] M'bala, Zambia	4.76	0.32	1.90	1.25	13.16		
[3] Kalene, Congo	0.74	0.41		0.31	16.78	1.01	
[4] Katambora, Zambia ..	0.86	0.31	0.51	4.31	30.14	0.02	
[5] Luangwa, Zambia ...	0.19	0.41		0.11	5.82		
[6] Rukwa, Tanzania	0.74	4.59	0.03	0.15	1.72	0.003	

[1] This sample is from a hill extensively excavated by game and livestock. It has long been customary to drive stock to this site as the earth is believed to be necessary for the fertility of animals. - [2] From a large deposit between Kalambo Falls and the Tanzanian border that is much used by game and goats. - [3] From pan excavations sought out by cattle, which eat the soil avidly. - [4] From a pit excavated by elephants but used by other game as well as stock. - [5] From an ar a of edible earth that attracts game in such numbers that it is used as a tourist attraction. - [6] From an edible earth pan of approximately 2 ha that is turned over by a vast number of game.

Manufactured sources of minerals. The percentages of minerals in some manufactured sources are shown in the following table.

MANUFACTURED SOURCES	Ca	P	I	Co	Fe
Tricalcium phosphate	13	10			
Bicalcium phosphate	24	20			
Monocalcium phosphate	16	12			
Phosphoric acid (100%)		32			
Potassium iodide			76		
Sodium iodide			84		
Potassium iodate			59		
Cobalt sulphate				34	
Ferrous sulphate					20

Useful references: 301, 156

To determine the protein content of a feedstuff, it is usual to ascertain first the percentage of nitrogen by chemical analysis. This estimate is then multiplied by 6.25 as the average protein content of a feed is 16% nitrogen ($6.25 \times 16 = 100$). The resulting value is called crude protein, as distinguished from true protein, because some of the nitrogen analysed is not derived from protein. In most grasses and other green feeds only a part of the nitrogen comes from protein; the balance consists of inorganic nitrogen salts, amino nitrogen, amides and other forms. This is of no importance, however, for ruminants as they can utilize inorganic nitrogen as well as protein nitrogen through the microbial activity in the rumen, where bacteria thrive on the nonprotein nitrogen and incorporate it in their own proteins. The protein in the bodies of the microorganisms is then digested in the intestinal tract of the ruminant and absorbed. Hence, instead of feeding ruminants expensive true protein, cheaper sources of nitrogen can be equally effective.

The most important nitrogen sources used in ruminant nutrition are ammonia, urea, biuret, diammonium phosphate and ammonium polyphosphate.

Ammonia. NH_3 is a gas which usually dissolves in water. It is the cheapest source of nitrogen that can be used in feeding, but being toxic and difficult to handle it is mostly used to increase the nitrogen content of low-protein feeds by ammoniation on an industrial scale. Low-protein feed (e.g., rice hulls or beet pulp) is allowed to react with the ammonia, usually under high pressure and temperature. The ammonia becomes chemically bound and is not released until the feed is fermented in the rumen.

Urea or carbamide. $CO(NH_2)_2$, the cheapest solid nitrogen source, is a white crystalline water-soluble powder that is used as a fertilizer. Urea contains 46% nitrogen; thus each kilogram of urea is equivalent to 2.88 kg of crude protein (6.25×0.46), which in most rations equals a digestible crude-protein content of 200%. Fertilizer urea is hygroscopic and cakes very easily, making it difficult to mix into solid feeds. To improve the flow characteristics, urea is processed into feed-grade urea (42% nitrogen), in which each grain of urea is covered with kaolin or some other non-hygroscopic substance. The cheaper fertilizer urea can be used, however, when mixed with liquid feeds or even in solid feeds if added in the form of a suspension or solution in molasses. Urea stops bacterial growth and fermentation in concentrations over 10%, but it has a very bitter taste and limits intake if used at high levels. Urea is the most widely used of the nonprotein nitrogens. The seeds of some legumes, especially soybeans, contain the enzyme urease, which breaks down urea and renders the feed unpalatable. Urease is largely destroyed by the heat during the processing of the beans, so that oil meals can usually be mixed with urea. A simple test to ensure that no ingredients that are to be mixed with urea contain urease is to moisten a mixture of urea and the suspected ingredients and allow it to stand under cover for one hour. If an odour of ammonia develops, the ingredient contains urease and should not be mixed with urea.

Biuret. NH_2-CO-NH-CO-NH_2, produced from urea by heating, contains 41% nitrogen (256% CP). It is only slightly soluble in water and is not toxic as the ammonia is slowly released in the rumen. It therefore has definite advantages over urea for use in dry feeds, although it is more expensive. An adaptation period of two weeks to two months is required before obtaining a response to feeding biuret. This adaptation is rapidly lost when biuret is not fed.

Diammonium phosphate. $(NH_4)_2HPO_4$, a white crystalline water-soluble powder, contains 21.4% nitrogen (134% CP) and 23.7% phosphorus.

Ammonium polyphosphate. This is a common supplier of phosphorus and nonprotein nitrogen in liquid supplements. For use in feed it must be produced by the thermal process, which yields a clear solution of ammonium polyphosphate of high purity. It is handled in liquid form and has the advantage over phosphoric acid (also a common source of phosphorus in liquid feed) of not being corrosive. The 11-37-0 grade contains 11% nitrogen (equivalent to 68.8% CP) and 16.1% phosphorus.

Toxicity

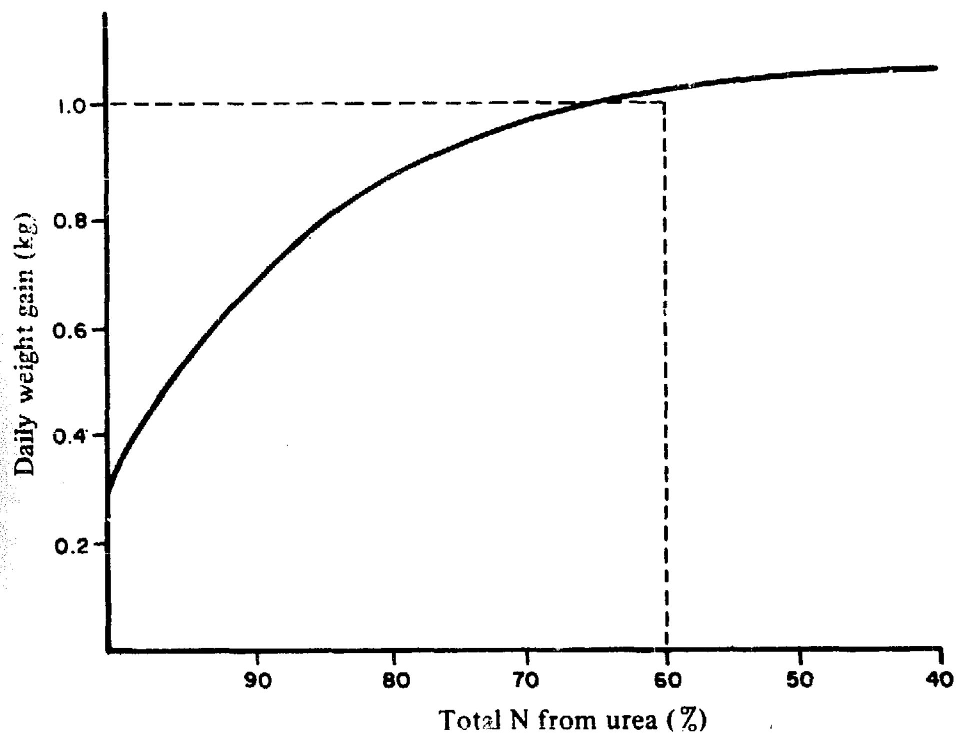
If the level of ammonia in the rumen is high, the amounts entering the bloodstream may reach toxic levels. Ammonia is released more quickly from a nonprotein nitrogen source with good solubility (urea and diammonium phosphate) than from a nonprotein nitrogen source with low solubility (biuret). The amount of ammonia in the rumen will also be low if the microflora is active and able to utilize the ammonia at a high rate. This can be ensured by providing an easily fermentable carbohydrate like molasses or a starchy feed. Consequently, biuret is safer when the animal does not have access to such a feed or is restricted to roughage.

