A Guide in Animal Nutrition to TNPSC examination for Veterinary Assistant Surgeon Aspirants

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FOREWORD

Livestock play an important role in the socio-economic life of India. India’s livestock sector is one of the largest in the world. It has 56.7% of world’s buffaloes, 12.5% cattle, 20.4% small ruminants, 2.4% camel, 1.4% equine, 1.5% pigs and 3.1% poultry. In 2010-11, livestock generated outputs worth ₹ 2075 billion which comprised 4% of the GDP and 26% of the agricultural GDP. Milk is the main output of livestock sector accounting for 66.7% of the total value of output of livestock. Meat and eggs share 17.5% and 3.6% of the value of livestock output.

The indigenous approach to livestock in India is based on diversity, decentralization, sustainability and equity. Indian cattle are not just milking machines or meat machines. They are sentient beings who serve human communities through their multidimensional role in agriculture. This contribution of the Indian livestock sector could not have been possible but for the effort of the Indian Veterinary profession. Veterinarians play a vital role in safe-guarding both human and animal health, by securing an adequate supply of safe food and protecting humans and animals from the spread of zoonotic diseases. They are also vital to improving the productivity of livestock for the benefit of producers in particular and for the wider population in general.

For today’s Indian Veterinary graduate, it is a world of competitiveness. The best way to rise above the lot is to toil with dedication and extraordinary enthusiasm. When one is endowed with strong conviction, absolute faith, total dedication and grim determination to the job in hand, nothing can stop the achievement of one’s goal. It is in this context, to make one’s preparation easy, a revised guide in Animal Nutrition as per the TNPSC syllabus for recruiting Veterinary Assistant Surgeon has been brought out by the staff, Department of Animal Nutrition, Madras Veterinary College. This guide, in a brief and comprehensive manner, presents concepts, information, updated data and technologies in an organised form. Considering the wide range of readership, the guide has addressed the subject in such a way that the readers are not burdened by the scientific nature of the information. I am very much confident that this guide will help the aspirants to become Veterinary Assistant Surgeons in the Department of Animal Husbandry, Government of Tamil Nadu. I appreciate the authors for their efforts in bringing out this guide.

Date : 22.02.2013

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PREFACE

Animal Husbandry and Dairy Development sector plays an important role in the socio economic development of India. Besides providing cheap nutritional food to millions of people, it is helpful in generating gainful employment in the rural sector, particularly among the landless labourers, small and marginal farmers and women by supplementing their family incomes. Livestock are the best insurance against the vagaries of nature like drought, famine and other natural calamities. The Animal Husbandry Department of Tamil Nadu plays a major role in providing veterinary health services, improving the production potentialities of livestock and poultry reared in the State implementing various beneficiary oriented schemes for the economic up liftment of the poor, downtrodden and weaker sections of the society. The sustained efforts of the Department in the above activities have contributed to growing commercial vibrancy of the sector in the State.

Tamil Nadu Public Service Commission is mandated with the task of recruiting veterinary assistant surgeons to the Animal Husbandry Department of Tamil Nadu. In this regard TNPSC has always strived to upgrade and improvise systems and procedures of selection in order that the best among applicants are selected to this post, while rigorously adhering to the policy of recruitment and reservation of the State Government.

In this context a guide exclusively on Animal Nutrition with important tips on animal husbandry for VAS aspirants has been brought out by the staff, Department of Animal Nutrition, Madras Veterinary College. A sincere attempt has been made by the authors to help the aspirants to prepare for one of the most competitive examination to be held to select Veterinary Assistant Surgeon in the Department of Animal Husbandry, Tamil Nadu. Efforts have been made to select and compile relevant material from the voluminous detailed data available, to make Animal Nutrition, more systematic and interesting. The authors have also made effort to present statistical data, relevant figures and schematic classification. Special attention has been paid to provide objective type multiple choice questions under each topic.

I am sure that this guide would be of immense help for those appearing to TNPSC competitive exam. I wish all our veterinarians appearing for TNPSC – (Veterinary Assistant Surgeon) a great success. I appreciate the authors for bringing out this valuable guide in the apt time.

Date : 22.02.2013

Sd. S. A. ASOKAN
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SYLLABUS

UNIT III: Livestock Nutrition

Nutritional terms and definitions - Role of nutrition in health and production; classification and composition of feeds and fodders including forest grasses; antinutritional factors and toxins in feeds and fodders; feeding standards and nutrient requirements of different categories of livestock and computation of rations. Nutritional deficiency and its influence on livestock performance; feed supplements and additives; conservation and preservation of feeds and fodders; economic utilization of agro by-products for feeding livestock. - utilization of unconventional feeds – Wildlife nutrition.
CHAPTER I
NUTRITION TERMS AND DEFINITION:

A glossary of terms frequently used in discussing matters related to feed and nutrition is presented in this chapter:

Additives: An ingredient or substance added to a basic feed mix, usually in small quantities, for the purpose of fortifying it with certain nutrients, stimulants and/or medicines.

Ad Libitum: Free-choice access to feed.

ADF: Acid detergent fibre. Contains cellulose lignin silica and insoluble NPN.

Agglomerated feed: A mixture of feeds in compacted or extruded form.

Agroforestry: A land management approach that deliberately combines the production of trees with other crops and/or livestock. By blending agriculture and forestry with conservation practices, agroforestry optimizes economic, environmental and social benefits.

Air-dry (approximately 90% dry matter): This refers to feed that is dried by means of natural air movement, usually in the open. It may be either an actual or an assumed dry matter content, the latter is approximately 90 per cent. More feeds are fed in the air-dry state.

Alfalfa Meal - the aerial portion of the alfalfa plant, reasonably free from other crop plants, weeds and mold, which has been suncured and finely ground.

Amino acids: Nitrogen-containing compounds that consists the “building blocks” or units from which more complex proteins are formed. They contain both an amino (NH₂) group and a carboxyl (COOH) group.

Amino acid Imbalance: Certain proteins contain excessive amount of some amino acids and are deficient in some other amino acids such proteins creates imbalance of amino acid and depresses growth. The condition can be corrected by supplementing the limiting amino acid.

Anabolism: Synthesis of complex substances from simple substances is called anabolism.

Analogue: Anything that is analogous or similar to something else (also spelled analog).

Animal Protein: Protein derived from meatpacking or rendering plants, surplus milk or milk products and marine sources. It includes proteins from meat, milk, poultry, eggs, fish and their products.

Animal Protein Factor (APF): The term formerly used to refer to an undefined growth factor essential for poultry and swine and present in protein feeds or animal origin. It is not known to be the same as vitamin B₁₂.

Antimetabolite: A substance bearing a close structural resemblance to one required for normal physiological functioning, which exerts its effect by replacing or interfering with the utilisation of the essential metabolite.

Antioxidant: A compound that prevents oxidative rancidity or polyunsaturated fats. Antioxidants are used to prevent rancidity in feed and foods.

Antivitamin: Any substance which inhibits the normal function of a vitamin.

Apparent metabolisable energy (ME): It the gross energy of the feed consumed minus the gross energy contained in the faeces, urine and gaseous products of digestion. For poultry the gaseous products are usually negligible, so ME represents the gross energy of the feed minus the gross energy of the excreta. A correction for nitrogen retained in the body is usually applied to yield a nitrogen-corrected ME (MEₙ) value. MEₙ as determined using the method described by Andeesson et al. (1958) or slight modifications thereof, is the most common measure or available energy used in formulation of poultry feeds.

Appetite: This immediate desire to eat when feed present. Loss of appetite in an animal is usually caused by illness of stress.

As-Fed: This refer to food as normally fed to animals. It may range from 0 to 100 percent dry matter.
Ash: The mineral matter of a feed. The residues that remain after complete incineration of the organic matter.

Assay: Determination of (1) the purity or potency of a substance or (2) the amount of any particular constituent of a mixture.

Available nutrient: A nutrient which can be digested, absorbed and/or used in the body.

Average Daily gain (ADG): The average daily live weight increase of an animal.

Balanced Ration: One which provides an animal the proper amounts and proportions of all the required nutrients.

Basal Diet: A diet common to all groups of experimental animals to which the experimental substances(s) is added.

Basal Metabolic Rate (BMR): The heat produced by an animal during complete rest (but not sleeping) following fasting when using just enough energy to maintain vital cellular activity, respiration and circulation the measured value of which is called the basal metabolic rate (BMR). Basal conditions include thermo neutral environment, resting post absorptive state (digestive processes are quiescent), consciousness, quiescence and sexual repose. It is determined in man 14 to 18 hours after eating when at absolute rest. It is measured by means of a calorimeter and is expressed in calories per square meter of body surface.

Biological value of a protein: The percentage of the protein of a feed or feed mixture which is usable as a protein by the animal. Thus, the biological value of a protein is a reflection of the kinds of amounts of amino acid available to the animal after digestion. A protein which has a high biological value is said to be of good quality.

\[
B.V. = \frac{\text{Nitrogen intake} - (\text{Nitrogen excreted in feces} + \text{Nitrogen excreted in urine})}{\text{Nitrogen intake} - \text{Nitrogen excreted in feces}} \times 100
\]

Blended: Combined or mixed so as to render the constituent parts indistinguishable from one another such as when two or more feed ingredients or mixed.

Bomb Calorimeter: An instrument used to measure the gross energy content of any material, in which the feed (or other substance) tested is placed and burned in the presence of oxygen.

Bran: It is the outer coarse coat of the grain, separated during processing e.g. Rice bran, wheat bran, maize bran etc.

Brix: A term commonly used to indicate the sugar (sucrose) content of molasses. It is expressed in degrees and was originally used to indicate the percentage by weight of sugar in sucrose solutions, with each degree Brix being equal to 1 percent sucrose.

By-product feeds: The innumerable roughage and concentrates obtained as secondary products from plant and animal processing and from industrial manufacturing.

Cake (presscake): The mass resulting from the pressing of seeds, meat or fish in order to remove oils, fats or other liquids.

Carrier: An edible material to which ingredients are added to facilitate their uniform incorporation into feeds. The active particles are absorbed, impregnated or coated into or onto the edible material in such a way as to carry the active ingredient physically.

Catabolism: Degradation of complex material into simpler substances is called catabolism.

Calorie: The basic unit of heat energy is the calorie it may be defined as the amount of heat required to raise the temperature of one gram of water through 1 degree C.

Cereals: A plant in the gross family (Graminae), the seeds of which are used for human and animal food; eg. Maize and wheat.

Chaff: Glumes, husks or other seeds covering, together with other plant parts, separated from seed in threshing or processing.

Chelate: The word chelate is derived from the Greek word meaning “claw”. It refer to a cyclic compound which is formed between an organic molecule and a metabolic ion, the latter being held within thenorganic molecule as if by a claw. Examples of naturally occurring chelates are the chlorophylls, cytochromes, hemoglobin and vitamin B_{12}. 
**Chemical score:** The quality of the protein is decided by that amino acid which is greatest deficit when compared with standard protein (egg protein).

**Coefficient or digestibility:** The percentage value of a food nutrient that is absorbed. For example, if a food contains 10 grams of nitrogen and it is found that 9.5 grams are absorbed, the digestibility is 95 per cent.

**Coenzyme:** A substance, usually containing a vitamin, which works with an enzyme (protein mainly) to perform a certain function.

**Collagen:** A white papery transparent type of connective tissue which is of protein composition. It forms gelatin which heated with water.

**Commercial feeds:** Feeds mixed by manufacturers who specialize in the feed business.

**Concentrate:** A broad classification of feedstuffs which are high in energy and low in crude fiber (under 18%). For convenience concentrates are often broken down (1) carbonaceous feeds and (2) nitrogenous feeds.

**Corn Gluten Meal** - the dried residue from corn after the removal of the larger part of the starch and germ, and the separation of the bran by the process employed in the wet milling manufacture of corn starch or syrup, or by enzymatic treatment of the endosperm.

**Cracked:** Particle size reduced by combined breaking and crushing action.

**Crimped:** Rolled between corrugated rollers. The gain to which this term refers may be tempered or conditioned before crimping and may be rolled afterward.

**Crude fat:** Material that is extracted from moisture-free feeds by ether. It consists largely of fats and oils with small amounts of waxes, resins and coloring matter. In calculating the energy value of a feed the cat is considered to have 2.25 times as much energy as either nitrogen-free extract or protein.

**Crubbles:** Pelleted feed reduced to granular form.

**Decortication:** Removal of the bark, hull, husk or shell from a plant, seed or root. Removal of portions of the cortical substance of a structure or organ, as in the brain, kidney and lung.

**Defluorinated:** Processed in such manner that the fluorine content is reduced to a level which is nontoxic under normal use.

**Dehulled:** Grains or other seeds with the outer covering removed.

**Dehydrate:** To remove most or all moisture from a substance for the purpose of preservation, primarily through artificial drying.

**Desiccate:** To dry completely.

**Depraved appetite (pica):** A craving for and eating of unnatural substances, such as dirt, hair, dung, wood, etc.

**Diet:** Feed ingredient or mixed or ingredient, including water, which is consumed by animals.

**Digestability:** denotes the percentage of the whole feed or single nutrient which is not excreted in the feces and is therefore assumed to be available for absorption from the GI tract.

**Digestible energy** Gross energy minus the energy loss in faeces is called as digestible energy.

**Digestible nutrient:** The part of each feed nutrient that is digested or absorbed by the animal.

**Digestible Protein:** The protein of the ingested food protein which is absorbed.

**Digestion coefficient (coefficient of digestibility):** the difference between the nutrients consumed and the nutrients excreted expressed as a percentage.

**Dry matter:** That part of a feed which is not water. It is computed by determining the percentage of water and subtracting the water content from 100 percent.

**Dry matter basis:** A method of expressing the level of nutrient contained in a feed on the basis that the material contains no moisture.

**Dry Rolling:** Refer to processing grains without added steam or other moisture.

**Efficiency of feed conversion:** This is expressed as units of feed per unit of product meal, milk or eggs.

**Element:** One of the many 105 known chemical substances that cannot be divided into simpler substance by chemical means.

**Emaciated:** An excessively thin condition of the body:
**Energy:**
Vigor power in action
The capacity of perform work.

**Energy Feeds:** Feeds that are high energy and low in fiber (under 18%), and that generally contain less than 20 percent protein.

**Essential fatty acids:** Certain fatty acids are essential for the growth and health of animals and they cannot be synthesized in the animal system hence they are dietary essential, such fatty acids are called as essential fatty acids. Linoleic, Linolenic and arachidonic acids.

**Essential amino acids** are those that are necessary for growth and maintenance of body but are not synthesized in sufficient amount by the body hence they are dietary essential. The essential amino acids are Histidine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Threonine, Tryptophan, Valine, Cysteine and Tyrosine. Taurine is essential in cats. Glycine is essential in chicks.

**Ether Extract (EE):** Fatty substances of feeds or foods that are soluble in ether.

**EUN:** Here the loss of nitrogen is due to the catabolism incidental to maintenance of the vital tissues of the body, which can be measured at the minimum urinary excretion on a nitrogen free otherwise adequate (particularly energy adequacy) diet

**Evaporated:** Reduced to a denser form; concentrated as by evaporation or distillation.

**Expanded:** As applied to feed, it refers to an increase in volume as the result of a sudden reduction in the surrounding pressure.

**Expeller process:** A process of the mechanical extraction of oil from seeds, involving the use of screw press.

**Extracted:** Having removed fat or oil from materials by heat and mechanical pressure. Similar terms: expeller extracted, hydraulic extracted, old process.

**Extrinsic Factor:** A dietary substance which was formerly thought to interact with the intrinsic factor of the gastric secretion to produce the anitianemic factor, now known to be vitamin B_{12} (also seed intrinsic factor).

**Extruded:** A type of feed preparation in which the feed is forced through a die under pressure.

**Fat:** The term fat is frequently used in general sense to include both fats and oils or a mixture of the two. Both fats and oils have the same general structure and chemical properties, but they have different physical characteristics. The melting points of most fats are such that they are solid at ordinary room temperature, while oils have lower melting points and are liquids at these temperatures.

**Fat Soluble:** Fat soluble in fats and fat solvents but generally not soluble in water.

**Fattening:** The deposition of energy in the form of fat within the body tissues.

**Feed (or feedstuff):** Any naturally occurring ingredient or material, fed to animals for the purpose sustaining them.

**Feed activities and implements:** Nonnutritive products that improve the rate and/or efficient of gain of animals, percent certain diseases, or pressure feeds.

**Feed efficiency:** The ratio expressing the number of units of feed required for one unit of production (meat, milk, eggs) by an animals.

**Feed Grade:** Feedstuffs suitable for animals, but nor for human consumption.

**Feed grain:** Any of several grains mostly commonly used for livestock or poultry feed, such as corn, sorghum, oats and barley.

**Feedings standards** are the tables which indicates the quantities of nutrients to be fed to the various classes of livestock for different physiological functions like growth, maintenance, lactation, egg production and wool growth.

**Feedstuff:** Any product, of natural or artificial origin, that has nutritional value in the diet when properly prepared.

**Fermented:** Acted upon by yeasts, moulds or bacteria in a controlled aerobic or anaerobic process in the manufacture of such products as alcohols, acids, vitamins or the B complex group or antibiotics.
Fiber content of a feed: The amount of hard-to-digest carbohydrates. Most fiber is made up of cellulose, hemicellulose and lignin.

Fibrous: High in cellulose and/or lignin content.

Finishing Animals: The laying on or fat prior to slaughter.

Fish Meal - the clean, dried, ground tissue of undecomposed whole fish or fish cuttings, either or both, with or without the extraction of part of the oil.

Flakes: An ingredient rolled or cut into flat pieces with or without prior steam conditioning.

Flavoring agent: Feed additives that are supposed to increase palatability and feed intake.

Flora: The plant life present. In nutrition it generally refers to the bacteria present in the digestive tract.

Formula feed: A feed consisting of two or more ingredients mixed in specified proportions.

Fortify: Nutritionally to add one or more feeds or feedstuffs.

Free-choice: Free to eat two or more feeds at will.

Germ: It is the embryo of any seed, rich in protein and fat.

Gluten: The though, viscid, nitrogenous substance remaining when the flour of wheat or other grain is washed to remove the starch.

Grits: Coarsely ground grain from which the bran and germ have been removed, usually screened to uniformed particle size.

Groat: Grain from which the hulls have been removed.

Gross Energy (GE): is the energy released as heat when a substance is completely oxidised to carbon dioxide and water. Gross energy is also referred to as the heat of combustion. It is generally measured using 25 to 30 atmospheres of oxygen in a bomb calorimeter.

Ground: Reduced in particle size by impact, sharing or attrition.

Heat of fermentation (HF): The heat produced in the digestive tract as result of microbial action.

Heat increment: Energy loss due to processes of digestion and metabolism is called heat increment.

Heat-processed: Subject to a method of preparation of involving the use of elevated temperature, with or without pressure.

Hemicellulose: A carbohydrate classified in the crude fiber fraction of feed stuffs that is similar to cellulose, except that it contains pentoses 95-carbon sugars) and uronic acid in addition to hexose.

Hulls: Outer covering of grain or other seed, especially when dry.

Hydraulic process: A process for the mechanical extraction of oil from seeds, involving the use of a hydraulic press. Sometimes referred to as “old process”.

Hydrogenation: The chemical and addition of hydrogen to any unsaturated compound.

Hydrolysis: The splitting of a substance in to a smaller units by chemically adding water to the material.

Hypervitaminosis: An abnormal condition resulting from the intake of an excess of one or more vitamins.

Hypocalcemia: Below normal concentration of ionic calcium in blood resulting in convulsion as in tetany or parturient paresis (milk fever in crude).

Hypomagnesemia: An abnormally low level of magnesium in the blood.

Implant: A substance that is implanted into the body from the purpose of growth promotion or controlling some physical function.

In Vitro: Occurring in an artificial environment, as in a test tube.

In Vivo: occurring in the living body.

Inert: Relatively inactive.

Ingest: To eat or take in through the mouth.

Ingesta: Food or drink taken into the stomach.

Ingestion: The taking in of food ad drink.

Ingredient: A constituent feed material.
**IU (International Unit):** A standard unit of potency of a biological agent e.g., Vitamin, hormone, antibiotic (antitoxin) as defined by the International Conference for Unification of Formulae. Potency is based on bioassay that produces a particular effect agreed on internationally. Also called USP unit.

**Joule:** An international unit (4.184 j = 1 calorie) for expressing mechanical chemical or electrical energy as well as the concept of heat. In the future, energy requirements and feed values will likely be expressed by this unit.

**Keratin:** A sulfur-containing protein which is the primary component of epiderms hair, wool, hoof, horn and the organic matrix of the teeth.

**Kernel:** The whole grain of cereal. The meats of nuts and drupes (single-stoned fruits).

**Kjeldahl:** A method of determining the amount of nitrogen in an organic compound. The quality of nitrogen measured is then multiplied by 6.25 to calculate the protein content of the feed or compound analysed. The method was developed by the Danish Chemist, J.G.C., Kjeldahl, in 1983.

**Labile:** Unstable. Easily destroyed.

**Lignification:** The process of impregnating cell walls of a plant with lignin.

**Lignin:** A practically indigestible compound along with cellulose, is a major component of the cell wall of certain plant materials, such as wood, hulls, straws and overripe hays.

**Limiting Amino Acid:** The essential amino acid of a protein which shows the greatest percentage deficit in comparison with amino acids contained in the same quantity of another protein selected as a standard.

**Macro (or major) Mineral:** The Major mineral calcium, phosphorus, sodium, chlorine, potassium, magnesium and sulfur.

**Malnutrition:** Any disorder of nutrition, commonly used to indicate a state of inadequate nutrition.

**Meat Analogos:** Food material usually prepared from vegetable protein to resemble specific meats in texture, colour and flavour.

**Meats:** Animal tissue used as food.

**Meat and Bone Meal** - the rendered product from mammal tissues, including bone, exclusive of blood, hair, hoof, horn, hide trimmings, manure, stomach and rumen contents, except in such amounts as may occur unavoidably in good processing practices.

**Meat By-Products** - the non rendered, clean parts, other than meat, derived from slaughtered mammals. It includes, but is not limited to, lungs, spleen, kidneys, brain, livers, blood, bone, partially defatted low-temperature fatty tissue and stomachs and intestines freed of their contents. It does not include hair, horns, teeth and hooves.

**Mechanically Extracted:** A method of extracting the fat content from oil seeds by the application of heat and mechanical pressure. The hydraulic and expeller process and both method of mechnica extraction.

**Medicated feed:** Any feed which contains drug ingredients intended or represented for the cure, mitigation, treatment or prevention of diseases of animals (other than man).

**Metabolism:** Refers to all the changes that take place in the nutrients after they absorbed from the digestive tract, including (1) the building-up process in which the absorbed nutrients are used in the formation of repair of body tissue and (2) the breaking down process in which nutrients are oxidised for the production of heat and work.

**Metabolizable Energy (ME):** It is the gross energy of the feed consumed minus the gross energy contained in the feces, urine and gaseous products of digestion. For poultry the gaseous products are negligible.

**MFN** (Metabolic faecal nitrogen) which comprises residues originated from the body, e.g. residues of bile digestive enzymes, epithelial cells derived from the alimentary tract and undigested bacteria.

**Metabolic body weight** ($W^{0.75}$): Body weight to the power of 0.75. This is calculated by using Logarithm tables of a calculator.
**Metabolite:** Any substance produced by metabolism or by a metabolic process.

**Mill by-product:** A secondary product obtained in addition to the principal product in milling practice.

**Mimosine** Mimosine is a toxic amino acid, also called as ‘leucenine’ found in the plants belonging to the genus Leucaena like subabul. This toxic substance mimosine can cause problems when the forage is eaten in large quantities for a long period.

**Minerals (ash):** The inorganic elements of animals and plants determined by burning off the organic matter and weighing the residue, which is called ash.

**Mineral Supplement:** A rich source of one or more of the inorganic elements needed to perform certain essential body functions.

**Mixing:** to combine by agitation two or more materials to a specific degree of dispersion.

**Moisture:** A term used to indicate the water contained in feed-expressed as a percentage.

**Moisture-free (M-F, oven-dry, 100% dry matter):** This refers to any substance that has been dried in an oven at 221°F (105°C) until all the moisture has been removed.

**Molasses:** Concentrated water solution of sugar, hemi-celluloses and minerals obtained as by-product of various manufacturing operations of the juices or extracts of selected plant materials are called molasses. e.g. Cane molasses, beet molasses and wood molasses.

**Molasses Brix:** The term is used in referring to the amount of sugar content of molasses.

**Mycotoxins:** Toxic metabolites produced by molds during growth. Sometimes present in fed materials.

**National Research Council (NRC):** A division of the National Academy of Science established in 1916 to promote the effective utilisation of scientific and technical resources. Periodically, this private, non-profit organisation of scientists publishes bulletins giving nutrient requirements and allowance of domestic animals, copies of which are available on a charge basis through the National Academy of Science, National Research Council, 2101 Constitution Avenue, N.W., Washington D.C., 20418.

**NDS** Neutral detergent solubles. Contains lipids, sugars and proteins.

**NDF** Neutral detergent fibre. Cell wall contents. Includes digestible and indigestible fibre.

**Net Energy (NE):** Is metabolisable energy minus the energy lost as the heat increment. NE may include the energy used for maintenance only (NEₘₗ) or for maintenance and production (NEₘₗ+ₚ). Because of NE is used at different levels of efficiency for maintenance or various productive functions, there is no absolute NE value for each feedstuff. For this reason, productive energy, once a popular measure of the energy available of NE is seldom used.

**Net protein utilisation (NPU):** Is the product of biological value and digestability coefficient of protein.

**Nitrogen:** A chemical essential to life. Animals get it from protein feeds; plants get it from the soil; and some bacteria get it directly from the air.

**Nitrogen Balance:** The nitrogen in the feed intake minus the nitrogen in the feces, minus the nitrogen in the urine.

**Nitrogen-Free Extract (NFE):** It consists principally of sugars, starches, pentoses and non-nitrogenous organic acid. The percentage is determined by subtracting the sum of the percentage of moisture, crude protein, crude fat, crude fiber and ash from 100.

**Nonprotein Nitrogen (NPN):** Nitrogen which comes from other than a protein source but may be used by a ruminant in the building of protein. NPN sources include compounds like urea and anhydrous ammonia, which are used in feed formulation for ruminants only.

**Noxious:** Harmful, not wholesome.

**Nutrient allowances:** Nutrient recommendation that allow for variations in feed composition, possible losses during storage and processing, day-to-day and period-to-period differences in needs of animals age and size of animal; stage of gestation and lactation; the kind and degree of activity, the amount of stress, the system of management, the health, condition, and temperature of the animal and the kind , quality and amount of feed-all of which exert a powerful influence in determining nutritive needs.
Nutrient requirements: This refers to meeting the animals minimum needs, without margins of safety for maintenance, growth, fitting, reproduction, lactation, and work. To meet these nutritive requirements the different classes of animals must receive sufficient feed to furnish the necessary quantity of energy (carbohydrates and fats), protein, mineral and vitamins.

Nutrient to calorie ratio: The energy needs of animals and their requirements of the several nutrients are quantitatively corrected. For those nutrients that are needed metabolise energy, it is logical to consider that the amount of energy metabolised “determines” their requirements. Hence, it is logical to express nutrients in weight per unit of energy needed. For example, it is suggested that the protein to calorie ratio should be expressed as grams of protein per 100 kcal metabolisable energy (g protein/100 kcal ME). If the ME is corrected for nitrogen retained or lost from the body, then the abbreviation should be g protein/100 kcal MEn. This same dimension may easily extend to other nutrients, such as g calcium 100 kcal or mg riboflavin/100 kcal. Etc.

Nutrients: The chemical substance found in feed materials that can be used and are necessary, for the maintenance, production and health of animals. The chief classes of nutrients are carbohydrates, fats, proteins, minerals, vitamins and water.

Nutrition: The science encompassing the sum total process that have as a terminal objective the provision of nutrients to the component cells of an animal.

Obese: Over weight due to surplus of body fat.

Off feed: Not eating with a normal healthy appetite.

Oil: Although fats and oils have the same general structure and chemical properties, they have different physical characteristic. The melting points of oils are such that they are liquid at ordinary room temperature.

Orts: Leftover feed which an animal refuses to eat.

Palatability: The result of the following factors sensed by the animal in locating and consuming feed, appearance, odor, taste, texture, temperature and in some cases, auditory properties of the feed (like the sound of pigs eating corn). These factors are affected by the physical and chemical nature of feed.

Palatable Feeds: Feeds that are well liked and eaten with relish.

Pantothenic acid: One of the B Vitamins. It is a constituent of coenzyme A, which plays an essential role in fat and cholesterol synthesis.

Parts per billion (PPB): It equals micrograms per kilogram or microliter per liter.

Parts per million (PPM): It equals milligrams per kilogram or microliter per liter.

Pearled: Dehulled grains reduced into smaller smooth particles by machanic brushing or abrasion.

Pectin: Any of the group or colorless, amorphous, methylated, pectic substance occurring in plant tissue or obtained be restricted treatment of protopectin that are obtained from fruits or succulent vegetables, that yield viscous solutions with water and when combined with acid and sugar, yield a gel.

Peelings: Outer layers of covering which have been removed by stripping or tearing.

Pellet binders: Products that enhance the firmness of pellets.

Pelletes: Ground feed compacted by steming and forcing the material through die opening.

Phase Feeding: Refers to change in animal’s diet (1) to adjust for age and stage of production, (2) to adjust for season of the year and for temperature and climate changes, (3) to account for differences in body weight and nutrient requirements of different strains of animals or (4) to adjust on or more nutrient as other nutrients are changed for economic or availability reasons.

Plant Proteins: This group includes the common oilseed by-products – soyabean meal, cottonseed meal, linseed meal, peanut meal, safflower meal, sunflower meal, rapeseed meal, and coconut (or copra) meal. They vary in protein content and nutrient value, depending on the seed from which they are produced, the amount of hull and/or seed coat included and the method of oil extraction used.
Polishing: By-product of rice, consisting of a fine residue that accumulates during polishing of rice kernel contains about 10-15% protein, 12% fat and 3-4% crude fibre. It is an excellent source of energy and vitamin B complex. Due to high fat content rancidity can pose problem.

Polyunsaturated fatty acids: Fatty acids having more than one double bond. Linoleic and linolenic acids, which contain 2 and 3 bonds respectively are essential in the diet of man.

Poultry By-Product Meal - consists of the ground, rendered, clean parts of the carcass of slaughtered poultry, such as necks, feet, undeveloped eggs, intestines, exclusive of feathers, except in such amounts as might occur unavoidably in good processing practices.

Precursor: A compound that can be used by the body to from another compound for example, carotene is a precursor of vitamin A.

Preservatives: A number of materials are available to incorporate into feed and their products, with claims made that they will improve the preservation of nutrients, nutritive value and/or palatability of the feed.

Pressed: Compacted or molded by pressure; having fat, oil or juice extracted under pressure.

Pressure cooker: An airtight container for the cooking of feed at high temperature under steam pressure.

Protein: From the Greek meaning “of first rank importance”. Complex organic compounds made up chiefly of amino acids present in characteristic proportions for each specific protein. At least 24 amino acids have been identified and may occur in combinations to form an almost limitless number of proteins. Protein always contains carbon, hydrogen, oxygen and nitrogen and in addition it usually contains sulfur and frequently phosphorus. Crude protein is determined by finding the nitrogen content and multiplying the result by 6.25. The nitrogen content of proteins averages about 16 per cent (100/16=6.24). Proteins are essential in all plant and animal life as components of the active protoplasm of each living cell.

Protein equivalent: A term indicating the total nitrogenous contribution of substance in comparison with the nitrogen content of protein (usually plant protein). For example, the non-protein nitrogen (NPN) compound urea contains approximately 45% nitrogen and has a protein equivalent of 281% (6.25 × 45%).

PER (Protein efficiency ratio) is the gain in body weight per gram of protein intake.

\[
\text{PER} = \frac{\text{Gain in body weight (g)}}{\text{Protein intake (g)}}
\]

Protein-sparing: An effect in which less proteins is used by the animal to meet the animal’s glucose needs in times of glucose shortage. Propionic acid is protein sparing in that it can be converted to glucose. Acetic and butyric acid cannot be converted to glucose. Likewise, fat cannot be converted. The glycogenic amino acids may be converted to glucose.

Protein Supplements: Products that contain more than 20 percent protein or protein equivalent.

Proximate Analysis: A chemical scheme for evaluating feedstuffs, in which a feedstuff is partitioned into the six fractions: (1) moisture (water) or dry matter (DM); (2) total (crude) protein (CP or TDN × 6.25); (3) ether extract (EE) or fat; (4) ash (mineral salts); (5) crude fiber (CF) – the incompletely digested carbohydrates and (6) nitrogen-free extract (NFE) – the more readily digested carbohydrates (calculated rather than measured chemically).

Purified Diet: A mixture of the know essential dietary nutrients in a pure form that is fed to experimental (test) animals in nutrition studies.

Quality: A term used to denote the desirability and/or acceptance of an animal or feed product.

Quality of protein: A term used to describe the amino acid balance or protein. A protein is said to be of good quality when it contains all the essential amino acids in proper proportions and amounts needed by a specific animal and it is said to be poor quality when it is deficient in either content or balance of essential amino acids.

Ration(s): The amount of feed supplied to an animal for a definite period, usually for a 24 hour period. However by practical usage the word ration implies the feed fed to an animal without limitation to the time in which it is consumed.
Respiratory quotient (RQ): This is the ratio between the volume of carbon dioxide produced by the animal and the volume of oxygen used.
Saturation fat: A completely hydrogenated fat-each carbon atom is associated with the maximum number of hydrogens; there are no double bonds.
Selenium: An element that functions with glutathione peroxidase an enzyme which enables the tripeptide glutathione to perform its role as a biological antioxidant in the body. This explains why deficiencies of selenium and vitamin E result in similar signs-loss of appetite and slow growth.
Silage Silage is the material produced by the controlled fermentation of a crop of high moisture content. Ensilage is the name given to the process and the container, if used, is called the silo. chaff consists of the husk or glumes of the seed which are separated from the grain during threshing.
Sodium Bentonite (clay): Used as a pellet binder. Also shows promise for improving the nitrogen utilisation or ruminants.
Solvent-extracted: fat or oil removed from materials (such as oilseeds) by organic solvents. Also called “new process”.
Sorhghum: A cereal grain used mainly for as feed grain.
Specific Dynamic Action (SDA): The increased production of heat by the body as a result of stimulus to metabolic activity caused by ingesting food.
Spray-dehydrated: Material which has been dried by spraying onto the surface of heated drum. It is recovered by scraping it from the drum.
Stabilised: Made more resistant to chemical change by the addition of a particular substance.
Starch equivalent is the number of kilograms of starch that would be required to produce the same amount of fat as that of 100 kg of feed.
Straws: Straws consist of the stem and leaves of plants after the removal of the ripe seeds by threshing and are produced from most cereal crops and from some legumes.
Steamed: Treatment of ingredients with steam to alter physical and/or chemical properties.
Sun-cured: Material dried by exposure in open air to direct rays of the sun.
Supplement: A feed or feed mixtures used to improve the nutrition value of basal feeds (eg. Protein supplement-soyabean meal). Supplements are usually rich in protein, minerals, vitamins, antibiotic or a combination of part or all of these and they are usually combined with basal feeds to produce a complete feed.
TDN (%) = % dig CP + (% dig EE × 2.25) + % dig CF + % dig NFE
Gross energy: The quantity of heat generated from complete oxidation of unit weight of a food is known as gross energy.
Toxemia: A condition produced by the presence of poisons (toxins) in the blood.
Toxic: Of poisonous nature.
Trace Elements: A chemical element used in minute amounts by organism and held essential to their physiology. The essential trace elements are cobalt, copper, iodine, iron, manganese, selenium and zinc.
Trace mineral: A mineral nutrient required by animals in micro amounts only (measurable in milligrams per kilogram or smaller units).
Transamination: It is the reversible reaction between amino acids and keto acids leading to the exchange of amino and ketonic groups.
Thermal Equivalent of Oxygen: The utilization of one litre of oxygen would lead to the production of 20.98 Kj of heat this value is known as thermal equivalent of oxygen.

True metabolisable energy (TME) for poultry is the gross energy of the deed consumed minus for gross energy of the excreta of feed origin corrected for nitrogen retention, may be applied to give a TME value. Most ME<sub>n</sub> values in the literature have been determined by assay in which the test material is substituted for part of the test diet or for some ingredient of known ME value.
When birds in these assay are allowed to consume feed on an *ad libitum* basis, the MEₙ value obtained approximate TMEₙ values for most feedstuffs.

**True protein**: A nitrogenous compound which will hydrolyze completely to amino acids.

**Unsaturated fat**: A fat having one or more double bonds; nor completely hydrogenated.

**Unsaturated Fatty acid**: Any one of several fatty acids containing one or more double such as oleic, linoleic, linolenic and arachidonic acids.

