ANIMAL NUTRITION (Paper -II) SYLLABUS

UNIT-3 APPLIED RUMINANT NUTRITION-II

Nutrient requirements and methods for assessing the energy and protein requirements in terms of growth, reproduction, milk, meat, wool and draft purpose. General principles of computation of ration. Formulation of rations and feeding of dairy cattle and buffaloes during different phases of growth and production (neonate, young, adult, pregnant, lactating and dry animals, breeding bulls) and working animals. Formulation of ration and feeding of sheep and goat during different phases of growth and production (milk, meat and wool). Feeding of high yielding animals and role of bypass nutrients. Metabolic disorders and nutritional interventions. Use of NPN compound for ruminants.

UNIT- 4 APPLIED NON-RUMINANT NUTRITION

Nutrient requirements in poultry, swine and equine - Energy and protein requirement for maintenance and production. Methods adopted for arriving at energy and protein requirements for maintenance and production in terms of growth, reproduction and production (egg, meat and work). Feeding standards for non-ruminants and poultry. Formulation of rations as per Bureau of Indian Standards and Indian Council of Agricultural Research specifications. Feeding of swine (Piglets, Growers, Lactating and pregnant sows, Breeding boar, Fattening animals), equine (foal, yeaning, broodmare, stallion and race horses) and poultry (Starter, Growers, Broilers, Layers) with conventional and unconventional feed ingredients. Feeding of ducks, quails, turkeys and laboratory animals. Nutrient requirements of mice, rat, rabbit and guinea pig. Diet formulation, preparation and feeding of rabbits and laboratory animals. Nutrient requirement and feeding of different categories of dogs and cats; peculiarities of feeding cats. Feeding of wild animals and birds in captivity. Metabolic disorders and nutritional intervention.

Reference Books

1. **Animal Nutrition**, P.McDonald, R.A.Edwards, Morgan and J.F.D Greenhalgh.
2. **Feeds and Principles of Animal Nutrition,** G.C.Banerjee.
3. **Animal Nutrition,** Aron, A. Bondi.
4. **Principles of Animal Nutrition and Feed Technology,** D.V.Reddy.
5. **Animal Nutrition in the Tropics,** S.K.Ranjhan.
6. **Advances in Dairy Animal Production,** V.D. Mudgal and Co-workers
7. **The Mineral Nutrition of Livestock,** E.J.Underwood and N.F. Suttle.
8. **Vitamins in Animal Nutrition,** L.R.McDowell.
9. **Text Book of Feed Processing Technology,** N.N.Pathak

UNIT-3
APPLIED
RUMINANT NUTRITION-II

NUTRIENT REQUIREMENTS AND METHODS FOR ASSESSING THE ENERGY AND PROTEIN REQUIREMENTS

(Maintenance and production in terms of growth, reproduction, milk, meat, wool and draft purpose)

Nutritive requirements are the amount of nutrients required by animals to support normal function. The difference between **nutrient requirement** and **nutrient allowance** is that the nutrient 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 ie. % of diets.

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 or nutrient 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 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**.

A. ENERGY REQUIREMENTS FOR MAINTENANCE

Maintenance requirement of energy in ruminants can be determined

1. Either by determining BMR or

2. Through conducting feeding trials.

1. Basal and fasting metabolism (BMR)

- The term **Basal Metabolism or Basal Metabolic Rate (BMR)** refers to the heat production of an animal resting in a thermally neutral environment (approximately 25°C) and in a post-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 breakdown 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 animal has been adequate, especially as regards to energy and protein. Poor state of previous nutrition tends to decrease basal heat production.
2. *Environmental temperature* – temperature of about 25°C
3. *Rest* - 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. Ruminants require about three or four days to obtain post absorptive state. Any ruminants can hardly fulfill this condition; hence it is measured after a starvation period of about 5 days.
5. Because of the fact that the last two conditions cannot be fulfilled fully in ruminants 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).

Unit of reference in fasting metabolism *viz* metabolic body weight:

- Heat production or basal metabolism rate varies with body size.
- **Rubner** developed the concept, referred to as the *surface area law* that the heat given off by all warm blooded animals is directly proportional to their **body surface.**
- Expressed on this basis, heat production is constant to body surface for all species.
- The surface area on the other hand is very difficult to measure, and methods were therefore devised for predicting it from their fractional or decimal power of body weight.
- Scientists decided to standardise the expression of fasting metabolism on ¾ power of body weight i.e., **Kg.W$^{0.75}$** because of the close relationship between metabolism and **metabolic body weight**.
- The fasting metabolism of adult animals of various species ranging in size from rat to cow has an average value of **70-77 kcal per Kg.W$^{0.75}$ per day**, but there are considerable variations from species to species.
- Basal metabolism of various body weights are now a days determined from the formula B.M (Kcal) = 70W $^{0.75}$ Kg
- The coefficient 70 represents an average value for the kilocalories of basal heat produced per unit of metabolic size in experiments with groups of adult mammals.
- It should be note that the above formula applies only in case of adult animals whose growth is complete.

Fasting metabolism as a basis for estimating maintenance requirement:

- Dry non-producing, mature animals were fasted, kept in a thermo neutral environment and their heat production was determined (fasting catabolism). This gives an estimate about the minimum quantity of net energy which must be supplied to the animal to keep it in energy equilibrium. This can be estimated by both direct and indirect calorimetry.

- Measurement of heat production in an animal is called as **calorimetry** Heat produced in an animal (energy for maintenance requirement) can be measured by direct method (direct calorimetry) or by indirect method (Indirect 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 airflow and change in humidity is measured.

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.

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 water 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

- Most of the work on energy requirement in India, was conducted using the indirect calorimetry method.
- The fasting metabolism is only a portion of the energy required for maintenance, since it is only the energy required in a fasting animal, in a comfortable temperature, without voluntary activity.
- Energy required for consumption and digestion of food, energy required for the increased respiration and heart rate due to walking and other movements, varying environmental temperatures are not accounted for in the determination of basal heat production.
- The amount needed for activity is known as activity increment.
- Cattle under feedlot require less than those under grazing or range system.
- In case of cattle, sheep and swine the activity increments may be of the order of 20 to 30%.
- Adding factors such as activity increment to the fasting metabolism to obtain the maintenance energy requirement is called the factorial method of estimating requirements.

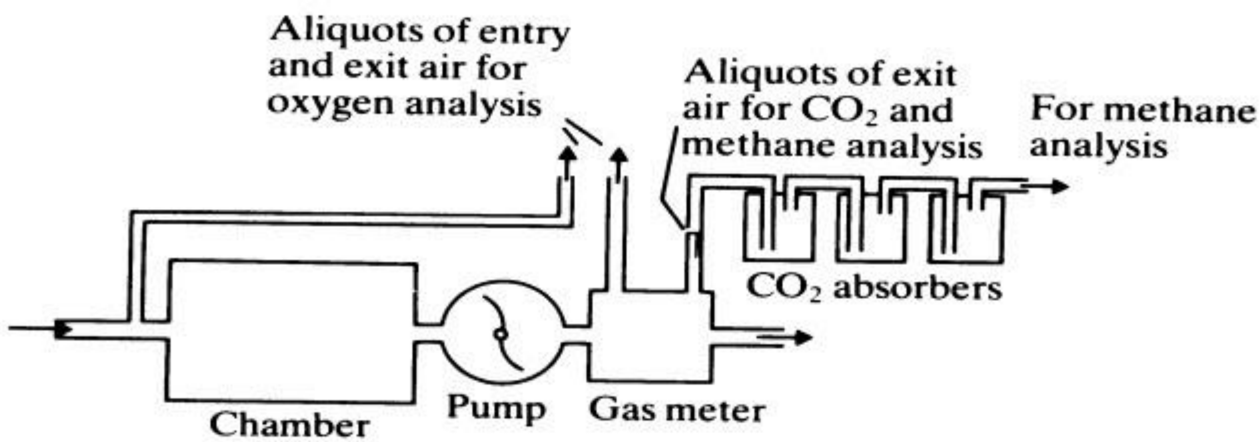
- Values obtained in this way are not as reliable as those determined under practical conditions in feeding trials.

Devices used for estimating gas exchange

- 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.
- A variety of techniques is available for measuring the respiratory exchange; all ultimately seek to measure oxygen consumption and CO_2 production per unit of time.

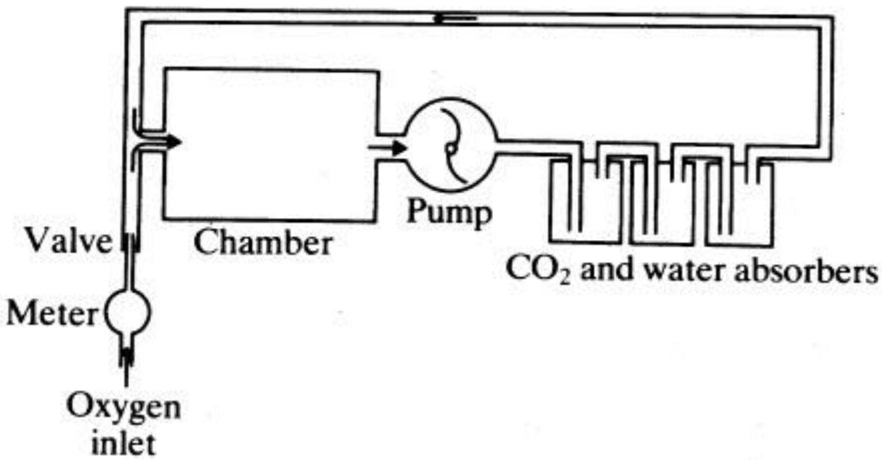
Open circuit system

- Devices allow the animal to breath 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 O_2 and CO_2 content.
- Analysis of gases has been accomplished with chemical and volumetric or manometric techniques.



Closed circuit system

- Devices require the animal to rebreathe the same air. CO_2 is removed with a suitable absorber which may be weighed before and after use 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 O_2 consumption and CO_2 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.



Indirect Calorimetry by the measurement of respiratory exchange:

The substances which are oxidised in the body, and whose energy is therefore converted into heat, fall mainly into the three nutrient classes of carbohydrates, fat and proteins. The overall reaction for the oxidation of a carbohydrate such as glucose is

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + 673Kcal \quad (1)$$

And for the oxidation of the typical fat, tripalmitin, is

$$C_3H_5(OOC.C_{15}H_{31})_3 + \longrightarrow 72.5O_2 \quad 52CO_2 + 49H_2O + 7657\ Kcal \quad (2)$$

Respiratory quotient (RQ)

- This is the ratio between the volume of carbon dioxide produced by the animal and the volume of oxygen used.
- Since, under the same conditions of temperature and pressure, equal volumes of gases contain equal numbers of molecules, the RQ can be calculated from the molecules of carbon dioxide produced and oxygen used.
- From equation (1) the RQ for carbohydrate is calculated as 6 Co2/6 O2 = 1, and from equation (2) that of the fat, tripalmitin, as 51 CO2/72.5 O2 = 0.70.
- If the RQ of an animal is known, the proportions of fat and carbohydrate oxidised can then be determined from standard tables.
- For example, an RQ of 0.9 indicates the oxidation of a mixture of 67.5% carbohydrate and 32.5% fat, and the thermal equivalent of oxygen for such a mixture is 4.924 Kcal/litre.
- The mixture oxidised generally includes protein.
- The quantity of protein catabolised can be estimated from the output of nitrogen in the urine, 0.16 g of urinary N being excreted for each gram of protein.
- The heat of combustion of protein varies according to the amino acid proportions but averages 5.3 Kcal per g.
- Protein, however, is incompletely oxidised in animals because the body cannot oxidise nitrogen, and the average amount of heat produced by the catabolism of 1 g. of protein is 4.3 Kcal.
- For each gram of protein oxidised, 0.77 litres of carbon dioxide is produced and 0.96 litres of oxygen used, giving an RQ of 0.8.
- In practice heat production calculate from respiratory exchange in ruminants is corrected for this effect by the deduction of 0.5 Kcal for each litre of methane.

Energy requirement for dairy cattle for maintenance / day: NEm=80 kcal/kgW$^{0.75}$; MEm=133 kcal/kgW$^{0.75}$ DEm= 155kcal/kgW$^{0.75}$ and **TDNm=35.2 g/kgW$^{0.75}$**

2. Determination of 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 as follows

  Pounds gained x 3.53 = TDN required for gain
  Pounds lost x 2.73 = 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.
- 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 of experiment and at the same time may not be practicable for all classes of livestock.

MAINTENANCE REQUIREMENT

Fasting catabolism & Fasting metabolism

Energy Requirement for Maintenance

Basal and Fasting Metabolism

Post Absorptive State
Thermo neutral Zone – 25ºC
Minimum Muscular Activity
Good Plane of Nutrition

Fasting Heat Production

Direct Calorimetry

Sensible Heat Loss

In Sensible Heat Loss

Adiabatic calorimeters
Gradient calorimeters

Indirect Calorimetry

Open Circuit – IVRI - India
Closed Circuit-RQ

RQ Value: CHO – 1.0; Protein – 0.8; Fat – 0.7

BMR Young > Adult; Un castrated > Castrated; Standing > Lying (Except Horse); Cattle, Poultry > Sheep, Swine

B. PROTEIN REQUIREMENTS FOR MAINTENANCE

Protein requirements for maintenance can be determined

1. by factorial method or
2. nitrogen balance method or
3. by feeding trial

1. Estimation of protein requirement for maintenance from endogenous urinary metabolic faecal nitrogen (factorial method)

- 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 substances, the animal will rundown in condition and its reproducing ability or 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.

a. Endogenous urinary nitrogen (EUN)

- Here the loss of nitrogen is due to the catabolism that occurs due to maintenance of the vital tissues of the body.
- This can be measured at the minimum urinary excretion on a nitrogen free ration otherwise adequate in other nutrients.
- The quantity of nitrogen thus lost through urine is **dependent on the body size of the animal and is equal to 0.02-0.03 g / kg b wt. or 2 mg / kcal basal metabolism**.
- This loss is directly proportional to metabolic body weight ($W^{0.75}$ where W is the body weight in kg) of animal.

$$\textbf{EUN (mg/day) = 146 } \mathbf{W^{0.72}}\textbf{kg}$$

b. Metabolic Faecal nitrogen (MFN / FNm)

- 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.
- **Metabolic faecal is dependent on the amount of feed ingested or dry matter intake of the animal and equal to 0.5 g / 100 g of DMI.**
- There is also species difference. The MFN values determined in Indian cattle were 0.35 g/100 g DMI and in buffaloes 0.34 g/100 g DM intake. These values are lower than the values determined in *Bos taurus.*
- Endogenous urinary nitrogen and metabolic faecal nitrogen put together has come to **350 mg N/kg metabolic body size per day in ruminants.** It is two to three times as great as in non-ruminants.
- The value will be lower with rations low in roughage and higher where roughage alone will be fed.
- It is evident from above 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.
- **Dermal losses of hair and scuff (2.2g N/d) are also included.**

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.,

Example:

- A cow weighing 450 kg body weight and consuming 7 kg dry matter will excrete 13 g of EUN everyday and 35 g of MFN totaling 48 g in all.
- The loss of nitrogen in adult like growth and renewal of hair, nails in cattle is practically negligible. Thus, 48 x 6.25 = 300 g protein loss is evidenced.
- Now to arrive at the protein requirement, this value has to be converted because the efficiency of utilization depends on the biological value of protein, which is about 70% in ruminants **(BV=70% in cattle, 65% in sheep and 30% for wool production).** Therefore, 100/70 x 300 = 428 g or say 0.43 kg is the amount of true digestible protein required for just maintenance.
- As the requirement of protein in the feeding standard is given in the form 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, 0.430 kg - (6.25 x 0.035) = 0.22 kg is the value expressed in DCP.
- Now this value is increased by 25% to provide margin of safety which thus becomes 0.28 kg. DCP-a value which has been recommended in the table of feeding standards.

It will appear from the above that in the calculation of protein requirement, first the value of MFN has been included but subsequently the same value has been subtracted for converting true digestible protein to apparent digestible protein or say DCP. The reason for this is to allow the wastage of amino acids incurred in the synthesis of metabolic faecal protein. From the above, the following formulae may be deduced for estimating the total digestible protein

$$\textbf{Total digestible protein} = (\mathbf{EUN} + \mathbf{MFN} + \mathbf{S}) \times 6.25 \times \frac{\mathbf{100}}{\mathbf{B.V.}}$$

In cattle, S for the loss of nitrogen in hair etc., may be determined from an estimate of 0.02 $W^{0.73}$ g nitrogen loss per day. This value may however, be omitted for all practical purposes as the amount is very negligible.

2. Nitrogen balance method as measure of protein requirement for 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.

Protein Requirement for Maintenance
Factorial method from EUN and MFN
Total digestible protein = (EUN + MFN + S) x 6.25 x (100 / BV)

- EUN - Endogenous urinary nitrogen
- MFN - Metabolic fecal nitrogen
- S - the loss of nitrogen in hair
- BV - Biological value of protein

Nitrogen Balance Method
Feeding Trial Method

- MFN is directly proportional to Dry Matter Intake
- EUN is directly proportional to Body Size
- EUN is lowest in Hibernating Animals, Highest in Young animals

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 adult non-producing healthy animal** for an extended period without loss of weight or otherwise is considered the maintenance requirement of protein.

- 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.

A.ENERGY REQUIREMENT FOR GROWTH

Energy requirement for growth can be determined from

1. Feeding trials or
2. By factorial method.

1. **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.

2. **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 Mcal DE or 4400 kcal DE

B. 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

1. factorial method or
2. by nitrogen balance method or
3. by feeding trials.

1. 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 70 kg and growing @ 0.5 kg per day.

2. 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.

3. 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
- 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 feed 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 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 feed, 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 utilized 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.
- Hence after 5 months of pregnancy the pregnant cow should be given an additional amount of **0.14 kg of DCP, 0.67 kg of TDN, 12 g of Ca, 7 g of P and 30 mg of vit.A** over and above the maintenance and production requirements for development of foetus (1.0 to 1.5 kg of additional concentrate mixture with 2% calcium carbonate).

Partitioning of energy requirement in pregnancy

Maintenance Requirement-80%**;** Maternal Weight Gain-15% and Foetal Requirement-5%

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 (ex. 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. **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 is **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 4.0%, the gross energy content of 1 kg of milk will thus be equivalent to 304.8 + (114.1 x 4.0) = **761.2 kcal (NE**l) or approximately **750 kcal.**
- The **gross energy also 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 ie **NE** is **62%;** Efficiency of conversion of DE to ME is **82%**; so that DE required to produce 1 kg

FCM = (750/0.62=1200/0.82=1460 kcal; Then the amount of **TDN required / kg of FCM= 1460/4400=0.330 kg or 330 g.**

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.
- **One kg of FCM contains about 35 g protein**. The efficiency of utilization of DCP for milk production is 60-70%. So about **50 to 55 g DCP is required** in addition to maintenance requirement per kg of milk produced by the animal.

Minerals requirement for lactation

- 1 kg of FCM contains about 1.3 g of Ca and 1.0 g of P. if efficiency is 60% then about 2.2 g Ca and 1.6 g of P are required / kg of FCM.

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 50 kg 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 characterized by its high content of the **sulphur-containing amino acid**, cystine, which although not an indispensable amino acid is synthesized 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 o**f these acids, compared with the 20 – 30 g/kg found in plant protein and in microbial proteins synthesized 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 week 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 oxidized in the system. All the organic constituents of feed are capable of being oxidized and utilized 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.

FEEDING OF CATTLE AND BUFFALOES

1. FEEDING OF CALVES UPTO 3 MONTHS OF AGE (pre ruminants / neonate / young calf)

- Good management is essential to raising healthy calves.
- Reducing death losses of newborn calves to less than 5% and raising strong, healthy heifers large enough to breed at 14 to 16 months of age are sound management objectives.
- Calves stunted from underfeeding or diseases may not develop into healthy and profitable cows.

Oesophageal groove

- The newborn calf is not a ruminant
- Pre ruminant refers to the period after birth when the calf is dependent on milk (or milk replacers) as it's major food.
- At birth and during the first few weeks of life, the compartments of the digestive system (i.e. rumen, reticulum, and omasum) are undeveloped.
- In contrast to the mature cow, the abomasum (true stomach) of the newborn calf is the main compartment, constituting 60% of the total tissue weight of the stomach.
- At this stage of life, the rumen is nonfunctional and the calf cannot utilize some feeds digested by the adult.
- During nursing or feeding from a bucket, milk bypasses the rumen via the esophageal groove and **passes directly to the abomasum**.
- Reflex action closes the groove to form a tube-like structure, which prevents milk or milk replacer from entering the rumen.
- When milk is consumed very rapidly, some may overflow into the rumen.

Development of the Rumen

- As long as the calf remains on milk, the rumen remains undeveloped.
- When calves begin consuming solid food, a microbial population becomes established in the rumen and reticulum.
- End products of microbial fermentation (i.e. volatile fatty acids) are responsible for the development of the rumen.
- This occurs as early as 3 weeks of age with most feeding programs.
- If grain feeding with or without forage is started during the first few weeks of life, the rumen will become larger and heavier with papillae.

Feeding colostrum in new born calves

- The calf should be fed colostrum **within 2 hours** of birth and this should be continued for 3 days.
- Colostrum provides antibodies which are absorbed intact in the first few days of the calf's life. The immunoglobulins are absorbed in the body by the process of **pinocytosis**. After this age, globulins carrying antibodies are broken down by proteolytic enzymes in the process of exogenous digestion.
- The colostrum also contains **anti tryptic enzyme** which may help in the protection of whey protein from the proteolysis.
- It also has a laxative effect in removing muconium. **The colostrum should be fed at the rate of one tenth ($1/10^{th}$) of body weight of the calves.**
- It should not be warmed since it will coagulate, due to the presence of higher quantity of protein (17%) as against 3.5% in normal milk.

Colostrum replacer/Artificial colostrum

- If mother's colostrum is not available, prepare the artificial colostrums as follows
  - -Warm water -275 ml
  - -Raw egg contents-1
  - -castor oil-3ml
  - -Vitamin A-10,000 IU
  - -Warm whole milk-525 ml
  - -Auromycin-80 mg. Mix well and feed at 40^{o}C
- In addition, it is necessary to inject the calf with dam's serum for augmenting the antibody titre in the body, particularly the buffalo calves.

Milk feeding in weaned calves

- In commercial dairy farms weaning of calves within 3-4 days of birth is carried out. After weaning, the calf is trained to drink milk from a pail either through hollow pressure rubber tubing or a nipple. Farmers having a few animals allow the calves to suckle their mother.
- Milk has a high nutritive value and should be given to calves after 4 days of age. Milk is a complete feed for calves. The calf must receive sufficient milk during the first three months.
- Economical feeding on restricted milk quantity slows rate of growth which delays maturity age.
- Milk should be given warmed to body temperature and preferably with a trace mineral supplement to make up for its deficiency of Fe, Cu, Mg, Mn and Zn.

Milk feeding schedule

Body wt (Kg)	Age in days	Colostrum (Kg)	Milk (Kg)
Up to 30	1-3	1/10 of b.wt.	-
Up to 30	5-30	-	1/10 of body wt.
25-30	31-60	-	1/15 of body wt.
35-70	61-90	-	1/20 to 1/25 of body wt.

Feeding of milk replacer to calves

- Milk replacer is fed to calves as early as at 10 days of age to replace milk from economic point of view.
- Milk replacer should resemble milk more or less on broad chemical composition especially in terms of protein quantity and quality, amino acid quantity and quality, volatile fatty acids, minerals and vitamins.
- It should have a biological value equivalent to that of milk.
- The ingredients used for preparing milk replacer should be low in crude fibre and free from any antimetabolites.
- In addition, milk replacer may contain butyric acid to stimulate ruminal pappilary growth, citric acid as preservative and some antibiotics as additives to stimulate growth and to build up vitality and resistance against diseases.
- The replacement of milk by milk replacer should be gradual to facilitate its acceptance and to avoid a drop in growth rate.
- **Milk replacer** can be fed as mash form or reconstituted in water and fed either using feeding bottles or using buckets. If reconstitution with water is done the milk replacer should be used immediately and the water used should be potable and free from microbial load.

Composition of milk replacer

Ingredients	Inclusion level (%)
Wheat flour	10
Fishmeal	12
Linseed meal	40
Skim Milk powder	13
Cottonseed oil/ coconut oil	7
Citric acid	1.4
Molasses	10
Mineral mixture	3
Linseed oil	3
Butyric acid	0.3
Antibiotic mixture	0.3
Rovimix (A, B_2, D_3)	15 g
Total	**100**

Calf Starter

- A standard calf starter is offered from 10th day of age to supplement the nutrients when they are raised on limited milk intake.
- The calf starter should contain 23-26 % CP and 70-75% TDN.
- About 20-25 % CP should be supplied through **an animal protein source** or skim milk powder for balancing the essential amino acid requirement of pre ruminant calves which are not able to synthesize them due to their non functional rumino-reticulum.
- Calf starter is gradually introduced at the rate of 50 to 100 g / animal / day and increase up to 500 g / animal / day.

Examples of some common calf starters

Ingredients	I	II
Ground Maize	-	50
Ragi / sorghum	50	-
Groundnut cake/ soya bean meal	20	20
Wheat bran /Rice bran	8.5	8.5
Fishmeal/Skim milk powder	20	20
Common salt	0.5	0.5
Mineral mixture	2	2
Total	100	100

To each 100 kg of above mixture, 5-10 kg of molasses, 10 g vitamin supplement and 20 g antibiotic mixture should be mixed thoroughly.

Overall feeding schedule of calves (up to 3 months)

Age in days	Colostrum (Kg)	Milk / Milk replacer (Kg)	Calf starter (g)	Roughage
1-3	1/10th LBW	-	-	-
3-21	-	1/10th LBW	100	-

22-35	-	1/15th LBW	150 -250	Ad-lib
36-60	-	1/20-25th LBW	250 -500	Ad-lib
60-90	-	Milk is gradually reduced	500 - 600	Ad-lib

2. FEEDING OF GROWING ANIMALS

Feeding dairy calves from three months to six months

The following feeding schedule should be followed for raising calves from 3 months to maturity.

From 3-6 months of age

Category	Concentrate (Kg)	Roughage (Kg)
Indigenous cattle/buffaloes	0.75, 1.0 and 2 Kg respectively for 4th, 5th and 6th month of age	Non leguminous green roughage -10 Kg or Leguminous green roughage 1.5-2.5 Kg + Dry fodder -2 kg
Exotic	1.6 – 2.0 Kg	Up to 4 months of age - Green roughage non legume and legume - 5 -10 kg From 4-6 months - Green roughage non legume and legume - 10- 15 kg

The concentrate feed offered to calves at this growing period is called as **calf grower meal.**

Calf grower meal requirements (BIS)

Sl.No.	NUTRIENT	REQUIREMENT (%)
1.	Moisture (max.)	10
2.	Crude fibre	10
3.	Crude protein	22-25
4.	Crude fat	4
5.	Total ash	5
6.	Acid insoluble ash (max.)	3.5

Example calf grower meal (DCP 18 -20% and TDN 60 -70%)

Maize	22
Wheat bran	25
Ground nut oil cake	30
Lucerne meal	20
Common salt	1
Mineral mixture	2

After 6 month of age, individual feeding of calves may be discontinued. The males and females should be kept in separate paddocks.

3. FEEDING OF HEIFERS (6 months to maturity)

- Under feeding in heifers will lead to retardation of growth below recommended levels and shortens the productive portion of the heifer's life.

- Acceleration of growth beyond recommended level is also not desirable since early onset of maturity is possible and lifetime milk production and longevity decreases.
- A feeding program should provide the heifer optimum nutrients to develop a healthy and strong body.
- A well-developed heifer has a far better chance of becoming a good producer than one poorly fed and cared for heifer.
- Varying amounts of roughage and concentrate may be fed during the growing period, with the amount of concentrate based on the desired growth rates and also based on the quality of roughage.
- Heifers are usually maintained on **grazing alone** from five to six months of age. They should be fed additional concentrate or supplements, the amount depending on the condition of the heifers. Generally, **1 to 2 Kg of concentrate** per day is needed for good growth.
- If the pasture contains **some legumes**, then a concentrate mixture containing 12 to 14% protein is adequate. If the pasture consists of only grasses the concentrate mixture should contain from 15 to 16% protein.
- Well-fed heifers can be bred at 14 to 15 months of age and should weigh about 350 Kg

4. FEEDING OF PREGNANT HEIFER

- How heifers are fed during this period can affect milk production during first lactation.
- Rapid growth of foetus occurs during the last trimester of pregnancy. Hence, the heifers should move from a steady growth rate after breeding to a rapidly growing phase (1.7 to 2.0 lb/day gain) during the last two to three months of pregnancy. The exact amount of grain to feed before calving will depend on forage quality, size, and condition of the heifer.
- During the last trimester of pregnancy heifers are fed 1.5 kg of a concentrate mixture (14% CP and 70% TDN) to supply about 200 g of CP and 1.0 kg TDN to meet the requirements of rapidly growing fetus.
- The mature body weight of elite buffaloes ranges from 450 to 650 kg. Similarly the adult body weight of cows ranges from 300-600 kg or even higher in some breeds.
- Even after conception, therefore, they continue to grow at the rate of 300-500% depending upon the plane of nutrition to achieve mature body weight at about second lactation.
- Therefore, they should be fed additionally for months to achieve mature body weight for successive normal reproduction cycle. Delayed growth in first and/or second lactation due to short supply of dietary energy is often attributed to repeat breeding and other reproductive disorders.
- Therefore, the **pregnant heifers are also fed 20 % of maintenance CP and TDN as extra allowance for their body growth.**
- The pregnant heifers should be provided more amount of good-quality forage and less concentrates to prevent fat deposition. They should receive adequate amount of carotene or vitamin A, as it is essential for maintenance of placental epithelium and foetal growth (deficiency leads to still-birth with hydrophalus). The vitamin A (alone in buffaloes) or vitamin A and carotene (in cows), stored in the body of cow, are secreted through colostrum in larger quantity. A reserve of this vitamin is thus essential. Since green fodders are very good source of carotenes (precursor of vitamin A), they should be fed in plenty. If green fodder /hay or silage is not available, synthetic vitamin A must be supplied through concentrate mixture. The green fodder has also laxative effect, which is helpful for pregnant animals.
- Feeding of concentrate to heifers 2-3 weeks before calving to adapt rumen microbes to the concentrates is the sound nutritional practice in certain countries

- The mineral mixture and common salt should also be supplied adequately. They should get free access to drinking water.