Toxicity is often caused by eating lumps of urea in the feed or by drinking water-urea solutions or molasses-urea liquids diluted with rain water. A sudden increase in the concentration of ammonia in the rumen may be fatal to the animal. It is advisable to distribute the daily intake of urea among several feedings, which will improve the utilization. Cattle should not be switched to urea abruptly, especially if they have been on poor feed, as the rumen needs some time to adapt to a new feed. The level of urea can gradually be increased as the tolerance of the cattle increases. A gradual change over a period of one week is recommended. The adaptation of cattle to urea is lost if they do not consume urea for two or three days.

Only animals with a functioning rumen can utilize urea; therefore it should not be given to young calves and monogastric animals. Unlike protein, urea does not contain energy, phosphorus or sulphur; hence a feed mixture containing urea should be supplemented to make up for these deficiencies. Poor results are usually experienced with urea when fats provide a substantial portion of the energy in the diet.

USE

As a specific maximum amount of bacteria can be produced each day by the rumen, it is not possible to provide high-producing animals with the total requirement of protein in the form of nonprotein nitrogen. How much of the total nitrogen required has been supplied by urea in diets for fattening bulls in Cuba is shown in the following graph (ref. 397):



As can be seen, an animal gaining 1 kg per day can be given a maximum of 60% of the required nitrogen in the form of urea. In this case the protein nitrogen was provided by insoluble Peruvian fish meal. The true protein required must be given in the form of insoluble or protected protein so that it will pass the rumen without being hydrolysed and reach the stomach unchanged. Generally, proteins that have been heated during processing (oil extraction or drying) are less soluble. For instance, soybean oil meal protein which has been heated to 80°C for ten minutes is only 67% as digestible as soybean oil meal protein processed at ambient temperatures; if heated to 120°C for fifteen minutes, the solubility decreases to about 20% of that of soybean oil meal processed at ambient temperature. At the optimum temperature the rumen digestibility is reduced while the digestibility in the true stomach remains high. Too high a temperature diminishes the biological value of the proteins by destroying essential amino acids. Proteins can also be protected from attack in the rumen by treatment with formaldehyde.

The energy source used with nonprotein nitrogen should easily ferment in the rumen. The carbohydrates in molasses are completely fermented in the rumen, whereas up to 30% of the starch in grain may pass undegraded to the stomach and thus be unavailable for synthesis.

There are two main ways of using nonprotein nitrogen:

1. Nonprotein nitrogen can be used alone or with a small amount of energy. Cattle consuming only poor-quality roughage usually have too low an intake of protein and energy. If extra nitrogen is provided, the intake of dry matter will usually increase and the nutritional status improve. Biuret can be provided alone, whereas urea should be mixed with a source of energy to avoid toxicity. The addition of starch alone or any other easily fermentable carbohydrate to a protein-deficient high-roughage diet decreases the digestibility of the roughage because of the competition for nitrogen between the fast-growing starch-consuming bacteria and the slow-growing cellulolytic bacteria. Additional nitrogen in the form of nonprotein nitrogen will thus increase the digestibility of roughage in such cases.

2. Nonprotein nitrogen (usually urea) can be used as a cheap substitute for true protein in balanced feeds.

Nonprotein nitrogen can be fed in the following ways:

(a) By spraying pastures with a mixture of molasses and urea. This method is now seldom used because of the high cost of labour and the high degree of waste.

(b) To supplement the crude protein in certain silages and hays. The silages supplemented with urea (mixed in during the silage-making process) are usually maize and sorghum silage and less frequently grass silage. Usually 0.5% urea, but occasionally close to 1%, is added; adding urea to hay is seldom economical. Where possible, biuret should be used for safety.

(c) In dry feeds as a partial replacement for more expensive true protein. If mixed into dry feeds, free-flowing feed-grade urea should be used. It is possible, however, to use the cheaper fertilizer-grade urea if it is added in a suspension or a mixture with molasses. The feed should be thoroughly mixed so that no lumps of urea can be eaten by cattle. As the risk of toxicity from urea is greatest in dry feeds, usually no more than 3% urea is added to a concentrate and no more than 1% to complete rations. Much higher concentrations have been used for adapted cows.

(d) As a block lick. These are often used under range conditions. A home-made block that has proved useful was developed by

extension officers of the Queensland (Australia) Department of Primary Industries (ref. 8) using the following formula:

Ingredients	Parts by weight	
	High palatability	Low palatability
Crushed grain	40	32
Coarse salt	20	32
Molasses	20	15
Urea	10	10
Bone meal	7	7
Meat meal	5	5

The block contains about 34% crude protein. All block licks containing urea should be cast in a tin or hard box to prevent the animals from biting chunks off the block. They should also be protected from rain so that the animals do not drink a solution of urea. Cattle with no previous access to salt must be given salt for at least ten days before introducing a lick containing urea, as animals with a craving for salt may inadvertently take an overdose of urea.

(e) In liquid supplements and feeds (ref. 390). Liquid supplements contain a high percentage of urea — usually about 10%. As liquid feeds are intended for maximum utilization of molasses, they have a lower percentage of urea.
The proprietary mixed liquid supplement consists of a liquid vehicle, most often molasses of some type, fermentation liquors or propylene glycol, to which nonprotein nitrogen, minerals and vitamins have usually been added. Liquid supplements can be fed like dry-concentrate supplements at a rate of 0.5-2 kg together with roughage. They can also be given as a supplement to range cattle. The intake, generally 0.5-1.5 kg per day, is controlled by regulators in the feed (ethyl acetate, phosphoric acid or calcium chloride) or by mechanical devices. These devices are usually feeders with a wheel that turns as the animals lick the mixture from it, thereby exposing a fresh layer of liquid. The reason for the popularity of liquid supplements is their low cost, as they are made of inexpensive ingredients, and there are also savings in handling costs and waste. Liquid feeds have solved most of the problems associated with the use of urea. Because they contain molasses and are gradually consumed over a long period, the problems of palatability and toxicity are overcome and utilization is improved.
The use of urea with molasses for maximum utilization of molasses is described in feed information summary 17.

(f) In ammoniated feeds. The ammoniation is usually performed on an industrial scale as efficient binding of ammonia to a feed requires high temperature and pressure. The most common ammoniated feeds are rice hulls, maize stovers, sugar-beet pulp and maize ears.