**Vacuum-dehydrated**: Freed or moisture after removal of surrounding air while in an airtight enclosure.

**Vitamins**: Complex organic compounds that function as parts of enzyme systems essential for the transformation of energy and the regulation of metabolism of the body, and required in minute amounts by one or more animal species for normal growth, production, reproduction, and/or health. All vitamins must be present in the ration for normal functioning except for B vitamin in the ruminants (cattle and sheep) and vitamin C.

**Wheat Bran**: the coarse outer covering of the wheat kernel as separated from cleaned and scoured wheat in the usual process of commercial milling.
CHAPTER II

ROLE OF NUTRITION IN HEALTH AND PRODUCTION

Proper nutrition is essential to the health and well-being of all domestic animals. Nutrition is important because animals must maintain a high level of production. The genetic advancement has led to increased productivity and production systems have become more intensified, hence there is increased pressure on animal husbandry to ensure that nutrition does not limit animal wellbeing, health, or production.

Role of Nutrition in health

Proper nutrition is also central to the prevention and control of many infectious and noninfectious diseases. Infectious diseases require successful colonization by a specific infectious organism(s) (eg, a bacterium, virus, parasite); the mere presence of the microbe is not usually sufficient for disease to develop. Environmental and host factors influence whether an animal will develop clinical disease or has impaired productivity as a result of becoming infected. Mostly animals that are in a poor plane of nutrition pick up infections to a greater extent than well fed animals in good nutritional status.

Nutrition plays a role in influencing the animal's susceptibility to disease (eg, feline lower urinary tract disease) as well as in managing certain diseases (eg, diabetes, hyperlipidemia, ketosis in dairy cattle). Rations/diets must be formulated to provide for the basic physiologic needs (eg, energy, protein, fats, carbohydrates, vitamins, minerals) of the animal and to ensure optimal growth and productivity.

Nutritionally related diseases include diseases associated with a nutritional excess (eg, direct toxic effect, digestive upset), nutritional deficiency (either a primary or secondary deficiency), or nutritional imbalance.

Feed preparation and delivery are often as important in ensuring animal health as the actual nutritional value of the ration itself. Inadequacies in nutritional delivery can directly cause disease (eg, ruminal acidosis, laminitis) or increase susceptibility to disease (eg, type D Clostridium perfringens enterotoxemia).

Nutritionally related diseases in companion animals include both diseases of excess (eg, developmental orthopedic disease in dogs related to excess calcium and energy) and diseases of deficiency (eg, blindness in cats related to taurine deficiency). Feeds and feeding management can also influence animal health if feeding results in exposure to foodborne physical hazards (eg, sharp objects), chemicals (eg, mycotoxins, toxic plants), allergens (eg, dust mites, mold spores), or microbes (eg, molds, Salmonella spp).

Nutritional and waste management practices are also important in preventing and controlling infectious diseases that are spread through fecal-oral transmission (eg, salmonellosis, paratuberculosis in ruminants, toxoplasmosis in cats).

Role of Nutrition in production

The term production refers to the ability of an animal to grow, reproduce and produce outputs such as milk, wool, draught power and transport. For performing these functions, essential nutrients in the form of energy, proteins, minerals, vitamins and water over and above that needed for the maintenance, must be provided. For a given animal species, the level of production achieved will, in turn, depend on the quantity and nutritive value of feed available, breed, genetic potential, sex, age and management.
The feed intake and its digestibility determine the amount of nutrients that is actually absorbed by an animal and therefore the availability of nutrients for various production purposes.

Animal production via animal nutrition may be improved by adopting the following methods: crop improvement, changes in livestock management, pasture improvement, and feed supplementation.

- **Crop improvement:** In mixed systems of production, livestock nutrition may be enhanced by improving the quantity and nutritive value of crop residues used by stock through the selection for crop varieties which yield residues of higher nutritive value or quantity and changing crop combinations so as to produce residues favoured by livestock.
- **Livestock management:** This involves changing livestock management to match feed availability with livestock feed requirements.
- **Pasture improvement:** Aims to improve the management and raise productivity, of pasture.
- **Feed supplementation:** Involves the use of fodder banks, fodder trees, by products such as oilseed cakes and meals, and urea/molasses licks to supplement crude protein shortages.

Poor nutrition delays puberty, reduces conception rate and increases pregnancy losses in heifers. Under feeding cows during pregnancy, leads to poor plane of nutrition postpartum and delays cycling and conception after calving. In poultry poor nutrition delays growth, has adverse effect on feed efficiency and egg production.

**Model questions**

1. Nutrition is important to maintain
   
   A. Health           C. None
   B. Production       D. Both A and B

   i. A is correct      ii. B is correct     iii. D is correct     iv. C is correct

2. Taurine deficiency in cat leads to
   
   A. Blindness       C. Encephalomalacia
   B. Rickets          D. All above

   i. A is correct     ii. A,B is correct     iii. D is correct     iv. A,B,C is correct

3. Poor nutrition in poultry leads to
   
   A. Delays growth    C. Low egg production
   B. Poor feed efficiency D. All the above

   i. A is correct     ii. A,B is correct     iii. D is correct     iv. A,C is correct
4. Poor nutrition in cattle leads to

A. Delays puberty  
B. Reduces conception

C. Pregnancy loss  
D. All the above

i. A is correct  ii. A, B is correct  iii. D is correct  iv. A, C is correct
CHAPTER III
CLASSIFICATION OF FEED STUFFS

- Feeds can be classified based on their moisture content or based on their fibre content.
- Feeds having high moisture are called high moisture or succulent feeds. Feeds having below 15% moisture are called dry feeds.
- Feeds having higher than 18-20% crude fibre are called roughages and feeds having below 18% crude fibre are called concentrates.
- Roughages can be succulent or dry based on moisture content
- Concentrates may be dry concentrates or high moisture concentrates (Molasses)
- Concentrates having high protein above 18% are called protein supplements
- Concentrates having high energy (above 60% TDN) are called energy supplements.
- Concentrates rich in minerals are called mineral supplements
ENERGY SUPPLEMENTS - CEREALS

The name cereal is given to those members of gramineae, which are cultivated for their seeds.

Cereal grains:

Cereal grains are essentially carbohydrate concentrates, the main component of the dry matter being starch. The crude protein is the most variable component, usually ranging from 8-12%, deficient in certain essential amino acids, particularly lysine and methionine. The oil content varies from 2-5% cereal oils are unsaturated the main acids being linolic and oleic and because of this they-tend to become rancid quickly and also produce a soft body fat. The crude fibre content is highest in oats and rice, which contains “husk or hull”, formed from the inner and outer palsae and is lowest in the ‘naked’ grains like wheat and maize.

The cereals are all deficient in calcium, containing less than 0.15%. The phosphorus content is higher, being 0.3-0.5%, but part of this is present as phytates. Cereal phytates have the property of being able to immobilize dietary calcium. The cereal grains are deficient in vitamin D and with the exception of yellow maize, in pro-vitamin A. They are good sources of vitamin E and thiamin, but have a low content in riboflavin. Commonly fed cereals are maize, barely, oats, wheat, rice etc.

Phytic acid:

Phytates are the salts of phytic acid. Phytic acid is formed due to combination of six phosphate molecules with Inositol, a cyclic alcohol with six hydroxy radicals like that of hexose sugar. Phytate occurs naturally in all foods of plant origin in association with vegetable protein. Thus the vegetable feed ingredients which are rich in protein, also are generally found rich in phytate content as in soyabean, sesame, rapeseed meal, cotton seed meal etc. The anionic character of phytate makes it ideal for forming complexes with mineral elements particularly the transitional element such as zinc, iron and manganese resulting the minerals insoluble in the intestinal tract.

About half or more of the phosphorus in cereal grains is in the form of phytin. The availability of phytin phosphorus to all non-ruminants is influenced by the level of vitamin D, calcium, the calcium to phosphorus ratio, amount of zinc in the feed, alimentary tract pH and other factors.

A good guide to assume that no more than 50% of the phosphorus in plant feeds is available to non ruminants. By contrast, the phosphorus, in inorganic mineral supplements and of animal origin are usually available at the rate of more than 80 per cent. In ruminants, the selected ruminal microbes are in a position to hydrolyse phytates by secreating the enzyme phytase so that it no longer binds the minerals as mentioned. Thus ruminants can utilise Phytin phosphorus satisfactorily. For non ruminants supplementation with adequate minerals (which are affected by phytates) is the usual practice followed to-day in livestock feeding to overcome the adverse effect of phytates.

Maize or Corn: (Zea maize)

Maize appears in a variety of colours, yellow, white or red. Yellow maize contains a pigment, cryptoxanthin, which is a precursor of vitamin A. Though an excellent source of digestible energy, maize is low in protein. Maize contains about 65% starch, is low in fibre and
has a high metabolisable energy value. The crude protein content ranges from 8-13%. The maize kernel consists of two main types of protein. Zein occurring in endosperm, is quantitatively the most important but this protein is deficient in the essential amino acids, tryptophan and lysine. The other protein, maize glutelin occurring in lesser amount in the endosperm and also in the germ, is a better source of these two amino acids. Recently plant breeders have produced new varieties of maize with amino acid components different from those present in normal maize; one such variety is Opaque-2, which has a high lysine content. The difference between this variety and normal maize is primarily attributed to the zein: glutelin ratio. A newer variety Floury-2 has both increased methionine and lysine content.

Maize is generally crushed or even roughly ground for feeding farm animals. Flaked maize is prepared by cooking maize with steam and passing it through rollers, thus producing a thin flake, which is then dried. Flaked maize decreased the proportion of acetic to propionic acids in the rumen and thus depresses the butter fat content of milk when fed in relatively large amount.

**Barley (Hordeum vulgare)**

A palatable, but fibrous feed. The crude protein of barley gain ranges from about 6-14% with average values of 9-10% with oil content less than 2%. Barley forms the main concentrate food for fattening pigs in the United Kingdom, producing a good carcass with hard fat of high quality.

Barley is low in lysine, variety Notch I and Notch II are rich in lysine, but low in yield. Barley should always have the awns removed before they are offered to Poultry or swine. Barley is usually steam rolled (flaked), crimped or coarsely ground before feeding.

**Oats (Avena sativa)**

Oats has the high crude fibre (10 – 18%) than maize and hence lower TDN. The crude protein content ranges from 7-15%, deficient in methionine, histidine and tryptophan. Glutamic acid is the most abundant amino acids. Oats are usually given ‘Crushed’ or ‘bruised’ to cattle and sheep by ground to pigs and poultry.

**Wheat (Triticum aestivum)**

The crude protein ranges from 6-12%, though it is normally between 8 and 14%. The most important proteins present in the endosperm are a prolamin (gliadin) and glutelin (Glutenin). The mixture of protein present in the endosperm is often referred to as gluten. Glutenin contains about three times as much lysine that are present in gliadin. The amino acids present in wheat gluten are the non-essential acids glutamic acid (33%) and proline (12%). Wheat gluten varies in properties and it is mainly the properties of the gluten, which decide whether the flour is suitable for bread or biscuit making. All glutsens posses the property of elasticity. Strong glutsens are preferred for bread making and soft dough, which traps the gases produced during yeast fermentation. This property of gluten is considered to be the main reason why finely ground wheat is unpalatable to animals. Wheat if finely milled forms a pasty mass in the mouth, and may lead to digestive upset.

**Millets**

Millets are cereals, which produced small grain and have higher percentage of fibre .e.g. Sorghum, Bajra, etc.
**Sorghum** (*Sorghum Vulgare*)

Sorghum is similar to maize in chemical composition except that sorghum is slightly higher in protein and low in oil than maize. Whole grain can be given to sheep, pig and poultry but are usually ground for cattle.

**Bajra** (*Pennisetum typhoides*)

It resembles in feeding value of sorghum containing 8-12% crude protein with rich tannin content. As the seed are hard, they should be ground or crushed before being fed to cattle.

**ENERGY SUPPLEMENTS - MILLING BY-PRODUCTS:**

**Bran:**

It is the outer coarse coat of the grain, separated during processing e.g. Rice bran, wheat bran, maize bran etc.

**Rice bran:**

Rice bran is valuable product containing 12-14% protein and 11-18% oil. The oil is particularly unsaturated and may become rancid very quickly. Presently the oil is removed from the rice bran and a product known, as deoiled rice bran is available in market for livestock feeding.

**Wheat bran:**

Wheat bran is popular food for horses contain more fibre. Its popularity as a food for ruminants and horses bring due to its well-known physical property. When made into a mash with warm water, it acts as a laxative, but when given dry it tends to counteract scouring. Because of the fibrous nature and low digestibility bran is not commonly given to pig and poultry.

**Flour:** Soft, finely ground meal of the grains consists primarily of gluten and starch from endosperm e.g. Corn flour, wheat flour and rice flour etc. Flour contains about 16% protein and 1 – 1.5% crude fibre.

**Germ:** It is the embryo of any seed, rich in protein and fat.

**Gluten:** When flour is washed to remove the starch, a tough, substance remains, which are known as gluten e.g., corn gluten. Gluten feed is generally not feed to non-ruminants due to bulkiness, poor quality protein and unpalatability.

**Grain Screening:** Small imperfect grains, weed seeds and other foreign material of value as a feed that is separated through the cleaning of grain with screen is called grain screening. The nutritive value depends on the composition.

**Hulls:** Outer covering of the grain, generally not utilized as livestock feed.

**Middling:**

A by-product of flour milling industry comprising several grades of granular particles consisting of varying proportion of bran, endosperm and germ.
Polishing:

By-product of rice, consisting of a fine residue that accumulates during polishing of rice kernel contains about 10-15% protein, 12% fat and 3-4% crude fibre. It is an excellent source of energy and vitamin B complex. Due to high fat content rancidity can pose problem.

Malt sprout:

Malt sprout are obtained as by-product of brewing processes etc. Barley sprouts is used as livestock feed, contains about 24% crude protein.

ENERGY SUPPLEMENTS - HIGH MOISTURE CONCENTRATES

Roots and Tubers

Roots:

A root crop consists of the under ground part of the harvested plant. The main characteristic of roots are their high mixture content (75-94%) and low Crude fibre (4-13%). The organic matter of root, consists mainly of sugars, roots are generally low in crude protein ex.turnipe, beet, carrot etc.

Tubers:

Tubers are short thickened, fleshy stems, usually formed underground such as potatoes, cassava, sweet potatoes etc. Potatoes: The crude protein content is approximately 11% about half of this being in the form of non protein nitrogenous compounds, one of these compounds is the alkaloid ‘Solaridine’. Solanidine and its diravities are toxic to animals, causing gastroenteritis. Cassava: Cassava tubers are used for production of tapioca starch for human consumption, although tuber is also given to cattle, pig and poultry. Cassava tubers contains two cyanogenetic glucosides (linamrin and lotaustralain), which readily break down to give hydrocyanic acid. Boiling or grating and squeezing or grinding to a powder reduces the toxicity.

Molasses:

Molasses is a product of the sugar refining industry; it is a black syrupy sweet solution. The principal types of molasses are cane and beet molasses.

Cane molasses

- Liquid molasses contain 20-25% water, 46% of sugars, 10-15% ash.
- Molasses can be used to a maximum of 30 percent of the diet, however to be on the safe side it can be included up to 10 percent of ration.
- At higher inclusion levels it has a laxative effect due to the high mineral content.
- Molasses is used in compounded feeds up to 2-5%
- to improve palatability and prevent dustiness of feed.
- It is also used as a pellet binder.
- When included above 10% it may cause milling problems due to stickiness.
- Molasses is used in liquid feeding systems for ruminants along with urea or other NPN sources.
- Molasses serves as readily available carbohydrate source during NPN supplementation.
- In molasses based feeding systems molasses toxicity may occur which is characterized by neurological symptoms such as in coordination and blindness.
The other types of molasses are citrus and wood molasses, which are available to a limited extent. **Citrus molasses** is a by product of citrus processing has a bitter taste due to its high organic acid content and is unpalatable. **Wood molasses** is a mixture of hemicelluloses and soluble carbohydrates produced during the process of manufacturing particle boards. It is primarily used as a pellet binder. It contains pentose sugar xylose which is toxic to non ruminants. It causes poor growth, diarrhoea and eye cataracts in pigs.

**ENERGY SUPPLEMENTS - FATS AND OILS**

- They contain 2.25 times more energy than carbohydrates and are concentrated sources of energy for animals.
- Fats are usually added to high-energy rations.
- Fats also increase the palatability of feeds and prevent the dustiness of feeds, acts as a lubricant in feed manufacturing and improves pelleting efficiency.
- Animal fats used in feeding are beef tallow, mixed animal fat and greese.
- Animal fats contain a high amount of saturated fatty acids and are less digested.
- Vegetable oil (sunflower oil, ground nut oil, etc) and marine oils (cod liver, Sardine) contain a high amount of unsaturated fatty acids and adding these oils to feeds may lead to the development of rancidity which can cause the destruction of a number of fat soluble vitamins. Rancidity can be prevented or reduced by adding a number of antioxidants (Vitamin E, BHT) to the feed.

**PROTEIN SUPPLEMENTS**

Protein supplements contains more than 18 % protein. They can be from animal origin or plant origin.

<table>
<thead>
<tr>
<th>Animal origin</th>
<th>Plant origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mostly over 47% protein</td>
<td>Mostly under 47% protein</td>
</tr>
<tr>
<td>Mostly over 1.0% Ca</td>
<td>Mostly under 1.0% Ca</td>
</tr>
<tr>
<td>Mostly over 1.5% P</td>
<td>Mostly under 1.5% P</td>
</tr>
<tr>
<td>Mostly under 2.5% fibre</td>
<td>Mostly over 2.5% fibre</td>
</tr>
<tr>
<td>Other sources includes NPN compounds, single cell protein etc.</td>
<td></td>
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</tbody>
</table>

**PROTEIN SUPPLEMENTS OF PLANT ORIGIN:**

Oil seed cake/meal & Leguminous seed  
**Commonly used oil cakes/meal in livestock feed are:**  
Groundnut or peanut oil meal  
Soybean oil meal  
Linseed Meal  
Coconut meal  
Cotton seed meal  
Safflower Meal  
Sunflower seed meal  
Mustard cake  
Sesame seed meal  
Rape seed meal  
Palm kernel meal, etc.,
Groundnut or peanut oil meal:

1) It is most widely used high protein feed that can be included upto 50% of the ration
2) It has about 45% protein and 10% oil in expeller variety
3) It is deficient in lysine, methionine and cystine
4) Particularly in warm rainy season liable to contain a toxic factor – Aflatoxin a metabolite of fungus *Aspergillus flavus*.

Aflatoxin can be produced at any stage from growing crop to the formulated feed. The greatest potential for mould spoilage and mycotoxin production is in the growing crop or stored raw material. The stressing of the plant by drought often results in cracked seeds favouring insect infestation. Thus the protective outer layer of the grain gets damaged and endogenous mould spores present within the grain or kernels are given access to oxygen, moisture and nutrients leading to mould growth. A wet period around harvest may result in the crop being harvested at a high moisture favouring mould growth and thereby toxin production. One of the greatest potential for mould growth and mycotoxin production is the storage of inadequately dried products. Out of four compounds designated afloxins B\(_1\), G\(_1\), B\(_2\), G\(_2\) of which B\(_1\) is the most toxic. There are considerable species differences in the susceptibility to these toxins, turkey poults and ducklings are highly susceptible, calves and pigs are susceptible while mice and sheep are classed as resistant. Young animals are more susceptible than adults of the same species. A common feature in affected animals is liver damage with marked bile duct proliferation, liver necrosis and in many cases hepatic tumours. Gastrities and kidney disfunction are the other symptoms.

Soybean oil meal:

1) The protein (44%) contains all the indispensable amino acids, but the concentrations of cystine and methionine are sub-optimal.
2) The cake is used for all kinds of livestock including poultry upto 30% of the ration.
3) As with most other oil seeds, soyabeans have a number of toxic, stimulatory and inhibitory substances. For example
   i) A goitrogenic material is found in the meal and its long term use may result in goitre in some animal species.
   ii) It also contains antigens, which are specially toxic to young pre-ruminants
   iii) Of particular importance in nutrition are the protease inhibitors of which six have been identified. Two of these, the *kunitz* anti-trypsin factor and the *Bowman-Brik* chymotrypsin inhibitor are of practical significance. Trypsin inhibitor affects the digestability of proteins specially in monogastric animals. These inhibitors will interfere with protein digestion, leading to poor growth rate, egg production and feed efficiency. This interference with protein digestion, leads to hypertrophy of pancrease and excess endogenous loss of essential amino acids.

Since, the trypsin inhibitors can be destroyed by heat treatment, proper heat treatment of the feed stuffs like soyabeen is essential, before feeding them to livestock and poultry.
A haemoglutinin, agglutinates red blood cell in rats, rabbits and human beings but not in sheep and calves.

Fortunately, these inhibitors and other factors like saponins are inactivated by proper heat treatment during processing.

4) Soyabees also contain genistein, a plant estrogen, which may account, in some cases for part of the high growth inducing properties.

**Linseed Meal:**

Linseed meal is unique among the oil seed residues in that it contains from 3-10% of mucilage. It is readily dispersible in water, forming a viscous slime. Immature linseed contains a small amount of a cyanogenetic glycoside, linamarin and an associate enzyme, linase, which is capable of hydrolysing it with the evolution of hydrogen cyanide. Normal processing conditions however, destroy linase and most of linamarin, and the resultant meals are quite safe.

The cyanogenetic glycosides or cyanogens are compounds that yield hydrogen cyanide (HCN) upon treatment with acid or hydrolytic enzymes. HCN is released when tissues of plants are crushed or otherwise disrupted. HCN is a potent respiratory inhibitor. The minimum lethal dose of HCN taken orally has been estimated between 0.5 to 3.5 mg/kg of body weight, depending on the species. Water washing, drying and storage will reduce the level of glycosides in the feedstuffs.

It has been reported that linseed meal has a protective action against selenium poisoning.

The protein of linseed meal is having a lower methionine and lysine content. Linseed meal has only a moderate calcium content but rich in phosphorus part of which is present as phytase. It is a useful source of Vitamin, riboflavin, nicotinamide, pantothenic acid and choline. Linseed meal can be included upto 10 % in poultry diet.

**Coconut meal (Copra meal):**

1. The crude protein content is low (20-26%) and poor in lysine and histidine.
2. The oil content of coconut meal various from 2.5 to 6.5% the higher oil meals tends to get rancidity and thus will cause diarrhoea. Hence low oil content type should be preferred.
3. Due to poor quality of protein and high fibre, its use should be restricted in swine and poultry rations. If it is fed to monogastric, it should be supplemented with lysine and methionine.

**Cotton seed meal:**

The protein of cotton seed meal is of good quality, but has the common disadvantage of oil seed residues of having a low content of cystine, methionine and lysine. The calcium content is low and as the calcium to phosphorus ratio is about 1:6 deficiencies of calcium may easily arise. Pigs and poultry do not readily accept the meal largely owing to its dry dusty nature. No such difficulty is encountered with lactating cows but complications may arise where large amounts are given, since the milk fat tends to become hard and firm and butter made from such fat is often difficult to churn and tends to develop tallory taints.
Cotton seed may contain from 0.3 to 20g/kg dry matter of a yellow pigment known as gossypol.

Gossypol is a polyphenolic aldehyde which is an antioxidant and polymerisation inhibitor and is toxic to simple stomached animals. The general symptoms of gossypol toxicity are depressed appetite and loss of weight, death usually result from circulatory failure. Addition of one per cent calcium hydroxide or iron salts to the diet decreases the Gossypol toxicity.

**Safflower Meal**

The meal is produced after removal of most of the hull and oil from safflower seed. In decorticated form it has about 40-45 per cent protein while the value goes down to about 18-20 if not decorticated. The 18-20 per cent protein safflower meals contains about 60 per cent hulls which limits its energy value and utilization in non-ruminants. Even the decorticated type contains about 14 per cent fibre. Safflower meal is low in lysine and methionine. It is always desirable that whenever safflower meal is fed to non-ruminants like pigs, it should be used in conjunction with other lysine rich protein concentrates.

**Sunflower seed meal:**

1) The meals are useful sources of protein (40%) which is low in lysine but has about twice as much methionine as does soya protein.

2) The meal is palatable but is laxative and has a very short shelf life.

The expeller variety of sunflower meal or cake tends to produce soft pork and it also makes the butter soft if fed in large amounts in cows because of the character of the oil it contains. This can be used in cattle ration and safely included at 20 per cent level.

**Mustard cake (Sarson)**

1) Widely used in many parts of India for cattle feeding

2) Nutritive value is much less than that of ground nut cake. D.C.P. and T.D.N. values are 27% and 74% respectively. It should preferably be mixed with other, more well-liked feeds. The deoiled type can be used for poultry upto 10 per cent of the ration and for pigs the amount may go as high as 20 per cent.

3) The calcium and phosphorus content are much higher, being about 0.6 per cent and 1.0 per cent.

**Sesame seed meal** (Til Cake)

Sesame seed meal is produced from what remains following production of oil from Sesame seed and the meal is extensively used for all classes of livestock including poultry. Contains about 40% protein rich in leucine, arginine and methionine and low in lysine. There are three varities – white, black and red. Nutritive value is highest in white while lowest in red variety.

**Rape seed meal / Cannola seed meal**

Contains more fibre (14%) with low ME Though low in protein content than soyabean meal, the balance of essential amino acid, Calcium : Phosphorus are favourable. Grown in
Europe fed to pig and poultry, contains glucosinolates which may lead to goitre, liver and kidney disfunction.

**Palm kernel meal**

Low in protein with poor amino acid balance. The ratio of Calcium to Phosphorus is more favourable than any other oil seed meal. The meal is dry and gritty and is not readily eaten. It has the reputation of increasing the milk fat content.

**LEGUMINOUS SEED:**

**Beans:**

Beans belong mainly to the vicieae and phaseoleae and are used as food for humans and animals all over the world. Beans are regraded primarily as sources of protein, which is of relatively good quality. This is a reflection of the amino acid composition which is characterised by a high lysine content, similar to that of fish meal protein, but by a low level of cystine and methionine which is lower than in the common animal and a vegetable protein sources.

**Peas:**

Peas are basically similar to beans but bare lower contents of crude protein (26% of dry matter) and crude fiber (<6% of dry matter.) The oil content is higher than that of beans but the degree of saturation is similar. Like beans peas are regraded primarily as a source of protein.

**ANIMAL PROTEIN CONCENTRATES**

1) Fish meal
2) Meat meal
3) Blood meal
4) Hatchery waste
5) Milk products

**Fish meal:**

Fish meal is the product obtained by drying and grinding whole fish or parts there of various species. Fish meals are produced in two ways. The first is by charging in steam jacketed vessels, which may be either a batch process carriedout under vaccum or a continuous process not employing reduced pressure. In both the cases heating is carriedout in steam jacketed vessels. In the flame drying process the meal is dried in a revolving drum by hot air from a furnace at one end of the drum.

The quality of the protein in fish meal is high. Processing conditions, particularly the degree and length of time of heating are probably the major derminant of protein quality. Fish meal protein has a high content of lysine, methionine and tryptophon and is a valuable supplement to cereal based diet. Fish meal has high mineral content (ca 8%, P 3.5%), good source of vitamin B complex and have an enhanced nutritional value because of their content of growth factor known collectively as the Animal protein factor (APF). Fish meal should be tested for salt content, as excessive salt may lead to salt toxicity in monogastric animals and birds. Fish meal should have minimum amount of scales, as their nitrogen content is of little value, since the scales are keratinised tissue. Fish meal should be tested for E coli bacteria.
The current trend in marketing of fish meal is towards specialised products tailored to suit particular species. Thus special low temperature meals are produced for aquaculture and for early weaned pigs, and ruminant grade products have strictly controlled levels of soluble nitrogen.

Fish meals find their greatest use with simple-stomached animals. They are used mostly in diets for young animals whose demand for protein and the indispensable amino acids is particularly high and for whom the growth-promoting effects of APF are valuable. Such diets may include up to 15% of fish meal. With older animals, which need less protein, the level of fish meal in the diet is brought down to about 5% and it may be eliminated entirely from diets for those in the last stages of fattening. This is partly for economic reasons since the protein needs of such animals are small, and partly to remove any possibility of a fishy taint development. Fully ruminant animals are able to obtain amino acids and B-vitamins by microbial synthesis and the importance of fish meal for such animals is as a source of undegradable protein. This is of particular importance for actively growing and pregnant animals. Rates of inclusion in the diet are usually about 5%. For lactating cows the daily intake of fish meal should be limited to not more than 1 kg. Above this the intake of oil could exceed 100 g/d resulting in detrimental effects on fermentation in the rumen.

**Squilla Meal:**

It is obtained from the fisheries industries and appears to be one of the promising by-products. This product is very rich in protein. Calcium content is very high, about 10 per cent while comparatively it contains low phosphorus, being 2.0 per cent only.

**Meat meal:**

It is the product obtained by drying and grinding carcasses and parts of carcasses of warm blooded land animals. It should be free from hair, feathers, horn, hoof and skin and contents of stomach and viscera.

Meat meal contains 60-70% protein with 9% fat, various unidentified beneficial factors have been claimed to be present in meat meal, among them. The entiric growth factor from the intestinal track of swine, the ‘Ackerman’ factor and a growth factor located in ash are important.

However, the low methionine and tryptophan levels in meals affect their protein quality.

**Liver Residue Meal:**

This can profitably be used as animal protein supplement in place of fish meal. Liver residue can be favourably introduced in poultry rations at 10 per cent level or at 5 per cent level along with the same level of fish as an animal protein supplement. A good quality of liver residue meal should contain about 65 per cent protein, 5 per cent lysine, 1.2 per cent methionine and 1 per cent cystine apart from other amino acids.

**Blood meal:**

Blood meal is a product obtained by drying the blood of slaughtered animals and poultry. Blood meal is a dark chocolate coloured powder with a characteristic smell contains about 80% protein, rich in lysine, arginine, methionine, cystine and leucine.

The meal is unpalatable and its use has resulted in reduced growth rates in poultry so that it is not recommended for young stock. For older birds, rates of inclusion are limited to about 1 to 2 % of the diet. It should not be included in creep foods for pigs. Normal levels of inclusion for older animals are of the order of 5% of diet and it is usually used along with a high quality protein source. At levels over 10 % of the diet it tends to cause scouring and is best regarded as a food for boosting dietary lysine levels.
Hatchery Waste:

**Incubator waste or Hatchery By-product Meal (HBPM):**

It is a mixture of eggshells, infertile and unhatched eggs which have been cooked, dried and powdered.

Broiler chicks when fed at levels of 3 or 6 per cent of the total ration with dried incubator waste proved a satisfactory substitute for fish meal or soyabean oil meal. Properly processed HBPM containing infertile eggs and eggs with dead embryos is found to replace 33 per cent fish meal and is a good supplement for increasing body weight of chicks.

Hydrolysed feather meal:

Product obtained by hydrolysing, drying and grinding poultry feathers is called as Hydrolysed feather meal.

The meal is of low palatability and must be introduced into the diet gradually. Dietary rates of inclusion are generally low, being of the order of 2.5 to 3.0 % of the total ration for adult ruminants, 2.5 % for layers, broilers and turkeys, and 1.0 % for calves, lambs, sows and growing and finishing pigs. The meal is not used for weaner and creep-fed pigs or chicks.

There is a risk of contamination of the base material with *Salmonella* and it is important that strict control of processing conditions should be maintained in order to minimize the risk of this in the finished product.

Milk products:

Skim Milk:

Skim Milk is a residue after the cream has been separated from milk has low fat content. Skim milk finds its main use as a protein supplement in the diet of simple stomach animals.

Whey:

When milk is treated with rennet in the process of cheese making, casein is precipitates and the remaining serum is known as whey. Whey has most of the β lactoglobulin. Whey find their main use as constituents of proprietary milk replacers for young calves.

**NON PROTEIN NITROGEN COMPOUNDS AS PROTEIN SOURCES (NPN):**

Non-protein nitrogen compounds are recognised as useful sources of nitrogen for ruminant animals. Their use depends upon the ability of the rumen microorganisms to use them in the synthesis of their own cellular tissues and they are thus able to satisfy the microbial portion of the animal’s demand for nitrogen and, by way of the microbial protein, at least part of its nitrogen demand at tissue level.
Urea:

It is a white, crystalline, deliquescent solid with the following formula:

\[
\begin{align*}
&/ \quad / \\
&\text{NH}_2 \\
&\text{C}=0 \\
&\text{NH}_2
\end{align*}
\]

Pure urea has nitrogen content of 46.6% which is equivalent to a crude protein content of 46.6 x 6.25 = 291%

Urea is hydrolysed by the urease activity of the rumen micro organisms with the production of ammonia. The ease and speed with which this reaction occurs when urea enters the ruminant gives rise to two major problems owing to excessive absorption of ammonia from the rumen. Thus wastage of nitrogen may occur and there may be a danger of ammonia toxicity. This is diagnosed by muscular twitching, ataxia, excessive salivation, tetany, bloat and respiration defects.

Urea should be given in such a way as to slow down its rate of breakdown and encourage ammonia utilisation for protein synthesis. The diet should also contain a source of readily available energy so that the microbial protein synthesis in enhanced and wastage reduced.

Urea, like other non-protein nitrogen sources, will not be used efficiently by the ruminant animal unless the diet does not contain sufficient degradable protein to satisfy the needs of its rumen microorganisms.

Although urea provides an acceptable protein source, there is evidence that where it forms a major part of dietary nitrogen, deficiencies of the sulfur-containing amino acids may occur. In such cases supplementation of the diet with a sulfur source may be necessary. An allowance of 0.13 g of anhydrous sodium sulfate/per gram of urea is generally considered to be optimal. Urea does not provide energy, minerals or vitamins for the animal, and when it is used to replace conventional protein sources care must be taken to ensure that satisfactory dietary levels of these nutrients are maintained by adequate supplementation.

To avoid the danger of toxicity, not more than one third of dietary nitrogen should be provided as urea, and where possible this should be in the form of frequent and small intakes.

Urea mixed in concentrates:

Most of the urea fed to growing and lactating dairy cattle is incorporated into the concentrate protein of the ration. Generally speaking, urea is employed in amounts not higher than 3% of the total concentrate fed or 1% of the total dry matter in the ration. The maximum safe limit is 136g of urea per animal over 260kg body weight.

Supplementation of the diet with a sulphur source may be necessary. Achieve a nitrogen, sulphur ratio not wider than 15:1. An allowance of 0.13g anhydrous sodium sulphate/g. of urea is generally considered to be optimal.
Urea is available in proprietary foods in several forms. It may be included in solid blocks which also provide vitamin and mineral supplementation and contain a readily available source of energy, usually starch. Animals are allowed free access to the blocks, intake. Intake being restricted by the blocks having to be licked and by their high salt content. There is some danger of excessive urea intakes, should the block crumble or should there be readily available source of water allowing the animal to cope with the high salt intakes. Solution of urea, containing molasses as the energy source and carrying a variable amount of mineral and vitamin supplementation are also in use. Like the blocks they contain 5-6% urea and about 25% sugar and are supplied in special feeders in which the animal licks a ball floating in the solution the animal thus has no direct access to the solution. Where urea is included in the concentrate diet thorough mixing is essential to prevent localised concentrations which may have toxic effects.

**Biuret:**

Biuret is produced by heating urea. It is a colourless, crystalline compound with the following formula.

\[
\text{NH}_2\text{Co-NH-Co-NH}_2
\]

It contains 40.8% nitrogen, equivalent to 255% of crude protein. Biuret nitrogen is not as efficiently utilised as that of urea, and it is very much more expensive.

**Poultry Litters:**

Despite aesthetic objections, dried poultry excreta have been successfully used for feeding ruminants. Poultry manures vary considerably in composition, depending upon their origins.

**Single-cell protein:**

In recent years there has been considerable interest in exploiting microbial fermentation for the production of protein. Single-cell organisms such as yeast and bacteria grow very quickly and can double their cell mass, even in large scale industrial fermentors, in three to four hours. A range of nutrient substrates can be used including cereal grains, sugar beet, sugar cane and its by-products, hydrolysates from wood and plants, and waste products from food manufacture. Bacteria such as _Pseudomonas_ sp. can be grown.

The protein content of bacteria is higher than that of yeast and contains higher concentrations of the sulfur-containing amino acids but a lower concentration of lysine. Single-cell protein (SCP) contains unusually high levels of nucleic acids, ranging from 5.0 to 12.0 % DM in yeast and 8.0 to 16.0 % DM in bacteria. Some of the purine and pyrimidine bases in these acids can be used for nucleic acid biosynthesis. Large amounts of uric acid or allantoin, the end-products of nucleic acid catabolism, are excreted in the urine of animals consuming SCP. The oils themselves are rich in unsaturated fatty acids. Although SCP does contain a crude fiber fraction, and this can be quite high in some yeast, it is not composed of cellulose, hemi-cellulose and lignin as in foods of plant origin; it consists chiefly of glucans, mannans and chitin.

In the case of poultry, dietary SCP concentrations of 2.0 to 5.0 % have proved optimal for broilers and 10.0 % has been suggested for diets for laying hens.
MARINE WASTES AND BY-PRODUCTS

Many countries have a long coastal belt and consequently many by-products are available from sea animals and weed industries. India has a long coastal belt, stretching 5,000km. Various by-products have recently been made available from fish / prawn / frog / shrimp industries.