FEEDING OF GROWING BULL CALVES (6 months to maturity)

- Feeding of growing bulls is important if they are to perform effectively during the breeding period.
- Nutritional requirement of growing bulls change according to their age. Younger bulls require lesser feed but of superior quality, their protein requirement is higher to meet the rapid growth of their muscles.
- Older bulls have a higher requirement for dry matter but percentage crude protein requirement as a component of dry matter decreases.
- Growing bulls can be maintained on a **good quality pasture** or **good quality hay feeding with concentrate supplementation at the rate of 1 % of its body weight**.
- The protein content of the concentrate can be adjusted according to the type of roughage offered. When roughage is made up of only grasses higher intake of protein is required.

Feeding growing heifers / bull Calf from 6-12 months of age

Category	Concentrate (kg)	Roughage (kg)
Indigenous cattle/buffaloes	1-2 kg	Non leguminous green roughage -15 - 20 kg (or) Non legume green roughage 5 kg + Straw 2– 3 kg + concentrate 1 kg
Exotic	2.0 – 2.5 kg	Green roughage non legume and legume -15 -20 kg

Feeding growing heifers from 1 year to age at conception

Category	Concentrate (kg)	Roughage (kg)
Indigenous cattle/buffaloes	1-2 kg	25 – 30 kg of Green roughage non legume (or) 5-6 kg crop residue + 1-2 kg concentrate
Exotic	1.5 - 2 kg	30 - 35 kg of Green roughage non legume

5. FEEDING OF ADULTS CATTLE / BUFFALOE

Feeding of breeding bulls

- Bulls must be in good condition to be fertile and sexually active.
- Adequate energy reserve has to be built up in the bull prior to its use for breeding.
- The bulls are likely too loose weight in the breeding season.
- The body condition of the bull must be periodically assessed so as to improve the feeding programme.
- When non-leguminous green fodders or grazing in good pastures form the basal roughage there is no need to feed concentrate mixture.
- Leguminous forages like lucerne/cowpea can be fed along with the straw or other good quality roughages like hybrid grasses without any concentrate.
- If the bull is fed with dry hay not more than 7-8 kg per day should be fed and always it has to be supplemented with some fresh grass and/or concentrate
- Straw is not good feed for bulls but if, for some reason, straw has to be fed to the bull, supplement the ration with leguminous crops and concentrates.

- Concentrates providing 12 -14 % crude protein and 60 % TDN can be used. Concentrates can be fed at the rate of 1.5-3 kg per day.
- The bulls must have free access to clean drinking water and mineral lick.

Maintenance ration

Two alternatives could be easily considered depending on the availability of green fodder. If green leguminous fodder like berseem, lucerne or subabul is available, a combination of about 6 to 8 kg of leguminous green fodder and 4.5 kg of paddy straw can easily meet the maintenance requirement of animals. The other alternative is to feed 1 kg of balanced concentrate mixture.

Option	Feed	Quantity(kg)
1.	Green legume Cereal straw	6 – 8 4.5
2.	Concentrate mixture Cereal straw	1 5

Nutrient required for breeding bulls

Live weight (kg)	**DCP** (kg)	**TDN** (kg)	**Ca** (g)	**P** (g)
400	0.38	3.6	9	9
500	0.45	4.5	11	11
600	0.53	5.4	13	13

Feeding of working bullocks

- The source of all potential energy in skeletal muscle (creatine phosphate or ATP) is the absorbed products of digestion from the diet.
- Therefore only carbohydrates need to be supplied to meet the extra energy required for work.
- In adequate nutrient supply, a working animal first draws upon the CHO and fats in the feed. If the supply is inadequate, the body fat is used for the purpose and as a last resort muscles and other protein tissues are used.
- Thus, as long as there is a sufficient supply of CHO in the feed, an ox at work needs no more protein than required for maintenance under resting condition.
- However, maintaining proper nutritive ratio is essential for better utilization of CHO / CF in the rumen, and therefore adequate protein level should be maintained.
- The requirement of energy depends on the intensity and duration of work.

Nutrient required for working animals

Live weight (kg)	**DM** (kg)	**DCP** (kg)	**TDN** (g)
Normal work 6hours carting 4 hours ploughing per day			
200	4.0	0.24	2.0
300	5.8	0.33	3.1
400	7.6	0.45	4.0
500	9.4	0.56	4.9
600	11.2	0.66	5.8
Heavy work 8 hours carting 6 hours ploughing per day			
200	5.0	0.25	2.7
300	7.0	0.42	4.0
400	9.8	0.57	4.8
500	11.2	0.71	6.4
600	13.4	0.82	8.0

National Dairy Research Institute, Karnal (1985).

Ration for 400kg bullocks with heavy work

Requirement: DM-8-10 kg; DCP-0.57 kg; TDN- 4.8 kg

Grass - 15 kg
Straw - 3 kg
Ground maize - 0.5 kg
Wheat / Rice bran - 1.2 kg
Gingilly oil cake - 0.5 kg
Mineral mix - 30 g
Salt - 30 g

When wheat/paddy straw form the basal ration, then a concentrate mixture containing 12% DCP and 75% TDN should be fed at the rate of 1, 1.5, 2 and 2.5Kg respectively to 200, 300, 400 and 500 Kg animal along with *ad libitum* bhusa.

For heavy work 2, 3, 4 and 5 Kg of concentrate mixture should be fed along with wheat straw. 2.5 Kg green fodder may be fed to satisfy the vit. A requirement.

Alternative Feeding Schedule for working bullocks

Light work:
Roughage: Ad libitum straw (6-10 kg)
Concentrate (12% DCP, 60% TDN): 1-2.5 kg/day

Medium work:
Roughage: Ad libitum straw (6-10 kg)
Concentrate (12% DCP, 70% TDN): 1.5-4 kg/day

Heavy work:
Roughage: Ad libitum straw (6-10 kg)
Concentrate (12% DCP, 75% TDN): 2-5 kg/day

Feeding for reproduction

The cow has a dry period of about 2 months but in practice it may be longer. During this period, cow should build up the body reserves lost in early lactation and will require nutrients to provide for the rapid growth of the foetus which occur during the later stage of pregnancy and for the regeneration of mammary tissue.

Steaming Up

Dry cows are offered quantities of concentrate which increase gradually during the last 6 weeks of **pregnancy**. By the time of calving, the amount of concentrates given is about 75% of the quantity, the cow is expected to require in early lactation. It is important to increase milk production and to prepare cows for large quantities of concentrate during early lactation. Normally 50% of DCP and 25% of TDN of the maintenance requirement are fed above the requirements. In order to cover these requirements 1 to 1.5 kg additional concentrate mixture over and above the maintenance ration should be given.

Some examples of concentrate mixture

Ration 1

Groundnut cake	35
Wheat bran	20

Maize	15
Oat/barley/sorghum	15
Gram chuni	15
	100

Ration 2

Mustard cake	20
Wheat bran	45
Green gram	35
	100

Ration 3

Tapioca chips	20
Groundnut cake	30
Gram chuni	25
Rice bran	25
	100

Ration 4

Groundnut cake	20
Rice bran	25
Wheat bran	10
Gram husk	30
Cotton seed cake	15
	100

Thumb rule for feeding concentrates in cattle and buffaloes

In case of cattle, for every 1 kg of milk production, 0.4 kg of concentrates should be given. In case of buffaloes, for every 1 kg of milk production, 0.5 kg of concentrates should be given.

FEEDING STRATEGIES FOR HIGH YIELDING DAIRY COWS

- Nutrient requirements of a dairy cow vary with the stage of lactation and gestation.
- Five distinct feeding phases can be defined to attain optimum production, reproduction and health of dairy cows:
    1. Early lactation - 0 to 70 days (10 weeks, peak milk production) after calving (postpartum).
    2. Peak DM intake - 70 to 140 days (20 weeks, declining milk production) postpartum.
    3. Mid- and late lactation - 140 to 305 days (42 weeks, declining milk production) postpartum.
    4. Dry period - 60 to 14 days before the next lactation.
    5. Transition or close-up period - 14 days before to parturition.

Phase 1. Early Lactation - 0 to 70 days (10 weeks) postpartum

- Milk production increases rapidly during this period, peaking at 6 to 8 weeks after calving.
- Feed intake does not keep pace with nutrient needs for milk production, especially for energy, and body tissue will be mobilized to meet energy requirements for milk production.

- Adjusting the cow to the milking ration is an important management practice during early lactation.
- Increasing concentrate about 500 g per day after calving will increase nutrient intake while minimizing off-feed problems and acidosis.
- Excessive levels of concentrate (over 60 percent of the total DM) can cause acidosis and a low milk fat percentage.
- Fiber level in the total ration should not be less than 18 percent. Physical form of the fiber is also important. Grinding, and/or pelleting all reduce physical form of fiber and its effectiveness to stimulate rumination.
- Protein is a critical nutrient during early lactation. Meeting or exceeding crude protein requirements during this period helps stimulate feed intake and permits efficient use of mobilized body tissue for milk production. Rations may need to contain 19 percent or more crude protein to meet requirements during this period.
- Low peak production and ketosis problems occur when nutrient levels are not met. Low peak production translates into low lactation production.

To increase nutrient intake

- Feed top quality forage.
- Make sure the diet contains adequate amounts of CP, RDP and UDP.
- Increase intake at a constant rate after calving.
- Consider adding fat (1 to 1.5 lb/cow/day) to diets of very high yielding cows.
- Allow constant access to feed.
- Minimize stress conditions.

Phase 2. Peak DM intake 70 to 140 days (20 weeks) postpartum

- Cows should be maintained at peak production as long as possible.
- Feed intake is near maximum and can supply nutrient needs.
- Cows should no longer be losing body weight, and are either maintaining weight or slightly gaining weight .
- High concentrate ration is to be provided.
- Forage quality should still be high with intakes of at least 1.5 percent of the cow's body weight (DM basis) to maintain rumen function and normal fat test.
- Potential problems during this period include a rapid drop or decline in milk production, low fat test, silent heat (no observed heat), and ketosis.

To maximize nutrient intake:

- Feed forages and grain several times a day.
- Feed the highest quality feeds available.
- Continue to minimize stress conditions.

Challenge feeding: Feeding of lactating cow during its peak milk yield period with balanced ration to meet the nutrients requirement in relation to its requirement.

Phase 3. Mid- to late lactation—140 to 305 days postpartum

- This phase will be the easiest to manage.
- Milk production is declining, the cow is pregnant, and nutrient intake will easily meet or exceed requirements.
- Concentrate feeding should be at a level to meet milk production requirements and begin to replace body weight lost during early lactation.
- Consider NPN as a source of supplemental protein.
- Avoid over-conditioning cows.

Phase 4. Dry period—60 to 14 days before parturition

- The dry period is a critical phase of the lactation cycle.
- A good, sound dry cow program can increase milk yield during the following lactation and minimize metabolic problems at or immediately following calving.
- DM intake will be near 2 percent of the cow's body weight.
- Forage intake should be a minimum of 1 percent of body weight or 50 percent of the dietary DM.
- Grain feeding should be according to needs, but not exceeding 1 percent of body weight.
- Meet calcium and phosphorus needs, but avoid large excesses. Calcium intakes of 60 to 80 grams and phosphorus intakes of 30 to 40 grams are sufficient for most cows. Provide adequate amounts of vitamin A, D, and E in rations to improve calf survival and lower retained placenta and milk fever problems. Trace minerals, including selenium for most producers, should be adequately supplemented in dry cow diets.
- Problems such as milk fever, displaced abomasum, retained placenta, fatty liver syndrome, fatty liver formation, and poor appetite, along with other metabolic disorders and diseases, are common in fat cows at time of parturition.

Phase 5. Transition period—14 days before to parturition

- The transition or close-up dry cow feeding program is critical to adjusting dry cows and springing heifers to the lactation ration and preventing metabolic problems.
- Some concentrate, if not previously fed, should be fed starting two weeks before parturition
- Also, addition of some ingredients used in the lactation ration during this period minimizes the stress of ration changes after calving.

- Increase protein in the ration to between 14 and 15 percent of the ration DM. Feeding some of this additional protein in the form of undegradable protein may be beneficial in supplying amino acids for fetal growth.
- Limit fat in the ration. High fat feeding will depress DM intake.
- Remove salt from the ration if edema is a problem.
- If niacin (to control ketosis) and/or anionic salts (to help prevent milk fever) are going to be used, they should be included in the ration during this period.

Bypass nutrients for high yielders

Protected protein / bypass protein feeding

- Ruminant animals require two types of digestible protein.
- The first is a degradable protein in the rumen which is used by the micro-organisms to produce microbial protein.
- The second is the bypass protein which is digested in the small intestine and used by animals itself.
- Rumen degradable protein is used to synthesize microbial protein. Metabolizable protein consists of bypass protein and microbial protein.
- Although the microbial protein alone is likely sufficient to meet the needs of cattle at or near maintenance young growing cattle and lactating cows need bypass protein in addition to microbial protein to meet their metabolizable protein.
- Extensive degradation of valuable protein in the rumen by the microorganisms results in some losses of nitrogen as urea in the urine. The reason behind the attempts to protect dietary protein is to avoid the degradation of high quality proteins and to further reduce wasteful ammonia production in the rumen.
- To protect protein degradation in the rumen by micro-organisms several procedures such as heat treatment, chemical treatment/modification, inhibition of proteolytic activity and identification of naturally protected protein were widely used.
- The most limiting amino acids for synthesis of milk and milk protein have been reported to be **Methionine and Lysine**.
- Feeding these amino acids in an unprotected form to dairy cows results in their degradation by microbes in the rumen before they pass to the absorption sites in the small intestine.
- To supply additional Methionine and Lysine for production of milk and milk protein, methods have been developed to protect these amino acids from microbial degradation resulting in the Rumen protected amino acids passing to the abomasum and small intestine where they are released and absorbed.

Protected fat or bypass fat feeding

During early lactation especially in high yielder, when demands on Cow's energy reserves are high and appetite is low, energy requirements can reach extremely high levels owing to the intensive onset of milk production. In such condition fat can be used as an energy source. A limitation to an extensive use of fat in ruminant diets is the subsequent disturbance of carbohydrate ruminal digestion. In order to overcome this problem, different kinds of protection of lipids have been proposed. In lactating cattle rations include tallow (animal fat), blends of animal and vegetable oils are used, these fat sources, are protected from rumen degradation and are termed as protected or "rumen bypass" fats. Protected indicates that the fat is inert or bypasses the rumen and as such does not interfere with rumen metabolism. Some of the protected fats include Calcium Soaps Protected Fats

High concentrate feeding

The practice of increasing the proportion of concentrate in the ration of high yielders in peak lactation and during the last few weeks prior to calving is sometimes practiced. Intake of excessive concentrate increases the risk of bloat and acidosis. Laminitis, an aseptic inflammation of the dermal layers inside the hoof and a major source of lameness for dairy herds, has been linked to acidosis.

Dietary supplementation of sodium bicarbonate elevates the decline in ruminal pH that is observed post feeding and may decrease the incidence of acidosis. The recommended inclusion rate for sodium bicarbonate is 0.75 to 1.0% of total dry matter. Feeding the concentrate at divided levels in increasing frequency also is recommended.

Mineral requirement for milk production

The Ca and P content of milk are almost constant and the deficiency will lead to low milk production. If the rate of Ca and P secretion is greater than its absorption, then it will be mobilized from bones. These minerals are also necessary for pregnancy. Usually in high yielding cows and buffaloes the body is in negative Ca and P balance in early lactation, in equilibrium in mid lactation and positive in the late lactation and in the dry period.

For maintenance: 3g/ 100 Kg BW and for every 50 Kg 1 g to be added.
For milk production: 2g Ca/Kg milk and 1.4g P/Kg milk.
Requirement: 400 Kg BWt, yielding 10 Kg milk with 4.5% fat.
Ca = 30-35 g/day and P = 25-30 g/day.
In the diet Ca = 0.38% and P = 0.30%.

Vitamin requirement for milk production

In tropics, ruminants require vit-A or its precursor for physiological function. Vit-D is not essential as it is synthesized in the skin. B-complex vitamins are synthesized in the rumen. Ascorbic acid is synthesized from glucose. Vit-E is present in feeds and fodders.

Cow milk is yellowish because of the presence of carotene. Buffalo milk is relatively white because carotenes are completely converted in to vit-A in the intestinal wall.

Carotene requirement for milk production	=	60 mg/100 Kg BW.
For pregnancy	=	30mg/100 Kg BW
For growth	=	11 mg /Kg BW

Green fodder contains 100 mg carotene per kg. Silage contains 20 mg/ kg and hay contains 10 mg/kg.

FEEDING OF BUFFALOES

- There is no difference in the digestive tract between the buffalo and the cow, the four-pouched stomach and the rest of the gastro-intestinal tract being the same in both species.
- The rumen in cows and buffaloes is well adapted to utilize the cellulosic matter and the main fermentative compartment precedes the main site of digestion, allowing the maximal use of fermentation products.

- From a functional point of view however, there might be a difference between the buffalo and the cow in **ability to digest poor quality roughage**, e.g. rice straw. The reason for this difference, reported from feeding trials, is not quite understood although differences in rumen bacterial growth rate between species were reported.
- The **ability of the buffalo to consume more DM from rice straw** than the cow could further explain the difference in digestion.

TRANSITION COW NUTRITION

The transition period for a dairy cow is from 3 to 2 week prepartum until 2 to 3 week postpartum. The term *transition* is to underscore the important physiological, metabolic, and nutritional changes occurring in this time frame. It constitutes a turning point in the productive cycle of the cow from one lactation to the next. The manner in which these changes occur and how they are managed are of great importance as they are closely linked to lactation performance, clinical and subclinical postpartum diseases, and reproductive performance that can significantly affect profitability.

Transition Cow Biology

We will proceed with a review of the biology of the transition cow and the phenomena that mark this period with the goal of developing nutritional strategies.

Dry Matter Intake

It is now well established that dry matter intake (**DMI**) decreases as calving approaches. Dry matter intake can decrease from 2 % of body weight (**BW**) in the first few weeks of the dry period to 1.4 % BW in the 7 to 10 days period before calving. This 30 % decrease in DMI appears to occur very rapidly in the transition period. During the 3 week after calving DMI will increase at the rate of 1.5 to 2.5 kg /week with this increase being more rapid in multiparous cows than primiparous cows. However, individual cow variation in the decrease prepartum and the increase postpartum in DMI is enormous.

The decrease in prepartum DMI has classically been attributed to the rapid growth of the foetus taking up abdominal space and displacing rumen volume. However, there is no doubt that hormonal and other physiological factors have the most important impact on this phenomenon. During the last week of pregnancy, nutrient demands by the foetal calf and placenta are at their greatest, yet DMI may be decreased by 10 to 30 % compared with the early dry period.

Physiological Changes

A number of profound physiologic changes occur in the transition cow that modifies her metabolism drastically. The rapidly increasing demands of the foetus and the development of the mammary glands, including the initiation of synthesis of milk components, are causing these changes. The daily demands for foetal and placental growth in the last 3 week of gestation are 360 g of metabolizable protein and 3 to 5 Mcal of net energy. The concentration of plasma insulin continually declines in the transition period until calving and that of somatotropin increases rapidly between the end of gestation and the initiation of lactation. Concentration of plasma progesterone, which is high in gestation, rapidly falls at calving and there is a transitory elevation in estrogens and glucocorticoids in the periparturient period.

These hormonal changes not only contribute to the decline in DMI, but also coordinate the metabolic changes that favour, if not force, the mobilization of body fat reserves from adipocytes. Resulting from this mobilization of lipids, we observe an increase in concentration of plasma non-esterified fatty acids (**NEFA**), which rise gradually in the prepartum transition period, but rapidly in the last 3 days of gestation. A portion of this increase in NEFA is obligatory and is under hormonal control while another portion is the result of an energy deficit (negative energy balance or **NEB**). The magnitude of the NEB prepartum, therefore, appears to be a variable that can be mitigated through nutritional management. Additionally, the NEB and resulting increase in plasma NEFA, if sufficiently high, contributes to the development of fatty liver; which itself is a contributing factor to other health problems in the postpartum.

Rumen Function

It is not unusual for a high producing cow in the first 100 days in milk (**DIM**) to consume 22 kg of DM/d, of which more than half is in the form of concentrates, without posing any particular problems to the cow if the diet is well balanced. However, this same diet consumed by a fresh cow can cause a severe ruminal acidosis. The major difference in rumen function between these 2 stages of lactation can explain the different responses to the same diet. During the dry period, cows generally consume a diet that is principally composed of forages and, by consequence, is more fibrous than the type of diet offered in lactation. This nuance affects rumen function in 2 ways. First, the rumen flora is adapted to a diet that is low in non-fibre carbohydrates (**NFC**) during the dry period allowing for a large population of cellulolytic bacteria and a low population of amylolytic bacteria. As the amylolytic bacteria also generate lactic acid, their decrease is accompanied by a decrease in the bacteria that utilize lactic acid.

If the ration is changed abruptly at calving the capacity of the rumen flora to metabolize lactate, the principal acid responsible for acute rumen acidosis, is at a minimum at the initiation of lactation. The lactate producing bacteria increase in numbers rapidly as the amount of NFC in the diet increases, but the lactate-utilizing bacteria adapt more slowly (3 to 4 wk). Therefore, the risk of lactate accumulation in the rumen is high with abrupt changes from high to low fiber diets. Further, it is a known phenomenon that as DMI increases rate of passage from the rumen increases as well. After calving, when DMI is relatively low, rate of passage is slow; allowing for greater extent of fermentation and acid accumulation in the rumen.

If dietary NFC increases abruptly at calving, with high levels of fermentable carbohydrates, the amount of VFA produced far exceeds the capacity of the rumen to absorb them leading to elevated concentrations of VFA in the rumen. This situation leads to the phenomenon known as **sub acute rumen acidosis** (**SARA**) and contributes to reduced DMI and feed digestibility as well as laminitis in the early postpartum period.

Health Problems Associated with the Transition Period

The conditions described above favour the occurrence of health problems during the transition period. The principal metabolic problems gravitate around 3 principal axes:

1. Disorders related to energy metabolism (fatty liver, ketosis, sub acute and acute ruminal acidosis)
2. Disorders related to mineral metabolism (milk fever, sub-clinical hypocalcaemia, udder oedema); and
3. Problems related to the immune system (retained placenta, metritis and mastitis).

NUTRITIONAL CONSIDERATIONS

The transition period is marked by major hormonal changes. While these hormones are causing a reduction in DMI there is an increase in nutrient requirements by the cow to support foetal growth, mammogenesis, and lactogenesis. This increase in nutrient demand is partially met by the DMI and partially by the mobilization of body tissues. Although the hormonal milieu will drive a certain amount of this body mobilization, excessive body catabolism is undesirable for health, reproduction, and milk production. It is, therefore, essential to pay particularly close attention to the formulation of rations in this transition period, both pre- and post-partum.

Requirements and Negative Energy Balance (NEB)

The energetic demands of gestating cows reach 1.3 to 1.5 times the maintenance requirements by the end of gestation. The growth of foetal tissues follows an exponential curve beginning in the third trimester of pregnancy. For those using the Cornell Net Carbohydrate and Protein System (**CNCPS**) version 6.1; the foetal, placental and mammogenesis requirements for nutrients are now more dynamic and added into requirements.

During both the prepartum and postpartum transition period cows require more energy than they are able to consume resulting in the NEB and the concomitant loss of body weight (condition) to supply the necessary energy even in healthy cows. The NEB and body weight loss begins in the prepartum transition period, but that the NEB is greatest in the first week postpartum. However, there is much variation in the magnitude of the NEB after calving depending upon body condition score at calving, the severity of the depression in DMI, the quality of the ration, and season.

A severe NEB in the transition period can aid in the development of metabolic diseases, prolong the interval between calving and first ovulation and decrease fertility. The first ovulation in cows occurs 10 days after the nadir in NEB. Energy during the transition period; therefore, has a major impact on cow performance and longevity. Severe NEB also can lead to fatty livers and compromised liver function essential in all metabolic functions including detoxification.

Metabolic Problems Associated with Energy Nutrition

The mobilization of lipids in the beginning of lactation is a normal and required process to help the cow meet her energy demands for lactation. However, when the quantity and/or the speed of mobilization are exaggerated, the incidence of metabolic problems increases significantly. It is not uncommon to find a ketotic cow also having problems with fatty liver and displaced abomasum. Ruminal acidosis is also a frequent problem for cows at the beginning of lactation, because of highly fermentable rations and insufficient rumen adaptation (slow passage rates) to these rations.

Total Mixed Ration (TMR) or Complete Feed

Total mixed rations (TMR), or complete rations, are defined as those with all the forage and grain ingredients blended together, formulated to specific nutrient concentration, and fed free-choice.

The main advantages to TMR feeding:

1. Cows consume the desired proportion of forages when two or more forages are offered.
2. Cows consume the desired amount of forage relative to the amount of grain offered.
3. There is less risk of digestive upsets.
4. Feed efficiency improves.
5. It allows for greater use of unpalatable feeds, NPN sources, and commodity feeds.
6. There is potential to reduce labor required for feeding.
7. It allows for greater accuracy in formulating and feeding.

The potential disadvantages include:

1. It requires a significant equipment investment in a mixer.

2. It creates a need to group cows into two or more groups.
3. Rations must be carefully formulated and continually checked.
4. Pasture feeding and large amounts of long hay are difficult to incorporate into rations.

Small mixing units and feed carts equipped with weigh cells are available. These work well in smaller herds (40 to 60 cows) or herds in tie-stall or stanchion barns. Equipment cost will vary depending on size, mobility, mechanization, and weighing devices involved. Electronic load cells are most accurate ($^{1}/_{10}$ to $^{1}/_{4}$ of 1 percent) but require a level setting. Weigh bars can be used on uneven slopes (such as mobile mixer-truck) but are less accurate (1 percent). Both types are acceptable when managed properly.

Dividing cows into production strings is a critical factor for the success of TMR feeding. Consider the following guidelines for grouping cows:

1. A minimum of two production groups plus a dry group. More groups may be required as herd size increases. A separate group for first-calf heifers is advisable because of their smaller size, lack of competitiveness, and additional growth requirements compared with mature cows.
2. Once fresh cows have recovered from calving (usually 3 to 7 days), put them in the high group to challenge them nutritionally for 3 months. Move cows to a lower production group when milk output does not warrant keeping them in a higher production group and/or body condition is restored.
3. Drastic drops in milk production should not occur when cows are moved from a higher to a lower production group if rations are properly formulated

Water

Ideally, water should be available to dairy cattle at all times. If this is not possible a rule of thumb is to supply one litre for every ten kilograms of bodyweight plus one and a half litres per litre of milk produced. So, a cow weighing 325 kilograms producing ten litres of milk per day should be given a minimum of: (325/10) + (1.5 x 10) litres = 32.5 + 15 = 45.5 litres daily.

METABOLIC DISORDERS IN DAIRY COWS

Nutritional imbalances, deficiencies, or erratic management of feeding programs for dairy cows can create large numbers and various types of health problems generally categorized as metabolic diseases.

Fat cow syndrome

Excess energy (concentrates, corn silage, some hays) fed during the dry period may cause obese cows near calving time. These “too fat” cows are more susceptible to a number of other metabolic problems (milk fever, ketosis, displaced abomasum, retained placenta, metritis), and the chance of dying is more likely.

Bloat

It is a common problem when forage-to-concentrate dry matter ratio is too low. Generally, bloat occurs when feeding predominantly concentrates more than 40 percent of the ration dry matter. Animals receiving rations that cause chronic bloat produce poorly as ruminal pH is too low (too acidic), and normal digestion of nutrients is impaired and further feed intake is minimal. A frothy, acute form of bloat can also occur when cows consume large amounts of certain legumes which have high saponin content. Grazing of these forages must be carefully managed to avoid bloat.

Displaced Abomasum

Displaced abomasum (DA) is a disorder of cattle in which the abomasum (fourth or true stomach) becomes distended with gas, fluid, or both, and shifts to an abnormal position. The abomasum generally moves to the left and upward, coming to rest between the rumen and the left abdominal wall. Most displaced abomasums cases occur in cows within two weeks after calving. A high concentrate level in the dry cow ration during late gestation and after calving appears to substantially increase the incidence of displaced abomasums. Signs of displaced abomasums resemble ketosis (off-feed, intermittent eating), scant bowel movements, normal temperature, reduced milk production, and listlessness and general discomfort. The treatment of these conditions usually involves abdominal surgery — correcting the displacement, by attaching the abomasum to its normal position by sutures, so the displacement cannot recur.

Low milk fat syndrome

It can occur by feeding low forage-to-concentrate ratios, or rations that are high in fat, in which the forage has been too finely ground. Milk fat depression may be associated with acidosis, off-feed problems, and sore feet. Supplying the cow with adequate dietary fiber, both in terms of level and particle size, usually eliminates these interrelated nutritional problems. Various buffers such as sodium bicarbonate can be useful in maintaining milk fat content when high concentrate rations are fed. Often buffers will stimulate feed intake, making them especially valuable for early lactation cows. Recommended feeding levels of sodium bicarbonate are between 0.5 and 0.75 percent of ration dry matter per head daily.

Hypocalcaemia/Parturient paresis/Milk Fever

Generally occurs at or near calving or within 2 days post calving. It is caused by a large calcium demand at the onset of milk production leads to low blood calcium level. The cow is unable to meet this calcium demand, due to ration imbalance, Vitamin D influence or parathyroid gland activity, all of which influence regulation of these metabolites during the dry period. Milk fever signs include staggering, inability to rise, muscular weakness, recumbency (laying down) and a subnormal temperature. Limit precalving calcium intake. Feeding an excess tends to inhibit normal calcium mobilization from the bones. Keep pre-calving potassium levels as low as possible because high forage potassium levels may predispose cows to milk fever regardless of calcium intake. Forages low in potassium is usually low in calcium.

