

Feeds and Principles of
ANIMAL NUTRITION

G.C. BANERJEE



Revised Edition

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FEEDS AND PRINCIPLES OF ANIMAL NUTRITION

The book is dedicated to my devoted wife,
ARATI

whose patience and assistance aided its completion and to our two sons
JOY and DEBJIT

who also had to share the pain on many occasions for bringing the book out.

PREFACE

The rapid changes in the scientific know-how of the science of Animal Nutrition which have taken place in the past decade, and since the publication of my book *Animal Nutrition* in 1978, have motivated the publication of this completely revised and enlarged edition, now entitled *Feeds and Principles of Animal Nutrition*.

The book is divided into two main sections. The first part exclusively covers Feeds. Although the feedstuff varies in all parts of the world, the basic information and principles remain the same and are applicable to most countries.

The second part deals with the Principles of Nutrition. We are at the point now where almost all essential nutrients have been defined. It is possible that some other mineral elements may eventually be determined to be essential and it is also possible that one or more vitamins may be added to the present list. However, all of the currently known nutrients appear to be adequate to sustain animals on purified diets, and therefore, any unidentified nutrients surely are not too important, or if required, are done so in extremely small amounts. This is not to say that all of the nutritionally-related problems have been solved because much remains to be learnt about nutrition and infectious disease, nutrition and many different stresses, and about various nutritional interrelationships.

In any event, with a book of this type there is always a question of how much and what type of detail to present to the reader. The author's preconception of the audience for the book may or may not be correct. Consequently, it is a matter of picking and choosing what to include or exclude. More space could have been allotted on any of the subjects. For some readers there may be more information on nutrient metabolism than they might desire. Others will probably wish for more complete coverage in either Part I or Part II.

Regardless of the approach, some areas of topics must be slighted in order to keep the size of the book within the bounds and at a reasonable cost. Whatever the deficiencies of this book may be, it is hoped that it will serve a useful purpose by covering in broad scope a complicated and voluminous subject, and that it will serve to guide the student through the important areas of basic and applied animal nutrition and feeds.

I wish to express my grateful appreciation to some of my colleagues in the Department of Animal Nutrition of Bidhan Chandra Krishi Viswavidyalaya, Dr. Lalmohan Mandal, Dr. Samirendra Biswas, Dr. Narayan Chakraborty, Dr. Tapan Kr. Ghosh and Dr. Gautam Samanta for their constructive criticisms.

I would also like to express a special thanks to my wife Mrs. Arati Banerjee who shared all my problems and worked with me as I wrote this book.

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DEFINITION OF NUTRITION AND ALLIED TERMS

Nutrition

In dictionary terms, it is defined as "series of processes by which an organism takes in and assimilates feed for promoting growth and replacing worn or injured tissues".

Thus the science of nutrition not only involves the physiological and biochemical phenomena of ingestion, digestion, absorption of various nutrients to all over the body cells but also encompasses the processes of excretion of waste products of metabolism from the body. By the processes of various chemical reactions individual nutrients are deposited in body tissues for further or immediate utilisation in various body activities including participation as components of animal products.

It is evident that to understand the nature of the nutrients themselves, to grasp the way in which they perform their roles, to perceive the consequences of their deficiency or of their imbalance in the diet, and to be able to prepare nutritionally adequate diets, it is necessary to call upon subject matter ordinarily considered a part of chemistry, biochemistry, physiology, endocrinology, microbiology, or biophysics. Because of genetic variability among animals, statistics are frequently needed to interpret observations in which both genetic and nutritional factors are involved.

Nutrient

The chemical substances found in feed materials are necessary for the maintenance, production and health of animals. The chief classes of nutrients include (i) 25 carbohydrates, (ii) 15 fatty acids, (iii) 20 amino acids, (iv) 15 essential and 10 *probably essential* minerals, (v) 20 vitamins, and (vi) water.

Nutriments

Anything that promotes growth or development.

Nutriture

Nutritional status.

Nutritious

Substances which promote growth and participate in repairing tissues of the body.

Nutritionist

A specialist in the problems of nutrition.

Nourish

To feed an animal with substances necessary to life and growth.

Feed (or feedstuff)

Food of animals comprising any naturally occurring ingredient or material fed to animals for the purpose of sustaining growth and development. The term is exclusively used for animals. In case of humans it is food while for animal it is termed as feed.

Diet

A regulated selection of a feed ingredient or mixture of ingredients including water, which is consumed by animals on a prescribed schedule. A balanced diet supplies all nutrients needed for normal health and productive functions.

Ingredients

Any of the feed items that a mixture is made of.

Ration

A fixed amount of feed for one animal, fed for a definite period, usually for a 24-hour period.

Balanced ration

The ration which provides an animal with the proper amount, proportion and variety of all the required nutrients to keep the animal in its form to perform best in respect of production and health.

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(C) *Lipids*: Classification. Essential fatty acids. Waxes. Phospholipids. Non-saponifiable lipids. Prostaglandins. Functions of lipids.