Fish wastes:

The main types and quantity of the waste material available from fishing and fish processing industry (approximate quantity in tonnage) are: prawn shell and head wastes, 40,000; lobster wastes, 800; fish wastes, 3000; frog wastes, 5,000; shark-liver residue, 2,000; and squilla (caught in trawl nets along with prawn and fishes), 1,00,000.

In the seafood canning industry, prawns and shrimps are utilised for manufacturing frozen headless fish, peeled and deveined fish, cooked/frozen and semidried fish, dry fish pulp, etc. In processing, large quantities of shells are left out as wastes. A scientifically processed shrimp-meal has an average of 47 per cent protein and 27 per cent ash. A process of fish ensiling using surplus fish as animal feed has been developed.

Frog-meal:

Frog-meal is the left over of the frog leg industry. About 1,000 tonnes of this by-product is available annually in Kerala State. It can replace fish-meal twice by weight in poultry rations for growth and egg production. It contains about 60 per cent protein.

Prawn wastes:

Shrimp shell powder, a waste product of the shrimp processing industry, consists largely of discarded portions of shrimps like heads and crustacean stills. These wastes can be incorporated up to 15 per cent in the broiler ration when fish-meal is not available.

ROUGHAGES

SUCCULANT (Moisture 60-90%)  DRY (Moisture 10-15%)
Pasture – Natural, Cultivated.  Hay
Tree leaves.  Straw and Chaff dry fodder
Silages  Others – Corn cob, Cotton seed
Roots and Tubers  hulls, Sugarcane bagasse
Miscellaneous

Succulent Roughages  
Pasture

Natural  Cultivated

Permanent  Temporary
Natural pasture:

In India most of the grazing land are situated on the undulating and hilly areas and in semi arid and arid tracts. The Indian grass cover has been classified into five groups: They are:

1. Sehima-Dichanthium type :- Maharashtra, AP, T.N. Karnataka, Kerala, Orissa
2. Dichanthium – Cernchts – Lasiurus type :- Gujarat, Rajasthan, U.P. Delhi, Punjab and Haryana
3. Phragmites – Saccharum type :- Punjab, Manipur, Assam, Tripura, West Bengal, Bihar, U.P.
4. Themeda – Arundinella type :- Northern and North Western mountain track upto 2100 MSL.
5. Temperate Alpine type :- This type access at elevation above 2100 MSL

The grazing pressure in INDIA is 2.35 cow unit/ ha, whereas at Australia and New Zealand, it is 0.2 cow unit/ ha. - Needs to be augmented to cater the needs of our livestock.

Nutrients in the Pasture:

The composition of pasture dry matter is extremely variable; for example, the crude protein content may range from 3 per cent in very mature herbage to over 30 per cent in young heavily fertilised grass. The crude fiber content is inversely related to crude protein content and may range from 20 to as much as 40 per cent in very mature samples. Moisture content is high in early stages of growth (75 to 85%) and falls as the plant mature to about 60 per cent. The cellulose is between 20 to 30 per cent while hemicelluloses vary from 10 to 30 per cent. Both these polysaccharides increases with maturity; so also, does the lignin. The lipid content of pasture rarely exceeds 4 per cent of the dry matter. The mineral content varies with species, stage of growth, soil type, amount of fertiliser applied etc. Green herbage is exceptionally rich in carotene, the precursor of vitamin A and quantities as high as 55 mg per 100 grams of dry matter of young green crops. Nutritionally the legumes are frequently superior to grasses in protein and mineral content (particularly calcium, phosphorus, magnesium, copper and cobalt), and their nutritive value falls less with age.

Cultivated Fodder Crops

In the absence of sufficient grazing ground of good quality for maintaining cattle, sheep, goat on pasture all the year round, the importance of growing fodder crops to provide feed economically for production of milk and for draught animals, need no special emphasis. For the sake of convenience, these are classified into two groups – leguminous and non-leguminous. Among leguminous fodders, cowpea (Vigna catjang), cluster bean (Guar; Cyamopsis psoraloides), are the most common kharif leguminous crops. They contain from 2-3 per cent D.C.P. and about 10 per cent T.D.N. on fresh basis and yield about 10 tones of forage per acre. Berseem (Trifolinum alexandrinum) and lucerne (Medicago sativa) are two other common leguminous fodder in India. The former is an annual crop, grown during the rabi season; the latter is a perennial one having maximum growth in winter and spring but is retarded during the monsoon. Both these crops can yield over 3 tones per acre in 5-6 cutting. The disadvantage is that, both the fodders are liable to produce “bloat” if given in large quantities and thus it is advisable that they should always be given along with some dry fodder. Lucerne and berseem contain on an average 2.5 to 3 per cent D.C.P. and 12 per cent T.D.N. on fresh basis. The phosphorus content of these two forages are poor and thus have wide calcium to phosphorus ratio. It is advisable to supplement a ration containing a large amount of leguminous fodder with a limited quantity of wheat or rice bran.
Among non-leguminous fodder jowar (Sorghum vulgare), maize (Zea mays) and sudan grass (Sorghum sudanense) are most common kharif fodder. Yield ranges from 10-20 tones per acre. Most of the fodders belonging to this group (non-legume kharif) are having 0.5-1 per cent D.C.P. and 11-15 per cent T.D.N. except maize, which is the nutritious of all, having 1 per cent D.C.P. and 17 per cent T.D.N. on fresh basis. Among the Rabi non-leguminous fodder crops, oats (Avena sativa) and barley (Hordeum vulgare) are the most important. Of these two, oat is by far excellent for milch cattle. It has 2 per cent D.C.P. and 17 per cent T.D.N. on fresh basis. Non-leguminous perennial fodder crops consists of Napier grass (Pennisetum purpureum), Hybrid Napier grass (cross between Napier and Bajra), Guinea grass (Panicum maximum), Para grass (Brachiariamutica). All these grasses flourish vigorously during summer and rainy seasons. About 4-6 cuttings can be taken under north India conditions so that an annual yield of 30-40 tonnes per acre is the yield. Two to three animals can be maintained per acre on these grasses.

PROBLEMS ASSOCIATED WITH FODDERS

Cyanogens
Nitrates and nitrites
Saponins
Sweet clover disease:
Refer the chapter on “Anti nutritional factors” for details

TREE LEAVES

The utilization of tree leaves for feeding to livestock is not common. They are, however, used for feeding sheep and goats, and are sometimes fed to cattle during periods of fodder crisis.

Nutritive value

The dry matter content varies from 20 – 40%. Tree leaves generally contains 6 - 15 % crude protein on dry matter basis. The leguminous tree leaves contains relatively higher crude protein. Early stages of their growth leaves contain fairly high amount of crude protein and a comparatively low percentage of crude fiber. As maturity progresses, there is a gradual decrease in protein content with a concomitant increase in crude fiber. The tree leaves and shrubs are generally rich in calcium but poor in phosphorus. Tree leaves of same species show wider variations in chemical composition due to season of lopping, locality.

Feeding Tree leaves

Since tree leaves contains tannin, it is better to restrict the level of feeding tree leaves (on dry matter basis) to less than 30% of the total dry matter intake in the case of cattle and sheep. Goats however, can consume tree leaves at higher level as they have Tannase (enzyme to detoxify tannin) in their saliva. It is advisable to feed wilted tree leaves than freshly lopped leaves, as wilting helps in reducing the anti nutritional factors as well increases the palatability.

Recommended practice for lopping tree leaves

- Fresh leaves should not be lopped as they are often toxic and there by nature’s device for protection.
- Sapling and poles should not be lopped.
- Lopping may be restricted to lower two third of the crown, protecting the upper one third which can manufacture the food for plants till new leaves come up.
• At the time of lopping branches having a diameter of over 7.5 cm may be avoided.

Some of the commonly fed tree leaves are: Acacia species, Delbergia sissoo, Ailanthus excelsa, Jack leaves, Neem leaves, Subabul, Luceana lecocephala Ficus species leaves, oak leaves, Bauhinia leaves, etc.

PROBLEMS ASSOCIATED WITH TREE LEAVES

Tannins, Mimosine, Refer the chapter on “Anti nutritional factors” for details

ROOTS AND TUBERS

Roots

A root crop consists of the fleshy subterraneous (under ground) part of the harvested plant. The main characteristic of roots are their high mixture content (75-94%) and low Crude fibre (4-13%). The organic matter of root, consists mainly of sugars, roots are generally low in crude protein ex. turnipe, beet, carrot etc.

Turnips

Contain 7-13% crude protein and the main sugar being sucrose, turnips are liable to stain the milk, if given to dairy cows at or just before milking time. The volatile compound responsible for the taint is absorbed from the air by the milk.

Fodder beet

Carne is required in feeding cattle on fodder beet since excessive intakes may course digestive upsets, hypocalcaemia and even death. The digestive disturbances are probably associate with high sugar content.

Carrot

Carrots are particularly favoured as a food for horses.

Tubers

Tubers are short thickened, fleshy stems, usually formed underground such as potatoes, cassava, sweet potatoes etc. Tubers differ from the root crop in containing either starch or fructorse instead of sucrose. The have higher dry matter and lower crude fibre content and consequently are more suitable than roots for feeding pig and poultry.

Potatoes

The crude protein content is approximately 11% about half of this being in the form of non protein nitrogenous compounds, one of these compounds is the alkaloid ‘Solaridine’. Solanidine and its derivatives are toxic to animals, causing gastroenteritis. Green potatoes should be regarded as suspects, although removal of the eye and peel, in which solandine is concentrated will reduce toxicity. Raw potatoes have a protease inhibitor which is destroyed on heating.
Cassava

Cassava tubers are used for production of tapioca starch for human consumption, although tuber is also given to cattle, pig and poultry. Cassava tubers contain two cyanogenic glucosides (linamarin and lotaustralin), which readily break down to give hydrocyanic acid. Boiling or grating and squeezing or grinding to a powder reduces the toxicity.

STRAWS AND CHAFF

Straws consist of the stem and leaves of plants after the removal of the ripe seeds by threshing and are produced from most cereal crops and from some legumes chaff consists of the husk or glumes of the seed which are separated from the grain during threshing. These products are extremely fibrous, rich in lignin and of extremely low nutritive value. They should not be used as pig or poultry food.

Paddy straw

It has an exceptionally high ash content about 170g/kg of dry matter, which consists mainly of silica. The lignin content of this straw, about 60-70g/kg dry matter is however lower than that of other cereals straw. In contrast to other straws, the stems are more digestible than the leaves.

The poor nutritive values of straws may be attributed to the following facts.

1) The digestibility of straw is limited due to the formation of strong physical and/or chemical bonds between lignin and the structural polysaccharides (Hemi-cellulose). Although cellulose by itself has a highly ordered crystalline structure, it has a very strong association with lignin, with the result that even the most potent cellulosic enzymes cannot have easy access to the cellulose unless the bondage between lignin and cellulose is broken.

2) Crystalline structure of cellulose is also responsible for low digestibility of cellulose.

3) Highly deficient in other nutrients like minerals, vitamins, fatty acids and in proteins. The minimum crude protein requirement for efficient lignocellulose break down of roughages fed as the sole diet is claimed to be from 3.8 to 5.0%.

4) High silica content of straw is known to depress organic matter digestibility.

In some cases, it is economical to increase the nutritive values of all types of poor quality roughages by physical chemical or biological treatment.

Model questions

5. Cereals are rich in
   A. Calcium    B. Iron
   C. Copper     D. Phosphorus

   i. C is correct    ii. D is correct    iii. A is correct    iv. B is correct
6. The available phosphorus is present largely in
A. Soyabean
B. Groundnut cake
C. Fishmeal
D. Maize
i. A and B are correct
ii. D is correct
iii. C is correct
iv. None are correct

7. The cereal grains are essentially
A. Fat concentrates
B. Carbohydrate concentrates
C. Fiber concentrate
D. Protein concentrates
i. C is correct
ii. B is correct
iii. A is correct
iv. D is correct

8. Yellow maize contain a pigment which is a precursor of Vitamin A that is
A. Cryptoxanthene
B. Phythogunine
C. Xanthphyll
D. Chlerophyll
i. B and C are correct
ii. D is correct
iii. A is correct
iv. C and D are correct

9. The Crude protein content of cereals ranges from
A. 2–4%
B. 5–7%
C. 8–12%
D. 13–15%
i. A is correct
ii. C is correct
iii. D is correct
iv. B is correct

10. The crude fiber content of oats ranges from
A. 2–5%
B. 6–9%
C. 10–18%
D. 19–22%
i. A and B are correct
ii. D is correct
iii. C is correct
iv. None are correct

11. The mixture of protein present in the endosperm of the wheat is often referred to as
A. Gluten
B. Glum
C. Mucilage
D. Compound protein
i. C and D are correct
ii. B is correct
iii. A is correct
iv. D is correct

12. The feed ingredient Bajra can be fed
A. As whole grain
B. Along with bran
C. After grinding
D. Mixed with maize
i. A is correct
ii. B is correct
iii. C is correct
iv. D is correct
13. Millets are cereals which has higher percentage of
A. Fiber  B. Protein  C. Fat  D. Minerals
i. C and D are correct  ii. B and C are correct  iii. A is correct  iv. B is correct

14. Flaked maize decrease the proportion of acetic acid to pripionic acids in the rumen and thus bufferfat content of milk
A. Depressed  B. Increased  C. Maintained  D. No effect
i. C and D are correct  ii. None are correct  iii. B is correct  iv. A is correct

15. Hull can be utilized as such for feeding of
A. Cattle  B. Sheep  C. Goat  D. Pigs
i. A and B are correct  ii. B and C are correct  iii. D is correct  iv. None are correct

16. Feeding of optimal level of molasses in ruminants
A. Simulates Rumen microbial activity  B. Reduces microbial activity  C. Leads to Tympacy  D. Causes Diarrhoea
i. A is correct  ii. B is correct  iii. C is correct  iv. D is correct

17. The common adulterant found in bran is
A. Sand and Silica  B. Husk  C. Broken wheat  D. Broken rice
i. C is correct  ii. D is correct  iii. A and B are correct  iv. None are correct

18. Animal origin protein supplements contain protein level
A. Mostly above 45%  B. Between 30% and 40%  C. Less than 20%  D. Between 20% and 30%
i. None are correct  ii. C and D are correct  iii. A is correct  iv. B is correct

19. Oil seed meal usually have high content of
A. Phosphorus  B. Calcium  C. Copper  D. Fiber
i. C and D are correct  ii. B and C are correct  iii. B is correct  iv. A is correct
20. Soyabean meal can be included in the ration of livestock and poultry in the range of
A. 10–15%  B. 20–30%
C. 5–9%     D. 31–40%
i. A is correct   ii. B is correct  iii. C is correct   iv. D is correct

21. Cotton seed meal is not readily accepted by pigs and poultry due to
A. Gossipol  B. Dry dusty nature
C. Poor palatability  D. Colour
i. C and D are correct  ii. A is correct  iii. B is correct  iv. None are correct

22. Sunflower seed meal can be included safely in the ration cattle at
A. Upto 20% level  B. 40% level
C. 50% level  D. 60% level
i. A is correct  ii. B is correct  iii. C is correct  iv. D is correct

23. Fishmeal should be tested mainly for its
A. Protein content  B. Salt content
C. Fiber content  D. Antivitamin factors
i. A and B are correct  ii. C is correct  iii. D is correct  iv. None are correct

24. Blood meal can be included in the ration of poultry at
A. 1–2%  B. 3–5%
C. 6–8%  D. 9–12%
i. A is correct  ii. B is correct  iii. C is correct  iv. D is correct

25. Urea is included in the ration of lactating cows not higher than
A. 3% of total concentrate  B. 2% of total consumption
C. 1% of total consumption  D. 4% of total consumption
i. A is correct  ii. B is correct  iii. C is correct  iv. D is correct

26. While feeding urea in ruminants diet should be supplemented with
A. Sulphur  B. Calcium
C. Phosphorus  D. Iron
i. D is correct  ii. B and C are correct  iii. A is correct  iv. None are correct
27. Single cell protein usually contain high level of
A. Fiber  B. Calcium
C. Nucleic acid  D. Iron
i. A and B are correct   ii. D is correct   iii. C is correct   iv. All are correct

28. Example of succulent feed is
A. Hay  B. Chaffed dry fodder
C. Roots and tubers  D. Bagasse
i. A is correct   ii. D is correct   iii. B&C are correct   iv. C is correct

29. Feeding of ground nut cake causes
A. Increase in milk yield  B. Decrease in milk yield
C. Soft butter fat  D. Hard butter fat
i. A and C are correct   ii. C is correct   iii. A is correct   iv. D is correct

30. The lipid content of the pasture rarely exceeds
A. 4% of the DM  B. 2% of the DM
C. 6% of the DM  D. 0.5% of the DM
i. A is correct   ii. C is correct   iii. D is correct   iv. B is correct

31. Leguminous fodder are
A. Jowar and casasava roots  B. Cowpea and cluster bean
C. Berseem and Lucerne  D. Sudan grass and maize
i. B and C correct   ii. A is correct   iii. D is correct   iv. A & B are correct

32. HCN toxicity can occur while feeding
A. Sorghum  B. Lucerne
C. Berseem  D. Cluster bean
i. B & D are correct   ii. None are correct   iii. A is correct   iv. C is correct

33. Nitrate toxicosis is more serious in
A. Poultry  B. Ruminants
C. Dogs  D. Horse
i. B is correct   ii. A & C are correct   iii. C is correct   iv. D is correct
34. “Sweet clover disease” is characterised by a fatal haemorragic condition in
A. Dogs          B. Cats
C. Cattle        D. Poultry
i. B is correct  ii. C is correct  iii. A is correct  iv. A & B are correct

35. As maturity progress in Tree leaves, there is gradual
A. Decrease in crude protein content and increase in crude fiber content
B. Decrease in crude fiber content and increase in crude protein content
C. Decrease in crude fiber content and decrease in crude protein content
D. Increase in crude fiber content and increase in crude protein content
i. A is correct  ii. B is correct  iii. C is correct  iv. D is correct

36. In tree leaves the ratio between calcium:phosphorus is
A. Optimum          B. Narrow
C. Wide            D. Equal
i. A is correct  ii. B is correct  iii. C is correct  iv. D is correct

37. ‘Top feed’ resources includes
A. Paddy straw     B. Grass
C. Tree fodder     D. Cereal fodder
i. A & B are correct  ii. C & D are correct  iii. C is correct  iv. D is correct
CHAPTER IV

ANTI-NUTRITIONAL FACTORS IN FEEDS AND FODDERS

Anti-Nutritional Factors in Animal feed stuffs:

Anti-nutritive substance are defined as “those generated in natural feedstuffs by the normal metabolism of the species from which the material originates and by different mechanisms exerting effects contrary to optimum nutrition”.

Type of Anti-Nutritive substances

On the basis of the type of nutrient affected and the biological response produced in the animal of the toxic factors can be classified into five major groups as follows:

1) Substance depressing digestion or metabolic utilization of protein:
   a) Protease inhibitors
   b) Lectins or Ricin (hemagglutinins)
   c) Saponins
   d) Polyphenolic compounds (TANNINS)

2) Substance reducing the solubility or interfering with the utilization of mineral elements:
   a) Phytic acid
   b) Oxalic acid
   c) Glucosinolates
   d) Gossypol

3) Substance inactivating or increasing the requirements of certain vitamins and hormones:
   a) Antivitamins A, D, E, K and anti-pyridoxine
   b) Minosine (Anti hormone)

4) Cyanogens

5) Nitrate and Nitrate

6) Moulds and mycotoxins in animal feedstuffs

Substance depressing digestion or metabolic utilization of proteins:

a) Protease inhibitors:

Substance that inhibit proteolytic enzymes and thereby growth and non-ruminants are distributed throughout the plant kingdom but are particularly abundant in seeds and legumes. In the case of soyabees identification of two main groups or protease inhibitors have recently been made namely: (1) Kumitz inhibitors have few disulphide bonds and a specificity towards trypsin (2) Bowman-Brik inhibitors have a high proportion of disulphide bonds, inhibiting both trypsin and chymotrypsin. Feeding raw soyabees to pigs, chicks and rats have resulted growth rate pancreatic hyperplasia and low production. Although ruminants are capable of utilising raw soyabees without suffering any deleterious effects, a better response in milk production and growth rate in obtained on diets containing treated soyabean. The inhibitory substances are mostly heat labile and thus before feeding any leguminous grain to non-ruminants, the situation is generally corrected by proper heat treatment. Since overheating can damages some nutrients, such as amino acids and vitamins, quality control tests have been developed to assess the adequacy of heat treatment. These includes trypsin inhibitor and unease assays, cresol red absorption, protein dispersibility (index) PDI) and nitrogen solubility index (NSI).
b) Lectins or ricin (hamagglutinin): 

This important group of anti-nutritional factor are found in both plant and animal tissue. At first, while studying the toxicity of castor been cakes (after the oil had been extracted) a toxic fraction capable of agglutinating human red blood cells was noted as “ricin”. Subsequently, similar active extracts from other edible legume seeds were obtained. Lectin are protein in nature, resistant to digestion by pancreatic juice. Although very resistant to destruction by dry heat, lectins are destroyed by the same conditions as those used to inactive protease inhibitors.

c) Saponins

The important common forages which have caused saponin poisoning of livestock are Lucerne, White clover, red clover and soyabean Saponins or Sapogenins are either steroids or triterpenoids, which are the break down products of certain glycosides found in soyabean, peas, alfalfa and certain varieties of beans. They are bitter in taste, lather forming and inhibit the action of proteolytic enzymes and cholinesterase. They also causes haemolysis of red blood cells. Water soaking and rinsing will remove them components in the feedstuffs. Chemically saponins are glycosides which on hydrolysis yield sugars such as pentoses, hexoses and uronic acids and aglycaons (Derivatives of polycyclic ring system.) Among forages saponins occur mainly in legumes such as alfalfa, clovers and Leucaena. Alfalfa and Leucaena saponins are present in leaves, stems, roots and blossoms of the plant to an extent of 2 to 3 per cent.

Adverse Actions upon Excessive Eating:
1) In ruminant saponins have been suggested as being involved in formation of bloat by altering the surface tension of the ruminant contents due to entrapment of countless bubbles of fermentation gases throughout the ingesta.
2) It also increases the respiratory rate which later on becomes irregular.
3) Saponins also have found to inhibit the actions of certain enzymes. E.g., x-chymotrypsin.
4) The compound has got the ability to lyse red blood cells.
5) In general the effects of ingestion of saponins include excessive salivation, increased respiratory tract secretion, gastroenteritis, vomiting, diarrhoea, haemolysis, haematuria, damage to livers and kidney tissues, cystitis, bloating, reduction of gastric motility, reduction of cholesterol absorption from the gut, lowering of blood and liver cholesterol levels, reduction of food intake, reduction of growth rate.

d) Polyphenolic compounds (tannins):

Definition:

Also known as tannic acid, gallotannin and gallotannic acid. It is now defined to include those naturally occurring compounds having high molecular weight (500-3000) and containing a sufficiently large number of phenolic hydroxyl groups (1 to 2 per 100 molecular weight) to enable them to form effective cross-links between proteins and other macromolecules.

Types of Tannins:

Chemically tannins may be grouped two broad categories: (1) Hydrolysable tannin and (2) Condenced tannins. Most tannins extracts appear to contain mixture of both the types of tannins but generally one or the other predominates at least in any given part of the plant.
Properties of Tannins:

1. The most important property of tannins is undoubtedly their capacity to bind proteins; they are thus inhibitors of enzymes.

2. The low palatability of some herbage plants such as cotton grass (Imperata cylindrica) and of some grains as has already mentioned have been attributed to their high tannin content.

3. They are also markedly astringent – that is they cause a dry or puckery sensation in the mouth, probably by reducing the lubricant action of the glycoproteins in the saliva.

4. The presence of tannins in a feedstuff has been assumed to affect voluntary intake as it cause a dry or puckery sensation in the mouth, probably by reducing the lubricant action of the glycoprotein in the saliva. High tannin content also depress cellulose activity and thereby affects digestion of crude fibre. Besides, tannins may cause loss of mucus, epithelial edema, irritation and damage of alimentary canal tissue, which in turn facilitate greater tannin absorption, thus causing toxicity.

Substance reducing the solubility or interfering with the utilization of mineral elements:

a) Phytic acid:

Phytates are the salts of phytic acid. Phytic acid is formed due to combination of six phosphate molecules with Inositol, a cyclic alcohol with six hydroxy radicals like that of hexose sugar. The anionic character of phytase makes it ideal for forming complexes with mineral elements particularly the transitional element such as zinc, iron and manganese resulting the minerals insoluble in the intestinal tract. Solubility of these complexes mainly varies with pH, and calcium ion concentration, e.g. Calcium enhances the formation of Zn-phytate complex. The effect of pH on solubility is particularly significant as because pH 6 is the approximate pH of the duodenum and upper jejunum the size of absorption of heavy elements including zinc. Neither phytate nor the zinc-phytate or calcium-Zn-phytate complex are absorbed under this pH range.

About half of more of the phosphorus in cereal grains is in the form of phyrin. The availability of phytin phosphorus to all non-ruminants is influenced by the level of vitamin D, calcium, the calcium to phosphorus ratio, amount of zinc in the feed, alimentary tract pH and other factors. How vitamin D specifically acts in improving the utilization of phytin phosphorus is not clear. In ruminants, the selected ruminal microbes are in a position to hydrolyse phytates by secreting the enzyme phytases so that it no longer binds are mineral as mentioned. Thus ruminants can utilize phytin phosphorus satisfactorily. For non-ruminants supplementation with adequate minerals (which are affected by phytates) is the useful practice followed to-day in livestock feeding to overcome the adverse effect of phytates.

b) Oxalic acid:

In both the vegetable and animal kingdoms oxalic is found as free and in salt forms. Plants which are particularly rich in oxalates include beet, spinach and a number of agro-industrial by-products used as livestock feed ingredient. Oxalic acid (oxalate) poisoning of livestock household pets and people is of important throughout the world. Oxalic acids is an organic dicarboxylic acid that readily forms insoluble salts with calcium ad magnesium. Oxalate is apparently split to carbon dioxide and formate and the hydrogen from formic acid is used to synthesis methane. Oxalate degrading aerobic bacteria have been isolated from rumen content. Bacterial degradation of oxalate to a non-toxic form and this tolerance for oxalate are acquired
by gradually increasing the quality of oxalate-containing plant material. Increased degradation rates were also induced by intra-ruminal infusion of sodium oxalate. When the dietary amount exceeds certain level, normal degradation is interrupted and the excess oxalate combine with feed calcium to form insoluble calcium oxalate and then become unavailable for absorption or excess oxalate (20-30 mg per cent) may be absorbed from the rumen into the blood stream where it can combine with calcium to produce hypocalcemia. The insoluble calcium oxalate may then crystalise in various tissue, specially kidneys and rumen wall.

c) **Glucosinolates (Thioglicosides):**

Glucosinolates are responsible for the pungent flavour found in some cultivated plants belonging to the *Cruciferae*, specially the genus *Brassica*, which includes cabbage, turnips, rapseed, mustered seed. Their main biological effect is to depress the synthesis of the thyroid hormone (Tryroxine and Triiodothyronine), thus producing goitre, although the later is not caused by the glucosinolates *per se* but by their products of hydrolysis. The glucosinolates occur in the root, stem, leaf and seed and are always accomplished by the enzyme *thioglucosidase*, which is capable of hydrolysing then to glucose, acid sulphate and either thiocyanates, isothiocyanates or nitrate. Some of the isothiocyanate are subsequently cyclised to oxazolidine-2-thiones (OZT). It is interesting to note that thioglucosidase is also present in some intestinal bacteria and is important when intact glucosinolates are fed to animals. In contrast, ruminants appear to be less susceptible to the toxic effect of glucosinolates compared with pigs and poultry. This is probably the result of the glucosinolates being relatively unhydrolised in the rumen. When feed containing goitrogenic substance are fed in excessive quantities but are soaked or cooked in water, the disease (goiter) is much less likely to develop as the cooking process eliminates the enzyme. An adequate supply of iodized salt in another preventive measure specifically in areas where non-ruminants consume goitrogenic substances in a large dose. For treatment a daily injection of thyroxide @ 0.1 to 0.3 mg is advocated.

d) **Gossypol**

Gossypol pigments are polyphenolic compounds found exclusively in the pigment glands of cottonseed. At least 15 such pigments have been identified in extract of both cottonseed meal and oil, but the most predominant is the yellow (*C*₂₇*H*₃₀*O*₈). These pigments can exist either in a free form or as gossypol-protein complex. Whole seeds contain a total of 1.09-1.53 g/100g, of which an average of 0.19 g/100 g exists in the free form. Decorticated seed contain a total of approximately 2 g/100 g, of which 0.15 g/100g is in the free form. The physiological effects of free gossypol, in addition to reduced appetite and loss of body weight, include accumulation of fluid in the body cavities, cardiac irregularity, reduced oxygen carrying capacity of the blood and an adverse effect on certain liver enzymes. Pigs and rabbits appear to be more sensitive than poultry where 0.06 per cent gossypol in the diet can depress growth in young chickens. In laying birds, 0.15 per cent of free gossypol reduce egg production. In the case of pigs a dietary level of 0.01 per cent reduces growth rate. The toxic effects of gossypol can be overcomes by supplementing the diet with iron in the form of ferrous sulphate.

**Substance inactivating or increasing the requirements of certain vitamins and hormones:**

**Cyanogens**

Cyanide in trace amount is fairly widespread in the form of glucosides and relatively high levels can be found in certain grasses such as ‘jowar (sorghum) and sudan grass, linseed maize and cassava root. These plants generally contain cyanogenetic glycosides, which can be hydrolysed to prussic acid by the enzyme usually present in the sample plant under a number of conditions during their growing period, or as they are being digested by animals. Maize linseed,
jowar, sudan grass may develop toxic levels of prussic acid also known as hydrocyanic acid (HCN) in the new growth that follows either a period of drought, or a period of heavy trampling or physical damage by frost etc. Heavy nitrate fertilisation of the soil followed by an abundant irrigation or rainfall may increase the prussic acid poisoning potential of these crops. Note that the grasses mentioned so far are not abused in any way if growing conditions are favourable. In plants the glucoside is non-toxic in the intact issues and as stated earlier, when the plants are damaged or begin to decay, hydrolytic enzyme from the same plant is released liberating HCN. This reaction can take place in the rumen by microbial activity. The HCN is rapidly absorbed and some is eliminated through the lungs, but the greater part is rapidly detoxified in the liver by conversion to thiocyanate. Excess cyanide ion can quickly produce anoxia of the central nervous system through inactivating the cytochrome oxidase system, and death can result within a few seconds. Based on the intensity animals show nervousness, abnormal breathing, trembling or jerking muscles, blue colouration of the lining of the mouth, spasms or convulsions and respiratory failure. Animals which have not shown much evidence of toxicity may be injected intravenously with 3 g of sodium nitrate and 15g sodium thiosulphate in 200 ml H2O for cattle, for sheep, 1g sodium nitrate and 2.5 g sodium thiosulphate in 50 ml H2O. Ruminants are more susceptible to HCN poisoning than are horses and pigs, because in the latter two species the enzyme concerned in the release of HCN is destroyed by the gastric HCl.

Nitrates and nitrites

Forages and drinking water when contaminated with inorganic nitrates and nitrites cause an acute toxicosis in cattle resulting from formation of methemoglobin (a true oxidation product of haemoglobin) which is unable to transport oxygen because the iron is in the ferric (Fe+++), rather than the usual ferrous (Fe+++) state. The situation is more common in forages where either nitrogenous fertilizers have been used at a very high dose or the forages have been harvested at a very early stage of their growth. It appears to be a more serious problem in the ruminant since nitrates are reduced to the more toxic nitrites in the rumen. If the amount is not much, nitrite is reduced to ammonia. When excess nitrate is ingested, the toxic nitrite may accumulate and absorbed from the rumen because the activity of nitrate reductase exceeds that of nitrite reductase. The rates of nitrate and nitrite reduction by a given population of ruminal microbes appears to depend upon the supply of fermentable energy sources which supply hydrogen for the reduction. A high dose of concentrates in the daily ration and adequate feeding or Vitamin A have a protective effect. Symptoms seen in acute toxicity include laboured breathing (dyspena), grinding of the teeth, uneasiness and excessive salivation.

Mimosine

Mimosine is a toxic amino acid, also called as ‘leucenine’ found in the plants belonging to the genus Leucaena like subabul. This toxic substance mimosine can cause problems when the forage is eaten in large quantities for a long period. Mimosine is a powerful depilatory agent that cannot be degraded after absorption. But it can be extensively degraded to Dihydroxy pyridone (DHP) in the rumen. Excess DHP is absorbed into the blood stream, reaches thyroid gland and inhibits biosynthes of the hormone thyroxine. Acceptable safe daily intake of mimosine was calculated to be 0.14% g/kg body weight. Among the various livestock, horses, sheep, pigs and even rabbits are highly sensitive to mimosine and thus subabul should not be fed to them. The main symptoms are reduced growth and weight loss, excessive salivation, loss of hair, eroded gums, enlarged thyroid gland and poor reproductive efficiency. Sun dried leucaena leaf meal contains 3.2% of mimosine. Ferrous sulphate supplementation also reduce the mimosine toxicity, by forming insoluble red iron complex. Certain strains of rumen microbes at Australia capable of detoxifying mimosine have been identified and are now being inoculated to livestock of other nation to overcome mimosine toxicity.
Substance inactivating or increasing the requirements of certain vitamins:

(a) Anti Vitamin A:

Raw soyabean contain an enzyme Lipooxygenase, which catalysis oxidation of carotene, the precursor of vitamin A. It has been noted that 30 per cent of ground, row soybeans in the diet of dairy calves products of sharp lowering of vitamin A and carotene in blood plasma. The enzyme can be destroyed by heating soyabean for 15 minutes with steam at atmospheric pressure.

(b) Anti-Vitamin B:

Rachitogenic activity of isolated soya protein (unheated) has been founded with chicks and pigs. The effect could be partially eliminated by increasing the vitamin D in the diet by 8-10 fold. Autoclaving eliminates this rachirtogenic activity.

(c) Anti-Vitamin E:

The author while working his Ph.D. programme at Cornell University in USA observed that diets containing raw kidney beans (Phaseolus vulgaris) produce muscular dystrophy in lambs by reducing plasma vitamin E. Alcohol extraction of the beans reveals two factors with anti-vitamin E activity, one being alcohol soluble and heat-stable, the other being neat-labile and alcohol-insoluble. By autoclaving beans the anti-vitamin activity is eliminated.

(d) Anti-Vitamin K:

“Sweet clover disease” is characterized by a fatal haemorragic condition in cattle and has been known for over 20 years. The active principle responsible for this disease is dicoumarol, which reduces the prothrombin level of the blood, thus interfering with the blood clotting mechanism. The effect is due to reducing vitamin KL utilization in the production of thrombin.

(e) Anti-pyridoxine:

It has been demonstrated that the nutritive value of linseed meal for chicks can be considerably improved after extracting the meal with water and autoclaving. An antagonist of pyridoxine (a member of B Vitamins) from linseed which has been identified as 1-amino-D-proline and occurs naturally in combination with glutamic acid as a peptide is known as linatine.