Acidosis

Lowering of ruminal pH to less than 5.8 occurs due to poor timing or adaptation to feed, wrong forage-to-concentrate ratios i.e. more concentrate or easily digestible carbohydrates or cereal grains and less roughage ie physically effective fibre (pe NDF) leads to sub acute ruminal acidosis (SARA).

Ketosis

It is a metabolic disorder that occurs in dairy cattle when energy demands (e.g. high milk production) exceed energy intake and result in a negative energy balance. This most commonly occurs in cows with poor appetites or fresh cows at a high level of production. Ketotic cows often have low blood glucose (blood sugar) concentrations. When large amounts of body fat are utilized as an energy source to support milk production, fat is sometimes mobilized faster than the liver can properly metabolize it. If this situation occurs, ketone production exceeds ketone utilization by the cow, and ketosis results. Dairy cattle normally produce ketones at low levels for use as energy substrates. It is only when ketone production exceeds demand that problems arise and ketosis occurs. Ketosis is important because it decreases feed intake in affected cows and greatly increases the risk of other diseases. Prevention by feeding **niacin** in the ration of cows prior to calving at the rate of 6-10 g /head/day. Feed **glucose precursors**. Glucose precursors should increase glucose production by the liver, thereby reducing the need to mobilize body fat to meet energy demands. The two commonly available glucose precursors are **propionate**, in the form of Ca+ propionate and **propylene glycol**.

SHEEP NUTRITION

INTRODUCTION

Sheep raring play an important role in lively hood of large percentage of small and marginal farmers and landless labourers. Sheep in India are mostly maintained on natural vegetation and rarely on concentrates and cultivated fodders. The present sheep population in India is about 50 million. Sheep are reared mostly for wool and meat however sheep skins and manure also obtained from sheep. Hence to obtain more wool from sheep care should be taken regarding their balanced feeding on a scientific live.

NUTRIENT REQUIREMENT OF SHEEP

a. PROTEIN REQUIREMENTS

Since wool fibres i.e. keratin composed almost entirely of protein, sheep need a somewhat greater proportion of protein. Sheep can convert NPN substances into good quality microbial protein in rumen. **Methionine** is first limiting amino acid in microbial protein. When NPN substances like urea, biuret are used in sheep ration, the Nitrogen : Sulphur ratio should be maintained as 10:1. A level of 10% protein in ration is adequate for wool production. The Nutritive ratio for lambs of body weight 50 kg or more should be 1:7 or 1:8, where as in ewes nursing lamb it should be 1:6.5.

Wool is very rich in **Cystine** and **Methionine** (sulphur containing amino acids). The ordinary rations provide the required quantity of cystine and methionine. However if sheep are fed a ration unusually low in cystine, then feeding of protein supplements high in cystine or methionine is beneficial (Blood meal is rich in cystine).

The approximate daily DCP requirement for maintenance is 1/10th of the TDN or 1 gm for every 1 kg of live body weight. This requirement increases by about 50% during pregnancy and 100% during lactation and growth.

Protein deficiency causes reduced feed intake and poor feed efficiency and may result in poor growth and development of muscles, reduced reproductive efficiency and wool production.

b) ENERGY (or) TDN REQUIREMENT

An abundance of good roughage alone will supply sufficient TDN or NE for breeding ewes up to about a month or six weeks before lambing. In pregnant ewes a small amount of grain or other concentrate can be fed for the growth and development of foetus. During this period the capacity of the ewe to use roughage is considerably reduced because of the space in the abdomen that is occupied by the foetus and foetal membrane.

Milking ewes need a liberal supply of TDN therefore concentrate allowance should be given in addition to roughages. For fattening lambs also additional concentrate mixture should be given to satisfy their energy requirements.

The TDN requirement of lambs is higher than that of adult sheep similarly the pregnant, lactating and breeding ewes require more energy than non-pregnant and non lactating ewes. As a thumb rule a non-pregnant, non-lactating ewe requires 10 g TDN per kg live body weight for maintenance and wool production. This requirement will be 50% more during last 6 weeks of pregnancy and 100% more during the first 10 weeks of lactation.

The energy deficiency may result in reproductive failure, poor growth and loss in body weight and may ultimately lead to death.

c) FAT REQUIREMENTS

Addition of 5% Tallow in sheep rations increases gain in weight and reduces feed cost. Minimum of 3% fat is essential in sheep ration.

d) MINERAL REQUIREMENT

Only 15 minerals are found essential for sheep. Out of which 7 are major mineral i.e. Na, Cl, Ca, P, Mg, K & S.

Salt

Sheep consume more salt per 100 kg body weight than do cattle. Under any managemental practice salt should be provided regularly. Generally salt is added at the rate of 0.5% in complete ration or 1% concentrate ration in sheep.

Calcium and Phosphorus

Sheep reared on good pasture or when 1/3rd roughage is legume do not suffer from calcium deficiency and therefore benefit of adding Ca and P depends on the amount of these minerals supplied by feeds they receive.

A phosphorus content of 0.16 - 0.19% in ration (on D.M. Basis) in adequate for ewes during pregnancy. In milch ewe it should be 0.23%, where as in fattening lambs 0.17. If rations low in phosphorus is fed to pregnant ewes abortion or weak lambs occurs. In fattening lambs deficiency result in low gain, poor feed utilization and depraved appetite. In Protein deficiency low flouring phosphorus supplements should be given.

Cobalt

Deficiency leads to anaemia, retarded growth rough hair coat. Drenches of about 1.0 mg cobalt chloride twice a week corrects deficiency.

Copper

It is essential in melamin production. It is observed that Cu reserve of the lamb can satisfy and wool (Keratin) formation the Cu requirement up to 6 months of age after that Cu supplementation is necessary. Deficiency affects the quality and quantity of wool produced. The wool looses its characteristic crimp this condition is called as "Stringy Wool" and the fibre resembles hair than wool.

Zinc

Clinical signs of zinc deficiency occurs in ram lamb manifested by impaired testicular growth and complete stoppage of spermatogenesis.

e) VITAMIN REQUIREMENT

If sheep have plenty of good roughage including pasture during growing season, all their vitamin needs are usually satisfied. Pasture suitable for sheep is generally high in vitamin A value (carotene content). Also they have considerable vitamin A storage in body.

Generally vitamin D deficient do not result as they are generally outdoors and exposed to sunlight for much of the time during grazing. Field cured dry fodder supplies vitamin D. The B complex vitamins are synthesized in the rumen by microbial action. Vitamin E requirement is usually met with normal ration, however **"Stiff lamb disease"** can be prevented by vitamin E supplementation.

f) WATER REQUIREMENT

Plenty of fresh clean water should always be available. Adult sheep on dry feed in winter may drink about 2 lit./head/day and 3.5-4 Lit during summer. Water requirement increases during growth, gestation, lactation and heat stress, when salt content of diet is more or when animals are made to travel long distances. Normally a sheep will drink approximate 2-3 litre of water for every kg of dry feed consumed. Sheep can tolerate salt content up to 1% in the drinking water.

g) DRY MATTER REQUIREMENT

In general a adult sheep consumes 2.5 to 3% Dry Matter of their live body weight under stall feeding and grazing conditions. However for a satisfactory growth lambs require DM of about 4-5% of the body weight.

FEEDING OF DIFFERENT CARAGORIES OF SHEEP

1. FEEDING OF PREGNANT EWES

Gestation period of ewes is about 143-151 days, on an average 147 days. During the first half of gestation period the growth of foetus is not so rapid and thus the maintenance required of nutrients can take care of pregnancy during early half of gestation period. But a precaution should be taken to avoid underfeeding during this period. During latter half of gestation period, the rate of growth of foetus increases with the result increasing nutrients requirement for its nourishment and that's why extra allowance of feed should be given during this period. For this purpose following concentrate mixture can be used.

Ingredients	Parts
Maize/Jowar/Bajra	30 parts
GNC/Deoiled GNC	20 parts
Rice Bran / Deoiled rice bran	40 parts
Molasses	7 parts
Mineral Mixture	2 parts
Salt	1 part.

This concentrate mixture should be given to about 150-250 g/day in addition to 8-9 hrs of grazing on good pasture or grasses. If grazing is not practiced this concentrates mixture should be supplemented with vitamin preparation at the rate of 25g/100 kg of feed. The excessive energy intake during last 6 weeks of gestation leads to fattening which results in birth difficulty in single bearing ewes. Whereas low energy intake can result in low birth weight with reduced viability in lambs, perhaps **pregnancy toxemia** may result in ewes.

The advantages of extra allowances of feed given during last half gestation are as below:-

1) It increases birth weight of lambs.
2) It reduces number of weak or crippled lambs
3) It reduces chance of lambing paralysis which occurs just before lambing.
4) It increases milk of ewes and thereby avoids tendency for disowning their own lambs.

2. FEEDING OF EWES AFTER LAMBING

Immediately after lambing the concentrate ration for ewes should be reduced which may otherwise leads to conditions like swollen udder and other udder complications. During this period good quality hay, legume should be given along with little quantity of concentrate (about 50-100 g).

3. FEEDING OF LAMBS FROM 10TH DAY TIL WEANING

After 10th day of age lambs should be fed good quality legume along with concentrate mixture about 50-100 g /day along with salt and mineral mixture. Following concentrate mixtures can be used for this purpose:

Ingredients	Parts
Maize	67
GNC	10
Wheat bran	10
Fish meal	10
Mineral mixture	2
Salt	1

It should be supplemented with Rovimix and antibiotic preparation like TM-5 or Aurofac.

4. FEEDING OF GROWING LAMBS

When good quality fodders are available following concentrate mixture can be used.

Ingredients	Parts
Wheat bran	40
Maize	25
GNC	32
Salt	1
Mineral mixture	2

The above mixture should be fed as per the following recommendations.

Body weight	Concentrate mixture
10-15 kg	50 g
16-25 kg	100 g
26-35 kg	150 g

If the quality of fodder is not good then the concentrate mixture should be given as 300g, 400g and 600 g respectively.

5. FEEDING OF FATTENING RAMS

The feedings schedule for fattening rams is dependent on the age and weight expected at the time of marketing. Generally simple concentrate mixture consisting of;

Cereal grain	- 2 parts
Bran	- 1 part
Oil cake	- 1 part

Supplemented with mineral mixture and vitamin mixture can be used. This concentrate ration should be fed at the rate of 110-450 g/day/lead depending on the weight of ram to be fattened.

6. FEEDING OF BREEDING RAM

Rams used for breeding purpose should not be too fatty, which may influence rate of fertility and mating behavior. If breeding ram is fatty, the allowance of concentrate mixture should be stopped completely and ram should be fed on dry fodder. This procedure should be followed for 8 weeks before ram is allowed to mate with ewes. Before 2 weeks of mating again normal feeding schedule is followed. During summer concentrate mixture consisting of;

Crushed gram	- 2 parts
Wheat bran	- 2 parts
Salt	- 1 part

can be given, whereas during winter crushed gram should be replaced by crushed guar seeds.

7. FEEDING OF ADULT SHEEP

The adult sheep should be allowed to graze free of choice on pasture or grass land and should be supplemented with 100 gm of concentrate mixture. If legume or hay is available then concentrate mixture need not be given. When legumes are fed alone the changes of developing digestive disturbance increases and so some of dry fodder like straws should be given along with legume fodder. When sufficient pastureland is not available and straw is available then feeding of straw along with 300-400g of concentrate mixture should be done.

8. FEEDING OF LACTATING EWES

During first 10 days after lambing legume hay may be fed. After 10 days up to weaning 250 gm of concentrate mixture may be supplemented with good quality legume hay. After 3 months maintenance allowance is sufficient. The requirements of energy and protein are higher during lactation. Feeding during the first 4 weeks of lactation is critical and affects lactational performance of the ewes and thereby growth and survival of lamb. Both energy and protein should be balanced in a diet of lactating ewe.

Therefore feeding of 800 g good legume hay or 100g/day-concentrate mixture for 75 days after lambing in addition to 8 hrs. of grazing is recommend for feeding of lactating ewes.

9. FLUSHING OR FEEDING OF BREEDING EWES

Flushing is the special nutritional care for improving nutritional status of ewes 3-4 weeks before mating by providing additional concentrate mixture. It is very much important to have better nutrition and body condition before ewe is allowed to mate with ram. The effect of flushing is more evident in ewes that were underfed. Thus with flushing ewes have better body condition and will increase fertility by way of increased incidence of oestrus and increased ovulation rate. The majority of sheep in arid and semi-arid regions are bred 2-3 weeks after the onset of rains as grazing conditions are improved by this time.

To obtain increased lambing rate, breeding ewes should be given 250g concentrate mixture or 500g of good quality hay/head/day 3-4 weeks before breeding in addition to usual hours of grazing.

GOAT NUTRITION

Goats are regarded as "Poor Man's Cow". In India total goat population is about 90 millions, which is about 18% of total goat population in the world. In India about 1/3rd goat population is contributed by Desi and unrecognised breeds which have low potential for meat, milk and hair production. The various important breeds of goat reared for specific purposes are as below.

Milch breeds	-	Jamnapari, Barbari
Meat breeds	-	Usmanabadi, Black Bengal, Marwadi
Hair producing breeds	-	Angora & Pashmini, Gaddi

The present situation of milk and meat production from goats is not to the satisfactory level. Much needs to be done to achieve this. The main thing is that, we have a scanty availability of pasture land, and lack in irrigation facilities for nutritious fodder production. Therefore careful attention is required to be given regarding feeding of goats.

Feeding Behaviour of Goats

1. Goats are considered to be the best converter of fibrous feed into good quality meat called as 'Chevon' and the reproduction.

2. Goats have upper mobile lip and very prehensile tongue, which helps them to graze on very short i.e. near to earth grasses and browsing on plant leaves which are not usually eaten by other species of animals.

3. Goats are more or less susceptible to toxic plants than other species also they are less sensitive than cattle to the toxic effects of tannic acid.

4. Goats refuses any kind of feed which has been soiled.

5. It has been observed that goats can distinguish between different tastes however they have higher tolerance for bitter taste plants than cattle.

6. They consume certain species of plants at definite stage of growth and may reject them at other time.

7. Goats have high efficiency for utilization of cellulose.

8. As a result of metabolic reactions after feeding NH_3 and TVFA are produced in highest concentration in goats than other species of animals, which is because of solubility of feed, digestibility, particle size, amino acid composition of protein, presence of other nitrogenous compounds and the level and nature of carbohydrates in diet.

9. In goats the BMR and Thyroxine production is higher than other species, and that is why goats require somewhat greater maintenance ration than sheep and cattle.

10. The nutrient conversion efficiency for milk production in goats ranges between 45-71%.

11. They are easily tired off consuming the same fodder for longer duration.

Nutrient Requirement of Goats

The nutrient requirement of goats are influenced by breed, body weight, age, lactation, pregnancy, breeding season, market choice, environmental temperature etc. However the average nutrient requirement for goats are as discussed below:

a) Dry Matter Requirement

The dry matter requirement depends on the type of breed. In meat type goat breeds the dry matter intake is on an average 3-4% of their live body weight. While in milch type goats it is 5-7% of their live body weight.

The factors, which affect dry matter consumption or intake, are availability of feeds, palatability, moisture content and amount of fibrous material present is feed. On an average an adult goat needs about 3 kg dry matter/100 kg body weight for maintenance, 3.5 to 4 kg for growth, 3-3.5 kg during pregnancy, 3.5-5.5 kg for lactation and 2.5 to 3.5 kg for meat and hair production.

b) Energy Requirement

Energy plays a vital role is goat diets which affects the overall productivity and utilization of other nutrients.

An average energy requirement for maintenance is 101 kcal ME/kgW$^{0.75}$/day. While for pregnancy it is 180 kcal ME/kgW$^{0.75}$/day. The daily energy requirement for milk production is found to be 1220 kcal ME/kg 4% FCM. In addition to this energy is necessary for increased activity, type of terrain, amount of vegetation on range and distance travelled for grazing.

The stall fed goats with minimum activity, requires, basic maintenance level in their diets, however for light activity goats require 25% more energy. The goats grazing in hilly area needs an increase of about 50% over and above maintenance requirements. Energy requirement for growth have been found to be 7.25 kcal ME/g of gain in body weight.

The diets deficient in energy causes growth retardation, delayed puberty, decrease in fertility rate and also lowers milk production. Prolonged energy deficiency in goats diet may loose the strength of resistance to infections and parasitic diseases. On the contrary excessive energy intake which leads to fat deposition is known to reduce quality of goat skin.

c) Protein requirement

For carrying out different physiological functions like growth, pregnancy, lactation, and maintenance proteins are required essentially. The daily average requirement of dietary proteins for maintenance is 20-30 g DCP/50 kg body weight and for milk production it is 60-70 g DCP/kg of milk produced. A minimum of 6% total proteins have to be provided otherwise fed intake gets reduced which may result in reduced semen activity and lowered feed efficiency.

Urea can replace part of protein in goat's diet however urea should not be added in lactating goats as it may cause toxicity. In complete forage diet urea can replace 1/3rd of dietary proteins while in concentrate ration it can replace 1/2 of the proteins in diet. The digestive tract of goats needs an approximately 3 weeks period to adapt to urea utilization efficiently.

An intake of 44 g urea/100 kg body weight at a single feeding results in acute toxicity. Therefore the level of urea should be gradually increased in the diet. When urea is used to replace proteins in the diet a care should be taken to add sulphur so as to maintain Nitrogen sulphur in ration at 10:1.

A protein deficiency in goats diet results in anorexia loss of weight, poor hair growth, decreased milk yield, impaired reproduction, anemia and edema.

d) Mineral Requirements

Mineral deficiencies rarely occur in goats as the common feeds and fodders used in goats feed provides adequate quantities of the important minerals. However some major minerals like sodium, chloride, calcium, phosphorus and sulphur are met while feeding the goats. Sodium chloride should be included in the concentrate mixture at the rate of 0.5% Calcium requirement for maintenance is 4.7g/day while for milk production it is 1.3 g /kg of milk produced.

Where as phosphorus requirement is 3.3 g /day for a adult goat. Provision of mineral licks/bricks in the shed is recommended to avoid occurrence of any deficiency.

e) Vitamin Requirements

The goats are generally allowed 5-6 hours grazing which takes care of their of vitamin A and vitamin D requirements. Therefore vitamin A and vitamin d deficiency rarely occurs in goats. However for stall fed goats these two vitamins should be necessarily supplied in their diet. The vitamin E and vitamin K requirements are satisfied from the browse, hence no additional care is needed in this regard.

Vitamin B complex is not dietary essential as it is synthesized by ruminal micro-organisms. However this vitamin should be included in diets of very young kids nursing their dams, animals and when diet is suddenly changed. In goats vitamin c is synthesized in body tissues in adequate quantities.

FEEDING OF DIFFERENT CATAGORIES OF GOATS

1. Starter or Creep Ration

From birth up to 3rd day, the kids are given mother's milk i.e. colostrum. After 3rd day the quantity of milk to be given to kids is reduced to about 100 ml/day. Along with mother's milk, green tender grasses, pasture or some legume fodders like leucerne, berseem, cowpea are fed. Expected body weight after 7 days is in between 1-5 kg. There after creep feed is given, which contains 14-18% DCP and 65-70% TDN Example of the creep feed is as below:

1)	Maize	-	60
	GNC	-	20
	Fish meal	-	10
	Wheat bran	-	07
	Mineral mixture	-	02
	Salt	-	01
2)	Gram	-	20
	Maize	-	22
	GNC	-	35
	Wheat bran	-	20
	Mineral mixture	-	2.5
	Salt	-	0.5

During 7 days - 40th days of age 4-5 times feeding is done and from 40-60 days 3 times creep feeding is done. At the end of 60 days i.e. weaning age the body weight of young one between 3-4 times more than the birth weight i.e. ranging to about 7-10 kg.

2) Grower Ration

After weaning period, the goats are turned to grower ration containing 9-10% DCP and 60-65% TDN. The grower period is of 1 year duration during this period goat attains about 1/3rd of its nature body weight. Thus expected body weight at the completion of 1 year is 18-20 kg.

Example of grower ration

Maize	-	50
Wheat bran	-	30
GNC	-	10
Molasses	-	07
Mineral mixture	-	02
Salt	-	01

3) Finisher Ration

The finishing period of goat, depends upon the market tendency, so as to sell it at different body weights. Generally goats are marketed at the overage body weight of 20-30 kg.

During finishing period the rate of growth is very low and that's why the maintenance ration satisfies the nutrient requirement. The DCP content of finisher ration is 5-6% and TDN 60-65%.

Example of finisher ration

Maize	-	15
Jowar	-	15
GNC	-	20
Wheat bran	-	40
Molasses	-	07
Mineral mixture	-	02
Salt	-	01

When fatty carcasses are needed for selling, roughage should form 20-25% of total dry matter requirement, where as for lean meat production roughages should form 30-40% of total dry matter requirement. For producing fatty carcasses, high-energy cereal grains should be included in the concentrate mixture.

4) Feeding of Replacement Stock

Most of the male and female kids are selected for breeding purpose; those are called as replacement stock. Feeding of such stock is adjusted so as to reach the sexual maturity and desirable body weight at 1 year of age. The desirable body weight is 1 year for smaller breeds is 15-18 kg. Where as for larger breeds it is 20-25 kg.

When sufficient good quality pasture is available for grazing, no supplementary feeding with concentrates is desirable, whereas during lean period about 250-500 gm of concentrate mixture with 10-12% DCP and 68-70% TDN should be given to replacement stock. The concentrate mixture should be necessarily supplemented with mineral mixture or otherwise mineral licks should be provided in shed.

5) Feeding of Dry Goats

For the non-lactating i.e. dry goats, if sufficient grazing facilities are available, the maintenance requirements get satisfied by sufficient hours of grazing on good quality pasture. However, during shortage of pasture, 200 gm to concentrate mixture with 5-6% DCP and 55-60% TDN should be fed. For milch type dry goats 30% of dry matter should be fulfilled by concentrate mixture.

6) Feeding of Pregnant goats

When doe is pregnant, a great care is needed regarding feeding specially during last one third period of gestation as this is the active period of total development and near about 70-80% gain in fetus mass in achieved during this period.

A requirement of protein, calcium and phosphorus are increased during this period. Therefore a ration containing 12% DCP and about 55-60% TDN should be given to about 300-500g however for pregnant but lactating goats, 300-400 g of concentrate mixture/kg of milk produced should be given in addition to maintenance amount of 150g/day. A free choice mineral licks should be made available.

7) Feeding of bucks

Bucks are the male goats used for breeding purpose. They require about 3-3.5% concentrate mixture of total body weight. Averagely breeding bucks need 500 g to 1 kg concentrate and yearlings about 250 g.

8) Feeding of Lactating goats

For adult doe in lactation about 400 g of concentrate mixture must be given for every litre of milk produced and over and above that 150 g should be added for maintenance. A concentrate mixture for lactating goats should contain about 9-10% DCP and 60-65% TDN. It should be necessarily supplemented with mineral mixture of standard quality.

9) Feeding of Pashmina and Angora Goats

The Pashmina and Angora goat breeds are well known for their quality hair production. Therefore a due care is needed regarding their nutrition. The Pashmina breed is found in uttarakhand region of U.P. and Leh region of Kashmir. The hairs on their body are called as Pashmina fibres which is used for preparation of famous shawls of Kashmir. On an average Pashmina goat produces 112 g Pashmina fibres in a year. It is observed that castrated males produces more Pashma fibres. Also females produces more fibres than males. The fibre production is affected by feed intake, conversion efficiency and rate of Nitrogen retention.

A Angora breed of goat, native of Turkisthan is known for its long, lustrous fleece called Mohair. A 2-3 clips per annum yields about 2 kg Mohair. Mohair is used for the manufacturing of blankets, fabrics, rugs, etc. presently

For Pashmina fibre and Mohair production the protein and energy content of the ration should be high. Their native tract is a hilly area which justifies more energy requirement for grazing. Also trace minerals like Cu, Zn, should also be provided in the diet in the required quantity.

10) Water Requirement of Goats

Goats should be provided with ad-libitum clean water. On an average a adult goat drinks about 400-700 ml. Water/day. Environmental temperature, lactation level, amount of body fat, age, water content of forage, exercise, salt and mineral content of ration at influences the total water intake.

Goats have the ability to conserve water by reducing losses in urine and feces. They are sensitive and reluctant to drink from foul tasting water sources than other species of animals, therefore taste of water also affects water intake. When there is water shortage, it reduces feed intake, reduced performance and gradual starvation. The mean DM, free water intake ratio for goats should be 1:1.2. If hard water is given continuously, higher calcium and phosphorus deficiency will cause male infertility.

USE OF NPN COMPOUNDS FOR RUMINANTS

Urea

Urea is non-protein nitrogen compounds which are recognised as useful sources of nitrogen for ruminant animals. Their use depends upon the ability of the rumen micro organisms 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. 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 micro organisms.

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. Supplementation of the diet with a sulphur source may be necessary. Achieve a nitrogen, sulphur ratio not wider than 15:1.

Feeding of Urea

Urea mixed in concentrates

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

Urea with Liquid supplements (Uramol)

It is a homogenous mixture in the liquid molasses along with vitamins and minerals. Normally it is prepared by completely dissloving 2.5 parts of urea in equal amount of water. The mixture is fortified with Vitablend AD3 at the rate of 25 g per 100 kg of liquid feed. Common salt at the rate of 1 part and mineral mixture at the rate of 2 parts are sprinkled over 92 parts of sugarcane molasses (2.5 parts of urea, 2.5 parts of water 1 part of salt + 2 parts of mineral mixture + 92 parts of molasses).

Urea mixed with silage

If chopped, 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 the wet material**.**

Urea added to dry roughages

Urea is also used in the upgradation of poor quality roughages like paddy straw.

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. The treated straws can form maintenance ration when supplied along with proper amount of minerals and vitamins. About 8 kg of enriched paddy straw per animal per day will supply sufficient nitrogen for the animals to synthesize the required amount of protein for maintenance.

Solid blocks (STAREA)

Urea may be included in **solid blocks** which also provides vitamin and mineral supplementation and contains 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.

Biuret:

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

NH_2-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.

F**ACTORS ESSENTIAL FOR OPTIMUM USE OF UREA**

1. Mix the urea thoroughly.
2. Feed urea only to mature cattle, buffalo, sheep, goat and never feed to mono gastrics.
3. Provide a readily available energy source, such as molasses or cereal grains.
4. Supply adequate and balanced levels of minerals.
5. Achieve a Nitrogen sulphur ratio not wider than 15:1.
6. Include adequate salt for more palatability.
7. Provide proper levels of Vitamins particularly Vit A.
8. Accustom animals gradually to urea containing feeds (over a period of 5-7 days).
9. Limit the intake of urea to recommend maximum level as below.

Urea toxicity

When urea is fed at excessive levels, large amounts of ammonia are liberated in the rumen. Eventually, the pH of the ruminal fluid increases, thus facilitating the passage of ammonia across the rumen wall. If the levels of ammonia absorbed are greater than the capacity of the liver to convert ammonia to urea, ammonia accumulates in the blood which when exceeds 1 mg per 100 ml in cattle, the animal is under toxic condition. Symptoms of ammonia toxicity may include tetany, dyspnoea, bloat, excessive salivation, ataxia, convulsions and bellowing. The common treatment consists of drenching 20-40 litres of cold water. Another way of curing is by drenching 4 litres of dilute acetic acids along with cold water.

UNIT-4

APPLIED NON-RUMINANT NUTRITION

FEEDING STANDARDS FOR NON-RUMINANTS AND POULTRY

The common feeding standards used for monogastrics are NRC feeding standards in USA and many other countries and in India we follow Bureau of Indian standards. In UK the ARC feeding standard is also used.

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

- National Research Council, USA, rec.
- recommends a nutrient allowance for different species of animals.
- The N.R.C. report for each species is the pooled judgment of a group of experts in the field of species in question.
- Today a number of countries follow N.R.C. standards.
- The NRC standards express energy requirement as metabolisable energy for poultry, digestible energy for swine and horses.
- The NRC revises these feeding standards in keeping with new information and changing feeding practices.

Agricultural and Food Research Council (A.F.R.C.) standard

- The nutritive requirement of various livestock in the United Kingdom has been presented in Ministry of Agriculture's Bulletins.
- The Technical Committee of the Agricultural and Food Research Council of Britain prepares these.
- Requirements are set forth in three separate reports dealing with poultry and pigs, each of these reports extensive summaries of the literature upon which the requirements are based.

Indian standards and ICAR

- India has been almost entirely dependent on standards drawn up by late F. B. Morrison.
- Dr. K. C. Sen had compiled the feeding standards on Morrison's recommendations where he adopted the average of maximum and minimum values recommended by Morrison.
- 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 realised the necessity of setting up suitable feeding standards for the Indian livestock and poultry.
- A scientific panel on Animal Nutrition and Physiology was set up. The scientific panel set up subcommittees for each species by inviting experts from various institutes of the country.
- On the basis of the scientific information arising from the experimental work carried out in India over the past two decades, nutrient requirement of Indian livestock and poultry.

Bureau of Indian standard (BIS)

- These standards have been specified for Swine, Poultry and certain laboratory animals.
- Energy is expressed as ME kcal/kg.
- Protein expressed as crude protein.
- The standard is revised periodically from time to time.

NUTRIENT REQUIREMENTS IN POULTRY
(Energy and Protein requirement for maintenance and production)

Nutrient **requirement** means adequate amount of nutrients required for optimum maintenance and production. Nutrient **allowance** means an extra amount of nutrient over and above the requirement and it gives a margin of safety.

- Nutrient requirements are the amount of nutrients required by poultry to support normal function.
- Requirements may be expressed in quantities of nutrients or in dietary proportions.
- Statements or quantitative descriptions of the amounts of one or more nutrients needed by poultry have been provided by various agencies or organizations.
    - In India we usually follow BIS specification.
    - In USA and in many other nations an NRC specification is followed.
    - However certain commercial poultry farms follow their own standards.
- Poultry feeds must be formulated and prepared so that it provides all of the bird's nutrient requirements.