APPENDIX

Table 1. AMINO-ACID COMPOSITION OF FEEDSTUFFS

No.	Feedstuffs	% of crude protein													Ref.
		Arg	Cys	Gly	His	Ils	Leu	Lys	Met	Phe	Thr	Try	Tyr	Val	
A40	Adlay, seed	4.4	1.7	2.8	2.3	4.0	14.4	1.9	3.0	4.8	3.1	—	4.2	5.6	80
A46	Cocksfoot grass, leaf	6.5	1.4	5.9	2.5	5.0	9.1	6.3	2.2	6.1	5.1	—	3.7	6.2	157
A81	Barley, leaf	5.7	1.7	5.7	2.5	4.9	9.1	6.6	1.8	5.9	5.2	—	3.9	6.4	157
A118	Elephant grass, leaf	2.1	0.2	—	1.9	4.7	6.2	3.1	1.4	7.3	3.8	0.6	4.9	5.9	376
A155	Maize, leaf	6.1	0.9	5.5	2.3	5.4	9.6	5.9	2.0	5.9	4.7	—	3.9	7.0	157
B24	Kokko, foliage	4.8	1.3	4.7	1.9	3.9	6.8	4.4	1.5	4.1	4.3	1.2	3.7	4.9	188
B27	Groundnut, leaf	6.7	1.0	5.2	2.2	4.4	7.6	5.6	1.6	5.5	4.3	—	3.6	5.6	80
B31	Pigeon pea, seed	6.7	1.2	3.6	3.4	3.8	7.6	7.0	1.5	8.7	3.4	0.3	2.2	5.0	92
B33	Jack bean, seed	8.0	0.6	4.5	3.5	—	10.2	5.1	—	5.3	4.2	0.8	3.0	4.4	137
B39	Centro, vines	4.3	1.0	4.3	1.6	3.8	6.2	3.5	1.6	4.0	4.2	1.1	3.0	4.5	188
B40	Carob, germ meal	1.2	1.4	5.5	4.7	4.7	6.1	5.9	0.8	4.5	4.4	1.0	—	3.6	158
B41	Chickpea, seed	7.3	1.0	3.9	4.5	7.9	14.1	10.0	1.1	8.0	5.0	1.8	4.7	4.9	259
B42	Kordofan pea, seed	7.4	2.5	4.1	2.4	4.2	7.4	6.1	1.0	3.6	2.2	1.2	3.3	4.4	485
B49	Guar, seed	12.5	0.6	5.1	2.5	3.2	5.9	4.0	1.4	3.7	2.8	1.9	3.3	4.2	485
B58	Greenleaf desmodium, aerial part	4.4	0.9	4.6	1.8	3.8	6.9	3.7	1.6	4.6	4.5	2.5	3.1	5.0	188
B65	Lablab, aerial part	6.8	0.7	8.2	4.2	6.8	10.4	6.9	0.9	2.2	4.2	—	1.8	7.4	354
B66	Elephant's ear, seed	6.2	2.0	—	3.0	4.0	2.4	6.8	1.0	3.5	3.5	0.8	1.4	4.1	74

Table 1. AMINO-ACID COMPOSITION OF FEEDSTUFFS *(continued)*

No.	Feedstuffs	% of crude protein													Ref.
		Arg	Cys	Gly	His	Ils	Leu	Lys	Met	Phe	Thr	Try	Tyr	Val	
B69	Soybean, aerial part	4.6	1.0	4.2	2.3	3.4	6.0	3.6	1.8	4.0	4.2	—	2.9	4.7	188
B70	Glycine, hay	3.8	1.0	4.3	1.6	3.5	6.2	4.0	1.7	4.0	3.8	2.0	3.2	5.7	188
B78	Chickling vetch, seed	3.3	—	3.9	2.7	3.9	6.4	9.7	0.6	3.0	3.8	—	1.4	5.9	419
B79	Lentil, seed	8.5	—	3.9	3.8	6.3	10.9	8.0	0.7	6.3	4.5	1.2	2.5	5.4	259
B81	Koa haole, leaf	6.4	3.3	5.1	2.7	5.0	9.0	6.7	1.4	5.4	4.6	—	4.3	5.8	433
B81	Koa haole, seed	4.3	0.6	—	3.5	1.9	2.4	2.9	0.3	1.9	1.9	0.5	1.4	3.2	376
B84	Yellow lupin, seed	9.9	1.5	4.3	2.5	3.9	7.5	4.8	0.5	3.6	3.1	1.0	2.7	3.5	485
B88	Lucerne (alfalfa), aerial part	4.5	1.1	4.5	1.8	3.9	6.6	4.3	0.9	4.1	4.0	1.5	3.3	5.1	505
B93	Velvet bean, seed	7.9	0.9	4.6	2.1	4.8	7.6	6.2	1.2	4.8	4.0	—	5.1	5.5	92
B95	African locust bean, seed	6.7	1.9	4.5	3.0	3.6	6.9	6.7	0.6	4.4	3.3	0.9	3.6	4.2	528
B96	Lima bean, leaf	4.2	—	—	1.3	3.6	6.6	3.6	1.2	7.0	4.0	1.4	—	5.0	256
B96	Lima bean, seed	6.3	1.1	4.8	3.0	5.6	8.8	6.7	1.7	6.6	4.9	1.0	3.8	5.8	79
B97	Haricot bean, seed	5.6	1.1	3.8	3.0	5.9	9.4	6.9	0.3	5.8	4.4	1.7	4.2	5.8	116
B99	Field pea, seed	5.5	—	3.1	1.5	3.9	6.6	5.5	1.9	3.9	4.1	—	1.8	4.5	419
B101	Algaroba, seed	6.3	—	2.5	2.2	1.2	6.3	6.1	1.2	2.6	2.3	—	1.4	2.9	419
B108	Kudzu, aerial part	4.0	1.1	4.5	2.7	3.9	6.7	4.4	1.8	4.2	4.2	2.4	3.3	4.5	188
B109	Tropical kudzu, aerial part	4.3	1.1	4.4	1.7	4.4	7.0	3.2	1.8	4.6	4.4	1.2	3.4	4.9	188

Table 1. AMINO-ACID COMPOSITION OF FEEDSTUFFS *(continued)*

No.	Feedstuffs	% of crude protein													Ref.
		Arg	Cys	Gly	His	Ils	Leu	Lys	Met	Phe	Thr	Try	Tyr	Val	
B115	Stylo, hay	5.3	1.2	4.5	1.6	3.8	6.1	3.5	1.7	4.1	4.1	1.4	3.8	5.2	188
B117	Tamarind, leaf	5.9	0.9	5.0	2.3	5.2	9.2	5.9	1.3	5.9	4.8	—	3.6	5.9	80
B120	Red clover, aerial part	2.6	—	4.0	—	—	—	3.1	—	1.5	2.9	—	2.0	4.5	430
B121	White clover, aerial part	3.4	—	2.9	—	—	—	4.3	—	2.0	3.0	—	1.9	6.3	430
B124	Fenugreek, aerial part	6.8	—	—	1.6	5.1	7.9	4.3	1.8	5.1	5.2	1.9	—	5.9	251
B124	Fenugreek, seed	9.2	1.2	4.4	2.0	4.5	6.8	6.0	1.3	3.8	3.0	1.6	2.5	3.4	485
B127	Common vetch, aerial part	5.3	—	1.9	1.3	3.7	7.5	5.3	0.9	2.7	5.8	—	1.2	1.8	419
B130	Mung bean *(Vigna mungo)*, seed	6.7	0.6	3.7	2.1	4.6	7.2	7.3	1.1	5.9	3.4	—	1.7	5.1	40
B131	Mung bean *(Vigna radiata)*, seed	3.4	0.7	1.8	—	—	—	8.2	1.9	3.1	2.0	1.8	1.8	3.6	37
B132	Red bean, seed	7.5	0.3	—	3.4	5.4	4.2	8.7	1.2	5.8	4.6	0.8	0.8	5.9	72
B133	Horse gram, seed	5.4	1.4	4.8	2.5	4.0	6.6	6.1	1.3	6.4	3.5	—	2.6	5.0	92
B134	Black-eyed pea, aerial part	4.6	0.9	4.8	1.8	4.3	7.4	3.0	1.8	4.6	4.6	1.4	3.2	5.3	188
B134	Black-eyed pea, seed	7.0	—	3.9	3.3	6.2	11.3	6.5	0.9	6.0	5.3	1.3	2.8	4.9	259
B135	Bambarra groundnut, seed	8.2	0.6	3.8	3.7	4.0	7.6	7.7	0.4	5.4	4.1	—	3.2	4.6	372
C2	*Acanthus mollis*, aerial part	3.9	—	—	1.9	4.1	6.9	4.1	1.3	10.0	4.1	0.9	—	5.8	331
C15	Margosa tree, leaf	—	8.4	—	1.0	—	—	10.0	—	5.8	6.0	—	4.2	4.2	307
C16	Desert date, fruit (mesocarp)	3.7	1.9	4.5	1.0	2.8	4.3	2.7	1.6	2.7	3.0	—	2.2	3.1	80