Moulds and mycotoxins in animal feed stuffs:

A mycotoxin is a fungal metabolite causing pathological or physiological changes in man or animal. Mycotoxins are highly toxic, small molecular weight, compounds non-antigenic secondary frugal metabolites that alter physiological response in higher animals regardless the route of administration. Aflatoxins are the most potent toxic, mutagenic, teratogenic and carcinogenic metabolites produced by the species of Aspergillus flavus and A.parasiticus on food and feed materials. Aflatoxins B1, B2, G1 produce liver cancer in cats. The occurrence of these toxins in food and feed materials and their consumption has caused not only health hazards in animals and humans, but also resulted in economic losses, especially to the exporting countries. Other fungal toxins include T2 toxin, Ochratoxin A and Zearalenone.
38. Pink colored discoloration of egg white is due to
   A. Gossypol
   B. Cyclopropenoids
   C. Discoumarol
   D. HCN
   i. None are correct  ii. D is correct  iii. B is correct  iv. A is correct

39. Phytic acid decreases the availability of
   A. Iron
   B. Calcium
   C. Phosphorus
   D. Vitamin A
   i. A and B are correct  ii. B and C correct  iii. B and D are correct  iv. C and D are correct

40. Aflatoxin is a
   A. Hepatotoxin
   B. Neurotoxin
   C. Carcinogens
   D. Nephrotoxin
   i. C and D are correct  ii. A and B are correct  iii. A and C are correct  iv. A and D are correct

41. Tannins are present in high quantity in
   A. Rice
   B. Wheat bran
   C. Cottonseed cake
   D. Accacia leaves
   i. C is correct  ii. B is correct  iii. A is correct  iv. D is correct

42. Compared to most domestic animals the species that can tolerate high level of tannin in feed is
   A. Sheep
   B. Pig
   C. Cow
   D. Goat
   i. C is correct  ii. B is correct  iii. A is correct  iv. D is correct

43. Trypsin inhibitor is present in
   A. Row linseed meal
   B. Corpus meal
   C. Plam kernal meal
   D. Raw soyabean
   i. D is correct  ii. A is correct  iii. C is correct  iv. B is correct

44. Goitrogenic substance are present in leaves of
   A. Cabbage
   B. Cauliflower
   C. Kale
   D. Bracasia family
   i. All are false  ii. All are correct  iii. C is false  iv. D is false
45. Linnamarin, amygdalin are precursors of
A. Goitrogens           B. HCN
C. Tannins              D. Lectins
i. D is correct         ii. A is correct    iii. C is correct    iv. B is correct

46. Soobabul leaves contain Antinutritional factor
A. Tannin               B. Mimosine
C. Gossypol             D. Cydopropenoids
i. B is correct         ii. A is correct    iii. D is correct    iv. C is correct

47. Tannin interferes with utilisation of
A. Lipids               B. Carbohydrates
C. Proteins             D. Vitamins
i. C is correct         ii. D is correct    iii. A is correct    iv. B is correct

48. The toxic effect of gossypol present in cotton seed can be overcome by supplementing the diet with
A. Ferrous sulphate     B. common salt
C. Antibiotic           D. Molasses
i. A is correct         ii. D is correct    iii. B is correct    iv. C is correct

49. Protease inhibitors present in raw soyabean can be destroyed by
A. water washing        B. Sundrying
C. Chemical treatment   D. Roasting
i. A is correct         ii. D is correct    iii. B is correct    iv. C is correct

50. Tannin content of Mango seed kernel can be reduced by
A. Water washing        B. Drying
C. Biological treatment D. Addition of salt
i. A is correct         ii. A and C are correct    iii. A and B are correct    iv. All are correct

51. The mimosine content of subabull can be reduced by
A. Soaking in water     B. Alkali treatment
C. Acid treatment      D. Wilting
i. C is correct         ii. B is correct    iii. A is correct    iv. D is correct

52. Storage of groundnut cake with high moisture contents leads to formation of
A. T2 Toxin             B. Ocharatoxin
C. Aflatoxin            D. Zeralin
i. A and B are correct  ii. C and D are correct    iii. None are correct    iv. All are correct
53. The most susceptible species for aflatoxin is

A. Sheep    B. Goat
C. Cattle    D. Duck

i. B is correct  ii. D is correct  iii. C is correct  iv. A is correct
CHAPTER V

FEEDING STANDARDS AND NUTRIENT REQUIREMENTS OF DIFFERENT CATEGORIES OF LIVESTOCK AND COMPUTATION OF RATIONS

FEEDING STANDARDS

Feedings standards are the tables which indicates the quantities of nutrients to be fed to the various classes of livestock for different physiological functions like growth, maintenance, lactation, egg production and wool growth. The nutrient requirements are generally expressed separately for each function or an overall figure for the combined functions may also be expressed. In the case dairy animals nutrient requirements are generally expressed for the separate body functions but in case of poultry and pigs combined requirements of maintenance and other body functions are given.

There are two terms which has been used in the feeding standards. One is the nutrient allowance and another is the nutrient requirements. The former gives an extra allowance of nutrient over the requirement which gives a margin of safety whereas latter term gives the requirement for optimum production.

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A. COMPARATIVE TYPE

1. Hay standard

In 1810 German scientist Thaer suggested that different feeds should be compared using meadow hay as a unit. This standard provided that 100 lbs. of meadow hay was equal in nutritive value to 91 lbs. of clover hay or 200 lbs. of potatoes, 625 lbs. of mangels. Nothing was known of the chemical value of these feeds and the physiological requirements of the animals. The only measure was the practical feeding experience.

2. Scandinavian “feed unit” standard

In 1884, Professor Fjord formulated the Scandinavian feeding standard. In this system only one factor, namely, the feed unit was taken into account. The value of one pound of common grain such as corn, barley or wheat, is given as one unit value and the value of all other foods is based upon this. According to this standard one feed unit is required for each 150 lbs. of body weight and an additional unit for every three pounds of milk production.

As the grains are of different types in different countries, the feed units should also be different. Hence the Scandinavian units are not applicable in our country unless experiments are conducted here with our own grains.

B. DIGESTIBLE NUTRIENT SYSTEM

1. Grouven’s Feeding standard

In 1859 Grouven, a German chemist published his feeding standard with crude protein, carbohydrates and fat contained in the feed as the basis of the standard. According to this standard a cow weighing 1,000 lbs. should be fed 28.7 lbs. of dry matter containing 2.67 lbs. of crude protein 0.6 lb. of crude fat and 14.55 lbs. of crude carbohydrates.

Very soon after standard of Grouven, Henneberg and Stohaan found that the total nutrient contained in a feed did not from an accurate guide to its value. The proportion of digestible parts varied with different feeds and hence the digestible nutrient would be more valuable. So due to this defect Grouven’s feeding standard is now abandoned.

2. Wolff’s feeding standard

In 1864 Dr. Emil Von Wolff proposed a standard on digestible protein, digestible carbohydrates and digestible fats contained in a feeding stuff. His standard for dairy cows weighing 1,000 lbs. was 24.5 lbs. of dry matter containing 2.5 lbs. of digestible carbohydrates and 0.4 lb. of digestible fats. This as a nutritive ratio 1:5.4. This standard through an improvement over the standard of Grouven, yet it does not consider the quantity and quality of milk produced.

3. Wolff’s Lehmann feeding standard

Dr. V. Lehmann of Berlin modified Wolff’s standard in 1896. Till then Wolff’s standard was in use. He took into account the quantity of milk produced, but he failed to take into account the quality of milk.
4. **Haecker’s feeding standard**

Haecker an American worker who for the first time considered quality as well as the quality of milk produced in formulating a milk standard. He was also the first to separate requirements for maintenance form the requirements of production. His standard included digestible crude protein, carbohydrates and fats. Later it was expressed in digestible crude protein and total digestible nutrients.

5. **Savage feeding standard**

Another American scientist Savage came to the conclusion that the Haecker standard was too low especially in protein. He suggested that in case of milking cows at least 24 lbs. of dry matter should be provided for an average cow. The nutritive ratio should not be wider than 1:6 or narrower than 1:4.5. About two-thirds of the dry matter should be from the roughages and one-third from the concentrates. Therefore, the protein requirement was increased about 20 percent above the standard of Haecker.

6. **Morrison feeding standard**

Morrison F.B. observed that stockmen are spending large sums of money for entirely unnecessary amounts on protein supplement, thus considerably reducing their profits. He therefore, endeavoured to combine in one set of standards what seem in the judgement to be the best guide available in computation of rations for the various classes of stock. These standards were first presented in the 15th edition of “Feeds and Feedings” published in 1915 and where then called “Modified Wolff and Lehmann standard”. They soon came to be known as the “Morrison Feeding Standard”. These standards have expressed in terms of Dry Matter (D.M.), Digestible Protein (D.P.) and Total Digestible Nutrients (T.D.N.)

7. **National Research Council (N.R.C.) standard**

On animal nutrition of the National Research Council recommended a nutrient allowance. The standard includes digestible protein and total digestible nutrients and also includes the recommended requirements for calcium, phosphorus, carotene and vitamin D for dairy cattle, beef cattle, pigs, poultry, sheep dogs, horses, laboratory animals etc. It is believed that these N.R.C. reports representing in each case are the pooled judgement of a group of experts in the field of species in question. Today in a number of countries N.R.C. standards are followed where they use ME for poultry, DE for swine and horses, De, ME and TDN for sheep, ME, TDN and NE<sub>m</sub> and NE<sub>L</sub> for beef cattle and for dairy cattle, values are given for DE, ME, TDN, NE<sub>m</sub> and NE<sub>L</sub> for growing animals with additional values as NE<sub>L</sub> for lactating cows. From time to time, the NRC revises these feeding standards in keeping with new information and changing feeding practices.

8. **Japanese feeding standards for dairy cattle**

Maintenance requirements based on live weight raised to the 0.75 power of Maintenance = 37.37 g TDN/kg or 116.3 kcal ME/kg (equivalent to 0.58 lb dig. Protein. 8.1 lb TDN of 11.4 Mcal ME per 1,000 lb cow). For milk production, nutrient requirements were calculated on the basis of 154 parts dig. Protein per 100 parts milk protein and 1,444 kcal ME per 1,000 kcal milk energy.
9. **Indian standards**

Considering the fact that nutrient needs of livestock and poultry breeds under tropical environments are different from those developed in temperate climate, the Indian Council of Agricultural Research draw suitable feeding standards for the Indian livestock and poultry.

**C. PRODUCTION VALUE TYPE**

1. **Kellner feeding standard**

   In 1907 Kellner, a German scientist, investigated a feeding standard based upon “Starch” as the unit of measurement. He took into account not only the digestibility of the feeds as calculated from the amount lost in faeces and urine but also the entire loss from the body including energy expended in digestion and passing the food inside the body (chewing, etc.). For measuring the amount of energy lost from the body as heat, Kellner devised a respiration apparatus. Here heat in determined indirectly by finding the amount of carbon dioxide gas liberated or by measuring the amount of oxygen gas used up in oxidation which take place in the body. The animal breathes through an airtight mask placed over its nose and mouth.

   According to this system, a 1,000 lbs. animal needs 0.6 lb. of digestible protein and 6.35 lbs. of starch equivalent. This starch equivalent in turn can be converted into energy by a method worked out by Armsby and Kellner.

   Any of the feeds the composition of which known be converted to starch equivalent by using the following factors:

   \[
   \text{Dig Protein} \quad X \quad 0.94 \quad = \quad \text{S.E.} \\
   \text{Fat from coarse fodder} \quad X \quad 2.1 \quad = \quad \text{S.E.} \\
   \text{Fat from cereal grain} \quad X \quad 2.1 \quad = \quad \text{S.E.} \\
   \text{Fat from oil seeds} \quad X \quad 2.4 \quad = \quad \text{S.E.} \\
   \text{Dig. Carbohydrates and fibre} \quad X \quad 1.0 \quad = \quad \text{S.E.}
   \]

2. **Armsby feeding standard**

   Armsby standard is based on true protein and net energy values. By means of the respiration calorimeter, Armsby determined the net energy required for mastication, digestion, assimilation and also the amount of heat and gases given off through the excretory channels. Thus after considering the various losses of energy such as in urine, faeces, gases and in the work of digestion, he was able to estimate the amount of net energy available for productive purposes. Armsby expresses his standard in two factors, that is true protein and therms of net energy.

   A common criticism of the Armsby standard is that the expense of determining requirements of the animals and the net energy in the various feeds is excessively high. The net energy values of only a very few feeds had actually been determined and most of the values have been computed from the Table of Morrison’s digestible nutrients. Armsby standard is not as widely used as are the standards based on digestible nutrients.

3. **Agricultural Research Council (A.R.C.) standard**

   The nutritive requirement of various livestock in the United Kingdom have been presented in Ministry of Agriculture’s Bulletins. These are prepared by the Technical Committee of the Agricultural Research Council of Britain. Requirements are set forth in three
separate reports dealing with poultry, ruminants and pigs, each of these reports extensive summaries of the literature upon which the requirements are based. The most attractive feature of the British Feeding Standards is that the unit of energy requirements has been expressed in terms of Starch equivalent instead of T.D.N. or ME of NE are in Morrison and in N.R.C. standards.

**NUTRIENT REQUIREMENTS**

Nutritive requirements are the statements of the amount of nutrients required by animals that should support normal function. A rough distinction between requirement and allowance is that the allowance is greater than the requirement by a safety margin designed principally to allow variations in requirement among the individual animals.

Requirements may be expressed in quantities of nutrients or in dietary proportions. Thus the phosphorus requirement of a 50 kg pig might be expressed as ii g. phosphorus per day or as 0.5% phosphorus in the diet. The exact amount of nutrient requirement is used mainly for animals given exact quantities of feed, the expression as per cent of the diet is used for animals feed appetite.

When the standard is set to represent the needs of the average in a population, many will require more than the figure stated, and many will require less the individual stockman does not know whether the average requirements are below or above the requirements of his animals. For this reason feeding standards should be considered as guides to feeding practice and the stockman should make finer adjustment of food intake to animal performance.

**NUTRIENT REQUIREMENT FOR MAINTENANCE**

An animal is in a state of maintenance when the amount of nutrients in the feed will maintain the animal in equilibrium i.e., its body composition remains constant and is not growing, not working or giving no product as milk or mutton or egg. This minimum demand of feed is referred to as the maintenance requirement. If this need is not met, animals are forced to draw upon their body reserves to meet their nutrient requirements for maintenance, commonly revealed by a loss in weight and to various other undesirable consequences. The knowledge of this maintenance requirement of farm animals is of utmost importance to find out the total requirements of feed for animals under various conditions such as pregnancy or yielding certain quantity of milk or doing certain amount of work. The procedure involves the summing up of the requirements of each function on top of maintenance requirement. The starting point of finding maintenance requirement is the fasting catabolism.

**ENERGY REQUIREMENTS FOR MAINTENANCE**

(1) **BASAL AND FASTING METABOLISM**

The term Basal Metabolism or Basal Metabolic rate refer to the heat production of an animal resting in a thermally neutral environment (temperature range in which environmental temperature does not stimulate normal metabolism, approximately 25°C) and in a past-absorptive state (that is after the digestion and absorption of the last food ingested has stopped). During this rest period although the animal will be doing no external or digestive work nor will it have any emotional excitement, still it will carry on a variety of internal processes which are essential to life. These processes include respiration, circulation, maintenance of muscular tonus, production of internal secretions, etc. In the absence of feed, the nutrients required to support these activities must come from the break-down of body tissues itself.
The heat production can be determined by direct calorimetry, or by indirect calorimetry. The conditions of the animals which are essential for measuring metabolic rate are as follow:

1. **Good nutritive conditions** – this implies that the previous diet of the subject has been adequate, especially as regards to energy and protein. Poor state or previous nutrition tends to decrease of basal neat production.

2. **Environmental temperature** – temperature or about 25°C specified as one which is above the critical and below the point of hyperthermal rise, thus avoids tissue breakdown.

3. **Relaxation on bed prior to and during measurement** - by this way the minimum muscular activity can be achieved. This is very difficult for any kind of animal other than man.

4. **Post-absorptive state** – state when the process or digestion or absorption disappears. It is reached by an overnight starvation in case of human, but for ruminants it may require about three or four days. This condition can hardly be fulfilled by any ruminants, hence it is measured after a starvation period of about 5 hours. Because of the fact that the last two conditions cannot be fulfilled and a modification is recommended for ruminant animals, hence the term *resting metabolism* is used in place of basal metabolism.

An animal in the resting state accomplishes little or no work in the physical sense of the word. All of the energy released, even that needed to carry out vital functions of the body is degraded to heat and lost to the environment. Under these circumstances the intensity of energy metabolism can be estimated either by calculating heat production from the exchange of respiratory gases (indirect calorimetry) or by measuring the heat which is lost from the body by radiation, conduction, convection and evaporation (direct calorimetry).

**DIRECT CALORIMETRY**

This is simple in theory, difficult in practice, sensible heat loss (heat of radiation conduction) from the animal body can be measured with two general types of calorimeters, adiabatic and gradient. The insensible heat (latent heat of water vapourized from the skin and the respiratory passages) is estimated by determining in some way the amount of water vapour added to the air which flows through the calorimeter. For this, rate of air flow and change in humidity is measured.

**1. ADIABATIC CALORIMETERS**

In this type an animal is confined in a chamber constructed in such a way that heat loss through the walls of the chamber is reduced to near zero. This is attained by a box within a box. When the outer box or wall is electrically heated to the same temperature as the inner wall, heat loss from the inner wall to the outer wall is impossible. Water circulating in a coil in such a chamber absorbs the heat collected by the inner wall; the volume and change in temperature of the water can be used to calculate sensible heat loss from animal body. The construction and operation are complicated and very expensive.
2. GRADIENT CALORIMETERS

Calorimeters of this type allow the loss of heat through the walls of the animal chamber. The outer surface of the wall of the calorimeter is maintained at a constant temperature with a jacket; the temperature gradient is measured with thermocouples which line the inner and outer surfaces of the wall. By the use of appropriate techniques it is possible to measure separately the radiation component of the sensible heat loss.

INDIRECT CALORIMETRY

Because the animal body ultimately derives all of its energy from oxidation, the magnitude of energy metabolism can be estimated from the exchange of respiratory gases. Such measurements of heat production are more readily accomplished than are measurements of heat dissipation by direct calorimetry. A variety of techniques are available for measuring the respiratory exchange; all ultimately seek to measure oxygen consumption and CO₂ production per unit of time.

1. OPEN CIRCUIT SYSTEM

Devices allow the animal to breathe atmospheric air of determined composition; the exhaust air from a chamber or expired air from a mask or cannula, is either collected or else metered and sampled and then analysed for O₂ and CO₂ content. Analysis of gases has been accomplished with chemical and volumetric or manometric techniques.

2. CLOSED CIRCUIT SYSTEM

Devices require the animal to rebreathe the same air. CO₂ is removed with a suitable absorbed which may be weighed before and after to determine its rate of production. The use of oxygen by the animal body decreases the volume of the respiratory gas mixture, and this change in volume is used as a measure of the rate of oxygen consumption. Oxygen used by the animal is then replaced by a metered supply of the pure gas. Both O₂ consumption and CO₂ production must be corrected for any differences in the amounts present in the circuit air at the beginning and end of the experiment. Methane is allowed to accumulate in the circuit air, and the amount present is determined at the end of the experiment.

2) ENERGY REQUIREMENT BY FEEDING TRIALS.

In this method an attempt is made to determine the amount of feed in terms of energy which is sufficient to maintain constant weight for an extended period. The value so obtained may be expressed in terms of TDN by inclusion of a digestion trial or may be calculated from the average digestion coefficients. The inclusion of metabolic trial helps to calculate the results in terms of ME. As live weight is the sole criterion of exactness of this method, it should be noted
that the weight should remain constant over an extended period for direct application into practice. If for any reason there be gain in weight or loss, necessary correction in intake should accordingly be made for such loss or gain in weight. Correction figures are shown below:

\[
Pounds \text{ gained} \times 3.53 = \text{TDN required for gain}
\]

\[
Pounds \text{ lost} \times 2.73 = \text{TDN equivalent to loss.}
\]

Such correction are, however, only approximate since the nature of tissue gained or lost is difficult to assess, eg., if the accumulation of water, which has no feed equivalent, be responsible for weight gain, then the use of the above correction factor form gain will be meaningless. The object, therefore, is to use these correction factors as minimum as possible for reasons as already stated above. Another defect of this method is that constancy of weight does not necessarily mean the integrity of body tissue or in other words the weight maintenance does not mean the energy maintenance. This defect, however, can be eliminated by inclusion of slaughter test which, however, adds to the cost experiment and at the same time may not be practicable for all classes of stock.

PROTEIN REQUIREMENTS FOR MAINTENANCE:

Loss of protein continuously occurs through wear and tear of body tissue, for renewal of hairs, nails, feathers, etc., and if the losses are not completed promptly by proper amount of protein either in the form of tissue protein or NPN substance, the animal will rundown in condition and its reproducing ability of productivity will be adversely affected. The losses of body protein in the animal when kept on a protein free ration occurs through urine and faeces in negligible amount, through shedding of hairs, loss of nail, skin etc. The loss which occurs through urine is known as EUN or *endogenous urinary nitrogen* loss and loss which occurs through faeces is called MFN or *Metabolic faecal nitrogen* loss.

**Urinary nitrogen:**

**EUN:** Here the loss of nitrogen is due to the catabolism incidental to maintenance of the vital tissues of the body, which can be measured at the minimum urinary excretion on a nitrogen free otherwise adequate (particularly energy adequacy) diet. It is so likely that the quantity of nitrogen thus lost through urine will be dependent on the body size. However, this loss like energy loss is not directly proportional to body weight but to \(W^{0.75}\) where \(W\) is the body weight in kg.

**Faecal nitrogen:**

Faecal nitrogen consists of two parts; undigested food nitrogen and another part known as MFN which comprises residues originated from the body, eg. residues of bile digestive enzymes, epithelial cells derived from the alimentary tract and undigested bacteria.

**MFN:** Metabolic faecal nitrogen unlike EUN is not proportional to body weight but rather this value is dependent on the amount of feed ingested. There is also species difference. The value will be lower with rations low in roughage and higher where roughage alone will be fed.
1. ESTIMATION OF PROTEIN REQUIREMENT FOR MAINTENANCE FROM ENDOGENOUS URINARY METABOLIC FAECAL NITROGEN (THE FACTORIAL METHOD)

From the above discussion it is evident that the minimum protein requirement of an adult for maintenance must be met by supplying digestible protein required to compensate losses through EUN and MFN plus losses for adult growth in an otherwise adequate diet. In practice, however, a larger amount is given to afford a margin of safety for variation of requirement from animal to animal arising out of variable wastage in metabolism like loss of nitrogen in hair etc., which being very negligible can also be omitted for all practical purposes or an account may be taken from an estimate of $0.02 W^{0.73}$ gm nitrogen loss per day in cattle.

2. NITROGEN BALANCE METHOD AS MEASURE OF PROTEIN MAINTENANCE:

The protein requirement as determined by nitrogen balance studies is a satisfactory and reliable measure. In this method, rations containing different levels of protein but adequate in all other respects are fed to the animals and the minimum protein intake capable of enforcing nitrogen equilibrium in well-nourished animal is said to be the maintenance requirement of protein it is important that animals chosen for such determination must be in a good state of protein nutrition at the start. Minimum intake capable of maintaining nitrogen equilibrium is also very important.

3. FEEDING TRIAL TO DETERMINE MAINTENANCE REQUIREMENT OF PROTEIN:

Rations containing different levels of protein but otherwise adequate in energy and other nutrients are fed to determine the amount of intake capable of maintaining an audit non-producing animal in sufficiently good condition for an extended period without loss of weight or otherwise. Data obtained from slaughter tests (although very difficult to perform in adult cattle) are very helpful to determine the integrity of the nitrogenous tissues.

**NUTRIENT REQUIREMENT FOR GROWTH**

- Growth is defined as increase in weight and size of the body of animal.
- Subject to individual variability there is a characteristic rate of growth for each species.
- The maximum size and development are fixed by heredity.
- Nutrition is key factor to determine whether this maximum weight is achieved.
- An optimum nutritional fulfilment is one, which enables an animal to take full advantage of heredity, but maximum size fixed by heredity cannot be exceeded by nutrition.
- True growth involves an increase in structured constituents such as bones, muscles and organs and not by deposition of fat.
- The growth is measured by increase in weight as growth/day. The relative measures which record the increase percent can also be used for measuring the growth. Along with this we can have dimensional measures such as increase in height, length and girth. A combination of both are more useful measure of growth.
- The rate of growth in an animal is influenced by level of nutrition that the animal gets.

**ENERGY REQUIREMENT FOR GROWTH:**

Energy requirement for growth can be determined from feeding trials or by factorial method.
From feeding trials

Here the experimental animals in different groups throughout the growth period are fed at different levels of energy intake so as to determine the optimum level most suited to normal growth and development without being unnecessarily high. The energy so found may be expressed in terms of any desired measure of energy. TDN data are most common in such studies by inclusion of digestion trial or by use of average coefficients of digestibility.

By the factorial method

- The principle of energy requirement for growth is that the energy of the tissue formed is determined first and the value of basal metabolism increased by an activity factor is added to it.
- Thus the requirement of energy is determined at any given period by the expected rate of gain and the average body weight during the period in question.
- Data from the slaughter experiment in respect of the fat and protein provides the figure for computing the calories for expected rate of gain while the body weight data provide the basis for arriving at the required energy for basal metabolism.
- An activity increment over the energy required for basal metabolism has to be considered.
- The data of basal metabolism and activity factor is to cover the maintenance requirement.
- Thus the sum of calories of basal metabolism + activity increment factor + growth tissue formed is the estimated energy requirement expressed as net energy which in turn can be converted to ME or DE or TDN by the appropriate conversion factors: 70% DE = NE, 80% DE = ME, 1 Kg TDN = 4.4 M.Cal. DE

PROTEIN REQUIREMENT FOR GROWTH:

Protein plays a vital role in growth as well as in production and reproduction. Young calves require relatively larger proportion of protein for rapid growth. As the animals grow older, the amount of protein requirement is proportionately lower. This is primarily due to growth in the beginning of life being protein in nature followed by growth of tissue of less protein and more fat.

Protein requirement for growth can be determined by factorial method or by nitrogen balance method or by feeding trials.

Factorial method:

The amount of protein required for maintenance is determined first. The value thus obtained is added to the amount of protein required for growth (or say gain in weight) plus losses in metabolism.

The maintenance needs can be determined directly on the basis of endogenous urinary nitrogen or calculated from the basal energy metabolism and later corrected for metabolic faecal nitrogen losses. The amount required for the growth tissue formed can be estimated from the slaughter data as shown below:
Example: A calf weight 70 kg and consumes 2 kg dry matter per day. Its EUN and MFN would be approximately 3.5g and 7.0g respectively. The slaughter tests reveal that the amount of nitrogen deposited in the tissue will be 16 g per day for a calf gaining at the rate of 0.5 kg per day.

Theoretically, the sum of nitrogen excreted as EUN and MFN plus the amount of nitrogen deposited in the body as growth tissue should be supplied in the diet for proper protein nutrition. Thus 3.5 + 7.0 + 16.0 = 26.5 g nitrogen x 6.25 = 166 g protein should be supplied in the diet. The biological values of protein for body building activity in growing animals is taken for only 65% as against 70% in adults in consideration of rumen function which is not fully developed in a growing animal and that there is greater loss of feed nitrogen in urine. Thus the amount of true digestible protein will be 100/65 x 166 = 255 g. As the feeding standards Table show the requirement of protein in terms of apparent digestible protein say, DCP, the value of MFN in terms of protein should be deducted from the figure of true digestible protein. Therefore, 255 – (6.25 x 7) = 211 g or 0.21 kg is the minimum requirement of DCP for calf weighing 70kg and growing @ 0.5 kg. per day.

Nitrogen balance method for estimation of protein for growth:

The protein requirement may also be determined by nitrogen balance studies and is said to be exact measure of actual requirement of protein. In this method, calves are raised on equal amounts of dry matter and on isocaloric rations which contain different levels of protein and the minimum intake of protein which provides maximum retention is taken as the estimate of requirement. However, in such studies, the animals must be making satisfactory rate of growth during the study.

Feeding trials for estimating protein need for growth:

In this method, the rations containing different levels of protein are fed to determine the minimum level required to give the maximum rate of growth. The nature of growth thus obtained may be further tested by slaughter tests for assessing the integrity of the nitrogenous tissues.

NUTRIENT REQUIREMENT FOR REPRODUCTION

The reproductive cycle may be considered to consist of three phases:

- The first phase, which is important to both the sexes, comprises the production of ova and spermatozoa.
- The second phase of the cycle is pregnancy
- and the third phase is lactation.

Nutrient requirements for the first phase in mammals are small compared with the egg production in birds. The quantities of nutrients required in excess of those needed for maintenance are moderate for the second and large for the third phase.

Consequently, nutrient requirements fluctuate considerably during the reproductive cycle, especially when there is an interval between weaning and the next conception.
Effect of nutrition on the initiation and maintenance of reproductive ability

Puberty in cattle is markedly influenced by the level of nutrition at which animals have been reared. In general terms, the faster an animal grows, the earlier will it reach sexual maturity. In cattle, puberty occurs at a particular live weight or body size rather than at a fixed age.

In practice, the factor which decides when an animal is to be first used for breeding is body size, and at puberty animals are usually considered to be too small for breeding. Thus although heifers of the larger dairy breeds may be capable of conceiving at 7 months of age, they are not normally mated until they are at least 15 months old. The tendency today is for cattle, sheep and goats of both sexes to be mated when relatively young, which means that in the female the nutrient demands of pregnancy are added to those of growth. Inadequate nutrition during pregnancy is liable to retard foetal growth and to delay the attainment of mature size by the mother. Incomplete skeletal development is particularly dangerous because it may lead to difficulties of parturition.

Rapid growth and the earlier attainment of a size appropriate to breeding has the economic advantage of reducing the non-productive part of the animal’s life. But there are also some disadvantages of rapid growth in breeding stock, especially if there is excessive fat deposition. Over fat animals do not mate as rapidly as normal animals and during pregnancy may suffer more embryonic mortality.

Nutrient requirement of breeding male animals:

In male the spermatozoa and the secretions associated with it represents only a very small quantity of matter. The average ejaculate of the bull, for example, contains 0.5g of dry matter. Therefore the nutrient requirements for the production of spermatozoa is small (inappreciable) compared with the requirements for maintenance and for processes such as growth and lactation.

Then adult male animals kept only for semen production would require no more than a maintenance ration appropriate to their species and size, but in practice such animals are given food well in excess of that required for maintenance in female of the same weight. There is no reliable evidence that high planes of nutrition are beneficial for male fertility, though it is recognized that underfeeding has deleterious effects. Males, however, do have a higher fasting metabolism and therefore a higher energy requirement for maintenance than females and castrates.

Effects of prolonged under or overfeeding of breeding animals:

Animals given a sub-maintenance ration eventually show some reduction in fertility. In males this may be brought about by a decreased output of spermatozoa or by a smaller output of the accessory secretions. In females continued underfeeding leads to a cessation of ovarian function; the farm animals most likely to suffer in this way are heifers kept on inadequate rations during the winter feeding period.

Overfeeding can also bring about impaired reproductive ability. Very fat animals frequently are sterile. Over-fat animals may continue to produce ova while failing to show signs of oestrus; it has been suggested that the oestrogens intended to be responsible for the exhibiting heat symptoms are absorbed in the fat depots.
Effects of specific nutrient deficiencies on the production of ova and spermatozoa:

Protein deficiency leads to reproductive failure. The effects of protein deficiency on reproduction appear to be much more severe in growing than in mature animals.

When deficiencies of minerals or vitamins occur in breeding animals, the general signs of deficiency described usually appear before reproductive ability is seriously affected. The effect of Vitamin A deficiency illustrates this point, for although such a deficiency ultimately causes complete failure of reproduction, animals blinded by the deficiency may still be capable either of producing semen or of conceiving. Prolonged deficiency leads eventually in males to degeneration of the testis and in females to keratinisation of the vagina.

Deficiency of Vitamin E has a profound effect on reproduction in rats, but the evidence suggests that deficiency of the vitamin does not play any appreciable role as a cause infertility in cattle and sheep.

Of the mineral elements, both calcium and phosphorus are important in reproduction, although of the two it is phosphorus whose deficiency is more commonly associated with reproductive failure. Phosphorus deficiency arises most commonly in ruminants grazing on herbage deficient in the element and in such circumstances the failure of reproduction occurs in conjunction with the general signs of phosphorus deficiency. In male animals, zinc deficiency may impair the production of spermatozoa.

NUTRIENT REQUIREMENT FOR PREGNANCY

During pregnancy nutrients are required for
1. Foetal growth
2. Uterus growth
3. Placental growth
4. Mammary gland development
5. Pregnancy anabolism

- The growth of the foetus is accompanied by the formation of the membranes associated with it, and also by considerable enlargement of the uterus.
- In the early stage of pregnancy the amounts of nutrients deposited in the uterus and mammary gland are small, and it is only in the last third of pregnancy (from the sixth month onwards in cattle) that it becomes large.
- Mammary gland development takes place throughout pregnancy, but it is only in the later stages that it proceeds rapidly.
- In a pregnant animal is given a constant daily allowance of food, its heat production will rise towards the end of gestation. The increase is due mainly to the additional energy required by the foetus for both maintenance and growth. It has been found that metabolisable energy taken in by the mother in addition to her own maintenance requirement is utilised by the foetus with comparatively low efficiency.
- The live weight gains made by pregnant animals are often considerably greater than can be accounted for by the products of conception alone. The mother herself, deposits 3 – 4 times as much protein and 5 times as much calcium as is deposited in the products on conception. This pregnancy anabolism, as it is sometimes called, is obviously necessary in immature animals which are still growing, but it occurs also in older animals. Frequently much of the weight gained during pregnancy is lost in the ensuing lactation.
Consequences of malnutrition in pregnancy

Malnutrition - meaning both inadequate and excessive intakes of nutrients - may affect pregnancy in several ways. The fertilized egg may die at an early stage (i.e. embryo loss) or later in pregnancy the foetus may develop incorrectly and die; it may then be resorbed in uterine, expelled before full - term (abortion) or carried to full term (still birth). Less severe mal nutrition may reduce the birth weight of young and the viability of small offspring may be diminished by their lack of strength or by their inadequate reserves (eg. of fat).

**Effect on the young:**

- Death of embryo
- Abortion
- Deformities in foetus
- Still birth
- Weak young one

Deficiencies of individual nutrients on pregnancy must be severe to cause the death of fetuses; proteins and vitamin-A are the nutrients most likely to be implicated, although deaths through iodine, calcium, riboflavin and pantothenic acid deficiencies have also been observed congenital deformities of nutritious origin often arise from

- vitamin-A deficiency, which causes eye and bone malformations in particular.
- Iodine deficiency causes goitre in the unborn, and pigs has been observed to result in a complete lack of hair in the young.
- Hairlessness can also be caused by an inadequate supply of riboflavin during pregnancy.
- Copper deficiency in the pregnancy eve leads to the condition of sway back in the lamb.

Young animals should be born with reserves of mineral elements, particularly iron and copper and of vitamin-A, D and E, because the milk, which may be the sole item of diet for a time after birth, is frequently poorly supplied with the nutrients. With regard to iron, it appears that if the mother is herself adequately supplied and is not anaemic, the administration of extra iron will have no influence on the iron reserves of the new born. The copper and fat soluble vitamin reserves of the newborn are more susceptible to improve through the nutrition of the mother.

**Effects on the mother:** The high priority of the foetus for nutrients mean that the mother is the more severally affected by directly deficiencies. The foetus has a high requirement for carbohydrate and by virtue of its priority is able to maintain the sugar connection of its own blood at a level higher than that of the mother. If the glucose supply of the mother is sufficient her blood glucose may fall considerably, to levels at which nerve tissues (which rely on carbohydrate for energy) are affected. This occurs in sheep in the condition known as pregnancy toxaemia, which is prevalent in ewes in the last month of pregnancy. Affected animals will become dull and lethargic, lose their appetite and show nervous signs such as trembling and holding the head at an unusual angle, in animals showing these signs the mortality rate may be as high as 90%. The disease occurs most frequently in ewes with more than one foetus - where its alternative name of ‘twin lamb disease' - and is most prevalent in times of food shortage and when the ewes are subjected to stress in the form of inclement weather or transportation. Blood samples from affected animals usually show, in addition to
hyperglycaemia, a marked rise in ketone content and an increase in plasma free fatty acids. In the later stages of the disease the animal may suffer metabolic acidosis and renal failure.

**NUTRIENT REQUIREMENT FOR THE LACTATING COW**

The nutrient requirement of the dairy cow for milk production depends upon the amount of milk being produced and upon its composition.

**Energy requirement for lactation**

The energy standard for lactation may be derived either by using formulate or by factorial method.

The formula is based on the statistical interrelationships between milk constituents to calculate the gross energy content from the percentage of single constituent since as fat (F) i.e. kcal per kg milk = 304.8 + 114.1 X F

Assuming fat content of a sample of milk 4.5%, the gross energy content of 1 kg of milk will thus be equivalent to 304.8 + (114.1 X 4.5) = 818.25 kcal.

Apart from formula, energy liberated per kg of milk may also be derived by two other methods.

- The gross energy determined either by bomb calorimetry
- or by a detailed chemical analysis; the amounts of protein, fat and carbohydrate which are then multiplied by their individual calorific values.

The efficiency of conversion of feed ME into energy content of milk is 70%; so that for providing sufficient energy the calorific value of milk is multiplied by 100÷70 = 1.43.

**Protein requirement for lactation**

Extensive studies have been made to determine the amount of protein requirement for milk production. Milk is rich in protein.

It is obviously, therefore, that the animal must be provided with sufficient quantity, in addition to maintenance requirement, in order to able to cope with the continuous drain of protein from its body. It has been shown that the lactating animals can efficiency convert food protein into milk protein.

Results of various studies have shown that provision 1.25 times as much protein as secreted in the milk will be sufficient for milk production. This allowance should be given in addition to maintenance requirement. This extra provision of protein for milk production will, therefore, depends on the amount of milk produced.

**NUTRIENT REQUIREMENTS FOR WOOL PRODUCTION**

The weight of wool produced by sheep varies considerably from one breed to another, and an average value is useful only for guidance. For eg: a Merino weighing 50 kg produces annually of 4 kg fleece. Such a fleece would contain about 3 kg of actual wool fibre, the remaining 1 kg being wool wax, suint, dirt and water. Wool wax is produced by the sabaceous glands, and consists mainly of esters of cholesterol and other alcohols.

The wool fibre consists almost entirely of the protein, wool keratin. To grow in one year, a fleece containing 3 kg protein the sheep would need to deposit a daily average of about 8 g
protein or 1.3 g nitrogen. If this latter figure is compared with the 6.6 g nitrogen which a sheep of 50kg might lose daily as endogenous nitrogen, it seems that in proportion to its requirement for maintenance, the sheep’s nitrogen requirement for wool growth is small.