Factors influencing nutrient requirements of poultry

The nutrient requirements of poultry are affected by a large number of factors, including:

- **Genetics** (the species, breed or strain of bird) - Different species, breeds or strains of bird have different average body sizes, growth rates and production levels and will also absorb and utilize nutrients from feed with different levels of efficiency, leading to different nutrient requirements.
- **Age -** Nutrient requirements are related to both body weight and the stage of maturity.
- **Sex -** Prior to sexual maturity the sexes have only small differences in their nutrient requirements. Differences in nutrient requirements are larger following the onset of sexual maturity.
- **Reproductive state -** The level of egg production in hens and sexual activity in males will affect nutrient requirements.
- **Ambient temperature -** Poultry have increased energy requirements to maintain normal body temperature in cold ambient temperatures and the opposite in hot ambient temperatures.
- **Housing system -** The type of housing system will influence the level of activity of the birds and therefore their energy requirements.
- **Health status -** Birds experiencing disease require an increase intake of some nutrients, commonly vitamins.

NUTRIENT REQUIREMENT FOR EGG PRODUCTION OF LAYING HENS

The Formation of an Egg

The Yolk: The chicken egg starts as an egg yolk inside a hen. A yolk (called an oocyte at this point) is produced by the hen's ovary in a process called ovulation.

Fertilization: The yolk is released into the oviduct (a long, spiraling tube in the hen's reproductive system), where it can be fertilized internally (inside the hen) by a sperm.
The Egg White (albumin): The yolk continues down the oviduct (whether or not it is fertilized) and is covered with a membrane (called the vitelline membrane), structural fibers, and layers of albumin (the egg white). This part of the oviduct is called the magnum.
The Chalazae: As the egg goes down through the oviduct, it is continually rotating within the spiraling tube. This movement twists the structural fibers (called the chalazae), which form rope-like strands that anchor the yolk in the thick egg white. There are two chalazae anchoring each yolk, on opposite ends of the egg.
The Eggshell: The eggshell is deposited around the egg in the lower part of the oviduct of the hen, just before it is laid. The shell is made of calcite, a crystalline form of calcium carbonate.
This entire trip through the oviduct takes about one day.

Egg composition

The egg white is about two-thirds of the total egg's weight out of its shell, with nearly 92% of that weight coming from water. The remaining weight of the egg white comes from protein, trace minerals, fatty material, vitamins, and glucose

The yolk makes up about 33% of the liquid weight of the egg; it contains approximately 60 calories, three times the caloric content of the egg white. The yolk of one large egg (50 g total, 17 g yolk) contains approximately: 2.7 g protein, 210 mg cholesterol, 0.61 g carbohydrates, and 4.51 g total fat. All of the fat-soluble vitamins (A, D, E, and K) are found in the egg yolk. Egg yolk is one of the few foods naturally containing vitamin D. Egg yolk is a source of lecithin. The yellow color is due to lutein and zeaxanthin, which are yellow or orange carotenoids known as xanthophylls.

Outer covering of egg is shell, composed largely of calcium carbonate. It may be white or brown depending on breed of chicken.

FACTORIAL METHOD FOR DETERMINING ENERGY REQUIREMENT FOR EGG PRODUCTION

Energy requirement of poultry depends on live weight, temperature in the poultry house, daily egg output, growth and physical activity.

Energy required for Leghorn hens

Energy required for Leghorn hens = (170 - 2.2T) W + 5 AW + 2 E

Where
W = mean live weight, kg
AW = mean daily gain, g
E = daily egg output, g
T = Environmental temperature, °C.

Calculation of Energy Requirement for Maintenance of Layers
The basal metabolism studies indicate that the Net energy requirement for maintenance (NE_m) of adult hen calculated as follow

$NE_m = 83 \times BW\ kg^{0.75}$ Kcal / day

Example

Body weight of hen is 1.75 kg
$NE_m = 83 \times 1.75\ kg^{0.75}$ Kcal / day
$NE_m = 83 \times 1.52 = 126$ Kcal / day
$NE_m = 126$ Kcal / day

(Assuming the efficiency of conversion of ME to NE as 82 %)

$ME_m = 126 \times (100/82)$
$ME_m = 154$Kcal/day

A. Energy requirement for hens reared in deep litter system

1. Non – Layer

Energy required for Activity of hen reared in deep litter system is 50 % of the basal metabolism

$ME_A = ME_m \times 50\%$

$ME_A = 154$ X (50/100)

$ME_A = 154$ X 0.5

$ME_A = 77$ Kcal / day

Total ME = $ME_m + ME_A$

Total ME = 154 + 77

Total ME = 231Kcal/day

2. Layer

Metabolizable energy required for laying hen at 40 wks with 90 % egg production

Energy content of one egg is 86 kcal

ME_{egg} = energy content of egg X % egg production

ME_{egg} = 86 X 90/100

ME_{egg} = 77.4 Kcal

Total ME = $ME_m + ME_A + ME_{egg}$

Total ME = 154 + 77 + 78

Total ME = 309 Kcal/day

B. Energy requirement for hens reared in cage system

1. Non – Layer

Energy required for Activity of hen reared in cage system is 37 % of the basal metabolism

$ME_A = ME_m \times 37\%$

$ME_A = 154$ X 0.37

ME_A = 57 Kcal / day

Total ME = $ME_m + ME_A$

Total ME = 154 + 57

Total ME = 211Kcal/day

2. Layer

Metabolizable energy required for laying hen at 40 wks with 93 % egg production

Energy content of one egg is 86 kcal

ME_{egg} = energy content of egg X % egg production

ME_{egg} = 86 X 93/100

ME_{egg} = 80 Kcal

Total ME = $ME_m + ME_A + ME_{egg}$

Total ME = 154 + 57 + 80

Total ME = 291 Kcal/day

Energy requirement for 100 per cent egg production = 211 + 86 = 297 Kcal / day

Energy requirement of broiler breeder

25 week old broiler breeder weighing 2.5 kg reared under deep litter system

Energy requirement for Maintenance

$NE_m = 83 \times 2.5\ kg^{0.75} = 83 \times 1.99 = 165$ Kcal / day

$ME_m = 165/0.82 = 201$ Kcal / day

Energy requirement for activity (@ 50 % of Maintenance):

$ME_A = 201 \times 0.50 = 111$

Energy Requirement for laying hen at 85% egg production with a weight gain of 500 g (18 % protein and 15 % fat) in 10 weeks time;

ME_{egg} = 86 Kcal × 85% = 86 X 0.85

ME_{egg} = 73 Kcal/day

Body gain: 500 g in 10 weeks or 7.14 g /day (18% protein, 15% fat)

For 100 g weight gain tissue protein requirement = 18/100

7.14 g weight gain tissue protein requirement = 18/100 X 7.14 = 1.285g

For 100 g weight gain fat requirement = 15/100

7.14 g weight gain fat requirement = 15/100 X 7.14 = 1.07g

<u>Rubners facter (Energy value) :</u>

1 g of protein = 4.1 Kcal
1 g of carbohydrate = 4.1Kcal
1 g of fat = 9.3 Kcal

18 % protein = 1.285 g $\times$ 4 Kcal = 5.14 Kcal

15 % fat = 1.07 g $\times$ 9.0 Kcal = 9.63 Kcal

$ME_{WG} = ME_p + ME_{fat} = 5.14 + 9.63 = 14.77 = 15$ Kcal

Total ME = $ME_m + ME_A + ME_{egg} + ME_{WG}$

Total ME = 201 + 111 +73 +15 = 390 Kcal / day /hen

Total ME = 390 Kcal/day/hen

Total energy requirement for Broiler breeder is 390 Kcal/day/hen

Protein requirement of chicken

1. Protein requirements of growing chicken

a) Protein requirement for Maintenance = 1.6 g protein /kg BW /day

b) Protein requirement for growth = Daily gain in g X 0.18
(Muscle contain 18% protein)

c) Protein Requirement for Feather growth:

Consider the following to calculate protein requirement for feather growth

- The crude protein content of feather is 82%
- Feathers constitute 7% of body weight at 4 weeks of age
  For feather growth = daily gain in g X 0.07 X 0.82
- The efficiency of utilization of protein for feather growth @ 50% should be considered

Protein requirements for a growing chicken:

$$\text{CP (\%)} = \frac{(\text{BW in g X } 1.6/1000) + (\text{daily gain in g X } 0.18) + (\text{daily gain in g X } 0.07\text{X}0.82)}{\text{\% efficiency of protein utilization}}$$

The efficiency of protein utilization for growing chicken is 61%. That is of the daily protein consumed about 61% is only retained in the body.

2. Protein requirement for egg production

Protein requirement (P) for egg production is a sum of maintenance requirements (M), daily egg output (E), live weight gain (G) and requirement for feather growth (F).

$$P = M + E + G + F$$

The efficiency of utilization of protein for egg production @ 55% should be considered.

Protein Requirement for Maintenance = 250 mg N /kg BW /day or = 1600 mg protein /kg BW /day

Protein requirement for maintenance laying hen	=	3 g/day
Protein content of one egg	=	6 g
Protein requirement for feather growth	=	0.1 g/day
Total protein requirement For 100% egg production	=	9.1 g/day
Total protein requirement for 90 % Egg production	=	3 + (6 X 0.9) + 0.1
	=	3+ 5.4 + 0.1
	=	8.5 g/day
Efficiency of protein utilization for Maintenance and egg production	=	55%
Therefore, the protein requirement of hen	=	Total protein requirement / % of efficiency of protein utilization
		= 9.1 / 0.55 = 16.54 %

Protein requirement of hen at 100% egg production is 16.54 %

- Poultry strain varies greatly according to the purpose for which they have been developed.
- Those intended for the production of eggs for human consumption (Leghorn-type) have a small body size and are prolific layers,
- Those used as broilers or broiler breeders (meat-type) have rapid growth rates and a large body size. They are less efficient egg layers.
- Methods of feeding differ for these two kinds of chickens.

Poultry Feed

- Poultry feeds are referred to as "complete" feeds, because they are designed to contain all the protein, energy, vitamins, minerals, and other nutrients necessary for proper growth, egg production, and health of the birds.

- Feeding additional grain or supplement with the complete poultry feed is not recommended.
- Complete feeds are prepared by feed manufacturers; cereal grains and oilseed meal are the major ingredients in the feed.
- Depending on cost, availability and age or type of poultry some of the following ingredients are used: cereal grains, by-products of cereal grains processed for human use, animal processing waste, fishmeal, waste oil from restaurants, yeast, alfalfa meal, oil cakes etc.
- Vitamins and mineral are also added in the correct proportions.
- The ingredients are ground (if required), mixed and may be pelleted.

Ingredients most frequently used

- *For energy*: Maize up to 65 %, sorghum up to 45 %, wheat up to 25 %; with enzyme, wheat by-products (bran, shorts, screenings) up to 15%, rice up to 15%, rice by-products (bran, polishings) up to 15%, molasses up to 5% after 2 weeks.
- *For protein*: Soybean meal up to 30%, sesame oil cake up to 10%, corn gluten up to 15%, linseed meal - 15 % (20% in layers), ground nut oil cake up to 20 %, safflower meal, sunflower meal up to 10%, meat meal, fish meal up to 10%, blood meal, feather meal up to 2%
- *Fats and Oils*: Tallow, lard, coconut oil, palm oil, after 3 weeks up to 5%, poultry fat, fish oil, restaurant grease up to 3%, after 3 weeks 6%
- *Minerals* source

  Calcium can be added as limestone, as prepared products such as Di-calcium phosphate or as oyster shell or other marine shell.

  Growing birds require about 0.9% calcium in the diet. Hens in lay require 3 to 4% calcium in the diet so that calcium is available for egg shell production.

  Phosphorus can be added from manufactured products such as di-calcium or mono-calcium phosphate.

  Phytate phosphorus (organic phosphorus) is present in small but varying amounts in plants feed ingredients. This phytate phosphorus is only 25-50% available unless phytase enzyme is added to the ration. Growing birds require about 0.4% phosphorus, adults about 0.3%.

  Calcium and phosphorus levels must be in balance since high levels of one cause deficiency of the other.

  Sodium and chlorine are usually added as common salt ($NaCl$) at about 0.25% of the ration (250g $NaCl$/100 kg).

  Magnesium and potassium are usually present in adequate amounts in the feed ingredients. Some ingredients such as soyabean meal and molasses are high in potassium.

MINERAL MIXTURE FOR POULTRY (BIS)

1.	Moisture (Max)	3%
2.	Calcium (Min)	30%
3.	Phosphorus (Min)	9%
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%

Trace Mineral mix

Element	**Mg/kg diet**	**Salt**	**Mg/kg diet**
Zinc	80	ZnO	99.7
Manganese	60	$Mn\ So_4$	164.7
Copper	5	$CuSo_4.5H_20$	19.69
Iodine	0.5	KIO_3	0.84
Selenium	0.1	$Na_2SeO_3.5H_2O$	0.33
Iron	20	$FeSo_4$	20

Vitamin Supplement

Vitamins	**Units/kg diet**
Vitamin A, IU	6000
Vitamin D_3, IU	1500
Vitamin E, IU	10
Vitamin K, mg	2
Vitamin B_{12}, mg	0.01
Choline chloride, mg	1000
Folacin, mg	0.5
Niacin, mg	30
Pantothenic acid, mg	15
Pyridoxine, mg	2
Thiamin, mg	2
Riboflavin, mg	4
Antioxidant, mg	100

WATER

Water is an essential nutrient. All body functions and processes require water.

Functions of water

- Water is the material in which all other nutrients are carried in solution. The tissues and cells in the body are made up mainly of water. Water is also present between cells so that material can be moved between cells.

- Water plays a very important role in digestion and metabolism of poultry. It comprises from 55 to 75% of the bird's body weight and about 65% of the egg.
- There is a strong correlation between feed and water intake.
- Water softens feed in the crop to prepare it for grinding in the gizzard.
- Many chemical reactions necessary in the processes of digestion and nutrient absorption are aided by or require water.
- As a major component in blood (90%) it serves as a carrier, moving digested material from the digestive tract to all parts of the body, and taking waste products to the points of elimination.
- Water cools the bird's body through evaporation. Birds do not have sweat glands, a major portion of their evaporative heat loss occur in the air sacs and lungs due to rapid respiration.
- Water should be clean and free from chemicals and minerals.
- It should not contain harmful parasites or bacteria.
- Water should be easily available free-choice.
- In hot climates water availability is even more important. In hot climates water has to be cool.
- If water consumption is restricted, growing chickens will grow more slowly. If water is not freely and easily available adults will lay fewer eggs and may suffer from kidney disease.

- Layers that go without water for a day or two will stop laying and may take 2-3 weeks to recover.

Supply of water

- Water in a trough or cup must be deep enough to allow the bird to drink properly.
- The drinkers must be easy to reach and poultry must not have to walk too far to get water; not more than 2 meters for broilers and 4 meters for adults.
- Newly hatched chicks should have water before or at the same time as they receive their first feed.
- It must not be in an open pan or trough that the chicks cannot get into.
- Wet chicks lose body heat quickly and may die.
- Water jugs inverted in pans with a narrow water source are satisfactory as are raised narrow troughs, bell-type drinkers and nipple drinkers.
- Water jugs, troughs etc. must be cleaned at least once a day.

Effects of water restriction
Water requirement

- Dry feed contains only 10-15% water and poultry need about twice as much water as feed (2 g of water for each g of dried feed).
- The amount of water required becomes much higher as the temperature rises above 25°C.
- If water consumption is restricted, growing chickens will grow more slowly. If water is not freely and easily available adults will lay fewer eggs and may suffer from kidney disease.
- Layers that go without water for a day or two will stop laying and may take 2-3 weeks to recover.

Typical daily water consumption for layers (litres per 1000 birds)

		20° C	**32° C**
Layer pullet	4 weeks	50	75
	12 weeks	115	180
	18 weeks	140	200
Laying hens	50% production	150	250
	90% production	180	300

Typical daily water consumption for broilers (litres per 1000 birds)

Age	**20° C**	**32° C**
1 weeks	24	40
3 weeks	100	190
6 weeks	240	500
9 weeks	300	600

SALT TOXICITY

Poultry require both sodium and chlorine. There is some sodium and chlorine in feedstuffs, but both must be added to the feed, usually as salt. The recommended level is 0.25 to 0.3% added salt (2.5 to 3 kg per ton).

If feed ingredients or drinking water contains salt, the amount of added salt must be reduced. Poultry can be poisoned by the sodium in salt and young chickens are very susceptible to high sodium. Chicks are frequently poisoned by salt in the drinking water. Salt toxicity is manifested as increased thirst, watery droppings and sometimes edema.

In chicks

- Chicks cannot tolerate salt as well as adults.
- Chicks are frequently poisoned by salt in the drinking water.
- Water for young chicks should not contain salt and many chicks die from salt poisoning at levels below 0.1% (0.9% is the level found in animal tissue).
- Chicks can be poisoned by eating salted fish and particularly by the brine used to preserve fish.
- 20g salt/kg DM in the diet of chicks is regarded as the maximum permissible level.

In hens

- Hens can tolerate larger amounts of salt if plenty of water is available
- Salt poisoning poses severe problem especially where fresh drinking water is limited.
- Salt toxicity is manifested as increased thirst, watery droppings and sometimes oedema.
- When the concentration of salt in the diet of hens exceeds 40 g/kg DM and the supply of drinking water is limited, then death may occur.

POULTRY FEED ADDITIVES

Common feed additives used in poultry diets include

- antimicrobials
- antioxidants
- emulsifiers
- binders
- pH control agents
- Enzymes
- Sometimes diets can contain other additives such as flavour enhancers, artificial and nutritive sweeteners, colours, lubricants, etc.

Additives used in poultry may also be classified as;

Growth promotion additives

- Antimicrobials used extensively in intensive poultry operations to minimize disease and improve growth and feed utilization.
- The development of resistant strains of microbes that could directly impact human health and cause negative impacts of the environment.
- The European Union has a complete ban of using antimicrobials

Feed enzymes

- Enzymes are proteins that facilitate specific chemical reactions. Although poultry produce numerous enzymes, they are not necessarily able to produce fibrolytic enzymes hence using fibrolytic enzymes facilitates digestion and absorption of fibre in normal feedstuffs and reduce anti-nutritional factors in feed that limit digestion.
- Some cereal grains (rye, barley, wheat, sorghum) have soluble long chains of sugar units (referred to as soluble non-starch polysaccharides – NSP) that can entrap large amounts of water during digestion and form very viscous (thick gel-like) gut contents. Non starch polysachridase enzymes can be added in feed to improve digestibility.
- Enzymes added to feeds can break these bonds between sugar units of NSP and significantly reduce the gut content viscosity.
- Lower viscosity results in improved digestion, absorption and gut health.

Antioxidants

- There are a variety of sources of reactive oxygen species (free radicals) in normal metabolism as well as those coming directly from feed ingredients. Oxidative stress can disrupt normal cellular function, damage tissues (also associated with the development of cancers) and reduce health status. Antioxidants bind these molecules and reduce their potential damage.
- Natural antioxidants include Vitamin E and C
- Synthetic antioxidants include Butylated Hydroxy Toluene (BHT) and Butylated Hydroxy Anisole (BHA).

POULTRY FEEDING SYSTEMS

Feeding Systems

Poultry can be managed under different feeding systems, depending on the husbandry skills and the feed available. These systems include the following

- A complete dry feed offered as a mash ad libitum
- The same feed offered as pellets or crumbles ad libitum
- A complete feed with added whole grain
- A complete wet feed given once or twice a day
- A complete feed offered on a restricted basis
- Choice feeding - Under choice feeding or 'free-choice feeding' birds are usually offered a choice between three types of feedstuffs:
  - An energy source (e.g. maize, rice bran, sorghum or wheat)
  - A protein source (e.g. soyabean meal, meat meal, fish meal or coconut meal) plus vitamins and minerals and
  - In the case of laying hens, calcium in granular form (i.e. oyster-shell grit).

Feed intake of poultry

There are a various factors that can affect the voluntary feed intake of poultry, these include:

- Breed or strain
- Age
- Nutrient balance of the diet
- Ambient temperature
- Health and welfare status of the birds
- Accessibility of the feed
- In addition, certain feed ingredients, poor feed quality or feed contamination can have adverse effects on voluntary feed intake due to poor palatability or the presence of toxic factors.

BROILER CHICKEN FEEDING (Meat production)

- Broilers are fed in 3 phases of different types of feed as Pre starter (0-7 days) broiler starter (7-21days) and Broiler finisher (21-42 days or till marketing).

- Feeding programs have primarily emphasized on live performance of meat birds taking into account effects on live weight or gain, feed conversion, and sometimes livability.

Feed consumption

The following table gives the cumulative feed consumption in broilers

Cumulative feed consumption for male and female broilers (g)

Age(weeks)	Male	Female
0	0	0
1	135	130
2	425	400
3	900	850
4	1600	1500
5	2500	2200
6	3700	3200

- Variation exists between the sexes in feed consumption
- As the age increases the feed consumption increases

Fats and oils in broiler feeding

- Lipids constitute the main energetic source for poultry and they have the highest caloric value among all the nutrients.
- Linoleic acid is the only fatty acid whose dietetic requirement has been demonstrated.
- Besides supplying energy, the addition of fat to poultry diets
    - improves the absorption of fat-soluble vitamins
    - increases diet palatability
    - the efficiency of utilization of the consumed energy
    - it reduces the rate of food passage through the gastrointestinal tract, which allows a better absorption of all nutrients present in the diet.
- In birds, body fat composition is similar to the composition of the fat from the diet.
    - Birds fed diets having higher levels of poly unsaturated fatty acids tend to produce soft fat.
- Higher inclusion of vegetable oils rich in unsaturated fatty acids necessitates inclusion of antioxidants.

Ideal protein concept

- The concept of Ideal Protein for broiler chickens is an important advance in broiler feeding and has seen widespread adaptation.
- An assumption of this concept is that broilers need Amino Acids in a certain balance to ensure optimum performance.
- Any absorbed amino acid which is in relative excess will be oxidized and the nitrogen excreted in form of uric acid.
- Thus, the Ideal Protein Concept is providing the right quantity and balance of amino acids that helps to improve nitrogen utilization.

Nutrient Recommendation for Broiler chicken as per BIS - 2007

Nutrient	**Broiler Pre-starter (0-7days)**	**Broiler Starter (8-21 days)**	**Broiler Finisher (22-42 days)**
Moisture, max %	11	11	11
Metabolizable energy, kcal/kg	**3000**	**3100**	**3200**
Crude Protein, min %	**23**	**22**	**20**
Crude fibre, max %	5	5	5
Acid insoluble ash, max %	2.5	2.5	2.5
Salt as (Nacl), Max %	0.5	0.5	0.5
Calcium, min %	**1.0**	**1.0**	**1.0**
Available Phosphorus, min %	**0.45**	**0.45**	**0.45**
Lysine, min %	**1.3**	**1.2**	**1.0**
Methionine, min %	**0.5**	**0.5**	**0.45**
Manganese, mg/kg	100	100	100
Vitamin A, IU/kg	11000	11000	10000
Vitamin D3, IU/kg	3000	3000	3000
Vitamin E, mg/kg	30	30	30
Vitamin K, mg/kg	1.5	1.5	1.5
Thiamine, mg/Kg	2.5	2.5	2.5
Riboflavin, mg/Kg	6.0	6.0	6.0
Pyridoxine, mg/Kg	5.0	5.0	5.0
Pantothenic acid, mg/Kg	15	15	15
Niacin, mg/Kg	40	40	40
Biotin, mg/kg	0.15	0.15	0.15
Choline, mg/Kg	500	500	500
Folic acid, mg/Kg	1	1	1
Aflatoxin B_1 ppb, Max	20	20	20

LAYER CHICKEN FEEDING (Egg type chicken)

- Good flocks of layer produce an average of about 250 eggs per bird per year (i.e. 70% production).
- Their eggs weigh on average 57 g.
- Birds usually start to lay at around five months (20-21 weeks) of age and continue to lay for 12 months (52 weeks) on average, laying fewer eggs as they near the moulting period.
- The typical production cycle lasts about 17 months (72 weeks)
- On average a bird produces one egg per day.
- Not all birds start to lay exactly when they are 21 weeks old.
- In areas where the climate is hot and humid, commercial hybrid laying birds produce on average between 180 and 200 eggs per year.
- In more temperate climates birds can produce on average between 250 and 300 eggs per year.

Feeding of layers depend on their age and physiological status

- Chicks require a ration that can provide the nutrients needed for rapid growth and feather development.
- Chick rations are relatively high in energy, protein and the vitamins and minerals required for growth and development.
- Once the chicks are fully feathered their energy requirements are reduced.
- Feeding management for layer pullets aims to maintain a growth rate that will lead to the pullet reaching sexual maturity at the desired age and to avoid obesity.
- Layer pullet ration have lower energy and protein levels than chick rations on a percentage basis.
- A pre-lay ration that increases calcium, is recommended for feeding 2-3 weeks before the bird begins to lay eggs.
- Layer ration is to optimize egg production, provide the nutrition required to safeguard health, maintain the desired bodyweight. This can be in terms of either egg numbers, egg size or egg mass.
- Calcium is increased in the ration for egg shell formation.

Feed intake g (DMB) for layers

Weeks	Intake g/day/bird	Cumulative intake g/bird
0-4	22	616
5-8	38	1680
9-12	50	3080
13-16	61	4788
17-20	70	6748
21 -72	110	46788

Chicken Starter feeds

- Are fed to newly hatched chicks until they are about 8 weeks old. Starter diets are formulated to give proper nutrition to fast growing baby chickens. These feeds usually contain 20% protein. The ME content of the feed is around 2800 kcal/kg.

Chicken Grower and developer feeds

- Once the birds reach about 8 weeks of age, the grower feed is used in place of the starter. Grower feeds contain about 15 or 16% protein and are formulated to sustain good growth to maturity. After about 18 weeks of age, the grower feed can be replaced with pre layer diet up to 20 weeks of age if they are available which contains more calcium. These prepare young chickens for egg production.

Chicken Layer feeds

- Once chickens have started laying eggs, layer feed is used.
- *Layer feeds* are formulated for chickens that are laying table eggs.
- Layer feeds contain about 18 percent protein and extra calcium so the chickens will lay eggs with strong shells.
- This feed is fed from about 20 weeks of age or when the first egg is laid, whichever occurs first.

Methods of feeding layer chickens depend on the age and activity (laying or breeding) of the bird. Feed requirements change as birds pass through the pre-egg-laying, egg production, and molt phases.

Phase feeding

- Phase feeding is used extensively. Phase –I (21-42 weeks) and Phase –II (43-72 weeks)
- Phase feeding was first proposed in the 1960s by Dr. G.F. Combs.
- This was the term that was given to the program of reducing the **protein** level in the feed as the hen aged.
- Currently levels of other nutrients, along with protein and amino acids, are lowered as the hen ages or when egg production in the flock declines to a certain percentage.
- Different feeds with varying protein content are formulated for various stages of production.
- Usually, the number of feeds ranges from two to four.
- Phase feeding reduces feed costs as egg production decreases because each change in formula is associated with a less fortified feed.

Restricted feeding

- There are two main types of restrictive feeding programs.
    - The first of these is every day feeding of a limited amount, or lower nutrient content diet. The amount fed will ensure adequate growth but not result in obesity.
    - Another type of restrictive feeding is an alternate day feeding program.
- Broiler breeders will eat until they become obese. Therefore, restricted feeding is necessary if the birds are going to be used as breeder stock. Otherwise, the obesity severely limits the numbers of eggs laid and the fertility of those eggs.
- Restricted feeding is also practiced in pullets to delay onset of sexual maturity, so that egg size can be improved and uniform sized eggs can be got from a flock.

- Restricted feeding is also practiced to bring about forced molting in layers at the end of the laying period.

Nutrient Recommendation for Layer chicken as per BIS-2007

Nutrient	**Chicks (0-8 wk)**	**Grower (9-20wk)**	**Layer Phase I (21-45 wk)**	**Layer Phase II (46-72 wk)**
Moisture, max %	11	11	11	11
Metabolizable energy, kcal/kg	2,800	2,500	2,600	2,400
Crude Protein, min %	20	16	18	16
Crude fibre, max %	7	9	9	10
Acid insoluble ash, max %	4	4	4	4.5
Salt as (Nacl), Max %	0.5	0.5	0.5	0.5
Calcium, min %	1.0	1.0	3.0	3.5
Available Phosphorus, min %	0.45	0.4	0.4	0.4
Lysine, min %	1.0	0.7	0.7	0.65
Methionine, min %	0.4	0.35	0.35	0.30
Manganese, mg/kg	70	60	60	60
Vitamin A, IU/kg	9000	8000	8000	8000
Vitamin D3, IU/kg	1800	1600	1600	1600
Vitamin E, mg/kg	15	10	10	10
Vitamin K, mg/kg	1.5	1.5	1.5	1.5
Thiamine, mg/Kg	2	1.5	1	1
Riboflavin, mg/Kg	6.0	5.0	5.0	5.0
Pyridoxine, mg/Kg	3.0	3.0	3.0	3.0
Pantothenic, mg/Kg	10	9	7	7
Niacin, mg/Kg	40	20	20	20
Biotin, mg/kg	0.1	0.1	0.1	0.1
Choline, mg/Kg	500	200	400	400
Folic acid, mg/Kg	1	0.5	0.5	0.5
Aflatoxin B_1, max ppb	20	20	20	20

Induced/ forced moulting or Molting

- Molting is the process of the bird shedding and re-growing feathers.
- Molting occurs naturally in the wild, as seasonal daylight shortens and females stop laying eggs.
- Laying hens are generally molted once or twice during their productive lives.
- Molting usually does not affect egg size, but allows for an improved egg laying rate, improved shell quality, and increased albumin height.
- Molting also allows a producer to keep the birds longer than they might otherwise be kept.
- To induce molt, a producer may use a period of fasting and a reduced amount of daylight, giving the birds water and allowing them to lose a proportion of their body weight.
- Daylight length will then be increased, and the hens begin laying eggs again.