Table 1. AMINO-ACID COMPOSITION OF FEEDSTUFFS *(continued)*

No.	Feedstuffs	Arg	Cys	Gly	His	Ils	Leu	Lys	Met	Phe	Thr	Try	Tyr	Val	Ref.
		% of crude protein													
C75	Drumstick tree, leaf	5.6	1.8	5.3	2.2	4.6	8.4	5.2	1.1	5.9	4.5	—	3.7	6.0	80
C77	Black mulberry, leaf	5.8	—	5.6	2.1	4.6	8.7	4.2	1.8	5.5	2.8	—	4.0	5.7	187
D2	Pineapple, bran	1.8	0.3	—	1.0	3.5	5.5	2.0	0.5	8.5	3.3	3.0	6.8	4.3	376
D3	Celery, leaf	4.0	—	—	1.5	3.9	6.8	2.4	2.2	4.5	3.4	1.3	—	4.8	256
D7	Citrus, pulp	4.8	—	—	1.6	3.1	5.3	3.4	1.4	3.1	3.1	1.0	—	4.3	303
D8	Coffee, pulp	—	—	—	2.0	3.8	5.5	3.4	2.6	3.1	3.1	0.9	—	4.7	303
D11	Okra, leaf	4.8	1.7	5.1	2.0	4.7	8.0	5.8	1.6	5.3	4.8	—	3.8	6.2	80
D15	Banana, immature fruit	1.4	—	1.6	0.7	—	—	1.1	—	—	0.9	—	0.5	—	469
D19	Tomato, press cake	5.3	—	—	1.9	3.3	7.6	7.2	0.2	3.8	3.4	0.9	4.1	4.4	505
E1	Whitespot giant arum, tuber	11.2	—	—	1.6	5.0	5.9	4.4	1.0	6.2	4.5	0.6	—	5.0	404
E2 (*a*)	Mangold, leaf	4.1	—	—	1.3	4.2	6.4	5.4	1.7	5.8	3.8	1.2	—	5.1	256
E2 (*b*)	Sugar beet, leaf	6.5	0.3	—	2.0	8.2	7.2	6.2	1.3	6.1	4.6	0.2	—	6.1	432
E2 (*b*)	Sugar beet, tuber	—	0.7	2.3	0.7	—	3.2	0.3	2.4	2.2	0.6	4.4	1.2	2.7	137
E2 (*b*)	Sugar beet, pulp	3.7	—	—	2.2	4.1	6.0	7.7	0.1	3.0	4.1	1.0	4.6	4.8	[illegible]05
E5	Taro, tuber	6.3	2.3	5.9	6.8	0.6	4.3	7.0	5.1	4.0	13.6	—	3.1	5.8	3[illegible]
E7	Carrot, tuber	3.2	0.7	3.1	1.7	3.5	5.2	3.2	1.2	3.1	3.2	1.9	2.6	4.6	127
E11	White yam, tuber	7.5	0.8	1.5	2.1	3.3	5.2	3.5	0.9	4.7	3.4	—	3.3	4.4	385

Table 1. AMINO-ACID COMPOSITION OF FEEDSTUFFS *(continued)*

No.	Feedstuffs	% of crude protein													Ref.
		Arg	Cys	Gly	His	Ils	Leu	Lys	Met	Phe	Thr	Try	Tyr	Val	
E13	Sweet potato, tuber	3.4	1.6	—	1.6	4.0	5.7	4.1	1.1	5.4	3.4	1.8	4.5	5.2	138
E14	Cassava, leaf	—	—	—	—	5.2	10.5	7.1	1.0	3.6	5.1	1.0	3.3	6.8	232
E14	Cassava, tuber	7.7	—	—	1.5	5.3	5.6	6.2	0.6	3.5	3.8	0.5	—	4.5	404
E17	Potato, leaf protein concentrate	—	1.6	4.9	2.4	6.8	11.1	8.3	—	6.2	—	1.8	6.1	8.0	226
E17	Potato, tuber	5.0	—	3.4	1.8	4.0	6.0	5.6	—	4.4	3.7	2.0	4.0	5.2	271
F1	Finger millet, seed	8.2	1.4	5.8	2.6	4.5	9.2	3.0	1.3	5.7	3.8	1.2	5.6	5.8	472
F1	Proso millet, seed	2.9	—	—	1.9	4.0	10.1	2.1	2.5	4.9	3.6	1.4	—	5.1	303
F1	Scrobic millet, var. I.P. 394, seed	3.9	1.1	4.6	2.1	3.1	10.4	3.6	1.9	5.6	2.7	0.9	4.1	4.6	472
F1	Bulrush millet, seed	4.9	1.1	4.0	2.5	4.1	9.5	3.7	0.9	4.6	4.5	—	3.1	5.4	372
F1	Foxtail millet, seed	—	—	—	—	6.0	13.2	1.7	3.1	5.7	4.1	1.6	—	7.1	41
F2	Oats, seed	6.5	2.4	4.7	2.1	3.6	7.1	3.8	1.5	4.8	3.3	1.4	3.6	5.0	449
F2	Oats, hull	4.0	1.5	4.4	1.3	3.4	6.6	4.0	1.8	5.3	3.3	2.1	2.8	4.8	118
F2	Oat-mill feed	4.1	—	—	1.1	3.4	5.8	3.5	0.4	2.8	2.6	0.7	2.8	3.7	505
F5	Acha, seed	3.8	2.8	3.2	2.1	4.0	9.8	2.6	5.6	5.1	4.0	1.4	3.6	5.8	89
F6	Barley, dehulled seed	3.4	2.0	3.5	2.0	3.5	6.5	3.3	1.3	4.4	3.1	1.5	1.3	4.6	473
F7	Rice, brown	7.7	1.1	5.0	2.3	3.9	8.0	3.7	2.5	5.2	4.1	1.4	3.3	5.7	249
F7	Rice, polished grain	8.5	1.1	4.9	2.5	4.5	9.0	3.8	1.9	5.8	3.8	—	3.5	5.9	249