These figures however do not tell the whole story, since the efficiency with which absorbed amino acids are used for wool synthesis is likely to be much less than that with which they are used for maintenance.

Keratin is characterised by its high content of the sulphur-containing amino acid, cystine, which although not an indispensable amino acid is synthesised from another indispensable amino acid, methionine.

The efficiency with which food protein can be converted into wool is therefore likely to depend on their respective proportions of cystine and methionine. Keratin contains 100 – 200 g/kg of these acids, compared with the 20 – 30 g/kg found in plant protein and in microbial proteins synthesised in the rumen and so the biological value of food protein for wool growth is likely to be not greater than 0.3.

Wool growth reflects the general level of nutrition of the sheep. At sub-maintenance levels, when the sheep is losing weight, its wool continuous to grow, although slowly. As the plane of nutrition improves and the sheep gains in weight, so wool growth too increases. There appears to be a maximum rate of growth for wool, varying from sheep to sheep within range as great as 5 to 40 g/day.

Wool quality is influenced by the nutrition of the sheep. High levels of nutrition increase the diameter of the fibres and it is significant that the finer wools come from the nutritionally less favourable areas of land. Periods of starvation may cause an abrupt reduction in wool growth; this leaves a weak point in each fibre and is responsible for the fault in fleeces with the self-explanatory name of ‘break’. An early sign of copper deficiency in sheep is a loss of ‘crimp’ or waviness in wool; this is accompanied by a general deterioration in quality, the wool losing its elasticity and its affinity for dyes.

**NUTRIENT REQUIREMENT FOR WORK**

Increased muscular activity results in nutrients being oxidised in the system. All the organic constituents of feed are capable of being oxidised and utilised as energy sources. As long as supply is adequate, the working animal is to draw sources of carbohydrates and fat to meet the energy need. If the supply is inadequate, body fat will be drawn upon first and in the last stage, the protein tissues may be broken down to furnish energy for work as it is now accepted that the protein is not the normal fuel of muscular work and that no protein catabolism or extra wear and tear of tissues occurs during work. Therefore, theoretically no extra protein is required to be supplied as long as the ration provides sufficient carbohydrate and fat for extra energy required for work. From the stand point of an efficient ration for work, however, other considerations appear more important than the question as to whether the protein requirement is actually increased during work or not. During hard work, the need for energy may be almost doubled and unless the protein content of the ration is simultaneously increased, nutritive ratio becomes wide. As a result efficiency of energy utilization will be poorer since digestibility will be depressed by wide ratio and metabolic heat losses will also be increased. Naturally, therefore an efficient ration in all respects will demand inclusion of additional protein along with energy for maintaining the proper nutritive ratio (as in lactating animals having different fat content mentioned earlier) for increased muscular activity although the additional protein may not be specifically required for muscular activity.
### NUTRIENT REQUIREMENT CATTLE

#### 1. NUTRIENT REQUIREMENTS FOR GROWING CALVES

<table>
<thead>
<tr>
<th>Live Wt. (kg)</th>
<th>DCP (Kg)</th>
<th>TDN (Kg)</th>
<th>ME (Mcal)</th>
<th>Ca (g)</th>
<th>P (G)</th>
<th>Carotene (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>0.17</td>
<td>0.9</td>
<td>3.29</td>
<td>7</td>
<td>6</td>
<td>5</td>
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<tr>
<td>70</td>
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<td>4.68</td>
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<td>10</td>
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<tr>
<td>100</td>
<td>0.28</td>
<td>1.9</td>
<td>6.90</td>
<td>13</td>
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<td>10</td>
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<tr>
<td>150</td>
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<td>2.6</td>
<td>9.36</td>
<td>13</td>
<td>12</td>
<td>16</td>
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<tr>
<td>200</td>
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<td>3.2</td>
<td>11.50</td>
<td>13</td>
<td>12</td>
<td>21</td>
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<tr>
<td>300</td>
<td>0.47</td>
<td>4.1</td>
<td>14.80</td>
<td>15</td>
<td>14</td>
<td>31</td>
</tr>
</tbody>
</table>

Growth rate 0.5 kg for first 2 years

#### 2. NUTRIENT REQUIREMENTS FOR PREGNANCY - CATTLE AND BUFFALOES

(MAINTENANCE AND PREGNANCY - LAST 2 MONTHS OF GESTATION)

<table>
<thead>
<tr>
<th>Body weight (kg)</th>
<th>Dry feed (kg)</th>
<th>DCP (g)</th>
<th>TDN (kg)</th>
<th>ME (Mcal)</th>
<th>Ca (g)</th>
<th>P (g)</th>
<th>Carotene (mg)</th>
<th>Vitamin – A (100 IU)</th>
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</thead>
<tbody>
<tr>
<td>300</td>
<td>5.6</td>
<td>290</td>
<td>3.4</td>
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<td>14</td>
<td>56</td>
<td>25</td>
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<tr>
<td>350</td>
<td>6.4</td>
<td>320</td>
<td>3.7</td>
<td>13.2</td>
<td>21</td>
<td>16</td>
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<tr>
<td>400</td>
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<td>350</td>
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<td>14.1</td>
<td>23</td>
<td>18</td>
<td>76</td>
<td>30</td>
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<tr>
<td>450</td>
<td>7.9</td>
<td>400</td>
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<td>430</td>
<td>408</td>
<td>17.3</td>
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<td>22</td>
<td>95</td>
<td>38</td>
</tr>
<tr>
<td>550</td>
<td>9.3</td>
<td>465</td>
<td>5.2</td>
<td>18.8</td>
<td>31</td>
<td>24</td>
<td>105</td>
<td>42</td>
</tr>
<tr>
<td>600</td>
<td>10.0</td>
<td>500</td>
<td>5.6</td>
<td>20.2</td>
<td>34</td>
<td>26</td>
<td>114</td>
<td>46</td>
</tr>
<tr>
<td>650</td>
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<td>124</td>
<td>50</td>
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<tr>
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<td>550</td>
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<td>39</td>
<td>30</td>
<td>133</td>
<td>53</td>
</tr>
<tr>
<td>750</td>
<td>12.0</td>
<td>600</td>
<td>6.7</td>
<td>24.2</td>
<td>42</td>
<td>32</td>
<td>143</td>
<td>57</td>
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<tr>
<td>800</td>
<td>12.6</td>
<td>630</td>
<td>7.1</td>
<td>25.6</td>
<td>44</td>
<td>34</td>
<td>152</td>
<td>61</td>
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</table>
3. **NUTRIENT REQUIREMENTS / KG OF MILK (PER CENT MILK FAT) - CATTLE AND BUFFALOES**

<table>
<thead>
<tr>
<th>Milk fat (%)</th>
<th>DCP (G)</th>
<th>TDN (kg)</th>
<th>ME (Mcal)</th>
<th>CA (g)</th>
<th>P (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0</td>
<td>40</td>
<td>0.270</td>
<td>0.97</td>
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<td>1.8</td>
</tr>
<tr>
<td>4.0</td>
<td>45</td>
<td>0.315</td>
<td>1.13</td>
<td>2.7</td>
<td>2.0</td>
</tr>
<tr>
<td>5.0</td>
<td>51</td>
<td>0.370</td>
<td>1.28</td>
<td>2.9</td>
<td>2.2</td>
</tr>
<tr>
<td>6.0</td>
<td>57</td>
<td>0.410</td>
<td>1.36</td>
<td>3.1</td>
<td>2.4</td>
</tr>
<tr>
<td>7.0</td>
<td>63</td>
<td>0.460</td>
<td>1.54</td>
<td>3.3</td>
<td>2.6</td>
</tr>
<tr>
<td>8.0</td>
<td>69</td>
<td>0.510</td>
<td>1.80</td>
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<td>2.8</td>
</tr>
<tr>
<td>9.0</td>
<td>75</td>
<td>0.500</td>
<td>2.06</td>
<td>3.7</td>
<td>3.0</td>
</tr>
<tr>
<td>10.0</td>
<td>81</td>
<td>0.600</td>
<td>2.16</td>
<td>3.9</td>
<td>3.2</td>
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<tr>
<td>11.0</td>
<td>85</td>
<td>0.700</td>
<td>2.34</td>
<td>3.4</td>
<td>3.4</td>
</tr>
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</table>

4. **NUTRIENT REQUIRED FOR BREEDING BULLS**

<table>
<thead>
<tr>
<th>Live weight (kg)</th>
<th>DCP (kg)</th>
<th>TDN (kg)</th>
<th>Ca (g)</th>
<th>P (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>0.38</td>
<td>3.6</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>500</td>
<td>0.45</td>
<td>4.5</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>600</td>
<td>0.53</td>
<td>5.4</td>
<td>13</td>
<td>13</td>
</tr>
</tbody>
</table>

5. **NUTRIENT REQUIRED FOR WORKING ANIMALS**

<table>
<thead>
<tr>
<th>Live weight (kg)</th>
<th>DM (kg)</th>
<th>DCP (kg)</th>
<th>TDN (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NORMAL WORK 6HOURS CARTING 4 HOURS PLOUGHING PER DAY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>4.0</td>
<td>0.24</td>
<td>2.0</td>
</tr>
<tr>
<td>300</td>
<td>5.8</td>
<td>0.33</td>
<td>3.1</td>
</tr>
<tr>
<td>400</td>
<td>7.6</td>
<td>0.45</td>
<td>4.0</td>
</tr>
<tr>
<td>500</td>
<td>9.4</td>
<td>0.56</td>
<td>4.9</td>
</tr>
<tr>
<td>600</td>
<td>11.2</td>
<td>0.66</td>
<td>5.8</td>
</tr>
<tr>
<td>HEAVY WORK 8 HOURS CARTING 6 HOURS PLOUGHING PER DAY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>5.0</td>
<td>0.25</td>
<td>2.7</td>
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<tr>
<td>300</td>
<td>7.0</td>
<td>0.42</td>
<td>4.0</td>
</tr>
<tr>
<td>400</td>
<td>9.8</td>
<td>0.57</td>
<td>4.8</td>
</tr>
<tr>
<td>500</td>
<td>11.2</td>
<td>0.71</td>
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<tr>
<td>600</td>
<td>13.4</td>
<td>0.82</td>
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6. **BIS SPECIFICATION FOR CONCENTRATE MIXTURES FOR CATTLE**

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>NUTRIENTS (%)</th>
<th>TYPE I</th>
<th>TYPE II</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Moisture % (max.)</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>2.</td>
<td>Crude fibre % (max.)</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>3.</td>
<td>Crude protein % (min)</td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td>4.</td>
<td>Ether extract % (min)</td>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td>5.</td>
<td>Acid insoluble ash %</td>
<td>3</td>
<td>4</td>
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7. **BIS SPECIFICATIONS FOR MINERAL MIXTURES FOR SUPPLEMENTING CATTLE FEEDS**

<table>
<thead>
<tr>
<th>S.No</th>
<th>Characteristics</th>
<th>Type I</th>
<th>Type II</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Moisture per cent by mass max</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>2.</td>
<td>Calcium per cent by mass min</td>
<td>18</td>
<td>23</td>
</tr>
<tr>
<td>3.</td>
<td>Phosphorus per cent by mass min</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>4.</td>
<td>Magnesium per cent by mass min</td>
<td>5</td>
<td>6.5</td>
</tr>
<tr>
<td>5.</td>
<td>Salt (NaCl) per cent by mass min</td>
<td>22</td>
<td>-</td>
</tr>
<tr>
<td>6.</td>
<td>Iron per cent by mass min</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>7.</td>
<td>Iodine as KI per cent by mass min</td>
<td>0.02</td>
<td>0.026</td>
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<tr>
<td>8.</td>
<td>Copper per cent by mass min</td>
<td>0.06</td>
<td>0.077</td>
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<td>9.</td>
<td>Manganese per cent by mass min</td>
<td>0.1</td>
<td>0.12</td>
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<tr>
<td>10.</td>
<td>Cobalt per cent by mass min</td>
<td>0.009</td>
<td>0.012</td>
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<tr>
<td>11.</td>
<td>Fluorine per cent by mass max</td>
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<td>0.07</td>
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<td>12.</td>
<td>Zinc per cent by mass min</td>
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<td>0.38</td>
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<tr>
<td>13.</td>
<td>Sulphur per cent by mass max</td>
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<td>0.5</td>
</tr>
<tr>
<td>14.</td>
<td>Acid insoluble ash per cent by mass max</td>
<td>3</td>
<td>2.5</td>
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</table>

2-14 values on moisture free basis
### 1. DAILY NUTRIENT REQUIREMENTS FOR GROWING LAMBS

<table>
<thead>
<tr>
<th>Body Weight (kg)</th>
<th>Rate of gain (g)</th>
<th>DM (g)</th>
<th>DM (as % of BW)</th>
<th>Energy TDN (g)</th>
<th>Energy ME (Mcal)</th>
<th>DCP (g)</th>
<th>Ca (g)</th>
<th>P (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>50</td>
<td>300</td>
<td>3.0</td>
<td>195</td>
<td>0.54</td>
<td>32</td>
<td>1.5</td>
<td>1.0</td>
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<tr>
<td></td>
<td>100</td>
<td>340</td>
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<td>1.7</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
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<td>385</td>
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<td>1.3</td>
</tr>
<tr>
<td>15</td>
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<td>450</td>
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<td></td>
<td>100</td>
<td>510</td>
<td>3.4</td>
<td>330</td>
<td>1.08</td>
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<td>2.5</td>
<td>1.7</td>
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<tr>
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<td>580</td>
<td>3.9</td>
<td>375</td>
<td>1.35</td>
<td>60</td>
<td>2.9</td>
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<td></td>
<td>200</td>
<td>690</td>
<td>4.6</td>
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<td>75</td>
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(Ranjhan, 1998)

### 2. DAILY NUTRIENT REQUIREMENTS FOR MAINTENANCE OF ADULT SHEEP

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<th>Energy ME (Mcal)</th>
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(Ranjhan, 1998)
### 3. Daily Nutrient Requirements of Sheep for Wool Production

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<th>Ca (g)</th>
<th>P (g)</th>
<th>S (g)</th>
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(Ranjhan, 1998)

### 4. Daily Nutrient Requirements of Pregnant Ewes

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<th>DCP (g)</th>
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(Ranjhan, 1998)

### 5. Nutrient Requirements of Lactating Ewes

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(Ranjhan, 1998)
6. **DAILY NUTRIENT REQUIREMENTS OF NON-LACTATING EWES DURING FIRST 15 WEEKS GESTATION:**

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(Ranjhan, 1998)

7. **DAILY NUTRIENT REQUIREMENTS OF REPLACEMENT EWE:**

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<th>Weight gain (g/day)</th>
<th>DM intake (% BW)</th>
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<th>CP (g)</th>
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<th>P (g)</th>
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(Ranjhan, 1998)

8. **DAILY NUTRIENT REQUIREMENTS OF REPLACEMENT RAM:**

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<th>Ca (g)</th>
<th>P (g)</th>
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(Ranjhan, 1998)

9. **DAILY NUTRIENT REQUIREMENTS OF FINISHING SHEEP** (4-7 month age):

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### NUTRIENT REQUIREMENT FOR GOATS

#### 1. DAILY NUTRIENT REQUIREMENTS FOR GROWING KIDS

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<th>DM (% of BW)</th>
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<th>ME (Mcal)</th>
<th>DCP (g)</th>
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<th>P (g)</th>
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</table>

(Ranjhan, 1998)

#### 2. DAILY NUTRIENT REQUIREMENTS FOR MAINTENANCE OF ADULT GOATS

<table>
<thead>
<tr>
<th>Body Weight (kg)</th>
<th>DM (g)</th>
<th>DM (as % of BW)</th>
<th>Energy TDN (g)</th>
<th>ME (Mcal)</th>
<th>DCP (g)</th>
<th>Ca (g)</th>
<th>P (g)</th>
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(Ranjhan, 1998)
3. DAILY NUTRIENT REQUIREMENTS OF PREGNANT DOES

<table>
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<tr>
<th>Body Weight (kg)</th>
<th>DM (g)</th>
<th>DM (as % of BW)</th>
<th>Energy TDN (g)</th>
<th>Energy ME (Mcal)</th>
<th>DCP (g)</th>
<th>Ca (g)</th>
<th>P (g)</th>
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<tbody>
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<td>15</td>
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(Ranjhan, 1998)

4. DAILY NUTRIENT REQUIREMENTS OF LACTATING DOES

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<th>Body Weight (kg)</th>
<th>Milk Yield (Lt)</th>
<th>DM (g)</th>
<th>DM (as % of BW)</th>
<th>Energy TDN (g)</th>
<th>Energy ME (Mcal)</th>
<th>DCP (g)</th>
<th>Ca (g)</th>
<th>P (g)</th>
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<tbody>
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<td>89</td>
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(Ranjhan, 1998)
## NUTRIENT REQUIREMENT POULTRY

### Nutrient requirement for broilers BIS specification (2007)

<table>
<thead>
<tr>
<th></th>
<th>Broiler Pre-starter (0-7 days)</th>
<th>Broiler Starter (8-21 days)</th>
<th>Broiler Finisher (22-42 days)</th>
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<tbody>
<tr>
<td>Moisture, max %</td>
<td>11</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Metabolizable energy, ME (Kcal/kg), Min</td>
<td>3000</td>
<td>3100</td>
<td>3200</td>
</tr>
<tr>
<td>Crude Protein, min %</td>
<td>23</td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td>Crude fibre, max %</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Acid insoluble ash, max %</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Salt as (Nacl), Max %</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Calcium, min %</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Available Phosphorus, min %</td>
<td>0.45</td>
<td>0.45</td>
<td>0.45</td>
</tr>
<tr>
<td>Lysine, min %</td>
<td>1.3</td>
<td>1.2</td>
<td>1.0</td>
</tr>
<tr>
<td>Methionine, min %</td>
<td>0.5</td>
<td>0.5</td>
<td>0.45</td>
</tr>
<tr>
<td>Aflatoxin B&lt;sub&gt;1&lt;/sub&gt; ppb, Max</td>
<td>20</td>
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<td>20</td>
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### Nutrient recommendation for layers BIS specification (2007)

<table>
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<tr>
<th></th>
<th>Chicks (0-8 wk)</th>
<th>Grower (9-20wk)</th>
<th>Layer Phase I (21-45 wk)</th>
<th>Layer Phase II (46-72 wk)</th>
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<tbody>
<tr>
<td>Moisture, max %</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Metabolizable energy (kcal/kg)</td>
<td>2,800</td>
<td>2,500</td>
<td>2,600</td>
<td>2,400</td>
</tr>
<tr>
<td>Crude Protein, min %</td>
<td>20</td>
<td>16</td>
<td>18</td>
<td>16</td>
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<tr>
<td>Crude fibre, max %</td>
<td>7</td>
<td>9</td>
<td>9</td>
<td>10</td>
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<tr>
<td>Acid insoluble ash, max %</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4.5</td>
</tr>
<tr>
<td>Salt as (Nacl), Max %</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Calcium, min %</td>
<td>1.0</td>
<td>1.0</td>
<td>3.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Available Phosphorus, min %</td>
<td>0.45</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Lysine, min %</td>
<td>1.0</td>
<td>0.7</td>
<td>0.7</td>
<td>0.65</td>
</tr>
<tr>
<td>Methionine, min %</td>
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<td>0.35</td>
<td>0.35</td>
<td>0.30</td>
</tr>
<tr>
<td>Aflatoxin B&lt;sub&gt;1&lt;/sub&gt; max ppb</td>
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<td>20</td>
<td>20</td>
<td>20</td>
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### MINERAL MIXTURE FOR POULTRY (BIS)

1. Moisture (Max)                  3%
2. Calcium (Min)                   30%
3. Phosphorus (Min)                9% TP
4. Iron (Min)                      2000 ppm
5. Copper (Min)                    500 ppm
6. Iodine (KI) (Min)               0.01%
7. Manganese (Min)                 0.40 %
8. Fluorine (Max)                  0.05%
9. Zinc (Min)                      0.40%
10. Acid insoluble ash (Max)       3%
## NUTRIENT REQUIREMENT FOR SWINE

### NUTRIENT REQUIREMENTS FOR PIG FEEDS (BIS)

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>NUTRIENT</th>
<th>Pig starter/Creep feed</th>
<th>Pig growth Meal</th>
<th>Pig finishing/Breeding meal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Moisture (Max %)</td>
<td>11.0</td>
<td>11.0</td>
<td>11.0</td>
</tr>
<tr>
<td>2</td>
<td>Crude protein (Min %)</td>
<td>20.0</td>
<td>18.0</td>
<td>16.0</td>
</tr>
<tr>
<td>3</td>
<td>Crude fat or ether Extract (Min %)</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>4</td>
<td>Crude fibre (Max %)</td>
<td>5.0</td>
<td>6.0</td>
<td>8.0</td>
</tr>
<tr>
<td>5</td>
<td>Total ash (Max %)</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>6</td>
<td>Acid insoluble ash (Max %)</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
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<tr>
<td>7</td>
<td>Metabolizable energy (kcal/kg), (Min)</td>
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## NUTRIENT REQUIREMENT FOR HORSES

### Nutrient requirements of horses (as % of ration)

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<tr>
<th>Class</th>
<th>TDN (kg/day)</th>
<th>Crude protein</th>
<th>Ca, %</th>
<th>P, %</th>
<th>Feed intake % body weight</th>
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<tr>
<td>Adult horses at rest</td>
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<td>Pregnant mare (last 3 months of pregnancy)</td>
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<td>10.0</td>
<td>0.45</td>
<td>0.35</td>
<td>1.75</td>
</tr>
<tr>
<td>Lactation (First 3 months)</td>
<td>6.4</td>
<td>12.5</td>
<td>0.45</td>
<td>0.35</td>
<td>2.75</td>
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<td>Nursing Foal (3-5 months) Requirements in addition to milk</td>
<td>1.6</td>
<td>16</td>
<td>0.8</td>
<td>0.55</td>
<td>0.75</td>
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<td>18-24 months</td>
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<td>10.0</td>
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<td>12-18 months</td>
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<td>12.0</td>
<td>0.50</td>
<td>0.35</td>
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<tr>
<td>2 year old to maturity</td>
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<td>9.0</td>
<td>0.40</td>
<td>0.35</td>
<td>1.75</td>
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## NUTRIENT REQUIREMENT FOR LABORATORY ANIMALS

### 1) BIS specifications for compounded feeds for mice and rats

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<th>Requirements</th>
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<tr>
<td>2</td>
<td>Crude protein (Min %)</td>
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<tr>
<td>3</td>
<td>Crude fat (Max %)</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>Crude fibre (Max %)</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>Total Ash (Max)</td>
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</tr>
<tr>
<td>6</td>
<td>Acid insoluble ash (Max %)</td>
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<td>7</td>
<td>Calcium (Min)</td>
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<tr>
<td>8</td>
<td>Available phosphorus (Min)</td>
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2. Nutrient requirements of feeds for intensively reared rabbits of different categories

<table>
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<tr>
<th>Components of feed</th>
<th>Unit</th>
<th>Growing rabbits (4-12 weeks)</th>
<th>Lactating doe+ young under mother</th>
<th>Pregnant doe, not lactating</th>
<th>Resting adults (males)</th>
<th>Mixed breeding does plus fatteners</th>
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<tbody>
<tr>
<td>Crude proteins</td>
<td>%</td>
<td>16</td>
<td>18</td>
<td>16</td>
<td>13</td>
<td>17</td>
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<tr>
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<td>15-16</td>
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<td>2500</td>
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<tr>
<td>Calcium</td>
<td>%</td>
<td>0.40</td>
<td>1.10</td>
<td>0.80</td>
<td>0.40</td>
<td>1.10</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>%</td>
<td>0.30</td>
<td>0.80</td>
<td>0.50</td>
<td>0.30</td>
<td>0.80</td>
</tr>
</tbody>
</table>

3. Recommended nutrient allowances for growing Guinea Pigs

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>DE Kcal/kg</td>
<td>2800</td>
</tr>
<tr>
<td>Protein %</td>
<td>18</td>
</tr>
<tr>
<td>Fibre %</td>
<td>15</td>
</tr>
<tr>
<td>Calcium %</td>
<td>0.8-1</td>
</tr>
<tr>
<td>Phosphorus %</td>
<td>0.4-0.7</td>
</tr>
<tr>
<td>Zinc mg/kg</td>
<td>20</td>
</tr>
<tr>
<td>Iron mg/kg</td>
<td>50</td>
</tr>
</tbody>
</table>

RATION FORMULATION

Ration formulation is a process by which different feed ingredients are combined in a proportion necessary to provide the animal with proper amount of nutrients needed at a particular stage of production.

- It requires the knowledge about nutrients, feedstuffs and animal in the development of nutritionally adequate rations that will be eaten in sufficient amounts to provide the level of production at a reasonable cost. The ration formulated should be palatable and will not cause any serious digestive disturbance or toxic effects to the animal.
  - The nutrient requirements can be arrived using feeding standards.
  - The list of commonly available feeds in that region is prepared.
  - The nutritional value of the feeds is obtained from any standard source such as NRC.
- Using the above information rations can be prepared by several methods that include
  - Square Method
  - Simultaneous Equation Method
  - Two-by-two Matrix method
  - Trial and Error Method and
  - Linear Programming (LP)
Factors to be considered in ration formulations

- Acceptability to the animal - The ration formulated has to be palatable.
- Digestibility - The nutrients in the feed have to be digested and released into the gastrointestinal tract to be utilized by the animal. Rations with high fiber content cannot be tolerated by poultry and swine.
- Cost - The requirement of the animal can be met through several combinations of feed ingredients. However, when the costs of these ingredients are considered, there can only be one least-cost formulation. The least-cost ration should ensure that the requirements of the animal are met and the desired objectives are achieved.
- Presence of anti-nutritional factors and toxins. The presence of anti-nutritional factors in the feed affects the digestion of some nutrients and makes them unavailable to the animal. The inclusion of these feed ingredients should therefore be limited in the formulation.
- Other factors that should be considered are texture, moisture and the processing the feed has to undergo.
- This is relatively simple and easy to follow. It satisfies only one nutrient requirement and uses only two feed ingredients. Another limitation is that the level of nutrient being computed should be intermediate between the nutrient concentration of the two feed ingredients being used.

The Pearson square or box method

- The Pearson square or box method of balancing rations is a simple procedure that has been used for many years. It is of greatest value when only two ingredients are to be mixed. The nutrient requirement is noted in the middle of the square. This value in the middle of the square must be intermediate between the two values that are used on the left side of the square which are actually the nutrient content of the two ingredients that are to be used. For example, the 14 percent crude protein requirement has to be intermediate between the soybean meal that has 45 percent crude protein or the corn that has 10 percent crude protein. Subtract the nutrient value from the nutritional requirement on the diagonal and arrive at a numerical value and note it down on the right side of the square. Two sets of values will be got. By summing those parts and dividing by the total, you can determine the percent of the ration that each ingredient should represent in order to provide a specific nutrient level.
SIMULTANEOUS EQUATION METHOD

- This is an alternative method for the square method using a simple algebraic equation.
- Here, a particular nutrient requirement is satisfied using a combination of two feed ingredients.

Ration formulation poultry algebraic method

Fix the nutrient requirements for the feed to be formulated

- Slack space for additives 0.5%
- Slack space for lysine – 0.05
- Slack space for methionine – 0.15
- Slack space for common salt if fish meal not included – 0.4
- Slack space for calcium and phosphorus. Chicks 3, growers 2, layers 10 -12
- Fix level of animal origin protein source if it is going to be included max 10%
- Fix level of cereal milling byproducts to be included (refer maximum inclusion level)
- Calculate the total of the ingredients so far added.
- Assuming that the following is the list of ingredients selected
### Ingredients

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Inclusion level</th>
<th>CP</th>
<th>ME Kcal/Kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>65</td>
<td>5.85</td>
<td>2145</td>
</tr>
<tr>
<td>Soya bean meal</td>
<td>19.2</td>
<td>9.6</td>
<td>518</td>
</tr>
<tr>
<td>Fish meal</td>
<td>8</td>
<td>4</td>
<td>224</td>
</tr>
<tr>
<td>Rice bran</td>
<td>5</td>
<td>0.55</td>
<td>135</td>
</tr>
</tbody>
</table>

- Total of ingredients other than Maize and Soya bean meal = 15.70
- Balance from maize and Soya bean meal = 100 – 15.70 = 84.30
- Total Protein requirement = 20%
- Protein already supplied = 4.55
- Balance protein required = 15.45

Let X = Maize and Y = Soya bean meal

- \( X + Y = 84.3 \) (Equation 1)
- \( 0.09X + 0.50Y = 15.45 \) (Equation 2)

Multiplying Equation 1 with 0.50

- \( 0.50X + 0.50Y = 42.15 \) (Equation 3)

Subtracting equation 2 from equation 3

- \( 0.41X = 26.7 \)
- \( X = 65.12 = 65 \)
- \( Y = 84.3 - 65.12 = 19.18 = 19.2 \)
<table>
<thead>
<tr>
<th>Lysine</th>
<th>0.05</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methionine</td>
<td>0.15</td>
</tr>
<tr>
<td>Additives</td>
<td>0.5</td>
</tr>
<tr>
<td>Mineral mixture (Calcium, P etc)</td>
<td>2</td>
</tr>
<tr>
<td>Extra ricebran</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>0.011</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

**TWO-BY-TWO MATRIX METHOD**

This method solves two nutrient requirements using two different feed ingredients. A 2 x 2 matrix is set and a series of equations are done to come up with the solution to the problem.

**TRIAL AND ERROR METHOD**

- This is the most popular method of formulating rations for swine and poultry.
- As the name implies, the formulation is manipulated until the nutrient requirements of the animal are met.
- This method makes possible the formulation of a ration that meets all the nutrient requirements of the animal.
- Greater control can be had on implementing restrictions and judging inclusion levels
- It is a time consuming method involving a lot of calculations and meeting out specifications may not be very precise.

**LINEAR PROGRAMMING (LP)**

- This is a method of determining the least-cost combination of ingredients using a series of mathematical equations. There are many possible solutions to each series of equations, but when the factor of cost is applied, there can only be one least cost combination.
- An electronic computer is capable of making thousands of calculations in a very short time. However, the machine is incapable of correcting errors resulting from incorrect data and errors in setting up of the program. Therefore, the resultant rations obtained from linear programming will be no better than the information and values which are entered

**FORMULATION OF RATIOS – CATTLE**

**CALCULATION OF NUTRIENT REQUIREMENTS:**

The nutrient requirements can be calculated by using a few factors without referring to the table. The protein and energy requirement is related to metabolic body weight.
CALCULATION OF BODY WEIGHT:

Where it is not possible to weigh the animals the body weight can be calculated by using Shaeffer's formula.

FOR CATTLE:

\[ W = \frac{LG^2}{300} \]

\( W \) = Body weight in pounds
\( L \) = Length of the animal in inches. It is from the point of the shoulder to the point of the buttock
\( G \) = Girth in inches. It is the circumference measured just behind the point of elbow.

The body weight can be converted to kgs.

1 kg. = 2.2 pounds.

FOR BUFFALOES:

\[ W = \frac{GL}{Y} \]

\( W \) = Weight of the animal in seers (1 seer is equal to 0.93 kgs.)
\( L \) = Length of the animal in inches.
\( G \) = Girth of animal in inches.
\( Y \) = Constant

- When \( G \) is below 65 \( \rightarrow \) \( Y \) is 9.0
- When \( G \) is between 65 and 80 \( \rightarrow \) \( Y \) is 8.5
- When \( G \) is above 80 \( \rightarrow \) \( Y \) is 8.0

METABOLIC BODY WEIGHT (\( W^{0.75} \)):

Body weight to the power of 0.75. This is calculated by using Logarithm tables of a calculator.

1) Using Logarithm tables:

\[ \text{Logarithm value} = 2.6021 \times 0.75 = 1.9516 \]
Antilogarithm value for metabolic boy weight = 89.44

(2) Using a calculator:

Body weight to the power of 3 and press the square root key twice, you will get the metabolic body weight.

Eg. 400 x 400 x 400 = 64000000
8000 89.44

Dry matter intake

The total quantity of dry matter the animal can consume per day should be known, so that we can compute the ration in such a manner that the entire quantity of the nutrient requirement is present in the dry matter which the animal is able to consume. Cattle will generally consume 2.0 to 2.5 kg of dry matter per 100 kg body weight. Buffaloes, crossbred animals and heavy yielders consume 2.5 to 3.0 kg dry matter per 100 kg body weight.

PARTITIONING OF DRY MATTER
TDN REQUIREMENT FOR MAINTENANCE:

\[ 34 \text{g TDN/kg } W^{0.75} \]

\(W^{0.75} = \text{Metabolic body weight.}\)

DCP REQUIREMENT FOR MAINTENANCE:

\[ 2.84 \text{ g DCP/kg } W^{0.75} \]

\(W^{0.75} = \text{Metabolic body weight.}\)

NUTRIENT REQUIREMENT FOR LACTATION:

**TDN requirement**

- 330 g TDN/kg fat corrected milk.
- Formula for fat correction of milk is 0.4 + 0.15F, where F is % of fat in milk.

**DCP requirement**

- The protein content of milk can be calculated by using the following formula. Percentage of protein = 1.9 + 0.4F, where F is percentage of fat.
- Then the DCP requirement is calculated by assuming that the Biological value of microbial protein in Cattle as 70.

Eg. The DCP requirement of 1 kg of milk with 5% fat

\[
\text{Percentage of protein} = 1.9 + (0.4 \times 5) = 3.9\% \text{ or } 39 \text{ g in 1 kg.}
\]

\[
\text{Quantity of DCP required is } (39/70) \times 100 = 55.7 \text{ or } 56 \text{ g of DCP for 1 kg of milk with 5\% fat.}
\]

Calculation of nutrient requirements for a cow weighing 400 kg and yielding 10 kg of milk with 5\% fat.

- The metabolic body weight is 89.44.

CALCULATION OF DRY MATTER REQUIREMENT:

- The dry matter requirement for crossbred heavy yielders is 2.5 to 3.0\% of its body weight. For an animal weighing 400 kg. It is 400 x 2.5/100 = 10 kg or 400 x 3/100 = 12 kgs.

- The dry matter requirement is 10 to 12 kg.

PARTITIONING OF DRY MATTER:

- 1/3 of dry matter from concentrate.
- 10 x 1/3 = 3.3 kg.
- 12 x 1/3 = 4.0 kg
- 7 to 8 kg from roughage.
- 1/3 from green roughage = 2 to 3 kg.
- 2/3 from dry roughage = 4 to 5 kg.

TDN REQUIREMENT:

**For maintenance:**

\[ 34 \times 89.44 = 3040 \text{g} \]

**For milk production:**

330g TDN/kg. FCM (Fat corrected milk)

\[ \text{FCM} = 0.4 + 0.15F \]

\[ 0.4 + (0.15 \times 5) = 1.15 \]

1 kg of milk with 5\% fat = 1.15 kg of milk with 4\% fat.

For 10 kg = 11.5 x 300 = 3795 g
Total TDN required = for maintenance = 3040 g
                 for Lactation = 3795 g
                          6835 g

DCP REQUIREMENT:

For maintenance  2.84 x 89.44 = 254 g.

For milk production:

10 kg of milk with 5% fat.

Percentage of protein = 1.9 + 0.4 F
                        = 1.9 + (0.4 x 5) = 3.9

DCP required = 3.9 x 100 = 5.6g/100g.
               70
56g for 1 kg milk.
560g DCP/10 kg milk.