(D) *Proteins*: Essential amino acids. Glucogenic and ketogenic. Functions served by amino acids. Non-protein nitrogenous compounds. Crude protein. Degradable and undergradable proteins. Methods to increase utilisation of crude protein in ruminants.

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(F) *Vitamins*: Vitamin A. Vitamin D. Vitamin E. Vitamin K. Vitamin C. Thiamine. Riboflavin. Niacin and nicotinamide. Pyridoxine. Pantothenic acid. Folic acid. Vitamin B₁₂. Biotin.

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Part I : FEEDS

CLASSIFICATION OF FEEDSTUFFS AND ROUGHAGES

Livestock feeds are generally classified according to the amount of a specific nutrient they furnish in the ration. They are divided into two general classes—*roughages* and *concentrates*. Roughages are bulky feeds containing relatively large amount of less digestible material i.e., crude fiber more than 18 per cent and low (about 60 per cent) in T.D.N. on air dry basis. Concentrates are feeds which contain relatively smaller amount (less than 18 per cent) of fiber and have a comparatively high digestibility and as a result higher nutritive value having more than 60 per cent T.D.N.

The number of substances used as feeding stuff to different species of livestock may exceed over 2,000 items. All that is being attempted in this section is to indicate the outlines of classification of the conventional feeds into broad categories and to give typical examples of different groups under this classification.

Nature of Roughages

To most livestock feeders, a roughage is a bulky feed that has a low weight/unit of volume. This is probably the best means of classifying a feedstuff as a roughage, but any means of classifying roughages has its limitations since, due to the nature of products we are dealing with, there is a great variability in physical and chemical composition. Most feedstuffs classed as roughages have a high crude fiber (CF) content and a low digestibility of nutrients such as crude protein and energy. If we attempt to classify all feedstuffs as roughages that have $>18\%$ CF and/or with low digestibility, immediately we find exceptions. Corn silage is a good example; nearly always it has $>18\%$ CF, but the TDN content of well-cared corn silage is about 70% on a dry basis. Lush young grass is another example. Although its weight/unit volume may be relatively low and fiber content relatively high, its digestibility is quite high. Soybean hulls are another exception for ruminants.

Most roughages have a high content of cell-wall material. The cell-wall fraction may have a highly variable composition, but contains appreciable amounts of lignin, cellulose, hemicellulose, pectin, polyuronides, silica and other components. In contrast, roughages generally are low in readily available carbohydrates as compared to cereal grains.

The amount of lignin is a critical factor with respect to digestibility. Lignin is an amorphous material which is associated closely with the fibrous carbohydrates of the cell wall of plant tissue. It limits fiber digestibility, probably because of the physical barrier between digestive enzymes and the carbohydrate in question. Removal of lignin with chemical methods increases digestibility greatly by rumen microorganisms and, probably, by caecal organisms. Lignin content of plant tissue increases gradually with maturity of the plant and a high negative correlation exists between lignin content and digestibility, particularly for grasses, although somewhat less for legumes. There is evidence that the silica content of plant tissue is related negatively to fiber digestibility.

Table 1

FEEDSTUFFS FOR ANIMALS

	Concentrates	1	Roughages	3	Succulent	<i>Pasture</i> , range plants and plants fed green <i>Tree</i> : leaves <i>Cultivated Fodder</i> Legume (cowpea, cluster bean, green pea, berseem, lucerne) Non-legume (Fodders of jowar, maize, bajra, oat, etc. and grasses of sudan, napier, guinea, etc.) <i>Silages</i> Corn Grass-legume Sorghum Legume Grass Miscellaneous <i>Root Crops and Tubers</i> <i>Miscellaneous</i> Brewery by-products Waste from food processing plants Cull fruits, vegetables and nuts Garbage, Roots and tubers, Bakery waste
						Hay Legume Non-legume (primarily grasses) Cereal crop hays <i>Straw and chaff dry fodder including stover</i> <i>Other dry products with >18% crude fiber:</i> Corn cobs, Shells, Sugar-cane bagasse, Cottonseed hulls
	2	5	Energy Feeds	6	Protein Supplements	<i>Cereal grains</i> <i>Milling by-products</i> (primarily from cereal grains) <i>Molasses of various types, Seed and mill screenings, Dried beet and citrus pulps, Animal and vegetable fats</i> <i>Oil seed meals</i> Cottonseed, soybean, linseed, etc. <i>Animal meat or meat & bone meals, Marine meals, Avian by-product meals, Milling by-products</i> <i>Distillers and Brewers dried grains, Dehydrated legumes, Single-cell sources</i> (bacteria, yeast, algae), <i>Non-protein nitrogen</i> (urea, etc.), Dried manures
						Mineral supplements (natural or pure elements) Vitamin supplements (natural or pure elements) Non-nutritive additives Antibiotics Enzymes Antioxidants Hormones Buffers Medicines Colours & flavours Miscellaneous Emulsifying agents