Table 1. AMINO-ACID COMPOSITION OF FEEDSTUFFS *(continued)*

No.	Feedstuffs	% of crude protein													Ref.
		Arg	Cys	Gly	His	Ils	Leu	Lys	Met	Phe	Thr	Try	Tyr	Val	
F7	Rice, bran	6.2	2.0	5.2	2.3	3.6	7.3	4.1	1.8	4.5	3.4	1.6	2.2	5.5	477
F7	Rice, polishings	8.4	1.5	8.9	3.9	5.5	6.8	6.3	4.4	4.8	3.9	3.5	7.1	6.4	262
F7	Rice, germ	7.3	2.3	5.1	2.9	1.4	2.7	5.3	2.0	1.7	3.5	1.3	0.9	4.7	477
F8	Rye, seed	4.6	2.3	4.2	2.0	3.2	6.0	3.2	1.1	4.3	3.3	1.3	2.7	4.7	449
F9	Sorghum, seed	3.5	1.0	3.1	2.5	3.8	13.9	2.1	0.4	5.4	3.8	—	4.1	4.7	372
F9	Sorghum, hybrid, seed	4.1	2.3	3.4	2.4	4.0	13.6	2.4	1.9	5.1	3.5	—	4.1	4.7	447
F9	Sorghum, gluten feed	3.2	1.6	4.0	2.0	2.8	8.0	1.6	1.6	3.2	3.2	0.4	2.4	5.6	500
F9	Sorghum, gluten meal	2.2	1.2	2.2	1.6	3.6	12.8	1.0	1.6	4.8	2.2	0.6	3.6	4.4	500
F9	Sorghum, germ oil meal	4.7	2.4	5.3	2.9	3.5	7.6	2.4	2.9	4.1	3.5	5.9	2.4	5.3	500
F10	Wheat, seed	4.4	1.7	3.9	1.9	3.8	6.4	2.6	1.3	4.3	2.7	1.1	2.9	4.9	215
F10	Wheat, germ	7.0	1.1	5.1	2.2	3.4	5.7	5.0	1.8	3.5	3.4	1.0	2.8	4.9	214
F10	Wheat, bran	6.6	1.5	4.9	2.1	3.4	5.6	3.8	1.5	3.7	3.0	1.5	2.8	4.7	214
F10	Wheat, middlings	6.9	1.4	5.1	2.1	3.3	5.8	4.1	1.6	3.6	3.1	1.3	2.8	4.8	214
F11	Maize, white, seed	4.6	1.2	3.6	3.3	3.1	12.7	3.0	1.1	5.1	3.8	0.6	3.7	4.4	372
F11	Maize, yellow, seed	4.6	1.4	3.4	2.9	3.1	13.1	2.4	0.6	4.9	3.6	0.6	3.7	4.2	372
F11	Maize, Opaque-2, white, seed	5.1	1.7	3.5	3.1	4.4	10.7	4.2	1.9	5.3	3.1	1.0	4.0	6.7	472
F11	Maize, Opaque-2, yellow, seed	3.9	2.0	3.6	3.7	4.1	11.3	3.5	1.8	4.8	3.2	1.0	4.4	5.4	472

Table 1. AMINO-ACID COMPOSITION OF FEEDSTUFFS *(continued)*

No.	Feedstuffs	% of crude protein													Ref.
		Arg	Cys	Gly	His	Ils	Leu	Lys	Met	Phe	Thr	Try	Tyr	Val	
F11	Maize, Floury-2, seed	4.3	1.8	3.0	2.5	4.0	13.0	3.3	1.6	6.1	3.2	—	5.0	5.6	472
F11	Maize, yellow, hominy feed	5.3	—	—	2.3	4.4	8.3	4.1	0.9	3.6	3.7	1.0	4.0	4.1	505
F11	Maize, gluten feed	3.5	1.2	3.7	2.6	3.1	12.5	2.3	2.2	4.9	3.7	0.9	4.1	5.0	449
F11	Maize, gluten meal	3.3	—	—	2.2	4.4	16.5	2.1	2.7	6.1	3.6	0.5	—	5.2	303
F11	Maize, germ oilcake	4.7	2.4	3.8	3.2	4.0	13.0	2.9	3.1	5.4	3.5	0.8	4.5	6.0	119
G1	Tung tree, undecorticated oilcake	10.6	—	—	2.2	4.8	7.4	4.1	2.1	7.1	4.4	—	—	8.1	303
G2	Cashew nut, kernel	9.9	1.7	4.2	2.0	3.8	6.6	3.9	1.4	3.7	3.1	1.3	2.7	5.2	530
G3	Groundnut (peanut), oilcake	11.0	0.9	6.0	2.5	3.0	6.1	3.6	0.4	4.9	2.8	—	3.7	3.7	372
G5	Mustard, black, oilcake	7.6	2.4	4.7	2.5	3.8	6.3	4.4	1.5	3.7	3.7	—	2.6	4.6	341
G5	Mustard, Indian, oilcake	6.4	2.5	4.9	2.6	3.8	6.3	3.4	1.7	3.8	4.0	—	2.7	4.7	341
G6	Field mustard, oilcake, extracted	6.0	—	—	3.7	4.1	6.1	7.9	1.5	3.7	4.1	1.3	—	7.9	54
G6	Field mustard, oilcake, expressed	5.6	—	5.9	2.6	4.6	6.7	4.3	1.7	3.9	4.4	1.3	2.6	5.1	54
G6	Rape, oilcake, expressed	5.9	—	5.9	2.6	4.6	6.9	3.8	1.7	3.9	4.1	1.3	2.5	5.0	54
G8	Hemp, seed	5.0	—	—	3.9	4.4	7.7	2.7	2.2	5.8	3.8	1.5	—	6.3	59
G9	Safflower, seed	9.4	1.7	5.0	2.6	3.7	6.0	3.2	1.5	4.3	3.2	0.9	2.9	5.3	486
G9	Safflower, oilcake	7.8	—	—	2.0	3.8	5.5	2.7	1.5	5.2	2.9	1.2	—	4.9	303
G12	Coconut, oilcake	11.0	0.9	4.2	2.1	3.0	6.0	2.5	1.0	4.1	3.0	—	2.2	4.7	372

Table 1. AMINO-ACID COMPOSITION OF FEEDSTUFFS *(continued)*

No.	Feedstuffs	% of crude protein													Ref.
		Arg	Cys	Gly	His	Ils	Leu	Lys	Met	Phe	Thr	Try	Tyr	Val	
G12	Coconut, paring meal	17.9	5.8	5.3	3.5	4.0	7.7	6.4	1.6	4.8	3.8	—	3.1	5.8	433
G13	Crambe, oilcake	5.7	2.6	5.3	2.2	3.9	6.2	4.9	1.6	3.5	4.6	1.5	2.5	5.1	486
G14	Pumpkin, seed	11.0	—	—	2.1	3.6	5.4	5.1	2.1	4.3	2.3	1.5	—	4.2	303
G15	African oil palm, kernel oilcake	13.9	1.9	4.8	2.5	3.8	6.4	3.7	2.7	3.6	3.5	2.8	2.7	5.7	119
G16	Soybean, meal	7.4	1.6	4.5	2.4	4.6	7.8	6.1	1.4	5.5	3.8	1.3	3.5	5.2	528
G17	Cotton, oilcake	11.1	1.5	4.1	2.6	3.2	5.9	4.1	1.3	5.4	3.2	1.1	2.7	4.5	452
G19	Sunflower, seed	10.0	1.7	5.6	2.3	4.1	5.5	3.6	1.5	4.6	3.4	—	1.6	4.0	40
G19	Sunflower, oilcake	9.1	1.8	5.6	2.8	4.2	6.9	3.5	2.2	5.1	3.4	1.4	2.9	5.8	119
G21	Walnut, oilcake	7.5	—	—	1.6	3.2	5.3	2.2	1.2	3.3	2.6	1.5	—	3.8	303
G23	Linseed, oilcake	9.7	2.0	5.7	2.3	4.0	5.8	3.5	2.4	4.8	3.6	1.5	2.9	5.6	119
G28	Corozo palm, seed	7.5	1.0	—	4.5	3.7	5.0	4.6	2.4	4.3	—	0.6	1.6	4.8	73
G29	Babassu, oilcake	14.1	—	—	1.8	3.9	6.2	4.3	2.3	5.9	3.2	1.0	—	5.3	303
G32	Castor, oilcake	10.0	—	—	1.7	5.3	6.4	3.0	1.5	4.7	3.2	1.1	2.9	5.4	304
G33	Sesame, oilcake	12.8	2.1	5.3	2.9	3.6	7.5	2.9	3.1	4.3	3.2	1.4	3.9	4.9	119
G36	Cocoa, seed	5.2	1.1	3.5	1.6	3.1	4.9	4.6	0.3	3.8	3.4	—	2.9	4.3	372
G36	Cocoa, shell	3.6	0.5	3.4	1.5	2.8	4.2	4.6	0.6	3.0	3.3	—	2.4	4.1	372
H1	Tankage	4.9	0.5	10.9	2.6	2.0	8.5	5.9	1.2	3.9	3.3	1.3	1.8	6.2	11