Total DCP required: Maintenance  254g
                    Lactation       560g
                          814g

COMPUTATION OF RATION:

<table>
<thead>
<tr>
<th></th>
<th>D.M</th>
<th>DCP</th>
<th>TDN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirement</td>
<td>10-12</td>
<td>814g</td>
<td>6835g</td>
</tr>
<tr>
<td>Ingredients</td>
<td>Quantity as fed</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Groundnut cake</td>
<td>1.1 kg.</td>
<td>1.0 kg</td>
<td>460g</td>
</tr>
<tr>
<td>Cotton seed</td>
<td>2.2 kg.</td>
<td>2.0 kg</td>
<td>250g</td>
</tr>
<tr>
<td>Tapica thippi</td>
<td>1.1 kg.</td>
<td>1.0 kg</td>
<td>15g</td>
</tr>
<tr>
<td>Bengal gram husk</td>
<td>1.1 kg.</td>
<td>1.0 kg</td>
<td>-</td>
</tr>
<tr>
<td>Green grass</td>
<td>10 kg.</td>
<td>2.5 kg</td>
<td>100g</td>
</tr>
<tr>
<td>Paddy straw</td>
<td>3.3 kg.</td>
<td>3.0 kg</td>
<td>-</td>
</tr>
</tbody>
</table>

|                | 10.5 kg | 825g  | 6850g |

To the concentrate part add 2% mineral mixture and 1% salt. If green grass is not included in the ration Vitamin A should be supplemented 1 mg. of carotene = 400IU of Vitamin A.
Nutritive value of feeds and fodder

<table>
<thead>
<tr>
<th></th>
<th>DM %</th>
<th>CP %</th>
<th>DCP %</th>
<th>TDN %</th>
<th>ME kcal/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereal grains</td>
<td>90</td>
<td>8-10</td>
<td>4-7</td>
<td>70-85</td>
<td>2500-3000</td>
</tr>
<tr>
<td>Oil cake</td>
<td>90</td>
<td>40-50</td>
<td>38-45</td>
<td>55-65</td>
<td>2000-2500</td>
</tr>
<tr>
<td>Bran</td>
<td>90</td>
<td>6-12</td>
<td>5-10</td>
<td>50-60</td>
<td>1500-1800</td>
</tr>
<tr>
<td>Non legume fodder</td>
<td>85</td>
<td>6-8</td>
<td>2-3</td>
<td>50-60</td>
<td></td>
</tr>
<tr>
<td>Legume hay</td>
<td>85</td>
<td>15-18</td>
<td>11-12</td>
<td>50-60</td>
<td></td>
</tr>
<tr>
<td>Paddy straw</td>
<td>90</td>
<td>3</td>
<td>0</td>
<td>45</td>
<td></td>
</tr>
</tbody>
</table>

Model questions

54. Tables which indicates the nutritive requirements of livestock are known as

A. Nutrient allowance  
B. Feeding standard
C. Tables  
D. Chart

i. A is true  
ii. B is true  
iii. C is true  
iv. D is true

55. Kellner’s feeding standard is

A. Comparative type  
B. Digestive nutrient type
C. Production value type  
D. Maintenance value type

i. A and D are true  
ii. B is true  
iii. C is true  
iv. None are true

56. Morrison feeding standards express requirements in terms of

A. Dry matter, Digestible protein  
B. TDN
C. NE  
D. CP and ME

i. A and B are correct  
ii. A, B & C are correct  
iii. D is correct  
iv. A and C are correct
57. ARC feed standard is adopted in

A. USA  
B. Japan  
C. India  
D. United Kingdom

i. D is correct ii. A is correct iii. Non are correct iv. B is correct

58. For measuring BMR animal has to be maintained in

A. Thermo nutral zone  
B. Relaxed  
C. Post absorptive state  
D. Good plane of nutrition

i. None are correct ii. All are correct iii. A, B & C are correct iv. C and D are correct

59. Direct calorimetry measures

A. RQ  
B. Carbon nitrogen balance  
C. Weight gain  
D. Sensible heat loss

i. A and B are correct ii. B and C are correct iii. C and D are correct iv. D is correct

60. Indian feeding standards is based on

A. Japanese feeding standard  
B. NRC  
C. Kellners  
D. Morrison

i. D is correct ii. A is correct iii. C is correct iv. B is correct

61. Kellners feeding standard is based on

A. TDN  
B. ME  
C. Starch equivalent  
D. DE

i. A is correct ii. D is correct iii. B is correct iv. C is correct
62. The RQ when carbohydrate is metabolized is

A. 0.7  
B. 0.9  
C. 1  
D. 0.8  

i. C is correct  
ii. D is correct  
iii. A is correct  
iv. B is correct

63. Consider the statement

(A) Nutrient allowance is higher than nutrient requirement  
(R) Nutrient allowance taken into account a safety margin

i. A is False 
ii. R is false 
iii. A and R are false  
iv. A and R are true

64. Kellners feeding standard is based on

A. TDN  
B. ME  
C. Starch equivalent  
D. DE  

i. A is correct 
ii. D is correct 
iii. B is correct  
iv. C is correct

65. The dry matter requirement of dairy cow is

A. 2.5 kg/100kg body weight  
B. 1.5 kg/100kg body weight  
C. 4 kg/100kg body weight  
D. 3.5 kg/100kg body weight  

i. D is correct 
ii. C is correct 
iii. A is correct  
iv. B is correct

66. While formulating a ration for lactating cow importance is given to

A. Fat percentage of milk  
B. Quantity of milk  
C. SNF percentage of milk  
D. Lactose percentage of milk  

i. A and C are correct 
ii. A and D are correct 
iii. A, B & D are correct 
iv. A and B are correct
67. Salt is added in the ruminant ration at the level of
   A. 2%  
   B. 3%  
   C. 1%  
   D. 4%  
   i. C is correct  
   ii. A is correct  
   iii. D is correct  
   iv. B is correct

68. Milk replacer is a substitute for
   A. Whole milk  
   B. Colustrum  
   C. Calf starter  
   D. Calf grower  
   i. A is correct  
   ii. B is correct  
   iii. D is correct  
   iv. C is correct

69. Colostrum feeding must be carried out within
   A. 1-2 hours after birth  
   B. 1-2 days after birth  
   C. 24 hours after birth  
   D. 12 hours after birth  
   i. A is correct  
   ii. D is correct  
   iii. B is correct  
   iv. C is correct

70. Calf starter meal must be
   A. Palatable  
   B. contain 20% DCP  
   C. 75% of TDN  
   D. fortified with vitamins  
   i. None are correct  
   ii. All are correct  
   iii. C and D are false  
   iv. A and B are false

71. Steaming up ration is provided
   A. Immediately after Parturition  
   B. Heifer stage  
   C. Before insemination  
   D. At last stage of pregnancy  
   i. D is correct  
   ii. A is correct  
   iii. B is correct  
   iv. C is correct
72. Green roughage in the ration helps to meet out
   A. Carotene requirement
   B. Vitamin D requirement
   C. Vitamin B₁₂ requirement
   D. Iodine requirement
   i. B is correct   ii. A is correct   iii. C is correct   iv. D is correct

73. In dairy cattle ration molasses can be added up to
   A. 10% level
   B. 15% level
   C. 20% level
   D. 0% level
   i. D is correct   ii. B is correct   iii. C is correct   iv. A is correct

74. Feeding concentrate above 60% in ration of dairy cow will lead to
   A. Ketosis
   B. Acidosis
   C. Pica
   D. Tetany
   i. D is correct   ii. A is correct   iii. C is correct   iv. B is correct
CHAPTER VI
NUTRITIONAL DEFICIENCY AND ITS INFLUENCE ON LIVESTOCK PERFORMANCE

Energy deficiency:

Deficiency of energy is the most common nutrient deficiency which limits the performance of grazing animals. Feed may be inadequate due to overgrazing, drought, poor quality or digestibility or expense. Sometime forage may contain an excess of water, limiting energy intake. Energy deficiencies result in retarded growth in young animals, delay in the onset of puberty, shortened lactation period and decline in milk production, especially during late pregnancy and early lactation. Prolonged periods of anoestrus, lasting several months, which have marked effect on the reproductive performance of a breeding herd. Calves and lambs may be born weak and undersized.

Protein Deficiency:

Protein deficiency usually accompanies energy deficiency. It can lead to reduced appetite in young animals, lowering feed intake. Can cause lack of muscle development, delayed time to reach maturity. In adult animals there is loss of weight and decreased milk production. In both young and mature animals, there is a drop in hemoglobin concentration, packed cell volume, total serum protein, and serum albumin. In the late stages, there is edema associated with the hypoproteinemia. Ruminants do not normally need a dietary supply of essential amino acids, in contrast to swine which need a natural protein supplement in addition to the major portion of total protein supplied by the cereal grains. The amino acid composition of the dietary protein for ruminants is not critical because the ruminal flora synthesize the necessary amino acids from lower quality proteins and non-protein sources of nitrogen. In poultry, protein deficiency causes depression in growth, egg production, egg weight, feed efficiency and weight loss, Immuno suppression, increased susceptibility to diseases.

Vitamin A deficiency:

Cattle: Roughened hair, scaly skin, and excessive watering, softening, cloudiness of the cornea leading to xerophthalmia. In calves constriction of the optic nerve canal leads to blindness. In breeding animal's leads to infertility.

Sheep: Deficiency is not common because of adequate intake. In addition to night blindness severe cases of deficiency may result in lambs being born weak or dead.

Pigs: Night blindness and Xerophthalmia may occur. Deficiency in pregnant animals may result in the production of blind deformed litters. In less severe cases appetite is impaired and growth retarded.

Poultry: Mortality rate is high. Early symptoms include retarded growth, weakness, ruffled plumage and a staggering gait. Egg production and hatchability are reduced.

Vitamin D deficiency:

In young animal's deficiency of vitamin D causes rickets and in adults it causes Osteomalacia.
Rickets: Calcium and Phosphorus deposition in bones is affected and the bones are weak, more prone to fractures and deformities. The conditions commonly seen are bowing of legs, swollen knees and hock and arching of back. Occasionally there is paralysis. Rickety Rosary — enlargement of Osteochondral junction in ribs are also noticed.

Osteomalacia: Resorption of the bone already laid down. Bones become weak, more prone to fractures and deformities. It can occur in pregnant and lactating animals, which require increased amount of calcium and phosphorus.

In poultry bones and beak become soft and rubbery legs become weak. Egg production is reduced and eggshell quality deteriorates.

**Vitamin E Deficiency**

The most frequent and, from a diagnostic point of view, the most important manifestation of vitamin E deficiency in farm animals is muscle degeneration (myopathy). Nutritional myopathy, also known as muscular dystrophy, frequently occurs in cattle, particularly calves. The myopathy primarily affects the skeletal muscles and the affected animals have weak leg muscles, a condition manifested by difficulty in standing and, after standing, a trembling and staggering gait. Eventually, the animals are unable to rise and weakness of the neck muscles prevents them from raising their heads. A popular descriptive name for this condition is white muscle disease. The heat muscle may also be affected and death may result.

Nutritional myopathy also occurs in lambs, with similar symptoms to those of calves. The condition is frequently referred to as stiff lamb disease.

In pigs, the two main diseases associated with vitamin E and selenium deficiency are myopathy and cardiac disease. The pigs demonstrate an uncoordinated staggering gait, or are unable to rise. The pigs heart muscle is more commonly affected. Sudden cardiac failure occurs and on post-mortem examination the lesions of the cardiac muscles are seen as pale patches or white streaks. This condition is commonly known as mulberry heart disease.

Vitamin E deficiency in chicks may lead to a number of distinct diseases: myopathy, encephalomalacia and exudative diathesis. In nutritional myopathy the main muscles affected are the pectorals although the leg muscles also may be involved. Nutritional encephalomalacia or crazy chick disease is a condition in which the chick is unable to walk or stand, and is accompanied by hemorrhages and necrosis of brain cells. Exudative diathesis is a vascular disease of chicks characterized by a generalized oedema of the subcutaneous fatty tissues, associated with an abnormal permeability of the capillary walls. Both selenium and vitamin E appear to be involved in nutrition myopathy and in exudative diathesis but the element does not seem to be important in nutritional encephalomalacia. It should be stressed that selenium itself is a very toxic element and care is required in its use as a dietary additive.

**Vitamin K Deficiency**

Low Prothrombin level in blood leads to haemorrhagic conditions. Deficiency rare in ruminants. In cattle sweet clover disease is associated with Vitamin K. Sweet clover that is spoiled contains a compound dicoumarol, which lowers prothrombin content of blood. In chicks Vitamin K deficiency causes anemia and delayed clotting time of blood.
**Vitamin C Deficiency**

Scurvy in Adults: Weakness, bleeding, loose teeth, Swollen joints hemorrhages.
Infantile scurvy: Anorexia, List, Leg drawn up to abdomen swelling at ends of long bone. Gums swollen, dyspnœa, cyanosis, convulsions and death if not treated. Delayed wound healing. Stress increases the requirement of this vitamin.

**Thiamine Deficiency**

Early symptoms: anorexia, emaciation, muscular weakness and progressive dysfunction of the nervous system.

Chicks: anorexia, emaciation, polyneuritis characterised by head retraction, nerve degeneration and paralysis. Thiamine deficiency leads to a deficiency of TPP. Oxidative de carboxylation of pyruvic acid does not take place and there is accumulation of pyruvic acid, which undergoes reduction to form lactic acid, which in turn causes muscular weakness. Nerve cells are also dependent on carbohydrate as source of energy. Thiamine deficiency leads to improper utilization of carbohydrate causing nervous lesions.

In Ruminant's thiamine deficiency is not common because of synthesis of in the rumen by certain bacteria. However certain bacteria are capable of synthesizing thiaminase which destroys the vitamin causing thiamine deficiency. It is characterised by circular movements, head pressing, muscular tremors and blindness. Lactic acidosis caused by the feeding of rapidly soluble carbohydrate may predispose to the production of thiaminases.

Thiaminase is also present in bracken fern and thiamine deficiency has been reported in horses feeding it. Raw fish also contains thiaminase, which is destroyed on cooking.

**Riboflavin Deficiency**

Poor appetite, retarded growth, vomiting, skin eruptions and eye abnormalities.

In sows riboflavin is necessary to maintain normal oestrous activity and prevent premature parturition.

In chicks riboflavin deficiency causes curled toe paralysis caused due to peripheral nerve degeneration, in which the chicks walk on their hocks with the toes curled inwards. In breeding hens deficiency causes decreased hatchability. Embryonic abnormalities occur including the clubbed down condition in which the feather continues to grow within the follicle leading to curled feather.

**Niacin Deficiency**

In pigs, deficiency symptoms include poor growth, anorexia, enteritis, vomiting and dermatitis. In fowls a deficiency of the vitamin causes bone disorders, feathering abnormalities and inflammation of the mouth and upper part of the oesophagus.

Deficiency symptoms are particularly likely in pigs and poultry if diets with a high maize content are used, since maize contains very little of the vitamin or of tryptophan.
Pyridoxine Deficiency

Because of the numerous enzymes requiring pyridoxal phosphate, a large variety of biochemical lesions are associated with vitamin B\textsubscript{6} deficiency. These lesions are concerned primarily with amino acid metabolism and a deficiency affects the animal's growth rate. Convulsions may also occur, possibly because a reduction in the activity of glutamic acid decarboxylase results in an accumulation of glutamic acid. In addition, pigs exhibit a reduced appetite and may develop anemia. Chicks on a deficient diet show jerky movements, while in adult birds hatchability and egg production are adversely affected. In practice, vitamin B\textsubscript{6} deficiency is unlikely to occur in farm animals because of the vitamin's wide distribution.

Pantothenic acid Deficiency

Deficiency of pantothenic acid in pigs causes slow growth, diarrhoea, loss of hair, scaliness of the skin and a characteristic 'goose-stepping' gait; in severe cases animals are unable to stand. In the chick, growth is retarded and dermatitis occurs. In mature birds, hatchability is reduced. Rumen microorganisms can synthesize pantothenic acid, like the entire B-complex vitamin. Escherichia coli, for example, is known to produce this vitamin. Pantothenic acid deficiencies are considered to be rare in practice because of the wide distribution of the vitamin, although deficiency symptoms have been reported in commercial herds of Landrace pigs.

Folic acid Deficiency

A variety of deficiency symptoms in chicks and young turkeys have been reported, including poor growth, anaemia, poor bone development and poor egg hatchability. Folic acid deficiency symptoms rarely occur in other farm animals because of synthesis by intestinal bacteria.

Biotin Deficiency

In pigs, biotin deficiency causes foot lesions, alopecia (hair loss) and a dry scaly skin. In growing pigs, both growth rate and food utilization is adversely affected. In breeding sows, a deficiency of the vitamin can adversely influence reproductive performance.

In poultry, biotin deficiency causes reduced growth, dermatitis, leg bone abnormalities, cracked feet, poor feathering and fatty liver and kidney syndrome (FLKS). The last condition, which mainly affects two-to five-week-old chicks, is characterized by a lethargic state with death frequently following within a few hours. On autopsy, the liver and kidneys, which are pale and swollen, contain abnormal depositions of lipid.

Giving animal's avidin, a protein present in the raw white of eggs can induce biotin deficiency, which combines with the vitamin and prevents its absorption from the intestine. Certain streptomyces spp. Bacteria present in soil and manure produce streptavidin and stravidin, which have a similar action to the egg white protein. Heating inactivates these antagonist proteins.

Choline Deficiency

Deficiency symptoms, including slow growth and fatty infiltration of the liver, have been produced in chicks and pigs. Chorine is also concerned with the prevention of peruses or slipped tendon in chicks. The choline requirement of animals is unusually large for the vitamin, but in
spite of this, deficiency symptoms are not common in farm animals because of its wide distribution, its high concentrations in foods and because it can be readily derived from methionine.

**Cyanocobalamine Deficiency**

Adult animals are generally less affected by vitamin B$_{12}$ deficiency than young growing animals, in which growth is severely retarded and mortality high.

In poultry, in addition to the effect on growth, feathering is poor and kidney damage may occur. Hens deprived of the vitamin remain healthy but hatchability is adversely affected.

On vitamin B$_{12}$ deficient diets, baby pigs grow poorly and show lack of coordination of the hind legs. In older pigs, dermatitis, a rough coat and sub-optimal growth result. Intestinal synthesis of the vitamin occurs in pigs and poultry. Organisms which synthesize vitamin B$_{12}$ have been isolated from poultry excreta and this fact has an important practical bearing on poultry housed with access to litter, where a majority, if not all, of the vitamin requirements can be obtained from the litter.

Microorganisms in the rumen synthesize Vitamin B$_{12}$ and a number of biologically inactive vitamin B$_{12}$ analogues and in spite of poor absorption of the vitamin from the intestine, the ruminant normally obtains an adequate amount of the vitamin from this source. However, if levels of cobalt in the diet are low, a deficiency of the vitamin can arise and cause reduced appetite, emaciation and anemia. If cobalt levels are adequate, then except with very young ruminant animals, a dietary source of the vitamin is not essential.

**Calcium deficiency**

If calcium is deficient in the diet of young growing animals, then satisfactory bone formation cannot occur and the condition known as rickets is produced. The symptoms of rickets are misshapen bones, enlargement of the joints, lameness and stiffness. In adult animals calcium deficiency produces osteomalacia, in which the calcium in the bone is withdrawn and not replaced. In osteomalacia the bones become weak and are easily broken. In hens, deficiency symptoms are soft beak and bones, retarded growth and bowed legs, the eggs have thin shells.

Milk fever (parturient paresis) is a condition, which most commonly occurs, in dairy cows shortly after calving. It is characterized by a lowering of the serum calcium level, muscular spasms, and in extreme case paralysis and unconsciousness. The exact cause of hypocalcaemia associated with milk fever is obscure, but it is generally considered that, with the onset of lactation, the parathyroid gland is unable to respond rapidly enough to increase calcium absorption from the intestine to meet the extra demand. Normal levels of blood calcium can be restored by intravenous injections of calcium gluconate, but this may not always have a permanent effect. It has been shown that avoiding excessive intakes of calcium while maintaining adequate dietary levels of phosphorus during the dry period, reduces the incidence of milk fever. Deliberate use of low calcium diets to increase calcium absorption in the practical prevention of milk fever requires a good estimate of calving date, or calcium deficiency may occur. Administration of large doses of vitamin D3 for a short period prior to parturition has also proved beneficial.
Phosphorus Deficiency

Extensive areas of phosphorus-deficient soils occur throughout the world, especially in tropical and subtropical areas, and a deficiency of this element can be regarded as the most widespread and economically important of all the mineral disabilities affecting grazing livestock.

Like calcium, phosphorus is required for bone formation and a deficiency can also cause rickets or osteomalacia. 'Pica' or depraved appetite has been noted in cattle when there is a deficiency of phosphorus in their diet; the affected animals have abnormal appetites and chew wood, bones, rags and other foreign materials. Pica is not specifically a sign of phosphorus deficiency since it may be caused by other factors. Evidence of phosphorus deficiency may be obtained from an analysis of blood serum, which would show phosphorus content lower than normal. In chronic phosphorus deficiency animals may have stiff joints and muscular weakness.

Low dietary intakes of phosphorus have also been associated with poor fertility, apparent dysfunction of the ovaries causing inhibition, depression of irregularity of oestrus. There are many examples, were phosphorus supplementation increases fertility in gazing cattle. In cows a deficiency of this element may also reduce milk yield.

Subnormal growth in young animals and low live weight gains in mature animals are characteristic symptoms of phosphorus deficiency in all species. Phosphorus deficiency is usually more common in cattle than in sheep, as the latter tend to have more selective grazing habits and choose the growing parts of plants which happen to be richer in phosphorus.

Potassium Deficiency:

The potassium content of plants is generally very high, grass for example has frequently above 25g/kg DM, so that it is normally ingested by animals in larger amounts than any other element. Consequently, potassium deficiency is rare in farm animals kept under natural conditions. One exception to this is provided by distillers grains which, as a result of the removal of the liquid after fermentation, is deficient in several soluble elements including potassium. Appropriate supplementation is necessary where draft forms as large proportion of the diet.

There are certain areas in the world where soil potassium levels are naturally low. Such areas occur in Brazil, Panama and Uganda and it is suggested that in these tropical regions, potassium deficiencies may arise in grazing animals especially at the end of the long dry season when potassium levels in the mature herbage are low.

Deficiency symptoms have been produced in chicks given experimental diets low in potassium. They include retarded growth, weakness and tetany, followed by death. Deficiency symptoms, including severe paralysis, have also been recorded for calves given synthetic milk diets low in potassium.

Sodium Deficiency

Sodium deficiency in animals occurs in many parts of the world, but especially in the tropical areas of Africa and the arid inland areas of Australia where pastures contain very low concentrations of the element. A deficiency of sodium in the diet leads to a towering of the osmotic pressure, which results in dehydration of the body. Symptoms of sodium pressure which results in dehydration of the body. Symptoms of sodium deficiency include poor growth and reduced utilization of digested proteins and energy. In hens, egg production and growth are adversely affected.
**Chlorine Deficiency**

A dietary deficiency of chlorine may lead to an abnormal increase of the alkali reserve of the blood (alkalosis) caused by an excess of bicarbonate, since inadequate levels of chlorine in the body are partly compensated for by increases in bicarbonate. Experiments with rats on chlorine-deficient diets have shown that growth was retarded, but no other symptoms developed.

**Magnesium Deficiency**

Symptoms due to a simple deficiency of magnesium in the diet have been reported for a number of animals. In rats fed on purified diets the symptoms include increased nervous irritability and convulsions. Experiments carried out on calves reared on low-magnesium milk diets resulted in low serum magnesium levels, depleted bone magnesium tetany and death.

In adult ruminants a condition known as hypomagnesaemic tetany associated with low blood levels of magnesium (hypomagnesaemia) has been recognized since the early 1930s.

Hypomagnesaemic tetany has been known under a variety of names including magnesium tetany, lactation tetany and grass staggers, but most of these terms have been discarded because the disease is not always associated with lactation nor with grazing animals. The condition can affect stall-fed dairy cattle, hill cattle, bullocks and cattle at grass as well as sheep. There is some evidence of a breed susceptibility in the United Kingdom where the condition appears to be more common in Ayrshires and least common in Jersey animals. Most cases occur in grazing animals, and in Europe and North America, the trouble is particularly common in the spring when the animals are turned out on to young, succulent pasture. Because the tetany can develop within a day or two of animals being turned out to graze, the condition has been referred to as the acute form. In this acute type, blood magnesium levels fall so rapidly enough. In the chronic form of the disease plasma magnesium levels fall over a period of time to low concentrations. This type is not uncommon in suckler herds.

Clinical signs of the disease are often brought on by stress factors such as cold, wet and windy weather. In adult animals bone magnesium is not as readily available as it is in the young calf.

The normal magnesium content of blood serum in cattle is within the range of 17 to 40 mg magnesium/1 blood serum, but levels below 17 frequently occur without clinical symptoms of disease. Tetany is usually preceded by a fall in blood serum magnesium to about 5mg/l. Subcutaneous injections of magnesium sulphate, or preferably magnesium lactate, can generally be expected to cure the animal if given early, but in practice this is sometimes difficult. Treatment of this kind is not a permanent cure and oral treatment with magnesium oxide, as described below, should be started immediately. Typical symptoms of tetany are nervousness, tremors, twitching of the facial muscles, staggering gait and convulsions.

The exact cause of hypomagnesaemic tetany in ruminant animals is unknown, although a dietary deficiency of magnesium may be a contributory factor. Some research workers consider the condition to be caused by a cation-anion imbalance in the diet and there is evidence of a positive relationship between tetany and heavy dressing of pasture with nitrogenous and potassic fertilizers.

Although the exact cause of hypomagnesaemia is still uncertain, the primary factor would appear to be inadequate absorption of magnesium from the digestive tract. A high degree of success in preventing hypomagnesaemia may be obtained by increasing the magnesium intake.
Feeding with magnesium-rich mineral mixtures, or alternatively by increasing the magnesium content of pasture can effect this by the application of magnesium fertilizers.

**Iron Deficiency**

Since more than half the iron present in the body occurs as haemoglobin, a dietary deficiency of iron would clearly be expected to affect the formation of this compound. The red blood corpuscles contain haemoglobin, and these cells are continually being produced in the bone marrow to replace those red cells destroyed in the animal body as a result of catabolism. Although the haemoglobin molecule is destroyed in the catabolism of these red blood corpuscles, the iron liberated is made use of in the re synthesis of haemoglobin, and because of this the daily requirement of iron by a healthy animal is usually small. If the need for iron increases, as it would after prolonged haemorrhage or during pregnancy, then haemoglobin synthesis may be affected and anaemia will result. Anaemia due to iron deficiency occurs most commonly in rapidly growing suckling animals, since the iron content of milk is usually very low. This can occur in piglets housed in pens without access to soil. The piglet is born with very limited iron reserves and sow's milk provides only about 1mg per day. The rapidly growing piglet’s requirement is 125mg per day which, in extensive systems, could be obtained by ingestion of soil. Providing the sow with supplementary iron in gestation does not increase the foetal piglets liver iron or the amount in the milk. Therefore, it is routinely supplied by intramuscular injection as a dextran complex by 3 days of age. Usually 200 mg of iron is injected. Alternatively oral iron supplements are available in the form of a paste of the citrate or fumarate or granules of iron dextran but these may not be eaten or the iron may be lost if diarrhoea occurs. Anemia in piglets is characterized by poor appetite and growth. Breathing becomes labored and spasmodic—hence the descriptive term 'thumps' for the condition. Although iron deficiency is not common in older animals, increased supplementation is required when high levels of cropper are used for growth promotion.

Iron deficiency anemia is not common in lambs and calves because in practice it is unusual to restrict them to a milk diet without supplementary feeding. It does, however, sometimes occur in laying hens, since egg production represents a considerable drain on the body reserves.

**Copper Deficiency**

Since copper performs many functions in the animal body there are a variety of deficiency symptoms. These include anaemia, poor growth, bone disorders, scouring, infertility, depigmentation of hair and wool, gastro-intestinal disturbances and lesions in the brain stem and spinal cord. The lesions are associated with muscular inco-ordination, and occur especially in young lambs. A copper deficiency of swayback condition known as ‘enzootic ataxia’ has been known for some time in Australia. A similar condition which affects lambs occurs in the United Kingdom and is known as ‘swayback’. The signs range from complete paralysis of the newborn lamb to a swaying staggering gait which affects, in particular, the hind limbs. The condition can occur in two forms, one congenital, in which the signs are apparent at birth and are due to the failure of the myelin sheath of nerves to develop, and the other in which the onset of the clinical disease is delayed for several weeks. The congenital form of the condition is irreversible and can only be prevented by ensuring that the ewe receives an adequate level of copper in her diet. Delayed swayback can be prevented or retarded in copper deficient lambs by parenteral injection of small doses of copper complexes.

Copper plays an important role in the production of 'crimp' in wool. The element is present in an enzyme which is responsible for the disulphide bridge in two adjacent cysteine
molecules. In the absence of the enzyme the protein molecules of the wool do not form their bridge and the wool, which lacks crimp, is referred to as 'stringy' or 'steely'.

Nutritional anaemia resulting from copper deficiency has been produced experimentally in young pigs by diets very low in the element and this type of anaemia could easily arise in such animals fed solely on milk. In older animals copper deficiency is unlikely to occur and copper supplementation of practical rations is generally considered unnecessary. There are, however, certain areas in the world where copper deficiency in cattle occurs. A condition in Australia known locally as 'falling disease' was found to be related to a progressive degeneration of the myocardium of animals grazing on copper deficient pastures.

**Cobalt deficiency**

When ruminants are confined to cobalt-deficient pasture it may be several months before any manifestations of pine occur because of body reserves of vitamin B\textsubscript{12} in the liver and kidneys. When these are depleted there is a gradual decrease in appetite with consequent loss of weight followed by muscular wasting, pica, severe anemia and eventually death. If the deficiency is less severe then a vague unthriftiness, difficult to diagnose. May be the only sign. Deficiency symptoms are likely to occur where levels of cobalt in the herbage are below 0.1 mg/kg DM. Under grazing conditions, lambs are the most sensitive to cobalt deficiency followed by mature sheep, calves and mature cattle in that order.

**Iodine Deficiency**

When the diet contains insufficient iodine the production of thyroxine is decreased. The main indication of such a deficiency is an enlargement of the thyroid gland, termed endemic goitre, and is caused by compensatory hypertrophy of the gland. The thyroid being situated in the neck, the deficiency condition in farm animals manifests itself as a swelling of the neck, 'big neck'. Reproductive abnormalities are one of the most outstanding consequences of reduced thyroid function; breeding animals deficient in iodine give birth to hairless, weak or dead young.

A dietary deficiency of iodine is not the sole cause of goiter, it is known that certain foods contain goitrogenic compounds and cause goitre in animals if given in large amounts. These foods include most members of the Brassica genus, especially kale, cabbage and rape, and also soya beans, linseed, peas and groundnuts. Goitrogens have been reported in milk of cows fed on goitrogenic plants. A goitrogen present in brassicas has been identified as L-5-vinyl-2-oxazolidine-2-thione (goitrin) which inhibits the iodination of tyrosine and thus interferes with thyroxine the diet. Thiocyanate, which may also be present in members of the Brassica genus, is known to be goitrogenic and may be produced in the tissues from a cyanogenetic glycoside present in some foods. Supplying adequate iodine in the diet prevents Goitrogenic activity of the thiocyanate type.

**Manganese Deficiency**

Low manganese diets for cows and goats have been reported to depress or delay oestrus and conception, and to increase abortion. Manganese is an important element in the diet of young chicks, a deficiency leading to perosis or 'slipped tendon', a malformation of the leg bones. Manganese deficiency in breeding birds reduces hatchability and shell thickness, and causes head retraction in chicks. In pigs lameness is a symptom. Other abnormalities associate with deficiency include impaired glucose utilization and a reduced vitamin K induced blood clotting response.
Zinc Deficiency

Subnormal growth, depressed appetite, poor feed conversion and parakeratosis characterize zinc deficiency in pigs. The latter is a reddening of the skin followed by eruptions which develop into scabs. A deficiency of this element is particularly liable to occur in young, intensively housed pigs offered a dry diet ad libitum, though a similar diet given wet may not cause the condition. It is aggravated by high calcium levels in the diet and reduced by decreased calcium and increased phosphorus levels. Pigs given diets supplemented with high levels of copper, for growth promotion, have an increased requirement for zinc. Gross signs of zinc deficiency in chicks are retarded growth, foot abnormalities, 'frizzled' feathers, parakeratosis and a bone abnormality referred to as the 'swollen hock syndrome'. Symptoms of zinc deficiency, in calves include inflammation of the noose and mouth, stiffness of the joints, swollen feet and parakeratosis. The response of severely zinc-deficient calves to supplemental zinc is rapid and dramatic. Improvements in skin condition are usually noted within 2 to 3 days.

Molybdenum Deficiency

Low- Molybdenum diets resulted in reduced levels of xanthine oxidase, but did not affect growth or purrine metabolism. Molybdenum deficiency has not observed under natural conditions in any species.

Model Questions

75. Xeropthalmia is caused due to deficiency of
A. Vitamin B₁₂  
B. Vitamin C  
C. Iron  
D. Methionine

i. A is correct  
ii. B is correct  
iii. C and D are correct  
iv. None are correct

76. Vitamin D is essential for absorption of
A. Calcium  
B. Manganese  
C. Protein  
D. Fat

i. C is correct  
ii. A is correct  
iii. B and D are correct  
iv. None are correct

77. Muscular dystrophy is due to the deficiency of
A. Vitamin A  
B. Vitamin C  
C. Vitamin E  
D. Vitamin D

i. A is correct  
ii. B is correct  
iii. C is correct  
iv. D is correct

78. Perosis in chicks is caused by the deficiency of
A. Vitamin A  
B. Choline  
C. Copper  
D. Vitamin B₁₂

i. A and D are correct  
ii. C and D are correct  
iii. A is correct  
iv. B is correct
79. Milk fever in dairy cows occurs due to the deficiency of
   A. Phosphorus
   B. Calcium
   C. Iron
   D. Cobalt
   i. C and D are correct
   ii. B is correct
   iii. A and D are correct
   iv. None are correct

80. Pica is a symptom seen in animals due to the deficiency of
   A. Calcium
   B. Manganese
   C. Phosphorus
   D. Copper
   i. A is correct
   ii. B is correct
   iii. C is correct
   iv. D is correct

81. Feather picking and cannibalism in birds is due to deficiency of
   A. Calcium
   B. Phosphorus
   C. Common salt
   D. Manganese
   i. C is correct
   ii. D is correct
   iii. A is correct
   iv. B is correct

82. Grass tetany in growing sheep is due to the deficiency of
   A. B complex vitamin
   B. Calcium
   C. Fatty acids
   D. Magnesium
   i. A is correct
   ii. C and B are correct
   iii. D is correct
   iv. A and C are correct

83. Sway beck (Enzootic ataxia) in lambs occurs due to the deficiency
   A. Cobalt
   B. Copper
   C. Iron
   D. Zinc
   i. A is correct
   ii. B is correct
   iii. C is correct
   iv. D is correct
84. For synthesis of the hormone Thyroxin the mineral required is

A. Iron  B. Copper  
C. Cobalt  D. Iodine

i. A is correct  ii. B is correct  iii. C is correct  iv. D is correct

85. “Slipped tendon” in chicks is a condition due to deficiency of

A. Zinc  B. Cobalt  
C. Iodine  D. Manganese

i. D is correct  ii. C is correct  iii. A is correct  iv. B is correct
CHAPTER VII

FEED SUPPLEMENTS AND ADDITIVES

What is Supplement?

The term, supplement, refers to feedstuffs that are used to improve the value of basal feeds. They can be used in large quantities, such as protein supplements, or in extremely small quantities, such as trace minerals.

While formulating ration, attention is first given to its dry matter, proteins and energy requirements. After this micronutrients such as individual amino acids, minerals, and vitamins are added to correct any deficiency in the ration.

Energy supplements are rich in energy ie above 60% TDN or 2500 Kcal ME. Eg Cereal grains, millets, brans, fats and oils.

Protein supplements contain more than 18 % protein. They can be from animal origin or plant origin

<table>
<thead>
<tr>
<th>Animal origin</th>
<th>Plant origin</th>
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<tbody>
<tr>
<td>Mostly over 47% protein</td>
<td>Mostly under 47% protein</td>
</tr>
<tr>
<td>Mostly over 1.0% Ca</td>
<td>Mostly under 1.0% Ca</td>
</tr>
<tr>
<td>Mostly over 1.5% P</td>
<td>Mostly under 1.5% P</td>
</tr>
<tr>
<td>Mostly under 2.5% fibre</td>
<td>Mostly over 2.5% fibre</td>
</tr>
</tbody>
</table>

Other sources includes NPN compunds, single cell protein etc.

Mineral supplements are rich sources of any one of the essential minerals. Eg shell grit, bone meal, dicalcium phosphate.

What is an Additive?

An additive is a substance that is added to a basic feed, usually in small quantities, for the purpose of fortifying it with certain nutrients, stimulants or medicines other than as a direct source of nutrient.

In general, the term “feed additive” refers to a non-nutritive product that affects utilisation of the feed or productive performance of the animal. Feed additives and implants can be classed according to their mode of action.

1. Additives that enhance feed intake

(a) Antioxidants:

Antioxidants are compounds that prevent oxidative rancidity of polyunsaturated fats. Rancidity once develops, may cause destruction of vitamins A, D and E and several of the B complex vitamins. Breakdown products of rancidity may react with lysine and thus affects the protein value of the ration. Ethoxyquin or BHT (butylated hydroxytoluene) can serve as antioxidant in feed.
(b) Flavouring Agent:

Flavouring agents are feed additives that are supposed to increase palatability and feed intake. There is need for flavouring agents that will help to keep up feed intake
1. when highly unpalatable medicants are being mixed
2. During attacks of diseases
3. When animals are under stress, and
4. When a less palatable feedstuffs is being fed either as such or being incorporated in the ration.

Ruminants prefer sweet compounds. Additionally cattle and goats respond positively to salts of volatile fatty acids. Horses will often refuse musty feed when there is so little mould that the owner fails to detect it.

2. Additives that enhance the colour or quality of the marketed product

Poultry man will often enhance the yellow colour by incorporating xanthophylls into broiler feed. Among various additives, arsanilic acid, sodium arsanilate and roxarsone are added for the purpose.