Calcium supplementation in laying hens

- The major mineral required for egg shell quality is calcium.
- Layers need 4 - 5 g of calcium per day from first egg throughout the laying period.
- The recommended strategy is to feed a constant, modest level of calcium in the feed and to use calcium grit (eg limestone or oyster shell) to provide the additional requirement.
- After peak production the feed volume will be gradually reduced and by increasing the amount of calcium grit fed, the total amount of calcium per day from feed and grit can be secured.
- The metabolic requirement for calcium occurs mainly during the night when the egg shell is formed.
- Feeding the additional grit in the afternoon will provide the bird with calcium during the night when it is needed most.
- Laying hens should have calcium available free-choice, even if calcium is being added to feed.

INTERNAL QUALITY OF EGGS

The internal quality of eggs and the quality of the egg shells are influenced by many factors.

These include;

- Bird strain
- Bird age
- Nutrition
- Disease
- Management practices

- Water quality
- Housing conditions
- Temperature
- Disturbance or Stress

Egg shell quality

- The egg shell consists of about *94 to 97% calcium carbonate*.
- The thickness of an egg shell is determined by the amount of time it spends in the shell gland (uterus) and the rate of calcium deposition during egg shell formation.
- If the egg spends a short period of time in the shell gland, then shell thickness will be less.
- The time of day when the egg is laid will also determine the thickness of the shell. The earlier in the day or light portion of the photoperiod the thicker the shell will be.
- The amount or rate of calcium deposition will also affect the thickness of the shell.
- Some strains of birds may be able to deposit calcium for the egg shell at a faster rate than others.
- Age of the hen plays a role in determining the quality of the egg shell. As the hen ages, the thickness of the shell usually declines.
- Other egg shell quality factors such as the formation of abnormal ridges, calcium deposits, or body checks (ridges) are important considerations in determining egg shell quality.

Nutritional causes for thin egg shells

- Calcium is the primary mineral that makes up eggshells and when not supplied in the diet, the hen does not have the basic materials needed to make the shell.
- The problem is produced when whole grains or feeds deficient in minerals and vitamins make up the bulk of the laying hen diet.
- Thin egg shells are observed when calcium, phosphorus, zinc and vitamin D3 are not provided in diets at adequate levels.

Dietary manipulation for enhancing nutritional quality of eggs

- Egg yolk is considered one of the richest sources of cholesterol in human diet. Normal cholesterol content of eggs (about 200-250 mg) and blood (around 150mg %) in chickens has found to vary quite considerably. The cholesterol content of chicken egg can be reduced up to 25 % through the use of additives, dietary fiber and polyunsaturated fatty acid supplementation.
- Omega-3 fatty acids have cardio protective and other beneficial effects. Poultry nutritionists have started research to incorporate more of these fatty acids in the egg and have succeeded in developing such an egg called Omega 3 designer egg. They also call it the 'diet egg' or the 'functional egg'.
- Diet eggs have a high percentage of *Vitamin E,* an antioxidant, which prevents oxidation of cholesterol and therefore its ill effects. These eggs contain *600 mg of Omega – 3 fatty acids*. Omega – 3 fatty acids help to reduce cholesterol triglycerides, clog formation, tumor growth and improved immunity.
- In order to improve the quality of these eggs further Vitamin E, selenium, and carotenoid pigments are also incorporated into these eggs.

Egg size too big – Reasons

- Over feeding – High energy feed, high linoleic acid feed, too high protein content, methionine content.
- Too high body weight at beginning of laying period.
- Onset of lay too late.
- Low house temperature increases feed intake.

Egg size too small – Reasons

- Under feeding – low energy feed, low linoleic acid feed, too low protein content, methionine content.
- Too low body weight at beginning of laying period.
- Onset of lay soon. Limited water intake. High house temperature increases feed intake.

FEEDING BREEDER CHICKEN

- Both male and female breeders should be placed on a breeder diet five to six weeks before saving hatching eggs.
- This time is required especially by the hen to deposit all of the essential nutrients required for proper embryo development in the yolk.
- Underfeeding the hen can have an impact on chick quality.
- Offering low feed to young commercial breeder flocks results in increased late embryonic death, poorer chick viability and uniformity.
- A breeder diet with an energy density of approximately 2750 Kcal/Kg should have a protein content of 15%.
- Excess protein reduces fertility.
- Optimum energy intake in breeders for optimal chick is 440 - 480 Kcal/bird/day.
- The inclusion fats in breeder feeds should be low
- Preference for unsaturated fats rather than saturated fats is given.
- Providing adequate vitamins in a breeding ration is very important. Vitamins account for about 4% of the cost of a breeder feed

- Deficiencies of various trace elements and vitamins may lead to reduced hatchability and poor chick quality.
- Dead embryos may exhibit conditions that reveal the particular vitamin deficiencies causing their death.
- A deficiency of Vitamin B-12 will cause a rapid decrease in hatchability. There's also a poorer survival rate for chickens that do hatch.
- Riboflavin deficiencies also cause poor hatchability with embryos showing clubbed down. The degree of the deficiency affects the stage at which death of the embryo takes place.
- Marginal deficiency of pantothenic acid may permit almost normal hatchability but poor chick viability. A greater deficiency results in heavier mortality at the end of 21 days. An extreme deficiency causes high mortality as early as twelve to sixteen days with no embryos surviving to hatch.
- Biotin, choline, and manganese help prevent a condition known as **perosis or slipped tendon.**
- An acute deficiency of biotin causes high embryo mortality during the period of 72 to 96 hours of incubation.

- Manganese deficiency gives rise to embryos with parrot beaks and nutritional chondrodystrophy, which is a shortening of the long bones of the embryo.
- Choline deficiency is unlikely as the hen seems fully able to synthesize her own requirements.
- Vitamins and minerals that must be included in the breeder's diet are riboflavin, pantothenic acid, Vitamin B-12, niacin, folic acid, biotin, cholin, Vitamin A, Vitamin D-3, Vitamin E, Vitamin K, manganese, phosphorus, and zinc.
- Most commercial breeder mashes and concentrates are sufficiently fortified and contain more than an adequate amount of these essential vitamins and minerals to ensure proper embryo development.
- The amount of feed required daily will depend on the body size, the rate of production and temperature.
- Mash exposed to sunlight or heat tends to lose part of its nutrition and most of its appeal. Therefore, frequent feeding of fresh feed is important.

Feeding Cocks

- Early Growth - Feeding chicks is important for development of sound skeleton that is critical for the mature male in the breeding house
- From 10 weeks growth rate is critical. Development of the sertoli cells begins around this time and testes development continues through to sexual maturity at 23 weeks. From 15 weeks there is rapid development of the testes and growth profiles must be followed or fertility will be delayed or lost.
- Loss of growth rate will delay early fertility and adversely affect late fertility.
- Male weight and body condition are controlled by adjusting feed quantity so that a slow constant increase in weight (30g/week) is achieved as the male grows older.
- After 30 weeks of age, male weekly body weight gain should be approximately 30 grams when averaged over a three week period.
- Normally an adult cock consumes 130-160 grams feed /day
- Both underfeeding and overfeeding of males are possible, and can cause problems.
- Underfeeding is more common after 40 weeks of age.
    - Cocks will appear dull and listless, excess feather loss, reduced mating, vent colour will become paler and overall there will be reduced fertility.
- Overfeeding of cocks leads to Excessive breast development and excessive weight which can lead to injury of hen while mating, more stress on the cock’s joints and foot pads.

BACK YARD POULTRY FEEDING

Benefits of backyard poultry farming

- The backyard poultry farming is more beneficial to small, marginal farmers, land less labourers, tribal and backward class peoples.
- Backyard poultry farming generates small income for house hold requirement.

Feeding habit

- Backyard poultry usually feed on household wastes, farm products and green vegetation, besides free scavenging for waste grains and insects.
- These birds can perform well with diets high in crude fiber. It has better feed efficiency even with diets containing low energy and protein diets.

- During the process of scavenging on grass fields these birds will have an access to insects, white ants, green grass, grass seeds, waste grains etc., thereby the supplemental feed requirement is much less than those reared under intensive poultry farming.

Energy needs

- If the temperature is below the birds comfort level, additional energy is required to provide internal heat by increased metabolism to maintain body temperature.

Supplemental feeding

- Activity also increases metabolism and birds that are allowed to run outside or that scavenge for their feed have a higher requirement for energy.
- Feed supplementation in the form of scratch is usually given in the morning /evening to develop habit to reach owner's place for laying eggs and for night shelter.
- Depending on the availability of free range area and also the intensity of vegetative growth, the requirement of supplemental feed varies between 25 to 50 g / bird / day.
- Backyard birds can also perform well on whole grain feeding under scavenging conditions.
- For better shell quality, shell grit or limestone has to be supplemented at the rate of 5 - 7 g / bird / day during laying period.
- Birds that get all their nutrients from scavenging may eat an excess of protein, if insects, worms, larvae etc. are available. Hence supplemental feeding of energy in the form of carbohydrate (cereal grains etc.) is needed.
- Fenced or backyard poultry fed household or garden waste may lack both energy and protein for good growth or egg production. In such cases supplementation with both cereal grains and some form of protein supplement is required.

Importance of grit

Birds that eat whole seeds, grains, vegetable material or fibre must have insoluble grit or small stones in their gizzard to grind the hard or fibre material. Limestone particles are not satisfactory as grit. Birds that forage pick up their own grit.

- Small chicks require small stones 2 to 4 mm.
- Hens 0.5 to 1.5 cm.

FEED EFFICIENCY IN POULTRY

Feed Efficiency in Poultry

- Together with growth rate, days to market and mortality, feed efficiency has been considered as one of the important parameters in assessing the potential of bird strain or feeding program.
- Feed efficiency is calculated by dividing feed intake (in g or kg) by weight gain (in g or kg) in broilers and dividing feed intake (in g or kg) by egg production / weight (in g or kg) of dozen eggs produced in layers.

Feed efficiency or feed conversion ratio = feed intake/weight gain

Feed efficiency or feed conversion ratio = feed intake/egg weight

- In some countries, the efficiency is calculated as weight gain or egg production (in g or kg) divided by feed intake (in g or kg).

Feed efficiency = weight gain/feed intake

Feed efficiency = Egg weight/feed intake

- Whatever system is used, measures of feed efficiency are useful in describing feed intake in relation to growth rate / egg production.
- Feed efficiency is, therefore, a useful measure of performance as long as all other factors affecting growth, production and feed intake are either minor or do not vary from flock to flock.

Factors influencing feed efficiency

The following are the factors that influence feed efficiency

Dietary Energy Level

- The single largest factor affecting feed efficiency is energy level of the feed.
- Bird eats to full fill their energy requirement.
- As the energy level of the diet is reduced, birds eat more feed.
- As the birds eat more feed at constant growth rate, then feed efficiency starts to deteriorate.

Male vs Female Birds

- The feed efficiency of female broilers will usually be higher (less efficient) than male birds of corresponding weight, after about 30 days of age.
- The reason for this is that female birds tend to deposit proportionally more fat in the carcass.
- Therefore it is usually uneconomical to grow female broilers much beyond 45 days.
- Likewise with heavy male birds, feed efficiency is greatly influenced by the growth of fat vs muscle.

Bird Age

- As birds get older, their feed efficiency will deteriorate.
- This situation is simply due to the fact that heavy birds use increasing quantities of feed to maintain their body mass, and less is used for growth.

Environmental Temperature

- The chicken maintenance needs are greatly influenced by the temperature of its environments.
- After initial brooding, the bird must use some of its feed to maintain its body temperature.

- Under ideal conditions of around 20-25°C, the bird uses a minimum of feed to maintain body temperature.
- In cooler conditions, more diet energy must be used to maintain body heat, (and so less feed is used for growth) and consequently feed efficiency will deteriorate.
- Feed intake will increase by about 1% for each 1°C below 20°C. Between 20-25°C, the bird will eat about 1% less per 1°C increase in temperature, and so here feed efficiency will improve.
- Above 25°C (depending upon acclimatization), heat stress conditions can occur, and here feed efficiency will again deteriorate because now the bird is using energy to stay cool (panting, etc.).
- Under these conditions, efficiency of feed further deteriorates because the bird is reluctant to eat feed, and so proportionally more feed is directed towards maintenance, and less can be used for growth.

Bird Health

- Unhealthy bird is likely to have poor feed efficiency.
- The main reason for this is that feed intake is reduced, and so again proportionally more feed is directed towards maintenance. With enteric diseases there can be more subtle changes in feed utilization because various parasites and microbes can reduce the efficiency of digestion and absorption of nutrients.

Medicated Feeds

- Poultry feeds are available with several types of medications for preventing or treating diseases.
- Coccidiostats or antibiotics are the two most common medications added to feeds.
- Coccidiosis is prevented by feeding a coccidiostat, or drug added to feed at low levels and fed continuously to prevent coccidiosis.
- Examples of coccidiostats added to the ration include Monensin sodium, Lasalocid, Amprolium, and Salinomycin.
- Antibiotics are also be added to some poultry feeds.
- Antibiotics help broiler performance. They are usually added at low levels to prevent minor diseases and produce faster, more efficient growth.
- Examples of antibiotics fed in the feed are Penicillin, Bacitracin, Chlortetracycline, and Oxytetracycline.
- The recommended withdrawal periods have to be followed before using the meat or eggs from the treated birds.

SOME REPRESENTATIVE FEED MIXES

- Given below are examples of feed mixes for different categories of poultry

Ingredients	Inclusion level (%)				
	Broiler starter feed	**Broiler finisher feed**	**Layer chick feed**	**Layer grower feed**	**Layer feed**
Maize	50	55	54	40	53.5
GNC	30	25	25	5	20
DORB	–	5	2.5	12	8
Wheat bran	10	6	8	10	6
Fish meal	8	6.5	8	6	5
Mineral mix	2	2.5	2.5	2.0	2.5
Vitamin mix	0.02	0.01	0.01	0.02	0.01
DL Methionine	0.10	–	–	–	–
L lysine HCL	0.15	–	–	–	–
Coccidiostat	0.05	–	–	–	–
Shell grit	-	–	–	–	5

YOLK OR SKIN PIGMENTATION

- The right color of the broiler skin and of the egg yolk is widely known as an important quality attribute.
- Each region of the world has established its own particular specifications for this parameter.
- So that the optimum pigmentation for the broiler skin and the egg yolk depends on cultural traditions or preferences
  - Traditionally, the poultry keepers have been incorporating red and yellow pigments (natural or synthetic), in the birds feed.
  - Synthetic *cantaxanthin* has been used for decades as active pigment to provide a yellow-orange color to the broiler skin, and to provide intense orange and even rose hues to egg.
  - *Traditional sources of yellow xantophylls are*: alfalfa, yellow corn, yellow corn gluten, and marigold meal concentrates.
  - There are also natural red sources as the capsanthin (paprika or red pepper).
  - The figure below illustrates the deep yellow egg yolk from bird fed yellow maize incorporated feed.

FEEDING MANAGEMENT OF CHICKEN DURING SUMMER
(heat stress or hot climatic condition)

Summer management of poultry is very important in tropical regions of the world. One of the important criteria during summer management of poultry is feed management.

The following guidelines could be adopted for efficient feeding management in poultry during summer

- Adequate water for all birds is essential during periods of hot weather.
- Increasing the watering space for floor birds by adding more waterers and by locating them in areas where water is not usually found can encourage increased water consumption.
- The electrolyte balance in birds is altered during heat stress due to panting. Panting increases carbon dioxide loss in the bird, which reduces the bird's ideal water intake. By adding electrolytes to the feed or water, birds increase their water intake, which aids in keeping a constant body temperature and maintains an effective system of evaporative cooling.
- Supplementation of vitamins (A, D, E and B complex) in drinking water is effective in combating heat stress mortality in broilers.
- In breeding poultry, Vitamin C supplementation is effective in controlling decline in egg production and eggshell quality in laying hens and sperm production in breeder males.
- Feed consumption rates usually go down in summer and birds may not be consuming enough of the nutrients to maintain growth or production at the desired level. Hence adjusting the feed formulation to take into account reduced consumption may be necessary.
- Feed withdrawal during the hot part of the day can also help reduce mortality. The birds should not be fed again until after the temperature has dropped below 90 degrees in the evening. Feed withdrawal should not be used as a routine practice or growth rates will be reduced. It should be used only in emergency situations.
- Maintaining bird comfort during periods of extremely hot weather is essential in all types of poultry operations.
- Through the use of proper ventilation, good bird and house management, and proper feeding and watering programs, the stress and mortality due to high temperatures can be minimized.

LOW COST POULTRY RATION

- Feed costs account for 60-70 per cent of the cost of commercial poultry production.
- Increased and more efficient use of locally available feed resources would reduce the cost of production.
- Various low cost rations can be formulated that are suitable for meat and egg production.
- These should be simple and make maximum use of low cost local materials. A maximum of five ingredients should be used.

Some low cost ingredients, depending on local availability and cost, include;

- Coconut and oil palm cakes
- Broken rice, broken wheat, millet and sorghum
- Milling byproducts like husk, bran, grain screenings
- Cassava starch waste, or sweet potato starch waste and yam waste can also be used as energy sources
- Animal protein feeds such as offal meal, prawn waste
- Oyster shell or other grit
- Animal wastes such as poultry litter

Common nutritional deficiencies in poultry

Nutrient	**Deficiency symptom**
Vitamin A	Blindness, discharge from eye, ruffled feathers, pale comb and wattle, depigmentation of shank, early embryonic mortality, ataxia and Nutritional Roup
Vitamin D	Thin shelled eggs, leathery eggs, rubbery beak, bone abnormalities
Vitamin E	Crazy chick disease (encephalomalacia), Exudative diathesis, Nutritional muscular dystrophy (White muscle disease), Early embryonic mortality
Vitamin K	Delayed clotting, Haemorrhages
Thiamine	Star gazing posture, Polyneuritis
Riboflavin	Clubbed Down condition, Curled toe paralysis
Niacin	Growth retardation, general weakness
Pyridoxine	Retarded growth, anemia, dermatitis, convulsions
Pantothenic acid	Decreased hatchability, subcutaneous haemorrhages in embryos
Biotin	Dermatitis – foot, skin , beak, Fatty liver and Kidney syndrome (FLKS), Perosis
Folic acid	Poor feathering, slow growth, anemia, Perosis
Vitamin B_{12}	Decreased feed intake, decreased weight gain, poor feathering and nervous symptoms.
Choline	Perosis
Calcium	Thin shelled eggs, leathery eggs, rubbery beak, bone abnormalities, Cage layer fatigue
Phosphorus	Weakness, bone abnormalities
Magnesium	Lethargic, convulsions
Manganese	Perosis, Nutritional chondrodystrophy (parrot beak, thickened and shortened bones)
Zinc	Weak chicks, shortening and thickening of long bones, enlarged hock, scaling of skin, poor feathering, decreased feed intake
Copper	Loss of feather pigmentation, lameness, anemia
Selenium	Exudative diathesis, Nutritional muscular dystrophy (White muscle disease), Early embryonic mortality
Iron	Anemia
Essential fatty acids (Linoleic)	Poor growth, small egg size
Amino acids	Decreased growth, decreased production

NON-CONVENTIONAL / UNCONVENTIONAL FEEDS

Non-conventional / unconventional feeds 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 the unconventional feeds often 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
    - Water soaking

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
- Fear psychosis of the farmers
- Malpractice
- Uncoordinated research and development efforts.

New technologies are to be developed in order to adopt such non-conventional products in large scale feed preparations.

CLASSIFICATION

The non-conventional feed stuffs can be generally grouped as

- Roughages and concentrates.
  - Succulent
  - Dry
- Concentrates
  - Vegetable origin
  - Animal origin.
  - Protein sources
  - Energy sources.
- Other miscellaneous non-conventional feeds.

NON-CONVENTIONAL PROTEIN SOURCES

Protein Sources

- The commonly available vegetable and animal protein sources of unconventional origin and their protein content are furnished below.
- 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 pig and poultry.

Non-conventional protein sources

Sl. No.	Feed resources	Protein %	Remarks
1.	Sunflower meal	25-30	Partial replacement of GNC in layer ration.
2.	Niger cake	36	Partially replace GNC in swine and poultry ration.
3.	Guar meal	40-45	Up to 20% in chicken ration if toasted and mixed with 0.1 to 0.2% cellulase enzyme. 50% replacement of GNC in layer ration.
4.	Karanja cake	30	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.
5.	Neem cake	34-48	Water washing reduces bitterness Has to be introduced gradually. Processed neem seed meal can be included up to 10% level in chicks and layers rations.
6.	Rubber seed cake	30	10 and 20% level in concentrate mixture of pigs. Up to 30% level for growing animals. 10% level in poultry ration.
7.	Sunhemp seed	30	Mixed with other palatable feeds after crushing

			and fed.
8.	Dhaincha seed	30-33	Mixed with other palatable feeds after crushing and fed.
9.	Cassia tora seed	-	Boiled seeds added to ration of swine.
10	Kapok seed	26	Can be used as protein source at low level.
11.	Kidney bean chuni	16.3-20.5	Protein supplements for young animals.
12.	Soundal seeds	-	Up to 30% level in the ration for adult animals.
13.	Thummba seed cake	20	Water soaking for 6-8 hours is required.
14.	Tamarind seed powder	15-20	can be added below 5 % in swine and poultry ration,
15.	Poultry by-product meal	50-60	Good substitute for fishmeal and an excellent source of protein for chickens. It provides some unidentified growth factor.
16.	Feather meal	80-86	Should be used with judicious supplementation for amino acid deficiencies.
17.	Poultry excreta	30	Not generally recommended for monogastrics.
18.	Incubator waste/ Hatchery by-product meal	-	3-6% level for broiler chicks. Can replace fishmeal up to 33% in chick's ration.
19.	Liver residue meal	65	5-10% level in poultry ration.
20.	Frog meal	-	Can replace fishmeal twice by weight in poultry ration.
21.	Dried poultry manure	31	10-15% in chick and broiler rations.
22.	Cow dung meal	-	10% replacement of maize in grower or layer rations. Sun dried sheep dung meal at 5% level in starter mash.
23.	Shrimp shell powder (prawn waste)	32-43	Can replace fishmeal at 5% level in broiler of chick rations.
24.	Crab meal	25-30	Can replace fishmeal. Ca and P content and ratio need to be adjusted.
25.	Squilla meal	37.6	High Ca feed (10%).
26.	Processed fish ensilage	31.18	-

- 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

NON-CONVENTIONAL ENERGY SOURCES

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 for equines.
- Potato waste*:* It is a good energy source.
- 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.

The other non-conventional energy sources of importance, their energy or TDN content along with level of inclusion in different rations are furnished below

Non-conventional energy sources

Sl. No.	Source	Nutritive value ME (Kcal / kg) or TDN (%)	Remarks
1.	Cassava root	TDN 65%	10% level in chick and broiler feeds; 20% in layer feed.
3.	Tapioca starch waste	TDN 64%	Can replace 50% maize in swine ration.
4.	Tapioca thippi	ME 2450 K cal / kg	Can be used in pig rations similar to tapioca starch waste.
5.	Tapioca milk residue	ME 8990 K cal / kg	Up to 20% for chicks.
6.	Palm flour		Up to 17.5% in chick ration. Up to 11.5% in layer ration.
7.	Triticale	ME 2043-3357 K cal / kg	Can replace maize by 50-100%
8.	Oak kernel		Can replace up to 5% maize in chick feed.

FEEDING OF DUCKS

Duck rearing in India

- Feeding practices of ducks will depend on the number of ducks raised.
- If only a few ducks are kept by a household, and access to areas for foraging is present, ducks survive, grow and lay eggs by consuming available food such as green plants, insects, snails, frogs, and table scraps.
- Under such conditions, ducks grow very slowly and produce a small number of eggs.
- In India ducks are mostly managed in the free range system. Ducks mostly forage and feed on small insects, snails and certain plants.

Differences between ducks and chicken

- The digestive system of duck is slightly different from chicken in that they do not have crop and their pro-ventriculus is cylindrical make the feed passage rate quicker than that of chicken.
- Ducks also possess a bill in place of a beak and are capable of separating feed mixed in water.
- Ducks bill is not well adapted for dry mash feeding as dry mash sticks on to the bill and the duck tries to remove it by shaking or washing out in water.

Regardless of how ducks obtain their food, whether it be by scavenging, or consuming a complete ration, the food consumed must contain all the nutrients, in an available form, that are needed for maintenance, growth and reproduction.

Nutrient requirements of ducks

- The following table gives the nutrient specifications for different categories of ducks

Nutrient	Starter 0-8 weeks	Grower 9-20 weeks	Breeder/ Layer
Protein (%)	20	17	16
Calcium (%)	1	1	3
Fat (%)	5	5	5
Methionine (%)	0.35	0.3	0.3
Phosphorus (%)	0.45	0.4	0.4
Manganese (mg/kg)	60	50	40
Niacin (mg/kg)	55	40	55
Pantothenic acid (mg/kg)	15	10	20
Pyridoxine (mg/kg)	3	3	3
Riboflavin (mg/kg)	10	6	10
Vitamin A (mg/kg)	3100	1720	4130
Vitamin D3 (mg/kg)	300	22.5	62.5
Vitamin K (mg/kg)	2.5	2	2.5
Energy (kcal/kg)	2850	2850	2650

Feedstuffs for duck ration

- Feed ingredients commonly used for preparation of chicken feed can be used for preparing duck feeds.
- Some feed ingredients contain substances that are toxic to ducks, and should not be included in duck rations.
- Groundnut meal (peanut meal) is often contaminated with aflatoxin, a toxin to which ducks are highly sensitive. Groundnut meal should not be used unless tests have proven it to be free of aflatoxin.
- **Ducks can tolerate only 0.03 ppm of aflatoxin** compared to chicken that can tolerate up to 0.2 ppm.
- Rapeseed meal is another feedstuff that is potentially toxic to ducks. Some older varieties of rapeseed meal contain erucic acid and goitrogens at levels high enough to be harmful to poultry. Ducks are much more sensitive to erucic acid than are chickens and turkeys.

FEEDING DIFFERANT CATEGORIES OF DUCKS AND WATERING OF DUCKS

Feeding meat type breeders

- Meat-type ducks, such as Pekins, that are kept as breeders will become excessively fat if fed all they will eat during their development prior to lay.
- It is therefore necessary to limit their daily intake of feed to an amount that will supply all the necessary nutrients.
- Spreading of the feed will prevent overconsumption and all ducks will get their share of feed.
- Feed can be spread out in long food troughs or on the ground if the area is dry and clean.

Feeding laying breeders

- Layer rations contain a higher level of calcium than other duck rations
- A level of 3.0% of the diet is adequate for most breeds of ducks including high egg producing breeds.
- When enough calcium is included in the ration, it is not necessary to feed oyster shells in addition.

Watering ducks

- Plenty of clean drinking water should be available to ducks at least 8-12 hours per day.
- Not providing water at night helps to maintain litter in a dry condition. This applies to breeder ducks or market ducks over 3 weeks of age.
- This practice is not harmful and has no effect on performance during periods of moderate temperatures.
- During periods when temperatures are above 90˚F, drinking water should be available in the evening until the temperature has dropped below 80˚F, or else made available all night.
- Ducks do not require water for swimming in order to grow and reproduce normally.
- Providing some water for wading or swimming can be beneficial, especially in hot climates.

Average feed consumption of ducks

Age (weeks)	Cumulative feed (kg)
0-1	0.15
1	0.55
2	1.30
3	2.25
4	3.25
5	4.55

PREPERATION OF DUCK FEED

- Feed can be presented to the ducks in different forms

Mash or Pellets

- Ducks grow faster, and utilize their feed more efficiently, when fed pelleted rations than when their feed is in mash form.
- Pelleting of duck feed is common practice in commercial duck production.
- Feeding ducks with dry mash is not recommended as it forms a sticky paste when mixed with saliva, which cakes and accumulates on the outer ridges of the mouth. In attempting and to free their bills of caked feed, ducks make frequent trips to water to wash their bills, causing feed wastage.
- Feeding mash also reduces feed intake, and in the case of market ducks, reduces their growth rate.
- For small flock owners who are not able to pellet feeds, wet mash can be fed.
- Water is mixed with the mash just before feeding.
- Enough water is added to form a thick mush without making it watery.

Pellet size

- When pelleted feeds are fed to ducks it is important to avoid feeding pellets that are too large in diameter or too long for ducklings to swallow.
  - For newly hatched ducklings, pellets should be not having a diameter more than 4.0 mm and length more than 7.9 mm.
  - After two weeks of age, ducklings can consume pellets of 4.8 mm in diameter and 12.7 mm in length.

Crop – Absent in Ducks
Proventriculus – Cylindrical in shape
Dry mash feeding – Not advisable
Tolerable level of Aflatoxin
Ducks – 0.03 ppm
Chicken – 0.2 ppm
GNC – Aflatoxin
Rape seed meal – Erucic acid, Goitrogens

Animal Origin Protein Sources
Rich in Lysine, Methionine and Tryptophan
Plant Origin Protein Sources
Poor in Lysine, Methionine, Cystine and Tryptophan (Exception - Soyabean Meal)
Max.Inclusion Level of Fishmeal – 10 %
>10% Inclusion of Fishmeal – Fishy Flavour

FEEDING OF QUAILS

Japanese quails reach adult body weight in about 5 - 6 weeks and start laying eggs for the next 12 to 18 months. Japanese quails are prolific breeders and have the ability to produce four generations in a year. Their meat and eggs contain less fat and cholesterol and thus are more healthy. Hence quails are becoming popular as an alternate meat bird to the broiler chicken. Since feed consumption is low, broiler quails require high levels of protein and critical amino acids in the diet. The egg weight of egg line quails is about 10g. Quails require more choline than chickens.