Table 1. AMINO-ACID COMPOSITION OF FEEDSTUFFS *(continued)*

No.	Feedstuffs	% of crude protein													Ref.
		Arg	Cys	Gly	His	Ils	Leu	Lys	Met	Phe	Thr	Try	Tyr	Val	
H1	Meat cracklings	7.2	1.3	14.7	2.1	3.7	7.3	5.2	4.3	4.0	1.9	1.0	3.0	6.3	120
H1	Meat-and-bone meal	5.9	0.7	14.1	1.4	2.6	6.5	5.0	1.4	3.1	3.4	1.1	1.7	4.7	11
H2	Blood meal	4.2	0.7	4.6	5.7	1.4	12.1	8.0	1.5	6.7	4.5	1.3	3.2	8.1	120
H3	Liver meal	6.2	1.2	8.0	2.4	4.0	8.3	6.1	2.0	5.3	4.1	1.3	3.5	6.5	120
H4	Raw bone meal	8.1	—	—	1.0	2.6	3.5	4.7	0.7	2.2	2.5	—	—	3.0	505
H4	Steamed bone meal	7.7	—	—	2.9	7.1	14.9	13.5	2.8	8.6	8.9	0.8	—	11.1	11
H6	Hydrolysed pig hair	9.2	4.0	7.4	1.3	4.9	9.2	3.3	0.8	3.9	7.1	0.8	3.8	7.5	346
H9	Hydrolysed leather meal	9.1	—	25.5	0.8	2.6	5.2	4.3	0.9	2.5	1.8	0.0	1.2	2.5	498
H10	Poultry by-products meal	5.5	1.4	12.7	1.4	3.2	7.4	5.7	1.4	3.1	4.3	1.2	2.6	5.2	11
H10	Chicken blood meal	6.2	1.1	4.3	4.9	4.6	10.5	8.0	2.0	5.7	4.7	1.1	2.8	6.8	120
H11	Hydrolysed feather meal	9.1	5.4	25.5	0.8	2.6	5.2	4.3	0.9	2.5	1.8	0.0	1.2	2.5	498
H13	Hatchery by-products meal	4.8	1.1	5.5	2.0	3.6	6.1	4.1	1.9	3.5	3.4	1.3	2.4	5.0	509
H15	Whale meal	5.0	0.9	—	2.3	5.1	7.6	7.3	1.7	4.4	6.5	1.0	2.3	2.8	399
H17	Pilchard press-cake meal	5.8	1.2	7.5	3.0	4.2	7.0	7.6	2.5	3.6	4.1	1.0	3.0	5.3	392
H17	Herring whole meal	7.8	1.2	6.8	2.3	5.1	7.0	8.2	2.3	3.5	4.0	0.8	2.8	6.6	392
H17	Fish meal (Chile)	5.9	0.9	5.6	2.6	4.8	7.6	8.0	3.1	4.3	4.3	1.2	3.4	5.5	261
H17	Fish meal (Peru)	5.7	0.9	6.1	2.3	4.6	7.5	7.5	3.0	4.2	4.1	1.1	3.6	5.2	261

Table 1. AMINO-ACID COMPOSITION OF FEEDSTUFFS *(continued)*

No.	Feedstuffs	% of crude protein													Ref.
		Arg	Cys	Gly	His	ils	Leu	Lys	Met	Phe	Thr	Try	Tyr	Val	
H17	Menhaden fish meal	5.4	0.7	6.3	2.4	4.1	7.0	7.5	3.1	3.7	4.1	1.0	3.0	4.5	455
H19	Fish protein concentrate	6.4	1.0	5.6	2.5	5.5	8.5	9.0	3.7	4.7	5.1	1.5	3.9	6.1	29
H21	Menhaden fish solubles	3.9	1.9	8.8	2.5	1.9	3.7	4.8	1.5	2.1	2.1	0.3	1.1	2.7	456
H23	Shrimp meal, whole shrimps	7.9	1.2	7.8	1.8	4.3	7.3	7.4	3.0	4.6	4.5	0.9	3.5	4.7	189
H25	African giant snail	18.9	—	—	2.8	9.2	10.0	17.5	2.0	7.6	8.8	1.2	—	8.7	338
H26	*Bombyx mori*, extracted	6.6	1.9	—	2.9	—	—	10.1	1.9	2.5	—	1.5	6.3	—	276
H28	Milk, fresh, whole	4.0	1.0	6.4	2.7	7.0	11.0	7.2	3.6	5.0	4.6	1.6	5.0	6.4	263
H28	Milk, skimmed	3.6	1.1	3.7	2.5	6.2	9.4	7.1	2.7	4.9	4.4	1.4	4.5	6.2	263
H28	Buttermilk	4.1	0.9	—	3.1	6.3	11.0	10.0	2.5	6.3	5.3	1.3	5.3	7.8	139
H28	Whey	2.5	—	—	1.6	5.8	8.9	8.4	2.0	2.8	6.5	1.7	—	5.7	303
I4	Sugar cane, tops	4.0	0.2	—	4.3	2.4	5.2	4.6	0.3	4.9	2.9	1.3	5.2	4.3	376
I10	Molasses distiller's spent wash	0.5	—	—	0.5	1.5	1.9	0.9	0.7	1.4	1.8	0.4	1.1	2.3	303
I11	Malt culms	4.3	—	—	1.8	3.8	5.7	5.0	1.3	3.1	3.5	1.4	—	5.0	303
I12	Brewer's spent grain	4.6	—	—	1.8	5.4	8.3	3.3	1.2	4.7	3.2	1.3	4.1	5.4	505
I14	Brewer's yeast	5.0	—	—	2.0	6.1	7.0	7.0	1.3	3.8	4.7	1.4	2.7	5.8	505
I15	Maize distiller's grain	4.2	—	—	2.4	3.7	8.9	3.1	1.9	4.0	3.4	0.9	5.4	4.5	304
I15	Maize distiller's spent wash	4.3	—	—	2.4	4.1	8.7	3.3	2.0	4.6	3.9	0.9	3.8	5.3	304

Table 1. AMINO-ACID COMPOSITION OF FEEDSTUFFS *(concluded)*

No.	Feedstuffs	% of crude protein													Ref.
		Arg	Cys	Gly	His	Ils	Leu	Lys	Met	Phe	Thr	Try	Tyr	Val	
119	*Chlorella vulgaris*	5.2	0.6	—	1.5	4.5	7.7	3.0	2.0	5.0	5.5	1.3	2.8	5.9	60
119	*Spirulina maxima*	6.5	0.4	4.8	1.8	6.0	8.0	4.6	1.4	5.0	4.6	1.4	4.0	6.5	99
119	*Scenedesmus obliquus*	5.6	0.8	6.0	1.5	4.4	9.3	5.7	1.4	4.6	5.2	1.4	3.6	7.2	458
120	Torula yeast	5.2	1.2	4.8	2.2	4.8	8.0	7.6	1.6	4.4	5.0	1.2	3.8	5.4	519
120	Molasses-grown yeast	3.4	0.2	4.6	1.7	3.9	2.3	5.2	0.9	4.3	4.8	1.2	2.8	5.1	376
120	Crude oil yeast	7.2	1.3	4.8	3.0	7.7	11.3	11.3	2.3	7.0	7.8	1.9	5.8	8.4	438
120	*Aspergillus niger*	1.6	—	6.7	6.0	5.2	6.5	10.3	4.0	3.2	4.0	—	1.6	4.0	496
121	Manure from cattle fed maize silage	2.0	0.8	3.6	1.5	2.9	2.6	4.3	1.0	tr.	3.9	—	tr.	3.4	24
121	Groundnut-hull broiler litter	1.6	4.1	8.1	7.8	2.0	3.2	1.9	0.4	1.7	1.8	—	1.3	2.5	57