3. Additives that facilitate digestion and absorption

a. Grit: Poultry do not have teeth to grind any hard grain, most grinding takes place in the thick musculated gizzard. The more thoroughly feed is ground, the more surface area is created for digestion and subsequent absorption. Hence, when hard, coarse or fibrous feeds are fed to poultry, grit is sometimes added to supply additional surface for grinding within gizzard. When mash or finely ground feeds are fed, the value of grit become less. Oyster shells, coquina shells and limestone are used as grit.

b. Buffers and Neutralisers: During maximum production stage ruminants are given high doses of concentrate feeds for meeting demands for extra energy and protein requirement of the animal. The condition on the other hand lowers the pH of the rumen. Since, many of the rumen microbes cannot tolerate low pH environment, the normally heterogeneous balanced population of microbes become skewed, favouring the acidophilic (acid-loving) bacteria. The condition often leads to acidosis and thereby upsets normal digestion.

The addition of feed buffers and neutralisers, such as carbonates, bicarbonates, hydroxides, oxides, salts of VFA, phosphate salts, ammonium chloride and sodium sulphate have been shown to have beneficial effects. Recently the use of baking soda (NaHCO₃) has been shown to increase average daily gain by about 10 per cent, feed efficiency by 5 to 10 per cent, and milk production by about 0.5 liter per head per day.

c. Chelates: The word “Chelates” is derived from the Greek word “Chele” meaning “claw” which is a good descriptive term for the manner in which polyvalent cations are held by the metal binding agents. Prior to union with the metal these organic substances are termed as “ligands”. Ligand + mineral = chelate element.

Organic chelates of mineral elements which are cyclic compounds are the most important factors controlling absorption of a number of mineral elements. A particular element in chelated form may be released in ionic form at the intestinal wall or might be readily absorbed as the intact chelate. Chelates may be of naturally occurring substances
such as chlorophyll, cytochromes, haemoglobin, vitamin B\textsubscript{12} some amino acids, etc., or may be of synthetic substances like ethylenediaminetetracetic acid (EDTA.)

In biological systems there are three types of chelates:

**Type I. Chelates that Aid in Transport and to store Metal Ions**

Chelates of this group behave as a carrier for proper absorption, transportation in the circulatory system and passing across cell memberances to deposit the metal ion at the site where needed.

a. Among amino acids, cysteine and histidine are particularly effective metal binding agents and may be of primary importance in the transport and storage of mineral elements throughout the animal body.

b. Ethylene diamine tetracetic acid (EDTA) and other similar synthetic ligands also may improve the availability of zinc and other minerals.

**Type II. Chelates Essential in Metabolism**

Many chelates of animal body are holding metal ions in such a cyclic fashion which are absolutely necessary to be in that form to perform metabolic function. Vitamin B\textsubscript{12} cytochrome enzymes and haemoglobin are some of the examples of this type. Haemoglobin molecule without its content of ferrous form of iron will be of no use in transporting oxygen.

**Type III. Chelates Which Interfere with Utilisation of Essential Cations**

There are some chelates found in the body which might have accidentally formed and are of no use to the subject. Rather, those chelates may be detrimental for the proper utilisation of the element. Phytic acid-Zn chelate or oxalic acid calcium chelate are examples of this type.

d. **Probiotics:** is defined as a live microbial feed supplement which beneficially affect, the host animals by improving its intestinal microbial balance. The probiotic preparation are generally composed of organisms of lactobacilli and/or streptococci species, few many contain yeast caltones.

They benefit the host by:
1. Having a direct antagonistic effect against specific group of undesirable or harmful organism through production of antibacterial compounds, elemanatry or minimising their competition of nutrients.
2. Altering the pattern of microbial metabolism in the gastro intestinal tract.
3. Stimulation of immunity.
4. Neutralization of entrotoxins formed by pathogenic organism.

Thus resulting in increased growth rate, improved feed efficiency.

**4. Additives that promotes growth and production**

a. **Antibiotics:** These are substances which are produced by living organisms (mould, bacteria or green plants) and which in small concentration have bacteriostatic or bactericidal properties. They were originally developed for medical and veterinary purposes to control specific pathogenic organisms. Later it was discovered that certain antibiotics could increase the rate of growth of young pigs and chicks when included in their diet in small amounts. Soon after this report a wide range of antibiotics have been tested and the following have
been shown to have growth promoting properties: penicillin, oxytetracycline (Terramycin), chlortetracycline, bacitracin, streptomycin, tyrothricin, gramicidin, neomycin, erythromycin and flavomycin. Increased weight gain is most evident during the period of rapid growth and then decreases. Differences between control and treated animals are greater when the diet is slightly deficient or marginal in protein, B-vitamins or certain mineral elements.

Mode of Action of Antibiotics

1. Antibiotics “spare” protein, amino acids and vitamin on diets containing 1 to 3 per cent less protein, but balance experiments have often failed to show increased nitrogen retention. Growth stimulation has been greatest when the antibiotic penicillin supplement has been added to a ration containing no protein supplements of animal origin or to a ration low in vitamin B$_{12}$. Under hygienic conditions growth increases are small.
2. Intestinal wall of animals fed antibiotics is thinner than that of untreated animals which might explain the enhanced absorption of calcium shown for chicks.
3. Reduce or eliminate the activity of pathogens causing “subclinical infection.”
4. Reduce the growth of micro-organisms that compete with the host for supplies of nutrients.
5. Antibiotics alter intestinal bacteria so that less urease is produced and thus less ammonia is formed. Ammonia is highly toxic and suppresses growth in non-ruminants.
6. Stimulate the growth of micro-organisms that synthesise known or unidentified nutrients.

Following points should be kept in mind while using antibiotics for animal feeding:

1. Antibiotics should be used only for (a) growing and fattening pigs for slaughter as pork or bacon; (b) growing chicks and turkey poults for killing as table poultry.
2. Antibiotics should not be used in the feed of ruminant animals (cattle, sheep and goats), breeding pigs and breeding and laying poultry stock.
3. While adding antibiotics at the recommended level, care should be taken that they are thoroughly and evenly mixed with the feed.
4. For best results, antibiotics should be used with properly balanced feeds. Also, the feeds containing antibiotics should be fed only to the type of stock for which they are intended.
5. Antibiotics are not a substitute for good management and healthy living conditions, or for properly balanced rations.

(b) Arsenicals

5. Additives that alter metabolism

(a) Hormones: These are chemicals released by a specific area of the body (ductless glands) and are transported to another region within the animal where they elicit a physiological response.

Extensive use is being made of synthetic and purified estrogens, androgens, progestogens, growth hormones and thyroxine or thyroprotein (iodinated casein) to stimulate the growth and fattening of meat producing animals. There is concern, however, about possible harmful effects of any residues of these materials in the meat or milk for the consumers.

The whole question whether hormones should be used as growth promoters is still debatable but it seems logical that with any feeding system the economic advantages, however great should never take precedence over any potential risk to human health. These substances may induce cancer in human beings if taken over a prolonged period through products of the treated animals. The use of such substances in poultry rearing has been prohibited by law in U.S.A.
(b) **Implants:** Implants are hormone or hormone like products that are designed to release slowly, but constantly, the active chemicals for absorption into the bloodstream. These are implanted subcutaneously in the ear. (eg.) diethylstilbesterol (DES).

6. **Additives that affect the health status of livestock**

   a. **Antibloat compounds:** Surfactants such as poloxalene is used as a preventive for pasture bloat, several other products have been shown to be highly effective to prevent bloat are also available in the market.

   b. **Antifungal additives:** Mould inhibitors are added to feed liable to be contaminated with various types of fungi such as Aspergillus flavus, Penicillium cyclopium etc. Before adding commercial inhibitors all feedstuff should be dried below 12 cent moisture. Propionic, acetic acid and sodium propionate are added in high moisture grain to inhibit mould growth. Antifungals such as Nystatin and copper sulphate preparations are also in use to concentrate feeds to prevent moulds.

   c. **Anticoccidials:** Various brands of anticoccidials are now available in the country to prevent the growth of coccidia which are protozoa and live inside the cells of the intestinal lining of livestock.

   d. **Antihelmintics:** Under some practical feeding conditions anthelmintics have also been used. The compounds act by reducing parasitic infections.

7. **Additives that improves digestion**

**Enzymes:**

Enzymes are protein which have the property of catalysing specific biochemical reactions. They are found in all plants and animals and are responsible for growth and the maintenance of health.

Microorganism also produce enzymes and in recent years it has been possible to produce enzymes using microorganism on an industrial scale, extract and use these enzymes in a wide range of processes for the production of feed and natural products.

Poultry feeds are largely composed or plant and vegetables materials and there are enzymes developed to degrade, modify or extract the plant polymers found in some of the cereals and their by-products. The enzymes can be used to improve the feeding of poultry in the following way:

1. By improving the efficiency of the utilisation of the feed.
2. By upgrading cereals by-products or feed components that are poorly digested
3. By providing additional digestive enzymes to help poultry to withstand stress conditions eg. Hot climates.

Some of the cereals are compounds of polymers either of glucose (beta glucan) or arabinose and xylose (pentosan or hemicellulose). These polymers are not well digested by poultry and this can be result in loss of energy in two ways:

1. Energy may be lost become these polymers hinder the digestion of starch by coating starch granules and preventing the action of starch digesting enzymes in the intestine.
2. Energy may be lost because the animals own enzymes are not capable of degrading the polymers and therefore they pass through the digestive system untouched.
By adding microbial enzymes to the feed these polymers can be degraded and their energy value made available to the bird.

The dual role of enzymes has been demonstrated in trials with barley based feed supplemented with beta-glucanase, where the apparent increase in available energy was far in excess of that available in the beta-glucan of the barley. In this case not only was the problem of sticky dropping completely eliminated but the chicken’s rate of growth was equivalent to that observed normally with feeds containing a higher energy density (eg. Wheat based).

Choice of enzyme:

Because of feed is normally composed of a single raw material of constant quality, it is important that the correct choice of enzyme product be made. Even in the case of a relatively well defined problem such as that in barley, the use of multi enzyme activity products in an advantage.

The enzymes should fulfill the following criteria for practical application:
1. The enzymes must be active at the pH of the animals digestive system and capable of surviving transit through the stomach.
2. They must be in a physical form in which they can be safely and easily mixed into all forms of animal feed.
3. The products should be of a high standardised activity that will remain stable both before and after incorporation into the feed or pre-mix.
4. The enzymes must be capable of surviving normal pelleting conditions.

8. Additives that improves feed quality

Anticaking agents:

Anticaking agents are anhydrous substance that can pick up moisture without themselves becoming wet. They are added to dry mixes to prevent the particles clumping together and so keep the product free flowing.

They are either anhydrous salts or substance that hold water by surface adhesion yet themselves remain free flowing:
1. Salt or long chain fatty acids.
2. Calcium phosphate
3. Potassium and sodium ferricyanide
4. Magnesium oxide
5. Salts silicic acid – Al, Mg, Ca, Salt.
Sodium aluminium silicate
Sodium calcium aluminium silicate
Calcium aluminium silicate

Humectants:

These are substances which are required to keep the product moist, as for example, bread and cakes. Anticaking agents immobilise moisture that was picked up. Humectants are not or much use in poultry feed.
Firming and crisping agents:

These are substances that preserve the texture or vegetable tissues and by maintaining the water pressure inside them, keep them turgid. It prevents a loss of water from the tissues.

Sequestrants:

Certain metals – copper, iron can act as pro-oxidant catalytic and therefore need to be immobilised. Sequestrants are compounds added to do this.

These compounds should have affinity to metal ions and should prevent the metal in becoming engaged in oxidative action. Most effective sequestrants EDTA.

Ethylene diamine tetraacetic acid.

Calcium salt of EDTA works satisfactorily as a sequestrant without interfering with trace mineral metabolism.

Sweeteners:

It is common constitution of food but yet used as additives. Eg. Sugar

Some are poorly digestible, may cause digestive upsets.

Saccharin – extensively used during World War I. It is a compound without any calorific value.

Additives such as humectants, firming and crisping agents, sweeteners, emulsifiers, stabilisers, acid, buffers are not commonly used in poultry feeds.

Model questions

86. Feed additive includes

A. Flavouring agent
B. Antioxidants
C. Antibiotic
D. Nutrients

i. None are correct
ii. B is correct
iii. D is correct
iv. A, B, C are correct

87. Additives enhances

A. Digestion and absorption
B. Increases feed intake
C. Reduce growth rate
D. Feed efficiency reduced

i. D is correct
ii. A and B are correct
iii. C is correct
iv. A is correct
88. Probiotic is a
A. Chemical       B. Deworrner
C. Fat solvents   D. Live microbial feed supplement
i. A and B are correct  ii. A is correct
iii. D is correct    iv. C is correct

89. Mode of action of antibiotic is by
A. Spare nutrients       B. Thinning of the intestinal wall
C. Increase the No. of Pathogenic organisms
D. Reduces the No. of favourable organisms
i. D is correct
ii. A and B are correct
iii. C is correct
iv. None are correct

90. Additives that affect the health status of livestock are
A. Antibloal boar compounds       B. Antifungal
C. Anticoccidials    D. Anthelmentics
i. D is correct
ii. None are correct
iii. All are correct
iv. A is correct

91. Animal protein factor (APF) is present in
A. Fishmeal       B. Groundnut cake
C. Soyabean meal   D. Meat meal
i. A is correct
ii. B is correct
iii. A and D are correct
iv. B and C are correct

92. Anti-metabolite is a compound that
A. Interferes in physiological function       B. Interferes in digestion
C. Improves growth rate    D. Improves weight gain
i. A is correct
ii. A and B are correct
iii. C is correct
iv. D is correct
93. Saccharin gives

A. Energy  
B. Protein  
C. Fat  
D. Increases palatability  
i. C is correct  
ii. A is correct  
iii. D is correct  
iv. B is correct

94. Oxidative rancidity of fats can be prevented by adding

A. BHT (Butylated Hydroxy Toluene)  
B. Enzymes  
C. Vitamin A  
D. Antibiotics  
i. D is correct  
ii. B and C are correct  
iii. A is correct  
iv. None are correct

95. Addition of shell grit in layer ration supplies

A. Magnesium  
B. Phosphorus  
C. Calcium  
D. Energy  
i. A is correct  
ii. D is correct  
iii. A and B are correct  
iv. C is correct

96. Enzymes used as feed additives

A. Proteins  
B. Inorganic substances  
C. Fats  
D. Carbohydrates  
i. C is correct  
ii. D is correct  
iii. B and C are correct  
iv. A is correct
CHAPTER VIII

CONSERVATION AND PRESERVATION OF FEEDS AND FODDERS

SILAGE

Silage making

Silage is the material produced by the controlled fermentation of a crop of high moisture content. Ensilage is the name given to the process and the container, if used, is called the silo.

Advantages of silage making:

i) Crops can be ensiled when the weather does not permit curing them into hay or dry fodder

ii) The use of silage generally makes it possible to keep more animals on a certain area of land

iii) An a low expense silage furnishes high quality succulent feed for any season of the year

iv) From weed crops, which would make poor hay, satisfactory silage can be produced, the ensiling process kills many kinds of weeds and seeds

v) Stemmy forage crops when converted into silage become soft and are better utilized by the stock.

The fermentation is controlled either by encouraging lactic acid formation by bacteria present on the fresh herbage, or by direct addition of a weak acid solution or of preservatives such as sodium metabisulphite. The first method sometimes referred to as the ordinary process, is the common most in use, and is dependent upon the fermentation to lactic acid of soluble carbohydrates present in the plant material, resulting in a lowering of pH to within the region of 3.8 – 4.2. Material of this type is described as ‘well preserved silage’ and normally has a lactic acid content within the range of 8-12% of the drymatter. Silage of pH about 4 will normally remain stable as long as the mass is kept under anaerobic conditions. If, however, rain is allowed to enter the silage (or) if lactic acid concentration is inadequate, then secondary clostridial fermentation is likely to occur. The lactate fermenting clostridia cause a break down of the lactic acid with the production of butyric acid. Proteolytic clostridia attack amino acids, with the formation of ammonia, organic acids, amines and CO₂. Either or both of these types of clostridia may become dominant in badly preserved silage which will have a relatively high pH value, generally above 5.

An entirely different process of silage making involves the sterilisation of the mass in the silo by adding chemical sterilisation agents such as formaldehyde, sulphur dioxide or sodium metabisulphate. The success of this method depends largely upon ensuring adequate mixing with the crop, which may often be difficult in practice. If satisfactory sterilisation is achieved and provided effluent production is not great, the nutritive value of the preserved material should be very similar to that of the original herbage. Another method of preserving herbage is by the direct acidification of the crop, and one such system is the finished A.I.V. process, named after
The mixture of acids used in this process varies, but generally consists of HCl & H$_2$SO$_4$. These acids are added to material during ensiling in sufficient quantity to lower the pH value below pH4. The resultant product may appear to be a very unnatural food for farm animals, but provided the correct amount of acids is properly distributed throughout the ensiled material no free mineral acids occur. A.I.V. silage has been shown to be palatable and harmless to ruminants even when as the sole item of diet.

**Chemical changes**

1) **Plant enzymes**

   In the first category the main changes are caused by aerobic respiration, which will continue, as long as oxygen present, until the plant sugars are depleted. Sugars are oxidised to carbon dioxide and water, with the production of heat of causing a considerable rise in temperature of the mass. If the herbage is not well consolidated during and after filling then air may penetrate into the mass and the temperature will continue to rise. If the rise in temperature is not checked, an over heated product, usually dark brown or black in colour will result. This will be of low feeding value because of an excessive loss of soluble carbohydrate and a lowering of the protein digestibility.

   Apart from carbohydrate break down, proteolysis also occurs immediately after the herbage is cut. Protein is rapidly broken down to simpler substances mainly amino acids.

2) **Microorganisms**

   After aerobic respiration has ceased, microbial changes continue. Fresh herbage contains bacteria on its surface, and these organisms multiply, using the contents of a cell as medium. As a result of this activity many chemical components of the grass are break down. Where conditions are favourable for bacteria which produce lactic acid, the acidity of the mass increases until, at about pH 4.0 – 4.2 organisms other than the aciduric lactic acid bacteria are inhibited as long as conditions remain anaerobic. These aciduric organisms are classified into 2 main groups, the homofermentative lactic acid bacteria and the heterofermentative lactic acid bacteria. Both types from lactic acid but the former are more efficient at converting hexose into the acid than are the heterofermentative organisms. The higher the proportion of homo-fermentative lactic acid bacteria, the more rapid will be the decline of pH, since homo-fermentative bacteria quantitatively convert soluble sugars to lactic acid and hetero-fermentatives produce CO$_2$. 
mannitol, ethanol and acetic acid in addition to lactic acid bacteria. The proportion of homo to hetro fermentative lactic acid bacteria is important in crops poor in water soluble carbohydrates. During ensilage about 60% of the proteins are broken down even in well preserved material. Where a rapid lactic acid type of fermentation occurs and a satisfactory degree of acidity is produced, the end products of protein break down are mainly amino acids. This break down to amino acids is not disadvantage as far as nutritive value is concerned, but in bad preserved material the amino acids are broken down further to produce various amines such as tryptamine, phenyl ethylamine and histamine, which are decarboxilated derivatives of tryphan, phenylalanine and histidine respectively. Many of these nitrogenous compounds may be toxic to animals if absorbed into the blood.

Apart from changes in carbohydrates and proteins, the mineral compounds present in herbage may be altered and potassium, calcium, sodium and magnesium salts of lactic acid, volatile acids may be formed. So far as is known the available the minerals is not affected. As a result of these chemical changes, gaseous losses, (mainly of CO₂) occur. The amount of dry matter lost in gaseous form may vary from 2 to 30% depending upon plant and bacterial enzyme activity.

**Nature of crop**

i) In order to obtain silage of high nutritive value, grass should be cut shortly after, the ear emergence stage of growth as digestibility falls rapidly with increasing herbage maturity.

ii) High protein grass crops and legumes are difficult to ensile satisfactory, because of low soluble carbohydrate content and because of their high buffering capacity. If the soluble carbohydrate content of the crop is known to be a limiting factor, then a sugar additive, such as molasses, may be sprayed on to the crop at the time of filling the silo.

The physical nature of the crop at the time of ensiling is important factor in the fermentation process, and it is known their chopping or brushing tends to produce more favourable condition for microorganism activity than leaving the material long.

**Losses of Nutrients during ensilage**

i) Field losses: With crops cut and ensiled the same day, nutrient losses are negligible and even over a 24 hours wilting period losses of not more than 1 or 2% dry matter can be expected. Dry matter losses as high as 6% after 5 days and 10% after 8 days wilting in the field have been reported. The main nutrients affected are the water soluble carbohydrates and protein which are hydrolysed to amino acids.

ii) Oxidation losses: These result from the action of plant and microbial enzymes on substrates such as sugars in the presence of oxygen, leading to the formation of CO₂ and water.

iii) Effluent losses: In most silos, free drainage occurs and the liquid (or) effluent carries with it soluble nutrients. The amount of effluent produced depends largely upon the initial moisture content of the crop, but it will obviously be increased if the silo is left uncovered so that rain enters. Effluent contain sugars, soluble nitrogenous compounds, minerals and fermentation acids all of which are of high nutritional value. Crops ensiled with a dry matter content of 15% may result in effluent dry matter losses as higher 10%, where as crops wilted to about 30% dry matter produce little, if any, effluent.
SILOS AND OTHER CONTAINERS

The container in which the silage made is of greatest importance and will determine to a large extent the nature and quality of the final product. The size of the container will generally depend upon the number and kind of animals to be fed from it, and its height on the length of the feeding different types of silos have been designed.

Clamp silo: In silo, greater part of crop remains above ground and the rest remains in slight excavated trench or pit. In addition the clamp will be long and narrow, and low in relative to length.

Pit silo: The pit silo is cylindrical or rectangular and its shape is like that of clamp silo, but extends below ground. The pit can be excavated in any suitable soil, not subjected to waterlogging. If silage is to be made annually, it better to have a concrete floor, making provision for effluent to escape. The dimension of the pit various with circumstances and the number of stock to be fed. A pit of average width of 4m and with silage settled to a depth of 2m will held 1½ m tonnes of silage for each 30 cm length.

Advantages of pit silo:
1) A pit silo is very economical to build
2) Owing to its depth and shape, the pit silo has a large capacity for its size
3) Less power is required for filling
4) The smooth plastered walls allows the silage to settle and retain the juices
5) Pit silo if kept in good condition will last indefinitely.

Disadvantage of pit silo:
1) It is inconvenient to take out the feed
2) The pit silo occupies farm land which is permanently inaccess for cultivation, and requires lot of labour.
3) The main difficulty is to ensure adequate compression, since depth of the silage is always out of proportion to the area cover in strong contrast to the tower silo.

Trench silo

The difference between the pit and the trench silo is merely one of size, the latter usually brawing greater length in relation to breadth. The process of ensiling is more or less similarly to that for pit silo.

Advantages of trench silo
1) Horses, cows (or) tractors can be used to pack the silage
2) Power required for filling the trench silo is less
3) It is well adopted to the ensilage of immature corn and emergency feeds
4) The major part of the material conserved will settle into the trench below ground level, the chance of air getting in is reduced to a minimum.
5) Unloading and carrying of silage are much easier.

Disadvantages of trench silo
i) Once constructed, it is not easy to abandoned
ii) More silage is spoilt
iii) The trench silo must be trimmed upon the edges and clean up if the silage is to be kept best.
**Tower silo:** It is round, cylindrical and is placed above the ground the height varies from 6 to 10m or more with a varying diameter (6 to 10m). The erection of such a silo is expensive. The material used include wood, reinforced concrete or sheet metal. Use wood is of much advantage is that it is not affected by silage acids, on the other hand wood tends to preserve it. For filling up the silo a chopper blower is necessary. In this types 3 types of silage are found

(a) In the bottom third it will be over compressed sour and will give out smell of butyric acid
(b) In the centre it will be good, not too tightly packed and yet compressed well enough to give well-preserved material. In the top third it is often dark and over heated, near the surface it will be of low value, perhaps with some moulds. In the tower, silo, the sealing is not much important as the pit silo.

**Advantages:**

i) Material can be well preserved, with no wastage due to air leakage
ii) Wilting of crop and the sealing of silo are not as important as in pit silo, because the mass itself applies pressure and and acts as an air seal to the lower layer.
iii) The loss of dry matter is minimal

**Disadvantages:**

i) It is very expensive to make
ii) Chopper blower is needed for filling up of the silo
iii) Emptying is very laborious
iv) In dry hot places the silage gets dehydrated

**Tube Silo**

The grass is filled in plastic cylindrical tubes of varying capacity.

**Advantages:** Does not occupy permanent location, can be shifted to various location with ease.

**Disadvantages:** Requires machinery to fill as well as to evacuate the silo.

**Haylages**

Haylages, sometimes called low moisture silage. It is a preserved forage with characteristics between those of hay and silage. It is made from grass and/or legume to a moisture level of about 45-55% when harvested (or) wilted to this level. If the harvested forage is having higher moisture percent, it should be brought down before ensiling. It must be preserved by processes some what different from those for wilted or unwilted silage. The silos should be well constructed and as airtight as possible so the oxygen present is soon used up, the CO₂ that is produced is trapped and held within the silo. These conditions prevent the forage from spoiling by moulding, oxidising, heating etc. Air exclusion likely to the success or failure of making low moisture silage.

**Advantages:**

i) Properly made haylage, has a pleasant aroma palatable high quality feed. Animals usually received more dry matter and feed value than silage made from the same cut.
ii) If forage is moved, with the intention of making hay and weather becomes unfavourable for drying, the partially dried forage can be made into haylage.

**Disadvantages:**

i) With haylage, fine chopping, good packing and complete sealing against air entrance inside the silo is a must and more critical than with silage.
ii) The danger of excessive heating which lowers protein digestibility is more acute in haylages than silages.
CHARACTERISTICS OF A GOOD SILAGE

1. VERY GOOD SILAGE

It is clean, the taste is acidic, and has no butyric acid, no moulds, no sliminess nor proteolysis. The pH is between 3.5 and 4.2. The amount of ammoniacal nitrogen should be less than 10 per cent of the total nitrogen. Uniform in moisture and green or brownish in colour. Taste is pleasing, not bitter or sharp.

2. GOOD SILAGE

The taste is acidic. There may be traces of butyric acid. The pH is between 4.2 and 4.5. The amount of ammoniacal nitrogen is 10-15 per cent of the total nitrogen. Other points same as of very good silage.

3. FAIR SILAGE

The silage is mixed with a little amount of butyric acid. There may be slight proteolysis along with some mould. The pH is between 4.5 and 4.8. Ammoniacal nitrogen is 15-20 per cent of the total nitrogen. Colour of silage varies between tobacco brown to dark brown.

4. POOR SILAGE

It has a bad smell due to high butyric acid and high proteolysis. The silage may be infested with moulds. Les acidity, pH is above 4.8. The amount of ammoniacal nitrogen is more than 20 per cent. Colour tends to be blackish and should not be fed.

Characteristics of silo pits

1) That its size should be decided on the basis of the number and kind of animals to be fed daily, the length of the feeding period, and the amount of forage available for ensiling.
2) That it excludes air from the stored material including entrance of air around the doors of tower silos.
3) That side walls be straight and smooth in order to prevent the formation of air pockets which may retard the normal microbial fermentation.
4) That it be of adequate depth, thereby making for better packing and less surface area to total mass exposed.
5) That the walls should be strong and rigid in order to withstand the pressure which develops inside the pit as fermentation takes place. Note that silage made from cut grass will exert from a half to two and a half times as much pressure on the walls as does maize silage. Reinforcement of walls will be desired.
6) That adequate provision be made for the escape of surplus juices, either by a drain or by a gravel bottom.
7) That it be conveniently located and accessible in all kinds of weather, from the standpoint of both filling and feeding.
8) That silo pits (not tower type) are always located preferably at the highest spot on the farm to avoid water seepage.

HAY MAKING

The aim in hay making is to reduce the moisture content of the green crop to a level low enough to inhibit the action of plant and microbial enzymes. In order that a green crop may be stored satisfactorily in a stack or bale, the moisture content must be reduced to 15-20%.
Schedule for harvesting and curing of hay

For efficient production of good quality hay the crop should be harvested early in the morning and left in the field as such for curing. Drying the harvested crop in the field is continued until the moisture content is reduced to about 40%. Usually in autumn it may take 2 to 3 days for field airing but in dry summer months the duration can be still less. At the end of 1st day, turn the grass with the side rake into small fluffy windrows. On the 2nd day, turn the windrows and watch its state of drying to note its readiness for staking or fit to be baled straight from the windrows. Caution is needed to store them in well ventilated place as otherwise, possibility of catching fire exist. In case, if the windrows require still more drying they may be placed over tripods or tetrapods or over the fence.

Characteristics of good hay

Hay must be leafy and green and have soft and pliable stems. It should be free from mustiness or mould and be palatable. It should be free from any weeds and should have the aroma of the original crop. Hay should be prepared out of herbage, cut at a stage nearing maturity, preferably at the flowering stage when it has the maximum of nutrients. Delay in cutting would mean losses of a part of nutrients which would be used up by the plant in seed formation. Hay should be green in colour. The green colour of leaves indicates the amount of carotene which is a precursor of vitamin A. Hay of average quality will usually run from 25-30 per cent crude fibre and 45-60 per cent TDN.

Factors influencing the nutritive value of Hay

<table>
<thead>
<tr>
<th>Chemical Changes</th>
<th>Plant &amp; microbial enzymes</th>
<th>Stage of cutting</th>
<th>Damage</th>
<th>Stack</th>
<th>Changes in Oxidation</th>
<th>Leaching</th>
<th>Microbial Enzymes</th>
<th>action</th>
</tr>
</thead>
</table>

Chemical Changes:

Plant & microbial enzymes

As a result of respiration, sugars and oxidised to CO₂ and H₂O with the result increase in concentration of cell wall constituents especially cellulose and lignin. Protein are also altered by the action of plant enzymes. Due to proteolysis free amino acids are formed and can be lost due to leaching.

Oxidation

When herbage is dried in the field a certain amount of oxidation occurs. The visual effect of this can be seen in the pigments many of which are destroyed ex. Carotene. On the other hand sunlight has a beneficial effect on vitamin D content in the hay, because of irradiation of ergosterol present in green plant.
Leaching

It causes loss of soluble minerals, sugars and Nitrogenous constituents. It may also encourage the growth of moulds.

Microbial action

If drying is prolonged because of bad weather conditions, changes brought about by the activity of bacteria and fungi may occur. Mouldy hay is unpalatable, and may be harmful to farm an animals and man because of the presence of mycotoxins. Such hay may also contain actinomycetes which are responsible for the allergic diseases affecting man known as farmers lung.

Plant species

Hay made from legumes are generally rich in protein and minerals than grass hay. Non legume hay has more carbohydrate but is less palatable. The other advantage being high yielding quality of these crops. The quality of mixed hay depends on the species and proportion of the mixture of leguminous crop in the hay.

Stage of growth/cutting

The stage of growth of the crop at the time of cutting is the most important factor determining the nutritive value of the conserved product. The latter the date of cutting the larger will be the yield, the lower the digestibility and net energy value and the lower the voluntary intake of dry matter by animals. It follows that if the drying conditions are similar hays made from early crops will be of higher nutritive value than hays made from mature crops.

Mechanical damage

During the drying process the leaves lose moisture more rapidly than the stems, so becoming brittle and easily shattered by handling, handling of the hay during early morning minimized the loss of leaves.

Another way to reduce shattering of leaves is by brushing or flattening of the herbage through which uniform drying is possible.

Changes during storage

At a higher moisture level during stacking, chemical changes brought about by the action of plant enzymes and micro organism are likely to occur. There may be oxidative degradation of sugars, although hexoses may also combine with amino acids or proteins. This chemical combination is probably partly responsible for dark brown colour observed in overheated hays. Browning has been observed at temperature as low as 32 °C.

Respiration cases at about 40 °C. Butt the action of thermophillic bacteria may go on up to about 72 °C. Above this temperature chemical oxidation can cause further heating. The heat tends to accumulate in hay stored in bulk and eventually composition may occur.

DRIED GRASS/ARTIFICIALLY DRIED FORAGES

The process of artificial drying is a very efficient, though expensive, method of conserving forage crops. The drying is brought about by allowing the herbage to meet gases at a high temperature which varies with the type of drier used. In the ‘low-temperature’ type
equipment, the hot gases usually at a temperature of about 150°C, the drying time varies from about 20 to 50 minutes depending upon the drier design and the moisture content of the crop. With high temperature design the temperature of gases is initially within the range of 500-1000°C, the time taken to pass through the drier varies from about 0.5 to 2 minutes.

**Model questions**

97. Silage is a

A. Conserved fodder  
B. Fodder fermented under controlled conditions  
C. Chopped fodder  
D. Dried fodder

i. None are correct  
ii. All are correct  
iii. A & B are correct  
iv. C & D are correct

98. The additives for silage are

A. Molasses  
B. Salt  
C. Culture  
D. Mineral acids

i. A & B are correct  
ii. C & D are correct  
iii. None are correct  
iv. All are correct

99. Factor affecting nutritive value of silage are

A. Chemical changes  
B. Nature of the crop  
C. Losses during in silage making  
D. Moisture level

i. A & B are correct  
ii. C & D are correct  
iii. All are correct  
iv. None are correct

100. Losses during silage making are

A. Field loss  
B. Oxidation loss  
C. Effluent loss  
D. Drying loss

i. A & B are correct  
ii. A,B,C are correct  
iii. All are correct  
iv. C & D are correct

101. Commonly used silo under field condition in India is

A. Pit silo  
B. Tower silo  
C. Clamp silo  
D. Tube silo

i. A is correct  
ii. B is correct  
iii. C is correct  
iv. D is correct
102. Advantages of pit silo are

A. Economical  
B. Less labour  
C. Less capacity  
D. Inconvenience to take silage  

i. A & B are correct  
ii. C & D are correct  
iii. None are correct  
iv. All are correct

103. Poor silage has

A. Bad smell  
B. High butyric acid content  
C. High proteolytic effect  
D. Infected with moulds  

i. A & B are correct  
ii. C & D are correct  
iii. All are correct  
iv. A, B & C are correct

104. Factors affecting nutritive value of hay

A. Plant species  
B. Stage of cutting  
C. Length of the grass  
D. Length of the cutting  

i. A & B are correct  
ii. C & D are correct  
iii. None are correct  
iv. All are correct

105. Characters of good hay are

A. Leafy and green  
B. Soft and pliable  
C. Bad smell  
D. Mould Formation  

i. A & B are correct  
ii. B & C are correct  
iii. C & D are correct  
iv. All are correct

106. Paddy straw is rich in

A. Keratin  
B. Lignin  
C. Soluble CHO  
D. Protein  

i. A is correct  
ii. B is correct  
iii. C is correct  
iv. D is correct
107. Paddy straw has got

A. high digestibility  
B. Poor digestibility

C. Optimum digestibility  
D. High nutritive value

i. C & D are correct  
ii. B is correct  
iii. A is correct  
iv. None are correct
CHAPTER IX

ECONOMIC UTILIZATION OF AGRO BY-PRODUCTS FOR FEEDING LIVESTOCK

OIL SEED CAKE/MEAL:

A number of oil bearing seeds are grown for vegetable oil for human and for paints and other industrial purposes. In processing these seeds, protein rich products of great value as livestock feeds are obtained. The by products left after extraction of oil from oil seeds are used for feeding of all kinds of livestock. According to the method of processing, oil content and protein content varies.

Three main process are used for removing oil from oil seeds. Two employ pressure to force out the oil, while the others uses an organic solvent to dissolve the oil from the seed. Only material with an oil content of less than 35% is suitable for solvent extraction. If material of higher oil content is to be treated it first undergoes a modified screw pressing to lower the oil content to a suitable level.

Nutritive value:

Protein: Some 95% of the nitrogen in oil seed meals is present as true protein. It usually has a digestibility of 75-90% and is of good quality. In general, oil seed proteins have a low cystine and methionine content, and a variable but usually low lysine content. As a result they cannot provide adequate supplementation of the cereal proteins with which they are commonly used and should be used in conjunction with an animal protein when given to simple stomached animals.

Fat: The oil seed cakes may make a significant contribution to the energy content of the diet, particularly where the oil content is high. This will depend upon the process employed and its efficiency. Digestive disturbances, however, may result from uncontrolled use of cakes rich in oil, and if the oil is unsaturated milk or body fat may be soft and carcass quality lowered.

Micro-nutrients: The oil seed meals usually have a high phosphorus content, which tend to aggravate their generally low calcium content. They may provide useful amounts of the B-vitamins but are poor sources of carotene and vitamin E.

Straws and chaff:

Straws consist of the stem and leaves of plants after the removal of the ripe seeds by threshing and are produced from most cereal crops and from some legumes. Chaff consists of the husk or glumes of the seed which are separated from the grain during threshing. These products are extremely fibrous, rich in lignin and of extremely low nutritive value. They should not be used as pig or poultry food.

Paddy straw: It has an exceptionally high ash content about 170g/kg of dry matter, which consists mainly of silica. The lignin content of this straw, about 60-70g/kg dry matter is however lower than that of other cereals straw. In contrast to other straws, the stems are more digestable than the leaves.