Body Weight, Feed Consumption and Feed Efficiency of Japanese Quail (ICAR, 1984)

Age (weeks)	Body Weight (g)		Average Feed Consumption (g/bird/day)	Cumulative Feed Efficiency
	Male	Female		
0	7.4	7.4	-	-
1	22.8	23.4	3	1.33
2	46.3	48.0	8	1.93
3	73.3	77.4	11	2.26
4	90.5	100.6	15	2.93
5	111.9	122.3	17	3.44
6	124.5	151.7	21	4.01
Adult (10 - 12 weeks)	139.8	170.6	23.8	3.00

Nutrient requirements (as fed basis) of Japanese Quails (ICAR, 2013)

Nutrient	Growing		Breeder/Layer (5 - 30 wks)	
	0 - 3 wks	3 - 5 wks	Meat line	Egg line
ME (Kcal/kg)	2900	2950	2950	2850
Crude Protein (%)	25	21.5	20.0	18.6
Lysine (%)	1.45	1.20	1.10	1.00
Methionine (%)	0.55	0.50	0.45	0.40
Methionine + Cysteine (%)	0.90	0.80	0.80	0.70
Arginine (%)	1.80	1.50	1.25	1.15
Threonine (%)	1.12	0.92	0.80	0.70
Linoleic Acid (%)	1.00	1.00	1.00	0.90
Calcium (%)	0.85	0.85	3.00	3.00
Available 'P' (%)	0.45	0.35	0.35	0.32

FEEDING OF TURKEYS

Turkey birds are mainly reared for meat purpose in India since turkey provides excellent meat. Turkey birds are reared in Central Poultry Breeding Farm (CPBF), Hessarghatta (Bangalore). They are as efficient as chicken in the utilization of feed for growth. The breeds reared in CPBF are Broad Breasted Bronze turkey and Broad Breasted Large White turkey. The data on average body weight and feed efficiency as published by CPBF, Hassarghatta is presented hereunder.

Age (weeks)	**Average Body Weight (g)**
Day old	43
4^{th}	568
8^{th}	1615
12^{th}	2989
16^{th}	4137
20^{th}	4787
24^{th}	6175

Age (weeks)	**Cumulative Feed intake / bird (kg)**	**Feed/gain**
0 – 4	0.606	1.067
0 – 8	2.600	1.610
0 – 12	6.114	2.046
0 – 16	11.123	2.689
0 – 20	16.350	3.416
0 – 24	22.291	3.610

Nutrient requirements of Turkeys are higher because of their faster growth. The protein requirement of poults is 28 % during 0 to 4 weeks and the energy requirement for the corresponding period is 2800 kcal ME_n/kg diet. The energy and protein requirement of turkey (20 - 24 weeks for males and 17 - 20 weeks for females) are 3300 kcal ME_n/kg diet and 14% (NRC, 1994). Female birds grow at a slower rate than males. However, the feeding standards suggested are common for both female and male birds. Turkey's requirement particularly for vitamin A, D, B12, Niacin and choline is substantially higher than for chicks.

Turkey birds have special requirements for lysine and methionine. Lysine has special role in feathering, as lysine-deficient Bronze poults show a characteristic white barring of the primary and secondary feathers of the wings. The requirement of protein can be brought down to 24 % during 0 – 4 weeks of age with appropriate supplementation of lysine and methionine.

Nutrient requirements (as fed basis) of Turkey (ICAR, 2013)

Nutrient	0 - 6 wk	6 - 12 wk	12 - 18 wk	18 wk pre-laying	Breeder
ME (kcal/kg)	2800	2800	2650	2600	2650
Crude Protein (%)	24	22	18	15	15
Arginine (%)	1.5	1.4	0.9	0.65	0.60
Lysine (%)	1.5	1.2	1.05	0.72	0.60
Methionine (%)	0.55	0.45	0.35	0.25	0.20
Threonine (%)	0.95	0.85	0.7	0.55	0.45
Linoleic Acid (%)	1.0	1.0	0.8	0.8	1.10
Calcium (%)	1.2	1.0	0.8	0.6	2.25
Phosphorus (%)	0.55	0.5	0.38	0.3	0.35

Feeding of Ostriches and Emus

The design of successful feeding programs for ratites (Ostriches and Emus) is a special challenge to nutritionists and production managers. The gastrointestinal tract of the Ostrich and Emu differ greatly each other, but both animals are considered to be monogastric herbivores, with an ability to utilize substantial amounts of dietary forage. In contrast to the digestive tract of chickens and turkeys, ostriches and emus have no crop in which to store ingested feed. Ostriches and emus, however, do have a relative large true stomach (Proventriculus) and gizzard, which has considerable feed storage capacity. The intestinal tracts of these two ratites differ markedly. The small intestine of ostriches is relatively short and the large intestine is very long, while the opposite is true for emus. Ostriches also possess relatively small ceca compared with emus.

It is important to efficiently achieve desirable body weight at early ages. A guide to calculating efficiency is the bird's feed:gain ratio, the ratio of quantity of feed consumed to body weight gain in a measured period of time. Feed:gain ratio measured under commercial conditions were 4:1 for Ostrich and 6:1 for Emus.

Nutrition guidelines for Ostrich on age and breeder categories wise as follows;

Nutrient	Starter (0-9 wks)	Grower (9-42 wks)	Finisher (42 wks to Mkt Wt)	Breeder Holding (42 wk to maturity)	Breeder (4 to 5 wk before onset of egg pdn)
ME (Kcal/kg)	2465	2450	2300	1980 to 2090	2300
Protein (%)	22	19	16	16	20 -21
Calcium (%)	1.5	1.2	1.2	1.2	2.4 to 3.5
Phosphorus (%)	0.75	0.6	0.6	0.6	0.7
Methionine (%)	0.37	0.37	0.35	0.35	0.38
Lysine (%)	0.90	0.85	0.75	0.75	1.00
Crude Fibre (%)	6 - 8	9 - 11	12 - 14	15 - 17	12 - 14

Nutrition guidelines for Emus on age and breeder categories wise as follows;

Nutrient	Starter 0-6 wks	Grower 6-36 wks	Finisher (36 wks to 48 wks)	Breeder Holding (48 wk to sexual maturity)	Breeder (From 3 to 4 wk before onset of egg pdn)
ME (Kcal/kg)	2685	2640	2860	2530	2400
Protein (%)	22	20	17	16	20 - 22
Calcium (%)	1.5	1.3	1.2	1.2	2.4 to 3.5
Phosphorus (%)	0.75	0.65	0.6	0.6	0.6
Methionine (%)	0.48	0.44	0.38	0.36	0.40
Lysine (%)	1.10	0.94	0.78	0.75	1.00
Crude Fibre (%)	6 - 8	6 - 8	6 - 7	6 – 7	7 - 8

Feeding Management of Ostrich and Emu

feeding programme for ostrich and Emu		
Ration	**bird age**	**feeding rate**
Starter	0-45 days,(or) until eating 0.9kgs/day	ad lib (free choice)
Grower	45 days to 365 days (or slaughter if earlier) alternative: 45 days to 180 days, then switch to grower-lite	ad lib to 7 months, thereafter ad lib or limit fed 2.1kg/day
Grower-lite	180 days - 365 days (or slaughter) note: To achieve earlier slaughter and improved feed conversion and meat yields, continue feeding grower to slaughter. before slaughter market established switch to grower-lite.	ad lib or limit fed 2.1kg/day
Maintenance	breeder "off season", future breeders age 12 months to start of breeder season around 24 months of age	limit fed 2.1kg/day
Breeder	breeder season	limit fed 2.1kg/day

Average feed consumption by Ostrich			
bird age	**Qty of Feed**	**approx. bird weight**	**feed conversion**
0-45 days	25kg	-	-
0-225 days	222kg	95kg	2.4:1
0-300 days	396kg-440kg	110kg	3.6:1 – 4:1
from 210 days	60-70kg/month	-	-
mature breeders	approx 500kg	Laying Season	-
mature breeders	aprox 260kgs	Off Season	-

Maximum inclusion level of common feed ingredients in poultry ration

Ingredient	**% Inclusion (Max.)**
Maize	60
Wheat	50
Broken rice	50
Sorghum white	30 -40
Sorghum dark	10-20
Bajra	10-20
Ragi	10-20
Rice bran	10-20
Deoiled rice bran	10-20
Rice polish	10-30
Tapioca meal	10-20
Molasses	0-5
Ground nut oil cake	10 -30
Sun flower oil cake	10-20
Safflower oil cake	10-20
Mustard oil cake	0-5
Soybean meal	40
Decorticated cotton seed cake	0 -5
Coconut oil cake	5 -10
Fish meal	5 -10
Meat meal	5 -10
blood meal	3
Silk worm pupae meal	6
Sesame/til/gingelly oil cake	5 – 10
Vegetable fat	3 – 5
Skim milk powder	30 – 35

Common feed ingredients used in poultry ration with their nutritive value

Ingredients	CP(%)	EE(%)	ME Kcal/Kg	CF	Ca	P	Lysine	Methionine
Energy supplements								
Maize	9	2.2	3300	1.0	0.02	0.29	0.24	0.20
Bajra (Cumbu)	13	2.2	2650	5.0	0.13	0.72	0.42	0.24
Jowar (Sorghum)	10	3.6	2650	5.0	0.18	0.32	0.32	0.28
Finger millet (Ragi)	12.5	2.6	2950	7.5	0.15	0.65	0.40	0.25
Broken Rice	8	9.8	2600	2.0	0.08	0.39	0.24	0.15
Broken Wheat	14	2.4	2800	2.5	0.05	0.37	0.4	0.19
Tapioca Flour	2.0	10.9	3300	3.0	0.58	0.12	0.06	0.006
Vegetable fat	-	99.4	8800	-	-	-	-	-
Rice polish	13	11.2	2700	18.0	0.27	1.37	0.4	0.38
Wheat Bran	13	11	1500	18.0	0.13	1.15	1.7	0.72
Rice bran (Deoiled)	16	13.8	1800	20.0	0.37	1.8	0.45	0.44
Molasses	3	0	2000	-	0.48	0.06	-	-
Limestone, Shell Grit	-	-	-	-	38.00	-	-	-
Protein supplements								
Soya Bean Meal	45	3.9	2250	7.5	0.27	0.62	3.18	0.72
Sun flower oil cake	28	11.6	1600	15.0	0.43	1.14	-	-
Ground nut oil cake(Exp.)	40	8.9	2400	10.0	0.23	0.59	1.5	0.42
Ground nut oil cake (Solv.)	45	11.2	2700	12.5	0.31	0.67	1.5	0.43
Seasame oil cake	40	4.7	2200	15.0	2.46	1.42	1.04	0.84
Cotton seed cake	30	12	2200	20.0	0.10	0.62	-	-
Mustard oil cake	35	8.2	1900	15.0	0.89	1.78	0.99	0.72
Fish meal	40 -60	1	2200	1.5	7.16	2	3.01	1.19
Meat meal	50 -70	2.2	2300	1.5	2.68	2.06	3.73	0.8
Meat cum bone meal	45	8.6	1850	1.5	10.0	5.0	2.48	0.65
Mineral supplements								
Mineral Mixture	-	-	-	-	30.00	6.0	-	-
Limestone, Shell Grit	-	-	-	38.00	-	-	-	-

SWINE NUTRITION

NUTRIENT REQUIREMENT IN SWINE

Swine / Pigs require many nutrients for their maintenance, growth and production.

- *Carbohydrates:* Pigs can utilize crude fibre to a lower extent. The utilization of fibre by the pigs depends on the age of and weight of pigs and characteristic of non-fibrous portion of the ration. For growing and finishing pigs 5-6% CF level in their diet is recommended. In sows, 10-12% level of CF in diet can be well tolerated.
- *Fats:* When high fat diets are fed to pigs there is deposition of excessive fat inside the body. If this feed fat contains higher concentration of short chained fatty acids (ex. Soyabean and groundnut). There is a production of soft pork which is not desirable pigs fed on rations containing 0.5% fat, make a satisfactory gain and stores normal amount of body fat. However, the practical level of fat inclusion is higher than this i.e. about 4%.
- *Protein Requirement:* In Swine/Pig feeding it is important to provide good quality protein in the ration. Therefore, it is expected that all essential amino acids should be present in right quantity and proper balance. Even if one essential amino acids is lacking or is in excess it will cause marked reduction in the fed intake which will affect the growth and production, therefore, a combination of animal and vegetable protein in a pigs diet will provide all essential amino acids in proper proportion. Protein requirements of pigs express as % in the feed are as below:

S.No.	Class of Pig	Dietary protein Requirement (%)
1.	Pre-weaning /creep feed	18-22
2.	Weaned pigs	16
3.	Growing pigs '45 kg body wt'	14
4.	Breed gilts	15
5.	Sows	14
6.	Breeding boars	14
7.	Lactating sow	15

Mineral Requirements

- If swine is fed on concentrates alone calcium is more likely to be deficient. Whereas if they are fed only on pasture, phosphorus deficiency results.
- The recommended calcium and phosphorus levels for swine diet are as below:

- In practical swine ration it is routine practice to add 0.5-1% limestone and 0.5% di-calcium phosphate/bone meal.
- As per the NRC 0.5% common salt is recommended in rations of all classes and ages of pigs.
- Iodine need of pig is 0.2 mg/kg diet which should be supplied in the form of iodized salt.
- **Piglet Anaemia** is seen in piglets, housed in concrete floors under intensive rearing system.
    - The condition is called as "thumps".
    - Anaemic piglets are listless and flabby with wrinkled skin and unhealthy looking hair coat.
    - At birth, a piglet contains 50 mg iron.
    - The daily requirement is 7 mg and about 1 mg is supplied in daily sow milk consumed by the piglet.
    - This deficit of 6mg/day will exhaust the body stores within a week if iron is not provided.
    - This condition can be prevented by giving iron orally or by injections.
    - Iron dextrose 100 mg on third day of birth followed by 50 mg on 21 day prevents anaemia.
- Requirement of copper is 6mg/kg diet.
- Requirement for Manganese is 10mg/kg diet.
- Requirement for zinc is 50mg/kg diet.

Vitamin Requirements

- Vitamin K is synthesised in the intestine of the pigs by micro-organisms in adequate amount and hence has no practical importance.
- Deficiency of vitamin B-complex may arise under practical conditions in pigs raised on feeds like cereal grains without much inclusion of green forage. Liberal supply of good quality legume fodder hay, dairy products will take care of vitamins of B-series. Vitamin C is synthesised in the body and hence not of practical importance.

As in the case of poultry pig / swine feeds may be formulated as per NRC specifications or BIS specification.

FEEDING OF SWINE

- Swine / Pigs have been classified as omnivores.
- Their cecum and colon are flexible. Depending on type of food offered these parts of gastrointestinal tract can increase or decrease in size.
- Thus, pigs can tolerate crude fibre in their diet to a greater extent than carnivorous animals but to a lesser extent than herbivorous species.

Methods of feeding of swine

- *Full feeding by hand or self feeding:* In self feeding grains and supplements may be offered free choice in separate compartments/completely mixed balanced ration may be self fed. The pigs have excellent ability to balance their rations if the grains and supplements are offered separately. It is generally more profitable than the controlled feeding. Self feeding has been proved too be more efficient and economical method of producing market pig. The pigs fed by this method gain faster body weight and require less feed and labour.

- *Restricted/controlled feeding:* It is not a economical one since it decreases the rate and economy of gain. However diets can be reduced to about 80% of the full feed without any serious effect.
- *Wet Vs. Dry feeding:* Large scale pork producers prefer dry feeding whereas backyard pig producers give wet feed because of the limited quantity of feed involved. Pigs generally like wet feed, when pigs are given wet feed the feed should consist of three parts of water to one part of dry fed.
- *Floor Vs Trough feeding:* Pigs some times are fed on floor instead of troughs. With the floor feeding cost of feeding equipments and the cleanliness factor gets reduced. Dry feeds alone can be used for floor feeding.

Water Requirements of Pigs

- If there is a loss of 10% of body water, disorder will occur. If body water loss is 20% and more pig may die.
- The factors which affect the water intake are environmental temperature, feed protein content, mineral intake, activity level and production
- On an average pig consume 2-3 times water than its dry matter intake.
- Generally pigs require 5-10 litres of water per 45 kg body weight except in lactation, where the water requirement is 25 litres/day.
- Pigs can tolerate up to 1% salt in water.

FEEDING OF PIGLETS

- Piglets are allowed to suckle their mother for colostrum immediately after birth
- Piglets feed on the milk from the sow up to 1-2 weeks of age.
- Beyond two weeks additional feed in form of creep feed is essential.
    - Creep feeding is necessary because the sow's milk alone does not meet the nutrient requirement of the rapidly growing piglet.
    - Moreover the large litter size also warrants creep feeding
- **Baby pig disease or Acute Hypoglycemia** in new born piglets within 48-72 hours after birth due to lack of milk in sow or fasting of piglets due to body abnormalities.

Creep Ration

- The practice of self feeding of concentrates to young ones away from their mother is called as "Creep Feeding".
- It is usually given in a separate enclosure which the sow cannot access.
- In pigs, it is given from second week of age.
- Creep feed should contain 20% CP and 3360 kcal/kg of ME.
- Major portion of creep feed should be of animal origin.
- The feed should contain appropriate quantity of vitamins and minerals.
- It should contain low crude fibre.
- Dry creep feed are called as pre-starter feed.

- Example of a creep feed is as follows;

Ingredients	Parts
Ground yellow maize	40
Skim milk powder	10
Ground nut oil cake	10
Sesame oil cake	10
Wheat bran	10
Molasses or jaggery	10
Fish meal	6
Brewers yeast	2
Mineral mixture	2

- This concentrate mixture should be supplemented with vitamin mixture at the rate of 10 g /100 kg feed as a general guide.

Starter Ration

- It is fed when pig attains body weight of 12 -14 kg and is continued till they attain a body weight of 23 kg.
- It should contain 18-20% crude protein and 3360 kcal/kg of ME.
- It should have low fibre.
- Should be rich in vitamin and minerals.
- Example of starter ration is as follows

Ingredients	Parts
Ground yellow maize	30
Ground nut oil cake	28
Wheat bran	30
Fish meal	10
Mineral mixture	2

FEEDING OF GROWER PIG

Grower Ration

- When pigs attain a body weight of 55 kg they can be turned from starter to grower ration.
- The grower ration should contain 16% CP and should contain 3170 kcal/kg ME.
- It should contain some animal protein and fibre.

- Example of grower ration is as follows

Ingredients	Parts
Ground yellow maize	30
Ground nut oil cake	20
Wheat bran	40
Fish meal	8.0
Mineral mixture	2.0

- It is supplemented with 10 gm of Vitamin mixture per 100 kg of feed.

Finisher Ration

- It is fed to pigs when they achieve 45 kg body weight and is fed until they attain marketing rate of about 90 kg.
- Finisher ration is also called as "Fattening Ration".
- It can be fed up to 4 Kg per animal per day.
- This ration contains 14% CP. The Metabolisable energy content can be 3170 kcal/kg.
- Example of finisher ration is as follows;

Ingredients	Parts
Ground yellow maize	40
Wheat bran	30
Ground nut oil cake	12
Sesame oil cake	10
Fish meal	5.5
Mineral mixture	2.5
Rovimix	10 g

Feeding Breeding boars

- The feed for young boar of less than 15 month age should contain 16% CP whereas for older boars CP % of feed should be 14%.
- The boar ration should contain 3170 kcal/kg of ME.
- Adult boar can be fed 3-4 Kg of feed per day.
- A ration similar to a growing ration can be prepared and fed.

FEEDING OF LACTATING AND PREGNANT SOWS

Gestation Ration

- A special care should be given during gestation of sow
- During first two-third period of gestation, a ration with 14% CP should be fed whereas during last third of gestation ration should contain 16% CP.
- The ration should have 3170 kcal/kg of ME.
- Pregnant sow are fed 3-4 kg feed per day per sow
- An example of gestation ration is as follows

Ingredients	Parts
Ground yellow maize	53
Ground nut oil cake	20
Molasses	5
Wheat bran	15
Fish meal	5
Mineral mixture	2

Feeding lactating Sow

- The sow largely uses dietary nutrients for the synthesis of milk. If the dietary nutrients are not provided, the body will use tissue reserves in an attempt to meet milk production demands. When this occurs, it will result in a loss of body weight.
- First-parity animals normally consume less feed during lactation than older sows. Because of this, the diet of first parity sows should be formulated to contain a higher concentration of nutrients.
- The feeding practice for lactating sows is to feed a minimum amount of feed the first day after farrowing and then to increase that amount so that the sow is on full feed by day five of lactation.
- It is a common practice to feed lactating sows twice a day, but most sows cannot consume enough feed with this feeding practice hence the frequency of feeding can be increased.
- The method of feeding lactating sows is critical during the summer months when feed intake is particularly low. In summer the sow is fed during the cooler times of the day.
- The inclusion of fat in the sow's lactation ration has been shown to increase milk-fat content.
- The dietary protein (amino acids) concentration provided to the sow during lactation is of extreme importance in meeting the needs for milk production. The ration should contain around 16-18% crude protein.
- The ration should have 3170 kcal/kg of ME.
- When constipation is a problem, the addition of a fiber source (wheat bran, alfalfa meal) at a 5% level may be helpful. Fiber inclusion in the lactation ration will, however, lower the energy value of the diet.

- Within a few days of farrowing, the fiber should therefore be withdrawn from the diet and replaced with energy supplements.
- As during late gestation, adequate quantity of calcium and phosphorous should be provided ration.
- Feed consumption of lactating sow 6 -10 Kg depending on litter size. (3.5 kg as maintenance ration + 100 g/piglet)

NUTRIENT REQUIREMENT IN SWINE (BIS, 1986)

- The following table gives the nutrient specification of various categories of swine / pig feed as per Bureau of Indian Standards specification;

Nutrient	Requirement		
	Pig starter / Creep feed	Pig growth meal	Pig finishing / Breeding meal
Moisture content (Max %)	11.0	11.0	11.0
Crude protein (Min %)	20.0	18.0	16.0
Crude fat or ether extract (Min %)	2.0	2.0	2.0
Crude fibre (Max %)	5.0	6.0	8.0
Total ash (Max %)	8.0	8.0	8.0
Acid insoluble ash (Max %)	4.0	4.0	4.0
Metabolizable energy (Kcal/kg), Min	3360	3170	3170

PREPARATION OF FEEDS FOR SWINE

- Fine grinding of feeds for pig is not recommended because such feed sticks to the feeder and there is increased incidence of gastric ulcers.
- Coarse grinding of cereals and millets is profitable than to feed them as a whole.
- Pelleting of feed is profitable if a ration is high in crude fibre content.
- Soaking of small grains like sorghum 12 hours prior to feeding improves their utilization by animal.
- Cooking can also improve the utilization of starch especially when tubers like potato and legumes like soyabeans are used as feed.

Feed ingredients used for preparing swine ration

- *For energy*: Maize up to 65 %, sorghum up to 45 %, wheat up to 25 %; with enzyme, wheat by-products (bran, shorts, screenings) up to 15%, rice up to 15%, rice by-products (bran, polish) up to 15%, molasses, up 5 -10 % .
- *For protein*: Soybean meal up to 30%, sesame oil cake up to 10%, corn gluten up to 15%, linseed meal - 15 % , ground nut oil cake up to 20 %, safflower meal, sunflower meal up to 10%, meat meal, fish meal up to 10%, blood meal, feather meal up to 2%
- *Fats and Oils*: Tallow, lard, coconut oil, palm oil, up to 5%, poultry fat, fish oil, restaurant grease up to 3 - 6%.

Mineral resources

- Calcium can be added as limestone, as prepared products such as di-calcium phosphate or as oyster or other marine shell.
- Phosphorus can be added from manufactured products such as di-calcium or monocalcium phosphate.
- Phytate phosphorus (organic phosphorus) is present in small but varying amounts in plants feed ingredients. This phytate phosphorus is only 25-50% available unless phytase enzyme is added to the ration.
- Calcium and phosphorus levels must be in balance since high levels of one cause deficiency of the other.
- Sodium and chlorine are usually added as salt (NaCl) at about 0.25% of the ration (2.5 kg NaCl/1000 kg).
- Magnesium and potassium are usually present in adequate amounts in the feed ingredients. Some ingredients such as soymeal and molasses are high in potassium.
- Minerals may be present in high or moderate levels in animal by-products. If animal by-products are being fed the minerals present in this feed should be used in the calculation of the amount to be added.
- Trace minerals and vitamins are required in small quantities.

Feed additives used for swine production

1. **Antibiotics** – different antibiotics used as growth promoting feed additives in swine at sub therapeutic level. Precaution that has to be adopted while using antibiotics as feed additives is that a sufficient withdrawal period has to be given prior to slaughter for pork, if not antibiotic residue in pork causes human health issues.
2. **Probiotics** – are live microbial cultures used as feed additive. Common probiotic species are lactobacillus and sachromyces. These promote growth and production in swine and cause no residual effect and hence are safer to use.
3. **Prebiotics** – Commonly used prebiotics include Mannan-oligosacharides and fructo-oligosacharides. They serve as substrate for growth of beneficial microbes in large intestine.
4. **Synbiotics** – are a combination of pro and prebiotics and are used as growth promoting feed additives.
5. **Feed enzymes**
    - Enzymes are proteins that facilitate specific chemical reactions. Although pigs produce numerous enzymes, they are not necessarily able to produce fibrolytic enzymes hence using fibrolytic enzymes facilitates digestion and absorption of fibre in normal feedstuffs andreduce anti-nutritional factors in feed that limit digestion.
    - Some cereal grains (rye, barley, wheat, sorghum) have soluble long chains of sugar units (referred to as soluble non-starch polysaccharides – NSP) that can entrap large amounts of water during digestion and form very viscous (thick gel-like) gut contents. Non starch polysachridase enzymes can be added in feed to improve digestibility.
    - Enzymes added to feeds can break these bonds between sugar units of NSP and significantly reduce the gut content viscosity.
    - Lower viscosity results in improved digestion, absorption and gut health.
    - Phytase helps to improve utilisation of phytate phosphorus and thus decreases the need for supplementing inorganic phosphorus in swine ration.

6. **Antioxidants**
    a. Antioxidants bind these molecules and reduce their potential damage caused by free radicals.
    b. Natural antioxidants include Vitamin E and C.
    c. Synthetic antioxidants include Butylated hydroxy toluene (BHT) and Butylated hydroxy anisole (BHA).
7. **Acidifiers** – these are organic acids that are used to decrease gut ph and thus be harmful for pathogenic microbes causing an improvement in the health and growth of swine.

FEED INTAKE IN SWINE

Factors influencing feed intake

- Energy density of feed - swine eat to meet out their energy requirement. Adding fat to the feed decreases feed intake as energy density increases. High fibre in ration increase feed intake until the gastro intestinal capacity is reached.
- Temperature – as the environmental temperature increases from moderate to stress full the feed intake declines. Cold climatic conditions increase the feed intake.
- Sex – Barrows consume more feed than gilts, however in growing period boars eat less than gilts.
- Genetics – the feed consumption of certain breeds of pigs are high.
- Weaning – Feed intake decreases post weaning.
- Gestation – Feed intake is increase during gestation. Last stage of gestation feed intake reduced.
- Palatability – Unpalatable feed if used in ration decreases feed intake.

Average feed consumption of Pigs

Age (Months)	Live Body Wt. (kg)	Average FI /head/day
2	15	0.5
2-3	27	1.0
3-4	40	1.25
4-5	50	1.50
5-6	60	2 - 3

Body weight (kg)	Feed intake (g/day)	Expected weight gain (g)	Feed intake / gain (FCR)
1-5	250	200	1.2
5 - 10	500	250	1.8
10 -20	1000	450	2.1
20 -50	2000	700	2.7
50 -110	3000	820	3.7

EQUINE NUTRITION

As in other categories of livestock the horse also has a requirement of various nutrients

Energy

- Energy is what horses use to do work.
- Energy requirements are influenced by age and by the work's degree and duration.
- Young, growing horses, horses at high work intensities and lactating mares have the greatest requirement for energy.
- Mature, idle horses and mares in the first 2 trimesters of pregnancy require less energy.
- In young, rapidly growing horses, horses at work and lactating should be supplemented with concentrated energy sources to meet their energy requirements

Energy requirement for work depends on the following factors;

- Speed of work
- Duration of work
- Terrain in which the work is performed
- Inclination of the terrain in which the work is performed
- The weight of the horse
- The horse’s fitness
- Rider’s ability
- Environmental temperature and humidity
- The horse’s soundness and conformation
- The type of movement

Protein

- Horses use protein to synthesize various body tissues, such as muscle.
- Proteins are composed of amino acids and will vary in amino acid composition.
- Currently, the exact amino acid requirements of horses are not known. But feeding an adequate source of protein should ensure that horses get the composition of amino acids they need.
- Protein requirements vary for different classes of horses.
- Young, growing horses have a higher requirement for protein because they are growing body tissues like muscle and bone.
- Mature horses have a much lower requirement for protein than do young horses since mature horses need protein for maintenance of body tissue rather than growing new tissue.
- Protein requirement is higher during last stages of pregnancy and during lactation.
- Working horses do not normally require additional protein however loss of protein in sweat, and incorporation of protein in muscle mass leads to a 2 % increase in requirement of protein.

Minerals - Are needed by the horse's body for various purposes, ranging from serving as components of the horses skeletal system to maintaining nerve conductivity, muscle contraction and electrolyte balance.

Vitamins - Vitamins A, D and E are the most common vitamins added to horse diets. Although B complex vitamins are synthesized in the large intestine of horses supplemented, including them in performance horse diets may be necessary.

Factors influencing nutrient requirements in horses

- Body weight of the horse or its size.
- Breed of the horse
- Age of the horse
- Physiological status of the horse - gestation, lactation, rate of growth
- Nature and intensity of work
- Temperament of the horse
- Hair coat of the horse
- Fat insulation
- Environment – temperature, wind velocity and relative humidity
- Health status of the horse
- Vices of the horse

Developmental orthopedic disease

Developmental orthopedic disease (or DOD for short) is the name given to a group of bone growth disorders that commonly occur in young horses. The DOD groups of disorders all result from defects in normal bone formation as young horses grow and develop.

Nutritional Imbalances causing DOD

Too much energy - High-energy diets lead to faster growth rates and larger body sizes.

Calcium and Phosphorus Imbalance - Adequate amounts of calcium and phosphorus are needed for cartilage to be converted to bone. Without adequate amounts the cartilage can become thickened, bone density and growth can decrease and DOD problems can develop. Young horses can tolerate high levels of calcium provided that phosphorus and energy levels are not excessive. However low levels of calcium, particularly when there are high levels of phosphorus and energy in the diet (eg. from too much grain), are a recipe for DOD.