Table 2. METABOLIZABLE ENERGY IN FEEDSTUFFS FOR POULTRY

No.	Feedstuffs	Kcal (dry matter basis)		Ref.
		per lb	per kg	
A	Grass meal, 16% CP	410	900	197
A	Grass meal, 23% CP	480	1 060	197
B40	Carob, bean meal	600	1 310	62
B79	Lentil, seed	1 660	3 660	197
B81	Koa haole, leaf meal	410	900	316
B84	Lupin, sweet, seed	940	2 060	197
B88	Lucerne (alfalfa), fresh	1 200	2 640	479
B88	Lucerne, meal, 13% CP	440	980	389
B88	Lucerne, meal, 17% CP	690	1 520	389
B88	Lucerne, meal, 20% CP	800	1 760	389
B97	Haricot bean, seed	700	1 540	479
B99	Field pea, leaf meal	510	1 110	345
B99	Field pea, seed	1 300	2 860	356
B120	Red clover, hay	540	1 200	479
B131	Mung bean *(Vigna radiata)*, seed	1 150	2 520	316
B134	Cowpea, seed	1 330	2 930	479
D1	Baobab, young leaves	760	1 680	345
D7	Citrus pulp	670	1 470	389
E2 (*a*)	Mangold, leaf	920	2 030	197
E2 (*a*)	Mangold, tuber	1 330	2 920	197
E2 (*b*)	Sugar beet, tuber	1 490	3 280	197
E2 (*b*)	Sugar beet, pulp	310	680	356
E2 (*b*)	Sugar beet, molasses pulp	330	720	356
E2 (*b*)	Sugar beet, molasses	1 020	2 230	197
E7	Carrots, tuber	1 270	2 760	479
E12	Jerusalem artichoke, tuber	1 520	3 330	197
E13	Sweet potato, tuber	1 370	3 000	479
E14	Cassava, tuber	1 600	3 510	345
E17	Potato, tuber, fresh	1 690	3 730	450
E17	Potato, tuber, flaked	1 320	2 910	197
E17	Potato, tuber, roller-dried	1 490	3 280	197
E17	Potato, tuber, steamed	1 380	3 050	197
E17	Potato, peelings	1 190	2 610	197
F1	Millet, whole seed	1 280	2 810	197

Table 2. METABOLIZABLE ENERGY IN FEEDSTUFFS FOR POULTRY *(continued)*

No.	Feedstuffs	Kcal (dry matter basis)		Ref.
		per lb	per kg	
F1	Millet, hulled seed	1 810	3 990	197
F2	Oats, whole seed	1 310	2 870	197
F2	Oats, hulled seed	1 610	3 540	389
F2	Oats, seed, flaked	1 810	3 980	197
F2	Oat-mill feed	950	2 090	479
F2	Oats, hull	170	370	316
F5	Acha, seed	1 290	2 840	345
F6	Barley, whole seed	1 380	3 030	197
F6	Barley, hulled seed	1 580	3 490	197
F6	Barley, hull	390	850	316
F7	Rice, whole seed	1 340	2 940	345
F7	Rice, polished seed	1 770	3 900	479
F7	Rice, bran, 13% EE	1 230	2 710	450
F7	Rice, bran, solvent extracted	1 110	2 440	389
F7	Rice, polishings, 12% EE	1 160	2 560	345
F7	Rice, polishings, 16% EE	1 330	2 910	345
F8	Rye, seed	1 440	3 180	389
F9	Sorghum, seed, average	1 730	3 800	345
F9	Hegari, seed	1 760	3 870	479
F9	Kaffir, seed	1 700	3 740	197
F9	Feterita, seed	1 730	3 810	479
F9	Sorghum, bran	950	2 090	345
F9	Sorghum, germ	1 670	3 680	345
F9	Sorghum, gluten feed	1 080	2 380	316
F10	Wheat, seed	1 560	3 420	316
F10	Wheat, screenings	670	1 470	356
F10	Wheat, germ	1 340	2 960	450
F10	Wheat, flour	1 740	3 840	479
F10	Wheat, bran	570	1 240	316
F10	Wheat, middlings	1 160	2 540	450
F11	Maize, seed	1 690	3 730	345
F11	Maize, seed, decorticated	1 890	3 990	316
F11	Maize-and-cob meal	1 430	3 150	389
F11	Maize, cob	270	580	316

Table 2. METABOLIZABLE ENERGY IN FEEDSTUFFS FOR POULTRY *(continued)*

No.	Feedstuffs	Kcal (dry matter basis)		Ref.
		per lb	per kg	
F11	Maize, hominy feed	1 440	3 170	356
F11	Maize, bran	920	2 030	345
F11	Maize, gluten feed	850	1 870	356
F11	Maize, gluten meal, 41% CP	1 630	3 585	316
F11	Maize, gluten meal, 61% CP	1 740	3 825	316
F11	Maize, oilcake, 9% EE	1 590	3 490	197
G3	Groundnut (peanut), kernel	2 270	4 990	479
G3	Groundnut, oilcake, 4% EE	1 330	2 910	345
G3	Groundnut, oilcake, 8% EE	1 490	3 280	345
G3	Groundnut, oilcake, solvent extracted	1 310	2 891	345
G6	Rape, oilcake, 5% EE	1 280	2 810	197
G6	Rape, oilcake, 10% EE	1 430	3 140	197
G6	Rape, oilcake, solvent extracted	1 150	2 530	197
G8	Hemp, seed	1 670	3 670	479
G9	Safflower, oilcake, undecorticated, expressed	850	1 870	316
G9	Safflower, oilcake, undecorticated, extracted	590	1 290	316
G9	Safflower, oilcake, decorticated, extracted	850	1 870	316
G9	Safflower, hulls	460	1 000	316
G12	Coconut, oilcake, 8% EE	1 270	2 800	345
G12	Coconut, oilcake, 13% EE	1 490	3 290	345
G12	Coconut, oilcake, extracted	760	1 660	316
G15	African oil palm, kernel oilcake, 6% EE	980	2 150	197
G15	African oil palm, kernel oilcake, 10% EE	1 400	3 070	197
G15	African oil palm, kernel oilcake, extracted	960	2 110	197
G16	Soybean, seed	1 700	3 750	197
G16	Soybean, oilcake, 1.2% EE	1 230	2 700	479
G16	Soybean, oilcake, 3.5% EE	1 290	2 840	450
G16	Soybean, oilcake, 5.0% EE	1 350	2 970	479
G16	Soybean, oilcake, dehulled, extracted	1 230	2 700	356
G16	Soybean, hull	20	30	316
G17	Cottonseed, oilcake, 4% EE	1 290	2 840	479
G17	Cottonseed, oilcake, extracted	910	2 010	316
G18	Niger seed, oil meal	1 370	3 025	537
G19	Sunflower, seed with hull	1 290	2 840	479