The poor nutritive values of straws may be attributed to the following facts.
1) The digestibility of straw is limited due to the formation of strong physical and/or chemical bonds between lignin and the structural polysaccharides (Hemi-cellulose).
Although cellulose by itself has a highly ordered crystalline structure, it has a very strong association with lignin, with the result that even the most potent cellulosic enzymes cannot have easy access to the cellulose unless the bondage between lignin and cellulose is broken.

2) Crystalline structure of cellulose is also responsible for low digestibility of cellulose.

3) Highly deficient in other nutrients like minerals, vitamins, fatty acids and in proteins. The minimum crude protein requirement for efficient lignocellulose break down of roughages fed as the sole diet is claimed to be from 3.8 to 5.0%.

4) High silica content of straw is known to depress organic matter digestibility.

**Other straws (Cereals) which are commonly fed to animals are:** Wheat straw and Rye straw, whereas in European Countries Oat straw. Paddy straw and maize straw are popular.

**Legume straws:**

The straws of beans and peas are richer in protein, calcium and magnesium than the cereal straws, and if properly harvested are useful roughage foods for ruminant animals. Because of their thick fibrous stems they are more difficult to dry than cereal straws and frequently become mouldy on storage.

In some cases, it is economical to increase the nutritive values of all types of poor quality roughages by physical chemical or biological treatment.

**SUCCULENT CROP RESIDUES**

**Tapioca Leaves:** Cassava is a tuber crop extensively grown in Tamil Nadu and Kerala State. At the time of harvest, the tuber is harvested and the leaves are thrown away. Tapioca leaves are a rich source of protein having a DCP value of 8 and TDN value of 45 per cent of dry leaves. It contains an ant nutritional factor HCN.

**Groundnut haulms:** Groundnut is the major oilseed produced in the country. At the time of harvesting large quantities of leaves and stem become available for feeding of livestock. The DCP value of groundnut haulms is superior to that of non-leguminous crops.

**SUGARCANE – *Sacccharum officinarum*** Sugarcane tops are important source as fodder during harvesting season, which may last for four to ten months in a year. Sweetness makes it very palatable and they are often fed hand chaffed green, which can easily provide the animal’s maintenance ration. Leaves of cane tops are lower in digestibility than stalks and its rate of digestion is also very low. Nutritive value of cane tops can be enhanced when the chopped cane tops are mixed with legume and fed. Sugarcane tops can be ensiled with 2% urea, 10% molasses, mineral mixture, 1% NaCl and 25g vitamin mixture and fed to animals.
IMPROVEMENT OF POOR QUALITY ROUGHAGES

PHYSICAL METHODS

A. Wet Methods

1. Green chopping

This refers to converting the green crop residues into 1 to 4 cm length pieces by chaff cutters. The main advantage is due to less wastage of unpalatable parts. By mixing poor quality roughages in chopped green materials, it will mask the effects of the fornet.

2. Soaking

This method is not considered to be practical except possibly with chopped straw.

3. Steam processing:

The steam treatment of forage particularly of low quality roughages like bagasse has been reported to cause increased voluntary intake and higher digestibility in cattle. Chemical studies indicated extensive degradation of cellulose and hemicellulose and the production of undesirable poly-phenolic compounds when bagasse was steam processed. Apart from this the method involves extra expenditure.
B. Dry methods

1. Baling:

Bailing is probably the most common method used in developed countries to harvest roughage. Forage is cut and allowed to dry in the field. For proper baling the moisture level must be sufficiently low (15 to 20 per cent) at the time of baling. Bales are packages of square or round type. Round bales, however, will shed rain and thus may be left in the field for extended periods without serious damage to the hay.

2. Grinding hays and straw

It is not necessary to grind good quality hay to realise its effective use. Grinding coarse, stemmy hays will encourage total consumption by livestock but will not improve their digestibility. However, for making the complete ration for livestock the entire hay must be ground. The coarser the hay that is ground, the more it will retain its bulk value. In general, grinding hay causes a drop in the milk fat in dairy cows due to low production of acetic acid in rumen.

3. Pelleting of roughages

Hays and straws must be ground prior to pelleting – thus, pelleting embraces most of the advantages and disadvantages of grinding. The method reduces the space requirement for storage by as much as 75 per cent. Pelleting of hay and straws increases consumption and performances in beef cattle. It also reduces dustiness. The process when applied to roughage, will cost twice as much as pelleting concentrates.

4. Cubing

“Cubing” are nothing more than large pellets. These may be of square or round shape having the diameter and length between 2 to 3 inches and 1 to 4 inches respectively. Grinding before cubing is not required, but usually water is sprayed on the dry hay and straw as they are cubed.

Although cubes have an advantage, as they can be fed on the ground in clean pastures, and no troughs are needed, it is difficult to detect (visually) low quality roughages in them, and besides the method is costly.

5. Drying of roughages

Drying entails removal of excess moisture of green crop residues to 14-15 per cent level either by artificial heat. In tropical countries like India, sun drying is the only feasible method. However, in some developed countries where sunshine is not plentiful, artificial drying is resorted to which involves a process, in which forage is cut by a hay chopper or silage cutter immediately after harvest and dried in large drum driers of different sizes.

6. Irradiation

Improvement of digestibility of wheat straw by high voltage X-rays has been found to be due to the breaking of the cellulose and hemicellulose bonds, resulting in formation of oligosaccharides, which can be utilised by the rumen organisms. Forage lignin on the other hand resists irradiation. Upon irradiation, ergosterol, a plant sterol, yields calciferol, commonly known as vitamin D$_2$. The method involves high cost and technology.
CHEMICAL METHODS

1. Alkali treatment

Treating straw with alkali can give a product of considerable nutritive value. It reduces the strength of the intermolecular hydrogen bonds which bind the cellulose fibre without affecting much of the cell wall.

The usual method requires large quantities of water and is impracticable in areas where water supplies are limited. The process consists of soaking the straw in 10 times its weight of 1.5 per cent NaOH solution for about 24 hours. The liquid is then drained off and can be used for succeeding batches of straw. The straw is washed after treatment until freed from the alkali. The treatment will in case of wheat straw increase organic matter digestibility from 46 per cent to more than 70 per cent. The method is tiresome as well as costly.

2. Ammonia treatment

Treatment of straw with anhydrous ammonia will add N\textsubscript{2} to the straw which can be used by rumen microorganisms, in addition, the ammoniation of straw will improve significantly the degradability of its fibrous constituents which will result in the production of more energy in the form of VFA.

The ammonia method requires that a stack of straw be covered so that the ammonia does not escape.

3. Lime treatment

Calcium hydroxide generated from lime may prove to be the cheapest alkali available for the effective treatment of coarse roughages. Both wet and dry methods of treatment have been used.

4. Urea-generated NH\textsubscript{3} treatment of roughages

Refer urea treatment of paddy straw described under roughages – dried grass

5. Urine treatment

Animal urine can also be used as a source of urea which can generate ammonia to have a similar effect on improving the degradability of fibrous constituents on the coarse fodders.

Urea added to dry roughages

An addition of urea molasses to straw has become popular for increasing nutritive value. A solution of 10 kg molasses and 2 kg urea in 10 kg of water is spread by a sprayer on straws in 100 kg lots and spread evenly under the sun over an area of 20 X 20 ft. The treated straws can form maintenance ration when supplied along with the proper amount of 2 per cent mineral and 1 per cent salt and vitamin AD\textsubscript{3} mixture. About 8 kg of this enriched paddy straw per animal per day will supply sufficient nitrogen for the animals to synthesise the required amount of protein for maintenance.
Urea mixed with silage

Another way of feeding urea to cattle – especially dairy cattle – through the addition of urea to crops which are being ensiled. If chopped, the whole maize plant is being ensiled at 35 per cent to 40 per cent dry matter, urea is then added at a level of 0.5 per cent of wet material. This level should increase the crude protein level of the silage on a dry matter basis about five points.

BIOLOGICAL TREATMENTS

Use of selected bacterial and fungal culture in roughages has been considered during the past few years to increase the nutritive value of roughages over the chemical treatments. Since plant residues constitute a good quantity of cellulosic materials including cellulose, hemicellulose and lignin, the biological treatment causes simplification of these compounds by releasing appropriate enzymes from microbes so that the materials ultimately become easily digestible upon intake by the ruminants. The fast growth rate of these microbes result in enriching the roughages with protein.

MISCELLANEOUS BY-PRODUCTS

A number of agro-industrial by-products are being used as livestock feeds

Milling byproducts: Include bran, polish, flour, middlings, gluten etc that could be used as animal feed.

Sugar industry byproducts: Include molasses, pressmud etc that could be used in animal feeding.

Brewery waste:

Brewery waste is mostly the brewer's grains left after the extraction of malt required for the production of beer. One quintal of barley produces about 170 kg of wet brewer's grains. Dried brewer's grain is a very good source of protein and energy for the livestock. Various reports have recommended to include not more than 10 per cent dried brewer's grain in poultry mash. It is a good feed for the ruminants.

It has 20 to 23 per cent dry matter, about 19 per cent protein, 3.5 per cent ether extract, 9.5 per cent crude fibre, 65.5 per cent NFE and 4.5 per cent ash. The calcium content is 0.26 per cent and phosphorus content 0.31 per cent on dry matter basis. The dried brewer's grain has 60 per cent TDN for cattle. The energy value for buffaloes is 55 per cent.

Coffee waste:

Coffee beans consist of about 70 per cent pulpy mass. India produces about 70,000 tonnes of coffee which yield about 45,000 tonnes of coffee husk. The use of coffee waste becomes important when sufficiently large quantities are available at any one spot.

Date stones:

The work in India and Egypt has shown that date stones can be used as one of the feed ingredients of the ruminant ration.
Maize gluten-feed:

Maize gluten-feed is a by-product obtained after the removal of most of the starch and germ from maize in wet milling manufacture of maize starch and their maize products. This material may or may not contain maize-soluble and maize germ oil cake. Maize gluten is obtained in the manufacturing process as a thick slurry. It is generally blended with maize bran to obtain the material for feeding livestock. Maize gluten meal generally contains 45 to 48 per cent protein. It is fed to cattle and poultry as a protein supplement.

Panewar seeds:

The panewar plant (Cassia tora) grows abundantly during the monsoon in uncultivated and barren lands. Seeds as sole concentrate portion of the ration are unpalatable to livestock. They become acceptable to the ruminants if mixed with other conventional energy or protein-rich concentrates. Boiled Cassia tora seeds can be incorporated at a level of 15 per cent of concentrate mixture in lactating cows without any detrimental effect on the yield and chemical composition of milk.

Silkworm pupae-meal:

Silk is being manufactured on a large scale in Assam, Karnataka, orissa and Kashmir. Large quantities of silkworm pupae are available after the silk thread is removed from the cotton. A good quality silkworm pupae meal containing 55 per cent crude protein and 25 to 27 per cent oil can be prepared. Its keeping quality can be improved by de-oiling. Silkworm pupae meal has found its way in poultry feeds as an excellent source of animal protein. It can replace whole of the fish meal in poultry rations.

Tea industry wastes:

India and Sri Lanka are the latest tea producing nations. India produces nearly 350 million kg and Sri Lanka 206 million kg of tea every year. Tea wastes in the form of fluffs, stalks and sweepings become available during production, storage and handling of tea garden factories, warehouses, packing factories and shipment sheds at ports. About 2-3 per cent tea is wasted. This amounts to 10,000 tonnes in India and 5,160 tonnes in Sri Lanka. Although caffeine can be isolated from waste tea leaves, these can be used as a feed ingredient. It contains about 18 per cent of crude protein.

Spent tea leaves (STL), available from the instant tea manufacture, can also be used as feed ingredient. It contains 25 per cent crude protein on dry matter basis. The STL contain about 60 per cent moisture and it is better to use them as such rather than on drying which becomes expensive. STL can be used up to 20 per cent in the concentrate mixture.

Tamarind seeds hulls:

Tamarind seeds are available commercially in India. The seeds contain about 30-45 per cent red hulls and 60-70 per cent white kernels. The hulls and kernels have about 2 and 1.5 per cent crude fibre respectively.

The hulls are available commercially and can replace 10-15 per cent of maize in concentrate mixture of crossbred calves. They are rich in tannins (13-14 per cent) which help in the better utilisation of the protein. Kernels can replace about 95 per cent of the maize component of concentrate mixture in growing crossbred calves. Crossbred bullocks can be fed
with 1.5 kg tamarind seed powder as a sole source of concentrate. It contains 1.3 per cent DCP and 64 per cent TDN.

Model questions

108. Chemical methods of improving poor quality roughages are
A. Ammoniation
B. Lime treatment
C. Soaking
D. Milling
i. A is correct  ii. A and B are correct  iii. C and D are correct  iv. All are correct

109. Pelleting of hays and straws increases
A. Intake
B. Reduce dustiness
C. Improves nutritive value
D. Reduce digestibility
i. A and B are correct  ii. C and D are correct  iii. A and D are correct  iv. B and C are correct

110. To improve upon the nutritive value of poor quality roughages by biological treatment we use
A. Bacteria culture
B. Fungal culture
C. Enzymes
D. Chemicals
i. A and B are correct  ii. C and D are correct  iii. All are correct  iv. None are correct

111. The physical methods employed to improve the poor quality roughage
A. Chopping
B. Grinding
C. Soaking
D. Steam processing
i. A and B are correct  ii. C and D are correct  iii. None are correct  iv. All are correct
The common method used in developed countries to harvest roughage is

A. Baling
B. extruding
C. Steam processing
D. Pelleting

i. A is correct  ii. B is correct  iii. C is correct  iv. D is correct
CHAPTER X

UTILIZATION OF UNCONVENTIONAL FEEDS

Unconventional feed or fodders are those that are not traditionally used in livestock feeding or not normally used in commercially produced rations for livestock.

Necessity for its use

Shortage of feeds and fodder has been considered as the major constraint in Livestock feeding. The heavy pressure on land and other aspects of forage production necessitates search for suitable alternatives to bridge the gap between the demand and supply of feeds and fodder. The estimates have shown that the shortage of animal feeds and fodder in terms of nutrients is 77% in DCP and 62% in ME. In order to mitigate such huge shortage of feeds and fodder’s a number of non-conventional materials such as by-products and wastes from agriculture, forest, and slaughterhouse and from a number of agro-industries have been identified. Often they are found to be potential source of energy, protein and/or minerals and have been explored to replace the expensive conventional dietary ingredients and supplements.

Constraints/limitations in use of non-conventional feeds

Many of these resources often may contain certain anti-nutritional factors, which needs suitable physical, chemical and/or microbiological treatments to minimise or to eliminate their ill effects. The most common and simple process to denature the anti-nutritional factors includes sun drying, decortications, roasting, and water soaking, etc. In addition to the presence of anti-nutritional factors, these non-conventional feed resources are also constrained by seasonal supply, poor nutritional value, bulkiness, availability limited to a certain locality, poor palatability, processing formalities including preconditioning, and fear psychosis of the farmers, malpractice and uncoordinated research and development efforts. New technologies are to be developed in order to adopt such non-conventional products in large scale feed preparations.

- The non-conventional feed stuffs can be generally grouped as
- Roughages and concentrates
- Roughages may be succulent or dry
- Concentrates may be of vegetable origin or animal origin. They may be protein sources or energy sources
- Other miscellaneous non-conventional feeds.

ROUGHAGES DRY

Spent straw: Mushroom harvested spent straw has soft texture and quite good acceptability but of low nutritive value. If supplemented with some cheap energy source it can form basal roughage for ruminants. Also needs washing before feeding to avoid mycotoxin problems.

Sugarcane bagasse: can serve as good source of roughage for cattle. It contains 46% cellulose, 3.55% wax, 19.95% lignin, 2.4% minerals and 2.0% silica. It can be utilised for the preparation of low cost feed after steam treatment and addition of bran, molasses, urea, minerals and vitamins.

The empty soybean pods containing 7.59% crude protein and 36.54% crude fibre can be a good source. Treatment with 6% urea at 30% moisture and storage for 4 weeks is recommenced for enriching the same.
**Paper Waste:** Contains about 70% cellulose. Ground paper waste (6Kg) supplemented with molasses (4Kg) salt (50g) and mineral mixture (50g) is sufficient to maintain an adult animal. It can be used as a feed during scarcity.

**Saw dust:** During scarcity when nothing is available even saw dust can be fed to the animals. Complete feed containing 30% saw dust, 32% bran, 31% molasses, 4% urea, 2% salt and 1% mineral mixture can be used as maintenance ration during scarcity periods.

**SUCCULENT**

**Aquatic weeds as feed:** May be of marine or fresh water origin. All aquatic plants are prolific and show high vegetative propagation during rainy season. Aquatic plants are rich in protein, vitamin and trace elements.

Lotus: It is an ornamental plant and in some parts of the country the rhizome and fruits are used as a vegetable. Rhizome is a rich source of starch and seeds are rich in protein.

Water spinach: Used in feeding livestock also used as a vegetable.

Water Hyacinth: It is a prolific weed in terrestrial and running water. It has a DCP of 2.4% and TDN of 44.69% on DMB. It could fed as such or in the form of silage.

Azolla: Aquatic fern having prolific growth. Contains upto 22% crude protein. Can replace vegetable origin protein supplements upto 10% in livestock feeds. When fed to layers it improves yolk pigmentation.

Sugar cane tops: It is the leaves of sugarcane available after the harvest of canes. It contains around 5% crude protein, 2% DCP and 49% TDN. It should be fed along with calcium supplements as it contains high level of oxalate. It can be converted into silage using molasses (1%), urea (4%) and salt (0.5%) as additives. It also can be used as a scarcity feed.

Cassava leaves: It is the leaves of Tapioca after the harvest of the tubers. It contains cyanogenic glycosides. Wilting drastically reduces the level of cyanogenic glycosides. Cassava leaves can be converted into hay or silage and used for feeding animals.

Banana stem and leaves: They contain around 6% DCP and 70% TDN. The moisture content is very high. It can be dried and fed or converted into silage.

Vegetable waste: Have varied nutritional value depending on what constitutes the waste.

**PROTEIN SOURCES**

The more commonly available vegetable and animal protein sources and their protein content are furnished. They can form cheaper protein supplements if care is taken to ward off the anti nutritional principles present in them by suitable means. These protein sources have also been recommended at various levels for inclusion in feed mixtures and rations of cattle, buffaloes, pig and poultry.
## Non-conventional protein sources

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Feed resources</th>
<th>Protein %</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Sunflower meal</td>
<td>40-44</td>
<td>Upto 20% level in cattle ration. Total replacement of GNC in layer ration.</td>
</tr>
<tr>
<td>3.</td>
<td>Guar meal</td>
<td>40-45</td>
<td>Upto 20% in chicken ration if toasted and mixed with 0.1-0.2% cellulose enzyme. 50% replacement of GNC in layer ration. Upto 10-15% for cows and 5-10% for calf rations.</td>
</tr>
<tr>
<td>4.</td>
<td>Karanja cake</td>
<td>30</td>
<td>Expeller variety not suited for chicken. Extracted verity can replace til cake to the extent of 30% on protein equivalent basis in starter and growing chicks.</td>
</tr>
<tr>
<td>5.</td>
<td>Neem cake</td>
<td>34-48</td>
<td>Water washing reduces bitterness Has to be introduced gradually. Can go upto 15-20% level in cattle ration. Processed neem seed meal upto 10% level in chicks and layers rations.</td>
</tr>
<tr>
<td>6.</td>
<td>Rubber seed cake</td>
<td>30</td>
<td>10 and 20% level in concentrate mixture of pigs and calves/lactating cows. Upto 30% level for growing animals. 10% level in poultry ration.</td>
</tr>
<tr>
<td>7.</td>
<td>Sunhemp seed</td>
<td>30</td>
<td>Mixed with other palatable feeds after crushing.</td>
</tr>
<tr>
<td>8.</td>
<td>Dhaincha seed</td>
<td>30-33</td>
<td>- do -</td>
</tr>
<tr>
<td>9.</td>
<td>Cassia tora seed</td>
<td>-</td>
<td>Boiled seeds upto 15% level in the concentrate ration of milch cows.</td>
</tr>
<tr>
<td>10.</td>
<td>Kapok seed</td>
<td>26</td>
<td>Can form a component of cattle feed concentrate.</td>
</tr>
<tr>
<td>11.</td>
<td>Kidney bean chuni</td>
<td>16.3-20.5</td>
<td>Protein supplements for young and milch animal.</td>
</tr>
<tr>
<td>12.</td>
<td>Soundal seeds</td>
<td>-</td>
<td>Upto 30% level in the concentrate mixture for cows and adult animals.</td>
</tr>
<tr>
<td>13.</td>
<td>Thummba seed cake</td>
<td>20</td>
<td>Upto 25% level in cattle feed. Citrullin gives better taste. Water soaking for 6-8 hours is required.</td>
</tr>
<tr>
<td>14.</td>
<td>Tamarind seed powder</td>
<td>15-20%</td>
<td>--</td>
</tr>
<tr>
<td>15.</td>
<td>Poultry by-product meal</td>
<td>50-60</td>
<td>Good substitute for fishmeal and an excellent source of protein for chickens. It provides some unidentified growth factor.</td>
</tr>
<tr>
<td></td>
<td>Ingredient</td>
<td>Level (%)</td>
<td>Notes</td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------</td>
<td>-----------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>16.</td>
<td>Feather meal</td>
<td>80-86</td>
<td>Should be used with judicious supplementation for amino acid deficiencies.</td>
</tr>
<tr>
<td>17.</td>
<td>Poultry excreta</td>
<td>30</td>
<td>6.68% uric acid. Upto 30% of dietary nitrogen ration of buffalo heifers.</td>
</tr>
<tr>
<td>18.</td>
<td>Incubator waste/Hatchery by-product meal</td>
<td>-</td>
<td>3-6% level for broiler chicks. Can replace fishmeal upto 33% in chick’s ration.</td>
</tr>
<tr>
<td>19.</td>
<td>Liver residue meal</td>
<td>65</td>
<td>5-10% level in poultry ration.</td>
</tr>
<tr>
<td>20.</td>
<td>Frog meal</td>
<td>-</td>
<td>Can replace fishmeal twice by weight in poultry ration.</td>
</tr>
<tr>
<td>21.</td>
<td>Dried poultry manure</td>
<td>31</td>
<td>10-15% in chick and broiler rations. Can also be used in cattle ration.</td>
</tr>
<tr>
<td>22.</td>
<td>Cow dung meal</td>
<td>-</td>
<td>10% replacement of maize in grower or layer rations. Sun dried sheep dung meal at 5% level in starter mash.</td>
</tr>
<tr>
<td>23.</td>
<td>Shrimp shell powder (prawn waste)</td>
<td>32-43</td>
<td>Can replace fishmeal at 5% level in broiler of chick rations.</td>
</tr>
<tr>
<td>24.</td>
<td>Crab meal</td>
<td>25-30</td>
<td>Can replace fishmeal. Ca and P content and ratio need to be adjusted.</td>
</tr>
<tr>
<td>25.</td>
<td>Squilla meal</td>
<td>37.6</td>
<td>High Ca feed (10%).</td>
</tr>
<tr>
<td>26.</td>
<td>Processed fish ensilage</td>
<td>31.18</td>
<td></td>
</tr>
</tbody>
</table>

The other non-conventional protein sources include meals from insects (house fly larvae, silk worm larvae meal, white ants), snails, earth warms (live or dead), etc

**ENERGY SOURCES**

*Spent brewers’ grains* and other distillery waste are good source of animal nutrients. The fresh spent Brewers’ grains contain 24% dry matter, 18.8% crude protein, 14.6% DCP and 54.6% TDN. It forms a good supplement (upto 50%) for concentrate mixture.

*Potato waste:* It is a good energy source. It can be used with urea. Helps in efficient utilisation of urea-N in ruminants.

*Spent coffee waste:* After the extraction of instant coffee from coffee beans, the left over material is the spent coffee waste. It is a good energy source but has poor digestibility.

*Corn steep liquor,* a by-product of maize starch industry is found to be a rich source of digestible crude protein (40%), soluble sugars (22.3%) and phosphorus. It can be used upto 15% level in the concentrate mixture for growing crossbred calves.

The other non-conventional energy sources of importance, their energy or TDN content along with level of inclusion in different rations are furnished in Table 12.2.
Non-conventional energy sources

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Source</th>
<th>Nutritive value (ME K cal / kg TDN %)</th>
<th>Remarks</th>
</tr>
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<tbody>
<tr>
<td>1.</td>
<td>Sal seed meal</td>
<td>2718-2653 55%</td>
<td>20% level in concentrate mixture. 5 and 10% levels in chick and layer rations respectively.</td>
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<td>2.</td>
<td>Cassava root</td>
<td>NFE 85%</td>
<td>10% level in chick and broiler feeds; 20% in layer feed.</td>
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<td>3.</td>
<td>Tapioca starch waste</td>
<td>64%</td>
<td>Upto 30% level in cattle feed. Can replace 50% maize.</td>
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<td>4.</td>
<td>Tapioca thippi</td>
<td>2450</td>
<td>Can be used in cattle and pig rations similar to tapioca starch waste.</td>
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<tr>
<td>5.</td>
<td>Tapioca milk residue</td>
<td>8990</td>
<td>For cattle use is similar to tapioca starch waste. Upto 20% for chicks.</td>
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<tr>
<td>6.</td>
<td>Palm flour</td>
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<td>Upto 17.5% in chick ration. Upto 11.5% in layer ration.</td>
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<td>7.</td>
<td>Triticale</td>
<td>2043-3357</td>
<td>Can replace maize by 50-100%</td>
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<tr>
<td>8.</td>
<td>Mango seed kernel</td>
<td>75-80</td>
<td>Can be used as an ingredient of concentrate mixture upto 40% level for bullocks, 20% level for growing cattle and 10% level for cows.</td>
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<td>9.</td>
<td>Oak kernel</td>
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<td>Can replace upto 5% maize in chick feed.</td>
</tr>
<tr>
<td>10.</td>
<td>Tomato waste</td>
<td></td>
<td>Upto 50 and 16% levels for maintenance and milk production.</td>
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MISCELLANEOUS NON-CONVENTIONAL FEEDS

The non-conventional materials of animal feed value that are not covered in the protein or energy groups are

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<tr>
<th>Sl.No</th>
<th>Source</th>
<th>Nutritive value (%)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Seaweed meal</td>
<td>CP: 9.00-19.93 T.Ash: 23.00-44.62</td>
<td>Upto 20 and 15% levels for maintenance and milk production.</td>
</tr>
<tr>
<td>2.</td>
<td>Prosopis juliflora pods</td>
<td></td>
<td>Ground pods can be incorporated at 45, 30 and 20% levels in the rations for maintenance, milk production and growth.</td>
</tr>
<tr>
<td>3.</td>
<td>Babul pods</td>
<td>CP: 14 DCP: 10 TDN: 74</td>
<td>Can be used as a component of concentrate mixture of cattle ration upto 30%.</td>
</tr>
</tbody>
</table>
4. Mahua seed cake  | Upto 50% level for adopted animals.  
                        | Upto 20% for growing and lactating animals.
5. Rain tree pods   | DCP: 8-9  
                        | TDN: 64  
                        | Can be used as a component of concentrate mixture of cattle ration.
6. Jack fruit waste | CP: 7.9  
                        | CF: 14.1  
                        | NFE: 65.3  
                        | TDN: 19.9  
                        | Can also be used as fresh materials.

Coconut pith, kokam cake, decaffeinated tea waste, sunflower straw, kosum cake, cocoa pods, maize cob pith, nahar seed meal, palm kernel meal, cashew apple meal, celery seed, tannery waste, banana stem, mango fruit waste, silk cotton seed, dried yeast sludge, azolla, kitchen disposals and left over in the restaurants have also been identified for use in animal feed. During periods of acute scarcity sawdust may be fed upto 30% of maintenance ration along with urea and molasses for ruminants. Similarly treated sago-molasses can also be used during scarcity.

For effective use of unconventional feed resources complete feed can be formulated. It is advocated to make use of sorghum or wheat straw, maize cobs, cotton stalk, sunflower straw, maize stover, cotton seed hulls, ground nut hulls, sunflower heads, sugarcane bagasse, saw dust, wood pulp waste, forest dry grass, fallen tree leaves case layer dropping or poultry litter etc.

Roughage blocks for maintenance of animals can be prepared from different types of crop residues by adding molasses, urea and mineral mixture. These blocks will serve as a good feed source for maintenance of animals. By making such blocks, wastage of feed material to the tune of 25% or even more can be checked. Transportation cost and storage space can be reduced tremendously. Agricultural Products Process and Engineering Department have developed a machine for making such blocks of different size in collaboration of this department.

Presently, with the improved technologies such as the treatment of straws and low grade roughage with urea-molasses solutions, two stage fungus treatment of straws, urea-molasses lick-blocks, cattle feed formulations at farm levels exploiting non-conventional feed resources, by-pass protein feeds, by-pass and other energy resources, standardisation of cattle feed, etc. has resulted in a real break through in dairy animal nutrition. Consequently an increase in milk yield by about 20% reduction in cost of milk production by 30% can be achieved.

Chalk powder, marble, lime and filter-press mud waste has been found to be good calcium supplements for animals. Dicalcium phosphate (feed grade: 23.25% Ca and 18% P), calcined bone meal (37% Ca and 16% P), sterilised bone meal (31% Ca and 14% P) and a number of such products are available for use as feed supplements.

The utilisation of by-products in animal feeding is beneficial in minimising the shortage of cattle feeds as well as cost of feeding without adversely affecting the performance of animals.
Model questions

113. Brewers grain is a good source of
A. Protein and energy  B. Fiber and minerals
C. Vitamin and minerals  D. Nucleic acid and calcium
i. D is correct  ii. C is correct  iii. A is correct  iv. B is correct

114. Silk worm pupae meal has got oil
A. 25–27%  B. 10–15%
C. 35–40%  D. 5–9%
i. A is correct  ii. B is correct  iii. C is correct  iv. D is correct

115. Tamarind seed hull are rich in
A. Saponins  B. Tannins
C. Trypsin inhibitor  D. Haeme agglutinins
i. C & D are correct  ii. A & C are correct  iii. B is correct  iv. A is correct

116. Dried poultry litter can be included in the ration of layer at a level of
A. 5–10%  B. 20–25%
C. 12–18%  D. 26–28%
i. A is correct  ii. B is correct  iii. C is correct  iv. D is correct

117. Processed shrimp meal has ash content of
A. 25–27%  B. 5–10%
C. 15–20%  D. 1–3%
i. C & D are correct  ii. B is correct  iii. A is correct  iv. None are correct
CHAPTER XI
WILDLIFE NUTRITION

To learn about feeding of wild animals one should know
- Availability of food resources
- Requirements of wild animals
- Possible beneficial out puts through diet
eg. control of pest population through diet

Availability of greens
- Percentage of protein in forage
- Breeding patterns
eg. ungulates give birth in spring

Measurement of food supply:
  I) By direct measurement of available food
  II) Sampling
  III) Estimation or measurements of twigs
Disadvantage: All based on assumption, food intake vary from time to time

Food chain -
- Prey predator relationship
- Hunting behavior
- Carrying capacity
- Variation in food requirements
- Due to seasonal fluctuations in BMR

Variation between species & breeds
- Sex variations (female, Lactation & Pregnancy)
- Regions (Tropics & sub tropics)

Behaviours of animals
(according to body weight)
- Small species (3-20 kg) – selective feeding
- medium 20-100 – grazers & browsers
- large 50-150 kg – mixed feeders
  (grazing in rains & browsing in dry)
  100-250 kg grazers of high class grass leaves
  > 250 kg – unselective grazers

Indices of Body condition
  Body length and body weight
  Body fat and body weight
Muscle weight and body size
Kidney fat index

CLASSIFICATION OF WILD ANIMALS

- Herbivores
- Carnivores
- Omnivores

Herbivores
- Fore gut fermentors
- Hind gut fermentors

Fore gut fermentors
- Rumen
- Recticulum
- Omasum
- Abomasum
  Eg. Deer, Bision

Dentition
Reflects the type of pray captured
- Well developed incisors and shearing canine teeth: Grasping and tearing flesh
- Simple pointed teeth (pinnic peds): Holding fish & aquatic invertebrates
- Cusped cheek teeth (seal): Small crustaceans from water
- Many cusped cheek teeth: Grasp the rigid exoskeleton of insect prey
- Reduced dentition with long tongue: Insectivores to collect ant and termites from cervices

Hind gut fermenters:
- Colon fermenters: Rhinos, Kangaroos, Elephants
- Caecum fermenters: Rodents Voles Lemmings Brown rat Zebra Rabbits Ringtail possum

Sudden change at diet
- Affects fore gut fermentors
- Does not affect hind gut fermentors

Dietary models for zoo herbivores
- Cattle for fore gut fermentors
- Horse for hind gut fermentors

Type of feed/fodder
- Hay
- Pelleted feed
- Browse
- Hydroponic crops
- Fruits

Carnivores
- Predation
- Scavenging
- Piscivores (feeding fish)
- Insectivores (feeding insects)
Felidae
- Strict carnivores – cat model
- Tiger, leopard, cheetah, lion, etc.
- Requires more Amino acids & N\textsubscript{2} in diet
- Limited transaminase and urea enzymes hence more loss
- Sensitive to arginine deficiency,
- Reduced ability to synthesis taurine
- Excretes high level of taurine in bile leading taurine deficiency
- Requires more methionine and cystine
- Inability to convert tryptophan to niacin
- In ability to utilise CHO sources, Lack hepatic glucokinase
- Hence glucose derived from Amino acid via. Gluconeogenic pathway
- Inability to convert provitamin A to Vitamin A
- High requirement of linoleic, linolenic and arachidonic acids

Type of food offered to carnivores
- Whole carcass
- Prepared meat (muscle)
- Complete diet (meat and grains)
- Carcass feeding

Requires mineral supplementation
- Selective eating resulting inadequate diet
- Food poisoning and diseases
  - Live pray - Inhumane – public objection
- Feeding of prepared meat
  - Nutritionally inadequate
  - Food poisoning and disease
  - Reduced sensory input

Feeding soft textured diets
- Complete feed
- Cheap, safe, public acceptance
- Poor oral health due to lack of vigorous tearing and chewing
- Orphan Feeding
- Mother’s milk analysis
- Dilute cow’s milk to match mother milk
- Supplement deficit nutrients
- Bottle feeding and care very essential

Omnivores:
Consumes bath diets of Animal and plant origin
Different anatomic, metabolic and digestive adaptations to facilitate feeding.
Eg. Massupials, Rodents, Bats

Diet Composes
- Fruits - 90%
- Immature leaves - 79%
- Mature leaves - 59%
- Seeds - 41%
- Other animal foods - 37%
Digestive and metabolic adaptations of omnivores

**Digestive:**
- Sacculatation of colon
- Capacious and compartment stomach
- Enlarges carcum and colon
- Special glandular areas in stomach eg. Rnsectivores
- Compartmented stomach eg. Hamsters
- Enlarged caecum & colon eg. Rhodents

**Model questions**

118. Wild animals that feed only on plant origin feeds are grouped as

A. Omnivores
B. Carnivores
C. Primates
D. Herbivores

i. B is correct ii. D is correct iii. C is correct iv. A is correct

119. Wild animals that could be grouped as omnivores are

A. Lion and Tiger
B. Deer and Giraffe
C. Monkeys and Wild rodents
D. Vultures and Eagles

i. A and D are correct ii. B and C are correct iii. C is correct iv. A and B are correct

120. During feeding wild herbivores (hind gut fermentors) in captivity the dietary model of

A. Cattle can be considered
B. Goat can be considered
C. Pig can be considered
D. Horse may be considered

i. D is correct ii. A is correct iii. B is correct iv. C is correct

121. Tiger, Leopard, Cheetah and Lion has a high requirement for the amino acids

A. Lysine
B. Methionine
C. Glycine
D. Taurine

i. D is false ii. D is correct iii. B is correct iv. C is correct

122. Animals that feed only on fish are called as

A. Carnivores
B. Inretivore
C. Herbivore
D. Piscivore

i. D is correct ii. A is correct iii. B is correct iv. C is correct
123. Fish eating birds are
A. Parrots  
B. Pigeons  
C. Vultures  
D. Penguins  
i. C is correct  
ii. A is correct  
iii. B is correct  
iv. D is correct

124. Seed eating birds have certain characteristic feature that facilitate their food habit
A. Heavy powerful skull and beak  
B. Large muscles  
C. Powerful gizzard  
D. Mandible protected from dislocation  
i. All are false  
ii. All are correct  
iii. D is false  
iv. A, B & C are false

125. Birds that feed on nectar
A. Humming bird  
B. Owl  
C. Heron  
D. Wood pecker  
i. D is correct  
ii. B is correct  
iii. A is correct  
iv. C is correct

126. Feeding soft textured diet to carnivores leads to
A. Food poisoning  
B. Selective eating  
C. Public objection  
D. Poor oral health  
i. D is true  
ii. A is true  
iii. B is true  
iv. C is true

127. Omnivores birds have
A. Large beak  
B. Flat beak  
C. Curved beak  
D. All purpose beak  
i. D is correct  
ii. B is correct  
iii. C is correct  
iv. A is correct
### Keys

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