Copper and Zinc - A copper deficiency is known to increase the risk of DOD as copper is involved in stabilizing bone development. Foals fed low copper levels had three to four times more DOD lesions than those fed adequate levels of copper. Excess zinc has been shown to decrease calcium absorption leading to a calcium deficiency in foals grazing pastures contaminated with residue from nearby zinc smelters. Adequate but not excessive levels of zinc should be included in the diet of growing horses.

DIGESTIVE SYSTEM OF A HORSE

Horses are classified as herbivores, or roughage eaters. They are grazing animals with digestive systems designed for constant consumption of plant food. Unlike most other herbivores, the digestive system of the horse is considered mono-gastric rather than ruminant.

Digestive organs include the stomach, small intestine and large intestine. The stomach and small intestine are commonly referred to as the upper gut, and are where most of the protein, fat, vitamins and minerals contained in feed are digested and absorbed.

Although the horse lacks the complex fore-stomach of a ruminant, unique characteristics of its large intestine, or hindgut, allow the horse to utilize cellulose and other fermentable substrates in much the same way as ruminants.

The large intestine of the horse has a greatly enlarged cecum which serves as a fermentation vat. Billions of bacteria and protozoa produce enzymes that break down plant fiber. In the horse, this fermentation process occurs posterior to the area where most nutrients are absorbed, and as a result, horses do not obtain all of the nutrients synthesized by microorganisms in its large intestine.

Hind gut fermentation in horse

The horse has the largest and most complex large intestine of any domestic animal. Its large intestine is made up of two large organs: the cecum and the colon. Together they represent about 60% of the horse's digestive tract. The cecum makes up about 25-30% of the large intestine.

The horse's large intestine is designed to utilize plant fiber. Insoluble carbohydrates such as cellulose and hemicellulose from forages, as well as starch and other soluble carbohydrates that were not digested in the small intestine, flow into the large intestine. As feed leaves the small intestine it first enters the cecum. Here the undigested nutrients are fermented in a process similar to that which occurs in the fore stomach of ruminants. After fermentation, feed enters the colon for further digestion and absorption.

Microbial fermentation in the hindgut results in the production of volatile fatty acids which are an important nutrient source for the horse. The hindgut also serves as a reservoir of water and electrolytes which are vital to sustain exercise performance. The rate of feed movement through the colon is relatively slow. Because the colon folds back on itself several times and its diameter varies, horses are predisposed to digestive upsets when nutrient flow is abnormal. Since the horse's digestive tract is primarily designed to digest forages, fewer problems occur when the diet is predominately hay or pasture.

The following are some of the important points that are to be considered while feeding horses.

- If a horse has been well bred, is well trained and managed, is in good health and lives in a suitable environment, then nutrition will be the main factor influencing its performance.
- Generally, horses undergoing only limited activity or light work are fully nourished by good quality pasture. However, pastures vary greatly in nutritional value.
- At times, horses might not get enough nutrition from grazing, and will need a supplement. Feeding a supplement should be aimed at providing that part of the horse’s nutritional needs not available from the grazing.
- When horses do not have access to grazing, a well-balanced ration which provides energy, plus protein, minerals and vitamins, needs to be supplied.
- When grazing is adequate, the addition of **minerals** and **vitamins** to the diet is not usually necessary. However, mineral/vitamin supplement may be necessary, if roughage quality is poor.
- **Salt** should be supplied freely to working horses because considerable quantities are excreted in sweat. The provision of salt blocks or rock salt in feed boxes will help ensure adequate intake.

Feeds for horses

There was no BIS standard for nutrient requirement / specification for horse feed.

- Two basic types of feeds are available to provide the nutrient requirements of the horse they include roughage such as hay or grasses and concentrates such as grains, grain by-products and oil cakes.

Dry matter intake

- The dry matter intake of horses is 1.5 - 2.5% of their body weight per day.

Roughage and concentrate requirements of horses		
Type of work	**Feed per 100 kg live weight**	
	Roughage (kg)	**Concentrate (kg)**
Idle	1.5	Nil
Light (2 hours/day)	1.25–1.5	0.5–0.75
Medium (2 hours/day)	1–1.5	1.0
Heavy (4 hours/day)	1.0	1.0–1.5

Factor		**Feed Intake**	
		% of body weight	**Forage: concentrate ratio**
Maintenance		1.5	100:0
Pregnancy		1.2	75:25
Lactation		2.2	55:45
Work	**Mild**	1.5	65:35
	Hard	1.5	30:70
3-month foal		3 - 4	0:100
6-month foal		2 - 2.5	25:75
12-month yearling		2	35:65

Feeding management

- Treat each horse as an individual, learn its feeding habits, and adjust rations accordingly.
- Feeding and watering is to be carried out according to a regular routine.
- The daily ration for working horses should be split into at least three feeds per day, with half the ration fed as the evening feed.
- Feed a quarter of the concentrate requirement at each of the morning and midday feeds, and feed the remaining half at night.
- Reduce the amount of concentrate by 50–70% on days when the horse isn’t worked.
- Make any changes in the ration gradually over a period of 10–14 days.
- Keep feed and water troughs clean, and remove leftovers.
- Measure feeds by weight, not by volume.

- Mix feed carefully and only in sufficient amounts for each day's feeding.
- Do not allow horses to drink large quantities of water immediately after exercise. Allow the horse to drink only 2–4 L, and then let it cool before allowing free access.
- Avoid working the horse on a full stomach. Allow at least 2 hours for digestion.

NUTRIENT REQUIREMENTS OF EQUINE AS PER ICAR

Class	TDN (Kg/day)	CP (%)	Ca (%)	P (%)	FI (%, B. wt)
Adult horses at rest	3.7	8.0	0.30	0.2	1.5
Pregnant mare (last 3 months of pregnancy)	4.2	10.0	0.45	0.35	1.75
Lactation (First 3 months)	6.4	12.5	0.45	0.35	2.75
Nursing Foal (3-5 months) Requirements in addition to milk	1.6	16	0.8	0.55	0.75
18-24 months	3.9	10.0	0.40	0.35	2.0
12-18 months	3.8	12.0	0.50	0.35	2.5
2 year old to maturity	3.7	9.0	0.40	0.35	1.75

Feeding of foals

- Is according to its age.
- The mare's milk will meet out the requirement for a foal up to the first 3 months of its life.
- Composition of mares milk: Fat - 1.25, Crude protein - 2.1%, Lactose - 6.3% and Ash - 0.4%. Gross energy - 480 Kcal/kg.
- Colostrum feeding is important because it provides immunity to the foal.

Feeding orphan foal

- The foal is injected horse serum for immunity.
- Fostering or hand rearing by bottle or bucket feeding can be carried out
- **Modified cow milk** – 600 ml cow milk + 150 ml lime water + 1 tea spoon sugar.
- Frequency of feeding once in 2 hours first two weeks once in four hours next two weeks and four times a day feeding up to weaning.

Creep feed

- Beyond one and half month (5 - 6 weeks) additional creep feed can be provided.
- The Creep feed should provide 75 % TDN and 18 % CP.
- It should be prepared from highly digestible ingredients.
- It can be fed at the rate of 0.5 to 1 % of the foal's body weight.
- Example of creep feed is as follows;

Ingredient	Percent in feed
Oats grouts rolled	15

Flaked oats	20
Flaked maize or sorghum	35.75
Soy bean meal	15
Skim milk powder	5
Molasses	5
Di-calcium phosphate	2
ground limestone	0.75
Trace min mix	1
Vitamin supplement	0.5

FEEDING OF WEANLINGS

The following is the feeding schedule for Weanlings

- *3- 6 months*: 500 g grain or concentrate mixture and 1 kg good quality hay.
- *6-9 months*: 1 kg grain or concentrate mixture and 2-3 kg good quality hay.
- *9-12 months*: 2 kg grain or concentrate mixture and 4-5 kg good quality hay

Concentrate mixture for Weanlings
The following is an example of concentrate mixture (CP -16%) to be fed to growing foals / weanlings;

Ingredient	Percent inclusion
Crushed oats	25
Flaked maize or barley	30.8
Crushed sorghum	15
Soy bean meal	15
Alfa alfa meal	5
molasses	5
Vitamin supplement	0.7
Dicalcium phosphate	2
Ground limestone	0.5
Trace mineral mix	1

Nutrients for growth at different Production Stages

Age of Horse (Weight/growth rate)	DE (Mcal)	CP (g)	Ca (g)	P (g)
6 months				
240 Kg/1000 g per day	15.5	750	39	22
12 months				
350 Kg/500 g per day	19	900	38	21
24 months				
470 Kg/200 g per day	19	850	37	20
Class of Horse				
Breeding Stallion	22	850	20	14
Broodmare				
Early Pregnancy	17	700	20	14
8 months pregnancy	18.5	850	28	20
11 months pregnancy	21	1000	36	26
Lactation (1st month)	32	1700	59	38
Lactation (3rd month)	31	1600	56	36
Lactation (5th month)	28	1450	40	25

Feeding of adult horses for maintenance

Maintenance requirements for Sedentary, Mature Horses of Different Body Weight

Size of Horse	DE (Mcal/day)	CP (g)	Ca (g)	P (g)
500 Kg	15	600	18	13
550 Kg	16.5	700	20	14
600 Kg	18	750	22	15

FEEDING OF STALLIONS

The feeding of stallion is critical for its breeding performance

- The actual amount of energy required by the stallion during the act of mating is quite small, but the additional physical activity and psychological response to breeding increases the dietary energy needs.
- During the breeding season, the addition of more energy-dense feeds, like grains, to the ration is usually necessary to meet the stallion's higher energy requirements.
- Vegetable oil can also be used to provide extra energy and can reduce the inclusion of large amounts of grain.

- The stallion should be fed high quality hay at a minimum level of 1.0 per cent of body weight.
- Stallions that are used to mate many number of mares will require energy-dense grains, fed at levels up to 0.75 kg/100 kg body weight.
- Other nutrient requirements also increase during the breeding season since they are needed in proportion to energy intake.
- Additional mineral and vitamin needs can be met by providing a suitable vitamin/mineral supplement.
- If the stallion is already receiving a properly balanced diet, adding extra feed or supplements to the diet will not enhance fertility.
- Unless the stallion is exercised, nutrient requirements in the off-season are similar to those of the idle horse at maintenance.
- Stallions that are exercised regularly will have higher nutrient requirements and should be fed according to their level of work.
- Stallions finishing the breeding season in good condition can be brought down to maintenance ration by increasing the hay portion and decreasing the grain portion of the ration.

FEEDING OF MARES

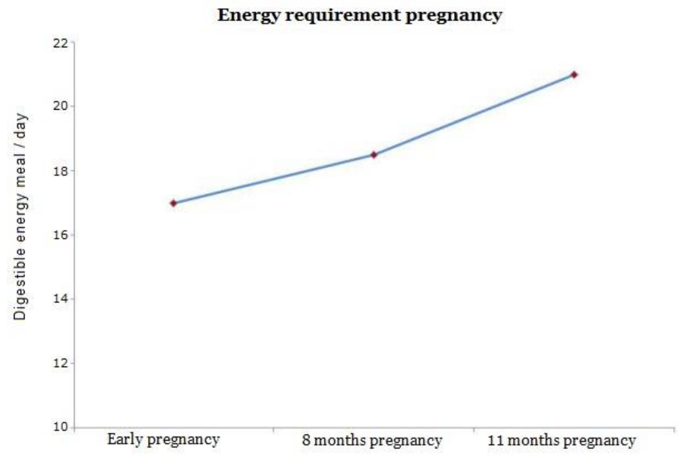
Feeding of mares should be carried out according to its physiological status

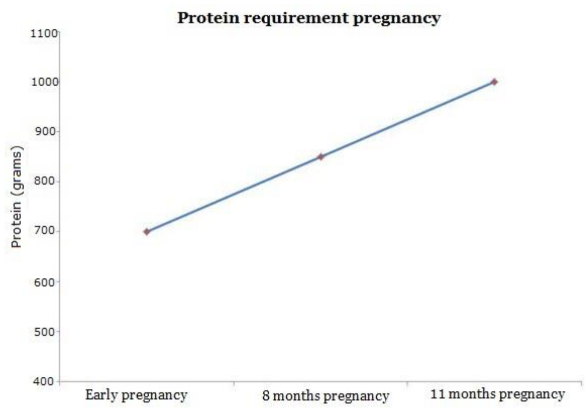
- Nutrients such as energy, protein, calcium, phosphorus, iodine, copper, zinc, manganese and vitamins A, D and E. are important especially for the pregnant and lactating mare.
- Good quality pastures or feeding high quality hays can meet the nutrient requirement of mares.
- Where pasture availability is limited, mares have to be supplemented with hay.
- Grain supplementation can be done when energy needs increase or if hay quality is not good.
- Additional calcium, phosphorus, trace mineral and vitamin needs can be met by providing a suitable mineral/vitamin supplement.

FEEDING OF PREGNANT MARES

- During early to mid-gestation the nutrient demands of the developing fetus are minimal. Growth of the foal ranges 90 to 220 g per day. Therefore, the mare's nutrient requirements in early to mid-gestation are similar to a mature, idle horse at maintenance.
- During late gestation the foal is growing at an accelerated rate of 350 to 450 g per day. To support this growth, the mare's energy and protein requirements increase.
- Fetal uptake of minerals is greatest during the last three months of gestation, so the mare's calcium and phosphorus needs increase substantially.
- The elevated energy and protein requirements of a mare in late gestation can be met by increasing the amount of mixed hay containing leguminous species and grass .
- Supplementing cereal grains and protein supplements is also done.
- Adequate intakes of minerals and vitamins are also provided with an appropriate mineral or vitamin supplement.

The following graphs illustrate the variations in energy and protein requirements in mare at different stages of pregnancy





FEEDING OF LACTATING MARES

- Mares at time of lactation should have a good body condition. Underfeeding mares during lactation can lower milk production, ultimately affecting the growth of foal. A thin body condition will also decrease the mare's ability to be rebred.
- In addition to its own needs, the mare has to produce 2 to 3 per cent of her body weight per day as milk.
- The mare also has to be rebreed after foaling.
- The energy and protein needs increase 75 to 100 per cent.
- The lactating mare needs three times more calcium and two and a half times more phosphorus as needed in early gestation.
- When grass hay alone is fed, a protein and energy supplement should be used.
- Increased mineral needs can be met by providing a mineral mixture, along.
- The mare's nutrient requirements begin to decline in the fourth, fifth and sixth months of lactation, as milk production declines.
- The ration can be altered decreasing the grains gradually.
- Once the foal is weaned, the dry, pregnant mare can be managed as an early gestating mare once again.

FEEDING OF WORKING HORSES

Example of ration for 500 kg horses performing light work

1. Alfa alfa / grass hay – 7 Kg
2. Crushed oats / barley – 2 Kg

3. Mineral mixture – 30 g
4. Iodised salt – free choice

Example of ration for 500 kg horses performing moderate work

1. Alfa alfa / grass hay – 8 Kg
2. Crushed oats / barley – 3 Kg
3. Mineral mixture – 30 g
4. Iodised salt – free choice

Example of ration for 500 kg horses performing intense work

1. Alfa alfa / grass hay – 9 Kg
2. Crushed oats / barley – 4.5 Kg
3. Oil – 500 g
4. Mineral mixture – 30 g
5. Iodised salt – free choice

Requirement per day

Working Horse	DE (Mcal)	CP (g)	Ca (g)	P (g)
Light exercise	20	750	30	18
Moderate exercise	23	850	35	21
Heavy exercise	27	950	40	29

Feeding of Race Horses

- Each horse is an individual, and their needs are influenced by breed, living conditions, build, work level, and age.
- For horses performing light work for two or three hours per day their energy requirements increases 50% above maintenance.
- If a horse performs moderate work such as fast trotting, cantering, jumping, etc. for four or five hours a day, the energy requirement is increased 70% above maintenance.
- In such horses it is not possible to meet the energy needs by feeding roughage alone.
- Further horses after several hours of work do not eat enough.
- Hence the energy density of the ration has to be increased.
- Cereal grains or concentrate mixture can be supplemented.
- Adding fat to the ration up to 10% also increases the energy density.

When to feed before riding

- High intensity work
  - remove hay four hours prior to competition
  - Feed grain four hours before competition.
- Light to moderate intensity work
  - remove hay four hours before riding
  - adapt horse to eating smaller quantity of ration spread throughout the day
  - Feed grain four or more hours before riding.

- Long distance races
    - Allow free access to hay right up to the competition.
    - Allow access to hay even during the ride.
    - Feed large quantity of grains / concentrate mixture four hours before the ride.
    - feed smaller quantity of grain throughout the ride

The performance horse uses 80–90% of its feed for energy metabolism. The muscles can actually be trained to use energy substrates (carbohydrates and fats) more efficiently.

There are two general muscle fiber groups:

- Fast twitch muscle fibers
- Slow twitch muscle fibers

Glycogen (carbohydrate) is the stored form of energy that hard-working fast twitch muscle fibers use most.

Research has shown that glycogen can be increased by 33% during a conditioning program of 10 weeks.

Slow twitch fibers are associated with endurance-type activities. Endurance conditioning can increase the aerobic capacity, or ability to deliver and utilize oxygen and energy-rich fatty acids.

Anaerobic exercise, or speed work

- Stored muscle glycogen is the predominant source of fuel for high-intensity speed work.
- At high speeds muscle glycogen metabolism occurs at a rate that limits the use of oxygen in the fuel-burning process.
- Anaerobic glycolysis, or the burning of glycogen without oxygen, is inefficient and results in the production of lactic acid.
- Although researchers no longer believe that lactic acid is the main cause of fatigue, they still believe it is one factor leading to fatigue.

Energy Requirement for Physical Activity
(In addition to Maintenance Requirement)

Physical Activity	**Mcal / Hour / 45 Kg Body weight**	**TDN / hour / 45 Kg Body weight**
Walking	0.02	4.53
Slow Trot	0.23	54.36
Fast Trot and Cantering	0.57	99.66
Cantering and Galloping	1.05	240
Strenuous effort	1.77	403.17

Aerobic exercise

- Energy for aerobic exercise is derived from glycogen and stored body fat and/or free fatty acids.

- These fuels are burned efficiently in the presence of oxygen with little buildup of lactic acid.
- While aerobic exercise is more efficient, it can result in glycogen depletion and fatigue if the work is prolonged.

Oxidative Stress

Oxidation provides energy for maintenance of cellular integrity and functions. Most of the consumed oxygen forms carbon dioxide and water; however, 1 to 2% of the oxygen is not completely reduced and forms reactive oxygen species (ROS). Exercise can create an imbalance between oxidant and antioxidant levels, a situation known as oxidative stress. Acute exercise in untrained subjects may increase oxidative stress. Long-term exercise may counter this effect by increasing the activity of antioxidant enzymes and reducing oxidant production.

The extent of the oxidative stress dependent on;
- Ambient temperature,
- Conditioning level of the horse,
- Intensity of work.

To counter act oxidative stress conditioning ie training the horse is important. Supplementation of antioxidants also helps in counteracting the problem.

Azoturia

A muscular disorder also called as;
- Equine Rhabdomyelosis
- Monday Morning Disease
- Tying-Up
- Paralytic Myoglobinuria
- Myositis
- Setfast

It is a condition that affects the muscles of horses, ranging from stiffness and mild cramps to the horse becoming unable to stand with discoloured urine.

Azoturia can occur due to carbohydrate overloading;
- Draught horse in work that is rested or the weekend on full feed, then when the horse returns to work several days later it suffers an attack of the disease.
- Muscle glycogen accumulates during the rest period and when used during exercise it produces excessive lactic acid.
- This causes local tissue damage and constriction of the blood vessels,
- Resulting in decreased blood flow to the tissues and further reduction in lactic acid removal.

LABORATORY ANIMALS

There are a number of factors that determine the nutrient requirements of laboratory animals such as:

- Type of animal - herbivore, carnivore or omnivore
- Species
- Sex
- Age
- Physiological status

Laboratory animals include Guinea pigs, rats, mice, hamsters and rabbits are all rodents, they have some distinct differences in their dietary requirements due to the diverse habitats from which they originate.

General guide lines

There are a number of requirements that must be assessed when determining what to feed a laboratory animal, such as:

- Is it a herbivore, carnivore or omnivore?
- Is it a monogastric, a foregut fermenter (ruminant) or a hindgut fermenter?
- Does it require certain nutrients in its diet, such as vitamin C?
- What is the animal's function (growth, reproduction, etc.)?
- What are the requirements of the experiment?

The food selected must be a balanced diet, providing all required nutrients. Most feeds are processed so that the animal cannot select out a preferred food. This food selection may result in an unbalanced diet and may lead to osteoporosis in rodents. Ground food has a large surface area and is easily digested. It can also, however, spoil rapidly. Most rabbit and rodent food is pelleted--large hard pieces must be gnawed, helping to wear down their open-rooted teeth. Rodents often hoard food, hiding it under bedding, making it difficult to assess how much food is being eaten.

Most feeds contain supplemental vitamins and minerals. Some diets have antibiotics or other drugs added during their manufacture. It is important to ensure that there are sufficient additives present in feed that will be heat-sterilized, because some loss of the additives will occur during the sterilization process.

Food should be stored in a room dedicated for that use. It should be cool (4° C) and well-ventilated. Feed should be located off the floor, on pallets or shelves. If the food contains supplemental vitamin C, which is unstable, it should be used within three months of milling.

Animal diets should be changed gradually to avoid gastrointestinal disturbances. Begin by adding a few pieces of the new diet to the old, and slowly increase the amount of new food and decrease the amount of old diet. Diarrhea or anorexia (loss of appetite) may occur in response to a sudden change in diet. It is important to be able to recognize signs of nutrient deficiency. Animals that are dehydrated may have: Dull dry hair coat, decreased skin pliability, dry mucous membranes, anorexia and decreased urine and feces output. Animals that are starving can be recognized by weight loss and a prominent skeleton. Nutrient deficiencies can produce a wide variety of clinical signs, from deformed bones to bleeding gums.

NUTRIENT REQUIREMENT IN DIETS FOR RAT AND MICE

Physiological characteristics of rat and mice include;

Characteristics	Rat	Mice
Birth Weight	4 - 5 g	0.5 - 1.5 g
Eyes open on	14 - 16 days	13 - 15 days
Weaning age	21 days (35 g)	21 days (10 - 12 g)
Gestation period	21 days	20 days
Adult Body weight	190 - 200 g	20 - 30 g

- The following table gives the nutrient requirements for diets of rat and mice.
- The high BMR of these animals causes their high need for energy.
- The protein requirement is higher for mice than rat. The quality of protein also should be good.

Gross composition of diets for rats and mice

Nutrient	Rat		Mice
	Maintenance	Growth /Gestation/ Lactation	
Metabolisable energy Kcal/kg	3800	3800	3800
Protein %	12	18	18-20
Fibre %	5	5	5
Methionine %	0.2	0.6	0.5
Lysine %	0.1	0.7	0.4
Calcium %	0.5	0.5	1.2
Phosphorus %	0.4	0.4	0.9
Iron mg/kg	35	35	255

- Rats and mice are omnivores they eat primarily plant material but are also know to eat some meat products.
- They possess continually growing incisors which wear down.
- Good-quality fresh, clean water must be readily available at all times.
- Pellets are preferred. The pellets should be 3-4 mm in diameter and no longer than 8 mm.
- Diets containing seeds and nuts are not recommended because they contain too many fats and oils, provide inadequate protein levels and are not necessarily balanced.

Food-delivery system

- The food can be "dispensed" from a specially designed wire or mesh cage top that provides a generous depression into which the dry food is supplied and through which the food can be eaten.

Feed intake rat and mice

- Adult mice will eat 4-5 g of feed per day (12% BW)
- Adult growing rats will eat 12-15 g of feed per day (8 - 10% BW)
- Pregnant rat will eat 15 – 20 g of feed per day
- Lactating rat will eat 30 – 40 g of feed per day.

Type of feed

- Pellet feed preferred due to gnawing
- Pellet size - 3-4 mm in diameter and no longer than 8 mm.

BIS specifications for compounded feeds for laboratory mice and rats

S. No	Characteristic	Requirements
1.	Moisture (Max)%	10
2.	ME (Min) Kcal/Kg	3800 - 4100
3.	Crude protein (Min)%	24
4.	Crude fat (Max)%	5
5	Crude fibre (Max)%	6
6.	Total Ash (Max)	9
7.	Acid insoluble ash (Max)%	1
8.	Calcium (Min)	0.6
9	Available phosphorus (Min)	0.3

DIET PREPARATION

- The feeding of rat, mice and guinea pig can be by using of three types of diets they are
- *Natural diets:* This diet is prepared from natural ingredients. It comprises of a blend of cereals, legumes, oilcakes, fruits, vegetables, roughages etc
- *Semi synthetic diets:* This diet is prepared from a combination of natural ingredients and is purified (starch, sugar, casein, fat, vitamins and minerals).
- *Synthetic diets or purified diet:* It is prepared from a combination of purified protein, amino acids, carbohydrates, fats, minerals and vitamins.

- **Germ free diet** is a diet meant for germ free or gonobiotic or specific pathogen free animals and is prepared in a sterile form.

Sample diet

- A sample diet that could be prepared for feeding rat and mice is given below;

Ingredient	Quantity (g)
Ground wheat	230
Wheat middling	100
Ground corn	245
Corn gluten meal	30
Soyabean oil	25
Dehydrated alfalfa meal	40
Soyabean meal	120
Fish meal	100
Dried molasses	35
DCP	12.5
Ground limestone	5
Iodized salt	7
Salt	5
Non fat dry milk solids	50

GUINEA PIG FEEDING

- Guinea pigs are herbivores and require plenty of grass hay and greens and limited concentrate.
- They have continuously growing incisors and molars which wear down with the normal action of eating.
- Guinea pigs produce nutrient rich cecotropes which they eat directly from the anal area.

NUTRIENT REQUIREMENT FOR GUINEA PIG

- The Guinea pig is a herbivorous animal. It is a hind gut fermenter and practices coprophagy.
- The following is the nutrient requirement for a guinea pig diet

- ME (Kcal/kg) - 2800
  - Protein (%) - 18
  - Fibre (%) - 15
  - Calcium (%) - 0.8 - 1.0
  - Phosphorus (%) - 0.4 - 0.7
  - Zinc (mg/kg) - 20
  - Iron (mg/kg) - 50
  - 1 gram of **vitamin C** per kilogram of ration has to be supplemented as Vitamin C is dietary essential in guinea pig.

Guinea pig feed

- Generally ration for guinea pigs contains 18-20% protein, 16% fiber and about 1 gram of vitamin C per kilogram of ration.
- On storage of feed about half of the vitamin C content is degraded and lost within 6 weeks of manufacture.
- Dark leafy greens are important to guinea pigs due to their requirement for an external source of vitamin C.
- The minimum daily requirement for vitamin C in the guinea pig is 10-30 mg per day.
- Guinea pigs can easily get this amount with the feeding of 1/2 to 1 cup of fresh leafy greens daily.
- Supplementing vitamin C in the water is not very effective due the rapid breakdown of the vitamin when it is exposed to light and heat and the fact that some vitamin C products have a very bitter taste.

Water

- It is to be kept free from contamination by providing it in water bottles. Guinea pigs contaminate and clog their water bottles by chewing on the end of the sipper tube and "backwashing" food particles into it.
- Guinea pigs do not tolerate changes in the presentation, taste, odour, texture or form of their food and water.
- Any changes in the food itself should be made gradually.

Recommended nutrient allowances for growing guinea pigs

Nutrient content		**Sample Diet**	
ME (Kcal/kg)	2800	Ingredient	g/Kg
Protein (%)	18	Alfalfa meal	350
Fibre (%)	15	Ground wheat	236
Calcium (%)	0.8-1	Ground oats	252.5
Phosphorus (%)	0.4-0.7	Soyabean meal	120
Zinc (mg/kg)	20	Ground limestone	10
Iron (mg/kg)	50	Iodized salt	7.5

		DCP	5
		Soybean oil	15
		Minerals and vitamins	4

Feed Consumption

- Average DM intake: 7 – 8% of B.Wt.
- Growing guinea pigs: 20 -30 g
- Adult guinea pigs: 30 – 50 g
- Pregnant and lactating: 40 – 60 g

RABBIT FEEDING

- The rabbit is a monogastric herbivore, hindgut fermenter, practicing coprophagy.
- The following table gives the nutrient requirements for different categories of rabbits.
- The energy requirement expressed as DE or ME. Protein is expressed as crude protein.
- Rabbits are able to tolerate up to 15% crude fibre.
- Rabbits are herbivores and require plenty of roughage and limited concentrates. They have continuously growing incisors and molars which wear down with the normal action of eating.
- As in guinea pigs they produce nutrient rich cecotropes which they eat directly from the anal area.

The colon uniqueness

- The proximal colon has dual function, if the contents of the caecum enter the colon in the early morning, they undergo few chemical changes and purely become pellets coated with mucus. These pellets gather into clusters and are known as soft or night pellets or *Caecotrophes.*
- At other times of the day the solid part of the food containing fibres over 0.3 mm long forms hard pellets and is excreted. Hard pellets are expelled directly, but the soft pellets are recovered from the anus immediately upon being expelled.
- To do this, the rabbit twists itself around, sucks in the soft faeces, and then swallows them without chewing.
- By the end of the morning there are large numbers of these pellets inside the stomach which comprises almost ¾ of the total contents. Soft pellets follow the same digestion pattern as normal feed.
- Some parts of the feed may be recycled up to 4 times. This process of recycling faeces in order to fully digest the feed is known as *caecotrophy***.** The soft pellets are mucus-coated.
- Half the pellets consist of imperfectly broken-down food and gastric secretions The other half consists of bacteria - contain a large amount of high-value proteins and water-soluble vitamins.

Nutrient requirements rabbits (NRC, 1977)

	CP (%)	**DCP (%)**	**Fat (%)**	**Fiber (%)**	**Digestible Carbohydrates (NFE, %)**	**TDN (%)**	**DE (Kcal/ Kg)**
Maintenance	12	9	1.5-2	14-20	40-45	50-60 (55)	2100
Growth and finishing	16	12	2-4	14-16	45-50	60-70 (65)	2500
Pregnancy	15	11	2-3	14-16	45-50	55-65 (58)	2500
Lactation (with litter of 7-8)	17	13	2.5-3.5	12-14	45-50	65-75 (70)	2500

Feeding rabbits through their stages of development

- Rabbits need to be fed differently at different stages of their growth to ensure healthy development, digestion, and weight. Throughout a rabbit's life, avoid any sudden changes in diet; new foods should always be introduced gradually.
- Fresh clean water should be available at all times. Water bottles are recommended.