Table 2. METABOLIZABLE ENERGY IN FEEDSTUFFS FOR POULTRY *(continued)*

No.	Feedstuffs	Kcal (dry matter basis)		Ref.
		per lb	per kg	
G19	Sunflower, oilcake, undecorticated	800	1 760	479
G19	Sunflower, oilcake, decorticated, 6% EE	1 430	3 140	197
G19	Sunflower, oilcake, decorticated, 10% EE	1 450	3 190	197
G19	Sunflower, oilcake, decorticated, extracted	1 030	2 260	197
G20	Rubber, seed, raw	2 190	4 830	542
G20	Rubber, seed, autoclaved	2 100	4 630	542
G20	Rubber, oilcake, extracted	1 080	2 380	542
G23	Flax, seed	2 140	4 710	197
G23	Flax, oilcake, 4.5% EE	780	1 710	479
G23	Flax, oilcake, 9% EE	1 420	3 130	197
G23	Flax, oilcake, solvent extracted	830	1 830	389
G33	Sesame, oilcake, 5% EE	1 300	2 870	197
G33	Sesame, oilcake, 8% EE	1 360	2 980	450
G33	Sesame, oilcake, solvent extracted	1 210	2 660	197
G36	Cocoa, shells, 6% EE	1 310	2 890	197
G36	Cocoa, shells, 16% EE	1 550	3 410	197
H1	Meat cracklings, 25% EE	2 220	4 870	197
H1	Meat meal, 58% CP	1 710	3 760	197
H1	Meat meal, 78% CP	1 890	4 170	197
H1	Meat-and-bone meal, 45% CP	840	1 860	389
H1	Meat-and-bone meal, 50% CP	940	2 060	389
H1	Tankage	1 650	3 060	356
H2	Bood meal (clotted)	1 280	2 820	345
H3	Liver meal, 14% EE	1 520	3 340	479
H4	Bone meal, raw, 6% EE	500	1 090	345
H4	Bone meal, steamed	460	1 000	479
H4	Bone meal, special steamed	130	280	197
H6	Pig hair, hydrolysed	1 020	2 250	346
H10	Poultry by-products meal	1 390	3 050	316
H11	Poultry feathers, hydrolysed	1 340	2 960	389
H13	Hatchery by-products meal	830	1 840	509
H15	Whale meal, 5% EE	1 820	4 000	197
H15	Whale meat-and-bone meal, 11% EE	1 310	2 880	197
H15	Whale bone meal, 10% EE	880	1 930	197

Table 2. METABOLIZABLE ENERGY IN FEEDSTUFFS FOR POULTRY *(concluded)*

No.	Feedstuffs	Kcal (dry matter basis)		Ref.
		per lb	per kg	
H15	Whale solubles	1 470	3 230	450
H17	Tuna meal	1 230	2 700	345
H17	Herring meal	1 470	3 240	356
H17	Sardine meal	1 400	3 090	356
H20	Fish oil	3 490	7 680	316
H21	Fish solubles	1 420	3 120	356
H22	Liquid fish, 2% EE	1 650	3 630	197
H23	Shrimp meal (heads and scales)	660	1 450	479
H23	Shrimp meal (whole shrimps)	1 120	2 460	197
H24	Starfish meal	80	170	316
H28	Whole milk, 3.9% EE	1 970	4 330	479
H28	Buttermilk	1 350	2 970	356
H28	Skim milk	1 220	2 680	356
H28	Whey	1 190	2 620	197
I1	Seaweed meal	200	450	197
I6	Dehydrated cane juice	1 560	3 480	316
I7	Blackstrap molasses	1 070	2 350	316
I8	Sugar (sucrose)	1 670	3 680	316
I11	Malt culms	890	1 960	389
I12	Brewer's spent grain	1 280	2 820	479
I14	Brewer's yeast	1 460	3 210	197
I15	Barley distiller's dried solubles	1 180	2 600	197
I15	Maize distiller's grain	810	1 780	356
I15	Maize distiller's grain with solubles	1 160	2 540	316
I15	Maize distiller's dried solubles	1 380	3 030	316
I16	Bakery waste	1 580	3 480	197
I17	Yellow grease	3 100	6 820	316
I17	Lard	3 980	8 760	316
I17	Feed-grade tallow	3 130	6 890	316
I17	Poultry fat	3 720	8 190	316
I17	Soybean oil, degummed	4 210	9 270	316
I17	Maize oil	3 980	8 760	316
I17	Soybean soapstock	3 300	7 260	316
I20	Torula yeast	1 190	2 610	356
I20	Crude oil yeast	1 090	2 400	438

GLOSSARY

Adventitious: Growth from an unusual place (e.g., roots growing from a stem).

Annual: A plant that grows from seed, flowers, produces seed and dies in one season.

Aquatic: A plant living partly or wholly in water.

Cultivar: A cultivated variety, or a variety of a plant bred in cultivation.

Cutting: A piece of a plant used to grow a new plant.

Compound: A leaf made up of two or more distinct parts, called leaflets, or a flower composed of many florets (see page 493).

Corm: The swollen base of a plant stem, which serves the same function as a bulb.

Deciduous: Plants that shed their leaves in winter.

Dioecious: Species in which unisexual flowers (pistillate or staminate) are borne on different plants.

Dormant: A plant that has temporarily stopped growing.

Endosperm: Food reserve tissue enclosing the embryo.

Evergreen: A plant that retains its leaves the year round.

Glabrous: Smooth, not hairy.

Habit: The shape or growth form of a plant (trailing, climbing, etc.).

Herbaceous: A plant with a soft non-woody stem.

Inflorescence: The arrangement of one or more flowers on a plant (see page 493).

Internode: The portion of a stem between two nodes.

Leaflet: One of the small leaves making up a compound leaf (see page 493).

Node: A joint from which a leaf or side shoot grows from a stem.

Perennial: A plant that can live for a number of years.

Pericarp: The whole structure developed from the seedbox. It can be divided into three layers: epicarp, mesocarp and endocarp.

Petiole: A leafstalk.

Pith: The central part of a stem or root.

Rhizome: An underground stem that grows horizontally.

Runner: A shoot that grows along the ground and roots to form new plants.

Shrub: A woody-stemmed plant without a trunk.

Stolon: Runner.

Succulent: A plant with thick fleshy stems or leaves that store water.

Tendril: A small twining stem that helps a plant climb by clinging to supports.

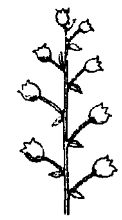
Terminal: The bud or shoot at the end or top of a stem.

Tuber: A swollen root or underground stem in which plant food is stored.

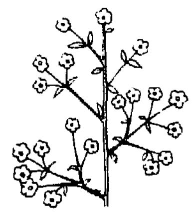
Variegated: Describes leaves that are patterned, blotched or spotted with contrasting colours.

Botanical names: The botanical name is printed in italics. The first name is the *genus* name. One genus can include a large number of plants which are fundamentally similar — for example, *Trifolium* (the clovers). The different plants within a genus are called *species*. The species name comes after the genus name: *Trifolium subterraneum* (subterranean clover), *Trifolium repens* (white clover) and so on. To save space, as long as no confusion can arise, the genus name is often abbreviated after the first occurrence in a particular section of the book: *T. repens*. Sometimes there is a third name after the genus and species names if there are two or more forms of a species that are not different enough to be classed as separate species but are nevertheless distinct — for example, a different leaf or flower colour. After the name of the plant, the complete or abbreviated name of the botanist who classified the plant is given in roman type.

Kinds of inflorescence

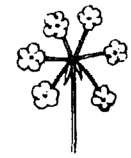


Raceme



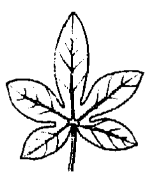
Panicle

Spike

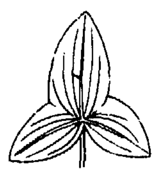


Whorl

Leaf forms and arrangements



Palmate

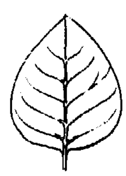


Sagitate

Truncate

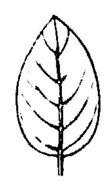
Lanceolate

Oblong

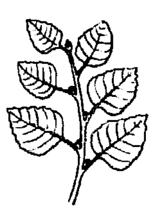


Ovate

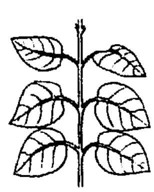
Digitate



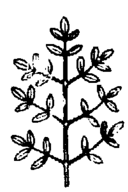
Elliptic



Alternate



Opposite



Bipinnate

Pinnate

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