Feeding kits

- A baby rabbit or kit, feeds solely on its mother's milk for about the first three weeks. During the first few days, the milk contains high levels of antibodies that help protect the kit from disease.

Energy and Protein requirement of Rabbits (ICAR, 2013)

Nutrient	Growing	Matured	Gestation	Lactating
CP (%)	18	14	18	19
DE (Kcal/Kg)	2700	2200-2300	2700	2700

- After three weeks, the kit will begin nibbling on any feed offered to its mother. By 7 weeks of age, kits can be fed feed similar to that of an adult. Weaning is practiced by 8 weeks of age.

Feeding Juveniles

- Between weaning and 7 months of age, the young rabbit can have an unlimited amount of feed both roughage and concentrate.

Feeding young adults

- Young adult rabbits from age 7 months to 1 year should be introduced to grass/ hays, and it should be available all day long. At this stage they will require little concentrate.

Mature adults

- Mature adult rabbits should be fed hay/grass. The concentrate can be reduced in maintenance rabbits.

Feeding pregnant and lactating does

- Hay / grass is fed ad libitum and concentrate can be fed up to 200 g /doe /day

Feed intake of Rabbits

- Growing rabbits (After weaning) - 100g
- Resting Does - 150g
- Does in Gestation - 250g
- Nursing Does (until litter is 3 weeks of age) - 250g
- Does with litter of 7 or 8 (3 to 8 weeks) - 1000g

For maintenance is 3.8 to 4% of body weight per day and it increases based on growth and production.

Feedstuffs commonly used for rabbits

- Green feeds - grasses, weeds and leafy vegetable
- Root crops - carrots, sweet potatoes, turnips and beets.
- Cereal grains - oats, wheat, barley, sorghum, corn and rye.
- Milled feed - bran
- Hays - alfalfa, clover,
- Protein supplements -soybean meal, peanut meal and dried milk products.
- Salt.

Complete feed for rabbits

- Rabbits can be fed complete feeds in a pelleted form given below is an example of ingredient composition of complete feed. Consist of cowpea / Desmanthus hay-30%, maize grain-28%, DORB-25%, Groundnut cake -15%, Min mix-1.5% and salt-0.5%.
- This feed provides a TDN of 68% and DCP of 16%.

Chewing items

- A feed that requires little chewing produces uneven tooth wear, causing enamel to grow on the sides of the teeth. These spikes can cause severe oral pain and excessive salivation.
- They also cause reluctance to chew, inability to close the mouth, and reduced food intake. In addition to roughages rabbits can be provided with chew sticks made of wood or any safe material.
- **Feed efficiency** for rabbits is 4:1 at 10 weeks old stage.

FEEDING OF PET ANIMALS

The basic nutrient requirements of dogs and cats is similar to those of all animals; energy, protein, vitamins, minerals and water. However, companion animals, and in particular cats, have a unique suite of requirements. Also, the objective of companion animal nutrition is to maintain a healthy pet for many years, unlike many other domestic animal species.

WATER

No amount of nutrients will be useful to an animal that is deprived of water. An animal can survive the loss of almost all of its body fat and more than half its protein; but a loss of 10 to 15% of the body's water is fatal. As domestic animals often have restricted access to water, it is important from a management perspective that we know what the daily water requirements are. From a health perspective, it is equally important to be able to assess whether an animal's voluntary water intake is normal.

The daily water requirement (ml) for a sedentary dog in thermo-neutral environs is approximately 2 to 3 times its DM food intake (g), or approximately 50 to 60 ml per kg BW. Cats have a greater capacity to concentrate their urine, and therefore require less than this amount.

Increased water losses must be compensated for by increased water intake. The following list summarises the main factors that will increase the body's daily requirement for water:

- Increased physical exercise (panting, increased food intake)
- Increased body temperature (panting, evaporation)
- Increased environmental temperature (panting)
- Lactation (water lost in milk)
- Illness (water losses from diarrhoea and vomiting)
- Inability of the kidney to concentrate the urine

It should be noted that significant water losses can result from panting in hot weather as this is a normal mechanism for dissipating heat in both dogs and cats.

ENERGY REQUIREMENT

The objectives of maximum weight gain and feed conversion efficiency do not generally apply to companion animals; rather our objective is to maintain ideal bodyweight.

There are two sides to the energy balance equation: energy intake from ingested food on the one hand, and energy expenditure on the other. When energy intake exceeds energy expenditure, the result is weight gain. Maintenance of bodyweight is achieved when there is a perfect balance between intake and expenditure, such that the animal's exact energy requirements are met, but not exceeded. The body's energy requirements do not remain constant, and fluctuations in energy intake are not automatically accompanied by corresponding changes in energy expenditure.

Energy Intake > Energy Expenditure = Weight Gain
Energy Intake < Energy Expenditure = Weight Loss
Energy Intake = Energy Expenditure = Maintenance of Bodyweight

While cats and dogs pancreatic and intestinal tissues can and do produce amylases that are fully capable of digesting carbohydrates, the lack of salivary amylase reminds us that nature did not intend carbohydrates to be their primary source of nutrition.

Maintenance energy requirement (MER) is the energy required for the body's internal metabolic processes, plus the energy needed to obtain and utilise food and maintain bodyweight in a thermoneutral environment. To maintain ideal bodyweight, dogs and cats are fed amounts calculated to meet their individual maintenance energy requirements (MER), and based on the metabolisable energy (ME) of the diet.

Calculating energy requirements for dogs is problematic, due to the vast range of bodyweights and sizes in this species. Several predictive equations have been proposed, all of which utilise metabolic bodyweight (the bodyweight raised to a specified power) which gives a better estimation of energy requirements for dogs. Cats, on the other hand, do not vary greatly between breeds, allowing their energy requirements to be expressed on a bodyweight basis.

Nutrients for energy

The nutrients that provide the body with energy are carbohydrates, fats and proteins. They are utilised as energy sources to varying degrees by different species, in different circumstances, and produce different end products. Fats are the preferred energy source for dogs, and they have a greater capacity to metabolise fats than most species; metabolising free fatty acids at twice the rate of humans. Cats, on the other hand, rely primarily on protein for their energy needs. Carbohydrates, although an important component of most canine diets and some feline diets, and a useful source of energy, are not essential for dogs and cats.

Carbohydrate metabolism

All animals have a metabolic requirement for glucose, which can be supplied by endogenous synthesis, or from dietary sources of carbohydrates. Although not an essential nutrient for dogs and cats, carbohydrates are well utilised and digested in both these species, providing a useful source of energy and glucose. Carbohydrates in the canine diet can reduce the requirement for dietary protein which might otherwise have been utilised to meet its energy needs. Glucose is produced endogenously in the liver and kidneys from amino acids, glycerol, propionic and lactic acids by gluconeogenesis. These gluconeogenic pathways are said to be active at all times in cats and other carnivores, enabling the cat to maintain normal blood glucose levels during prolonged periods of fasting.

Calculating Maintenance Energy Requirements (MER) and Protein requirement

The following equations can be used to calculate MER (kcal ME per day) for adult dogs and cats:

Dogs: Energy MER = 115 x BW (kg) $^{0.75}$

Maintenance Energy Requirement (MER) to obtain daily energy requirement for Dogs

Activity	Details	Energy Requirement
Work	1 hour light work (hunting)	1.1 x MER
	1 full day light work	1.4 – 1.5 x MER
	1 full day heavy work (sled dog)	2 – 4 x MER
Inactivity	Inactiveness	0.8 x MER (dog)
Gestation	First 6 weeks	1 x MER
	Last 3 weeks	1.1 – 1.3 x MER
Peak lactation	3 - 6 weeks	[1+0.25(No. in litter)] x MER =2 – 4 x MER
Growth	Birth to 3 Months	2 x MER

	3 - 6 Months	1.6 x MER
	6 - 12 Months	1.2 x MER
	3Months to 9 Months (Giant dogs)	1.6 x MER
	9 Months to 24 Months (Giant dog breeds)	1.2 x MER
Cold	Wind chill factor of 8.5°C (47°F)	1.25 x MER
	Subfreezing wind – chill factor	1.75 x MER
Heat	Tropical Climate	Up to 2.5 x MER

Protein requirement

Growing puppies = 12.2 g/ $kgW^{0.75}$

Adult dog = 3.28 g/ $kgW^{0.75}$

Late pregnancy and peak lactation bitch

Small size bitch (2 puppies) = 10 g/ $kgW^{0.75}$

Medium size bitch (6 puppies) = 20 g/ $kgW^{0.75}$

Large size bitch (8 puppies) = 25 g/ $kgW^{0.75}$

CATS

Maintenance Energy Requirement (MER)

For sedentary cats, MER = 70 kcal / kg $BW^{0.67}$

For moderately active cats, MER = 80 kcal / kg $BW^{0.67}$

For very active cats, MER = 100 kcal per kg $BW^{0.67}$

Growing kitten

Rapidly growing (up to 4 months) = 2.0-2.5 x MER

Actively growing (4 to 9 months) = 1.75-2.0 x MER

Growing (9 to 12 months) = 1.5 x MER

Pregnant and lactating Queens

Pregnant Queen = 140 kcal / kg $BW^{0.67}$

Lactating Queens = MER + 60 x kg BW x 1.2 (3-4 kittens at 3-4 wks of lactation)

Protein requirement

Growing kitten = 11.8 g/ $kgW^{0.67}$

Adult cat = 5 g/ $kgW^{0.67}$

Late gestation = 7.4 g/ $kgW^{0.67}$

Peek lactation = 16 g/ $kgW^{0.67}$

Fat requirements

For maintenance =1.8 g / $kg^{0.75}$

For growth = up to 15.7 g / $kg^{0.75}$

FEEDING OF DOGS

The domestic dog is an opportunistic feeder, with the ability to adapt to a wide variety of foodstuffs when required. The dentition of the domestic dog is consistent with a more omnivorous diet and this is reflected in its nutritional requirements compared with those of the carnivorous cat. The dog has a lower protein requirement than the cat and is able to convert beta-carotene to active vitamin A, and linoleic acid to arachadonic acid, enabling the dog to meet these particular nutrient requirements from plant sources, whereas the cat cannot. Additionally, it appears that the dog (but not the cat) is able to meet its taurine requirement from dietary sulphur amino acids supplied by plants. From this we can infer that it is possible for the dog to subsist on a diet based on plant ingredients, whereas the cat, an obligate carnivore, cannot gain all of its essential nutrients from plant sources.

Minimum recommended nutrient levels for dog foods (FEDIAF, 2011)

Adult dog		**% on DM basis**	**Growing pups and reproduction**	**% on DM basis**
Crude protein	-	18	Crude protein	25
Fat	-	5.5	Fat	8.5
Crude fibre	-	3.5-6.0	Crude fibre	3.5-6.0
Linoleic acid	-	1.32	Linoleic acid	1.30
Calcium	-	0.5	Calcium	1.0
Phosphorus	-	0.4	Phosphorus	0.9
Vitamins and minerals balanced			Vitamins and minerals balanced	

TYPES OF DOG FOOD

Although dog food doesn't come in as many shapes, colors, sizes, and flavors as human food, there are still quite a few varieties to choose from. No matter which type you choose, the most important factor is that a food that meets all of the dog's nutritional needs.

There are five main types of dog food:

1. Kibble/Dry

Dry food is the most economical type of commercial dog food, and this is the reason that many owners choose it for their dog. It also lasts for a long time and does not need to be refrigerated. Dry food can also help to keep your dog’s teeth healthy, since chewing crunchy dry food helps to reduce tartar buildup. When it comes to choosing a specific dry food, read the ingredients carefully, and choose a brand that uses wholesome food as its primary ingredient.

2. Canned

Most dogs love canned, or wet, food; it has a long shelf life, but it can be expensive. But not every brand of commercial canned food provides the protein that your pup needs. The real question is how much digestible protein it provides. Indigestible protein will pass through your dog’s system without being broken down into absorbable nutrients, so it's pretty much useless to him.

Also, most canned food is about 75 percent water. The higher the water content, the less nutrient content, so the more food your dog must consume in order to get the nutritional value his body needs. If you decide to feed your dog canned food, it's best to go with a kind that's labeled "100% nutritionally complete."

3. Semi-Moist

Commercial dog foods shaped like pork chops, burgers, or other meaty foods are called semi-moist foods. These kinds of foods are the least nutritional of all dog foods and contain many artificial flavors and colorings. It can be given to dog as an occasional treat, but they should not be considered a diet in themselves, as they do not provide the nutrition that your pup requires.

4. Home Cooked

Some dog owners value the ability to be in complete control of their dog’s diet. A home-cooked diet allows the owner to know for certain exactly what is in everything her dog eats and to be absolutely sure that his nutritional needs are being met. Feeding a dog with a home-cooked diet is time consuming and expensive, but many owners think the extra effort is worth the peace of mind they gain. A home-cooked diet should be prepared to contains all vital nutrients.

5. Raw

A raw diet consists of raw meat, preferably with some bones (never cooked bones, only raw) and organs mixed in, as bones are a natural source of phosphorus and calcium. This type of diet works well for many dogs, since dogs have short intestinal tracts and strong stomach acids, both of which make it easy for them to consume and digest raw food.

Composition of commercial pet foods

Nutrients	**Dry foods**	Soft-moist	***Canned diet***
Moisture (%)	<12	30	75
Fat (%)	7-15	5-10	2-15
Protein (%)	18-27	16-25	8-15
Carbohydrates (%)	35-50	25-35	-
M E (Kcal/kg)	3000-4400	2600-3000	850-2100
Palatability	Moderate	Moderate-high	High
Cost	Low	Moderate-high	High

FEEDING OF PUPPIES

- Up to eye opening (7-10 days)- Mother milk
- Up to 3-4 wks- Mother milk is sufficient which stimulate GIT development
- Weaning from 5-6 wks of age onwards
- Weaned puppies are gradually shifted to artificial feeding of milk based semi-solid or liquid diet
- Cow milk as such induces diarrhea in puppies due to higher lactose content
- Eggs are added to dilute the lactose concentration of the milk.
- Milk substitute for orphaned puppies

Cow milk	800 ml
Cream	200 g
Egg yolk	1 no.
Steamed bone meal	6 g
Vitamin A	2000 IU
Vitamin D	500 IU
Citric acid	4 g

Age of the puppy	Frequency
1 week	12 times
II week	8 times
III & IV week	6 times
V week	3 times
VI week: Weaning and introduces semi moist or liquid diet containing 25-30% dry matter should be fed @ 15% of its body weight	

Diet chart for growing puppies (5 kg b.wt) ME-400 kcal; CP-40 g

Ingredients	Balanced diet I	Balanced diet II
Milk	300 g	200 g
Egg	100 g	50 g
Wheat	50 g	-
Pulses	50 g	-
Beans	50 g	-
Meat	-	125
Rice	-	75

Feeding schedule for dogs: A guide chart

Body weight, kg	Cereals, g	Meat, g*	Milk, g
2-5	100-200	50-100	125-150
5-10	200-300	100-200	150-250
10-20	300-500	200-400	250-400

*The meat portion of the diet may be completely avoided by including 1-2 eggs and pulses/oilseeds. Vegetables may also be added to meet the requirement of fibre and micronutrients.

NUTRITIONAL IDIOSYNCRASIES OF THE CAT (Peculiarities of Feeding Cat)

The evolutionary history of the cat suggests that felids have adhered to a strictly carnivorous diet for many millions of years, and have developed specific metabolic adaptations as a result. This has manifested in unique nutrient requirements, some of which can only be obtained naturally from the flesh of animals.

The unique nutritional requirements of cats that differentiate them from dogs, and are of practical importance, can be summarised as follows:

- High protein requirement
- Taurine is an essential amino acid (limited ability of liver to synthesis)
- Require preformed vitamin A (lack of enzyme to convert Beta carotene to Vit A)
- Require arachadonic acid (Unable to synthesis from linoleic acid)
- Unable to synthesis niacin from tryptophan

- The high protein requirement in cats is partly due to their unique energy and glucose metabolism; but also to their requirement for a higher dietary intake of specific amino acids such as taurine, arginine, methionine, and cysteine. Cats use protein as an energy source as well as for other metabolic processes (eg urea cycle) even when dietary protein is restricted.

- Dietary intakes of taurine are essential for the cat because it is not able to synthesise adequate quantities from the usual precursors (methionine and cysteine). Further, endogenous taurine losses are greater in cats as they conjugate bile acids using only this amino acid. Preformed vitamin A (found naturally only in animal tissues) must be included in feline diets as the cat is not able to convert beta-carotene to active vitamin A.
- Unlike most other species, cats are not able to convert linoleic acid to arachadonic acid, and therefore have a dietary requirement for this nutrient also.

Taurine deficiency in cats

Deficiency of taurine will also lead to a weakening of the muscle cells in the heart, causing a condition called dilated cardiomyopathy (DCM). Taurine-depleted cats develop retinal degeneration (Feline corneal retinal degeneration (FCRD), altered white-cell function, and abnormal growth and development and reproductive failure.

Minimum recommended nutrient levels for cat foods (FEDIAF, 2011)

Adult cat		% on DM basis	Growing kitten and reproduction	% on DM basis
Crude protein	-	25	Crude protein	28-30
Fat	-	9.0	Fat	9.0
Crude fibre	-	3.5-6.0	Crude fibre	3.5-6.0
Linoleic acid	-	0.50	Linoleic acid	0.55
Calcium	-	0.59	Calcium	1.0
Phosphorus	-	0.50	Phosphorus	0.84
Vitamins and minerals balanced			Vitamins and minerals balanced	

Diet chart (ME-210 kcal; CP-10-12 g)

Ingredients	Balanced kitten diet (1 kg active)	Balanced cat diet (3 kg active)
Milk	130 g	140 g
Meat	35 g	25 g
Rice	15 g	20 g

FEEDING OF WILD CAPTIVE ANIMALS

In their natural environment wild species have little need for supplementary feeding as their free ranging habits enable them to pursue more nutritious grazing and therefore satisfy their nutritional requirements. But in case of Zoo animals their total feed requirements have to be met.

With the exception of zebra, elephants, rhinoceroses, hippopotamuses, the larger herbivorous game are classified as **ruminants.** Game species would (in the habitat to which they are adapted) select a diet with a digestibility in accordance with their feeding habits and are thus classified accordingly:

- **Bulk and roughage eaters (grazers**) characterized by capacious stomachs normally filled to capacity with relatively low-quality feed composed mostly of grass; Bulk grazers are defined as large, essentially grazing animals, which normally do not exercise a high degree of selection. Bulk eaters have most of the times the poor digestive efficiency. Relatively bigger rumen, omasumm, more feed retention time, higher cellulolytic bacteria, and protozoa Examples: cattle, buffalo, camel, African antelope sp.
- selectors of juicy, **concentrated herbage (browsers)** characterized by small stomachs normally filled to only 50-60% of their capacity, but with concentrated food composed mostly of leaves, flowers and fruits of forbs, shrubs and trees (**concentrate feeders**); Concentrate grazers are generally small animals (less than 200 kg mean individual live weight), which are predominantly grazers. However, they may include any grazing animal, which exercises some or other form of extreme selective defoliation. Browsers are animals, which feed mostly on the leaves, flowers and fruits of woody plants and forbs. Ex. Deer, giraffe, moose
- **intermediate feeders** (herbivores that eat both grass and leaves) which are not strictly intermediate between the previous two groups but have the ability to adapt in different seasons and places towards one or the other of the above two feeding types, i.e. they have greater ability to tolerate variations in the quality of their diet. Ex. Reindeer, gazelles

Adverse effects of malnutrition in captive animals

Malnutrition in captive animals results in

- Deficiency symptoms (due to mineral deficiency)
- Stunted growth
- Effecting the reproductive potential of animals
- Increased frequency in neonatal and post natal deaths
- Increased Disease susceptibility etc.

How to overcome it

In order to overcome problems related to the nutritional disorders the Zoo administration should formulate the diet chart of the animals and reviewing it periodically is very important. While formulating the diet chart for different animals care be taken on the following aspects.

A useful approach when formulating diets for wild animals is to consider their

- Dietary habits in the wild,
- Oral and gastrointestinal morphology and physiology needs of similar species whose requirements are known, and
- Environmental features that affect energy and nutrient need.

Collection of information on natural food preference provides an indication as to nutrient intakes and whether the diets are high or low in protein, fiber or secondary plant metabolites, which may influence acceptability, digestibility or metabolism.

The factors those should be considered before feeding the wild and zoo animals

- Description of the animal :
- Common and scientific name
- Normal body weight adult males and females
- Age at maturity
- Longevity in the wild and in captivity
- Description of the gastrointestinal tract
- Physiological needs like effect of seasonal changes, growth spurts in juveniles, weaning, old age etc.
- Digestive strategies (browser, grazer, carnivore etc.)
- Feeding ecology: Composition of the natural diet and its nutrient content
- Feeding behaviour

Oral anatomy and gastrointestinal tract morphology have a high correlation with natural diet.

Foregut fermenters -Ruminants (Herbivores)

The presence of a rumino-reticulum suggests that qualitative nutrient requirements are similar to those of cattle and sheep, with significant syntheses of amino acids and B-vitamins. (Cervidae / Antelope /Deer, Kangaroo, Giraffe, Camel)

Pseudo ruminants- Hippopotamuses

Hindgut fermenters (Monogastric herbivores)

If the gut has a cecum and sacculated colon, capacious enough to support microbial fermentation, nutrient needs are likely to be similar to those of the horse. (zebra, elephants, rhinoceroses)

Monogastric (Carnivores / Omnivorous / Vegetarian)

A simple stomach with limited lower gut space for microbial activity is similar to that of the pig.

Carnivores- *Canid species* (Wolf, Fox, Jackal), *Tiger, Lion, Leopard*.

Carnivores need the followings always, during feeding : -Preformed vitamin A - Taurine (an amino acid) - Arachidonic acid (an essential fatty acid)

Omnivores: Majority of feeds is from plant varieties Examples : -Rodents -Flying foxes -Bears and -Non-human primates

Feeding habits: The feeding habit varies from species to species. Chewing bones is a preferred activity among lions, tigers and jaguars and the activity is less in panthers. These carnivores prefer larger pieces of meat to alleviate hunger more readily than the smaller meat pieces.

Lions and tigers carry the beef pieces to one side of the cage before it sits for feeding. In lion, tiger and jaguar the posture of consumption was of extending the fore legs and holding the meat while the hind legs are tucked up within the body, where as in panthers all the four legs tucked up within the body. Wild dogs eat while they were in standing position in a hurried gulping manner.

Among the large felines like tiger, lion, panther and jaguar the time taken to consume the meat was from 15 minutes to 40 minutes in a very slow manner. Tigers soon after feeding they lick the cage wall few times and then drink water, where as in lions they drink water soon after feeding. After the weekly starvation in lions and tigers a characteristic restlessness was evinced by the sound and arrival of the food delivery vehicle.

Thus, one can extrapolate nutrient requirements from domestic species with known needs to wild species that are similar in dietary habits and gastrointestinal structure and function.

Wild / Captive wild animals

Herbivores		Carnivores	Omnivores
Ruminants	- Foregut fermenter	Canid sp.	Bear
Non-Ruminants	- Foregut fermenter	Felines	Birds
Monogastric	- Hindgut fermenter	Reptiles	Turtles
			Rodents
			Raccoons
			Primates
			Wild pig

Dry matter intake (as % of body wt) of wild herbivores

1	Elephant & Rhinoceros	1.0 - 1.5
2	Hippopotamus	1.5
3	Giraffe	1.6 - 2.1
4	Camel	1.7
5	Guar	2.0
6	Zebra	2.0 - 2.5
7	Llama	2.4

Diet Sheet for wild Animals

Type of Animal	Diet / Animal	Quantity/Day
Elephant	Ragi	6 kg
	Horse gram	4 kg
	Rice	1 kg
	Salt	200 g
	Jaggery	250 g
	Grass	200 g
	Sugarcane	8 Nos.
	Green Tree Leaves – Bamboo	100 kg
	Coconut	1 kg
	Banana	20 Nos.
	Banana stem (Weekly once)	1 No.
	Seasonal fruits Wood apple Water melon	 250 g 500 g
Hippopotamus	Wheat bran	10 kg
	White Bengal Gram	250 g
	Salt	250 g
	Apple	2 Nos.
	Potato	500 g
	Carrot	2 kg
	Cabbage	1 kg
	Onion	250 g
	Banana	10 Nos.
	Grass	**100 kg**

	Greens	**1 kg**
	Bread	800 g
	Multivitamin Mixture	50 g
Pheasants	Onion	25 g
	Greens	50 g
	Shell grit	10 g
	Sunflower seeds	10 g
	Green Gram	25 g
Camel	Wheat bran	1.5 kg
	Cattle feed	1.5 kg
	Banana	3 Nos.
	Cabbage	500 g
	Bengal gram	500 g
	Salt	50 g
	Greens	500 g
	Grass	10 kg
Lion and Tigers	Beef with bone	7 kg
	Liver	150 g

REPTILE DIET CHART

The lingual glands of Crocodylus porosus are functional salt glands which play an essential role in osmoregulation in salt water. **Lingual glands** are known to occur in several other Crocodylidae and Alligatoridae Crocodiles have the **most acidic stomach of any vertebrate**. They can easily digest bones, hooves and horns.

Food items	**Marsh Crocodiles**		**Gharial**
Fish (twice a week)	250 g		1.0 kg
Beef	250 g		-
Bone (vertebral column)	100 g		100 g
Food items / day	**Iguana**		**Star tortoise**
Carrot	50 g		30 g
Cabbage	50 g		30 g
Tomato	50 g		30 g
Green leafy vegetables	100 g		500 g
Food items / day	**Python**	**Viper**	**Cobra**
Chicken	1.0 kg, twice a month	3 nos. (chicks)	3 nos. (chicks)
Rat (each 150 g wt)	8 nos., twice a month	4 nos. weekly once	4 nos. weekly once

Captive birds

Altricial birds (nidicolous birds) are hatchlings which are helpless and featherless and require intensive care by their parents for a number of weeks before they are ready to confront the world. They are normally fed directly by a parent. **Pigeons** feed their chicks exclusively through regurgitation of "**crop milk"** during the first week. Crop milk is a special secretion originating in the crop containing 58.6% protein and 33.8% fat. These chicks are weaned onto nearly 100% grain by 2 weeks. **Parrots** are also altricial birds.

Precocial birds (nidifugous birds) are nearly ready to make it on their own as soon as they hatch. They will commonly follow the parent around searching for food. The parent in turn may provide instruction and protection for the young. **Ducks** are precocial birds.

Pet Bird Dietary Classification	Primary Diet	Examples
Florivore	Seeds, fruits, nuts, bark, roots, berries	Military macaw, Blue and gold macaw, Red-faced parrot
Granivore	Grains, seeds	Budgerigar, cockatiel, Hyacinth macaw
Frugivore	Mostly fruit and flowers; some nuts and seeds	Blue-throated macaw, Green-winged macaw
Omnivore	Seeds, fruits, insects, invertebrates	Sulpher-crested cockatoo, Red-tailed Amazon
Nectarivore	Nectar, pollen; some insects and seeds	Lorikeet, lory

Diet chart for peacock

Cabbage	25 g
Mixed grains	25 g
Paddy	100 g
White Bengal gram	50 g
Green gram	25 g
Greens	100 g
Garlic	10 g
Groundnut	50 g
Shell grit	10 g

METABOLIC DISORDERS AND NUTRITIONAL INTERVENTION

POULTRY

1. **Gizzard erosion**

   An obscure dietary-deficiency disease of young chickens marked by local lesions or extensive sloughing of the **gizzard** lining.

2. Round heart or Aortic rupture in Turkeys due to intake of high salt diet associated with ascites

3. **Cage layer fatigue (osteoporosis)**

   Pullets or hens reared in cages with insufficient dietary calcium, phosphorus, or vitamin D_3 may die suddenly or be found paralyzed from hypocalcemia while shelling an egg. This may be associated with high production and withdrawal of calcium from bones for egg shell production, in which case the main lesion may be osteoporosis.

4. **Proventricular hypertrophy**

5. **Fatty liver haemorrhagic syndrome (FLHS)** in caged layer chicken fed with high energy diet.
6. **Fatty liver and kidney syndrome (FLKS)** in young broilers due to deficiency of biotin and stress is also a factor.
7. **Gout, Urolithiasis** (Visceral gout, Articular gout, Baby chick nephropathy, Blue comb, Acute toxic nephritis, Renal gout, Kidney stones, Nutritional gout,)

   It occurs due to high intake of protein and calcium with less water intake leads to accumulation of uric acid as urates in visceral organs. Urine acidification can reduce urolith formation.

8. **Oily bird syndrome (OBS)** in broilers. Occur during hot climatic condition due to copper deficiency and higher vit A in the diet led to collagen structure abnormalities
9. **Skeletal deformities**

   Tibial dyschondroplasia (TD),
   Osteochondrosis
   Rickets (osteodystrophy)
   Chondrodystrophy (Perosis, Angular bone deformity, Valgusvarus bone deformity)
   Spondylolisthesis (Kinky back, Scoliosis)
   Femoral head necrosis (Brittle bone disease)
   Foot pad dermatitis (Pododermatitis)
   Turkey leg disorders

10. **Electrolyte imbalance** leads to either acidosis or alkalosis
11. **Pectoral myopathy**

    Deep ***pectoral myopathy*** (DPM) is a degenerative muscle disease of heavy chickens and turkeys commonly referred to as 'Green Muscle Disease result of a restriction in blood supply that develops in the tender mainly because the tender is surrounded by a tough inelastic muscle covering or membrane and the sternum.

12. **Heat distress**
13. **Sudden death syndrome (SDS)** Acute cardiac death, Acute-death syndrome, Flip-over Disease. Occur in fast growing broilers. Prevention by inducing period of initial slow growth. This can be achieved by reduction in day length, physical feed restriction and/or the use of low-nutrient dense diets. Economics will dictate the degree of early growth suppression to be implemented.
14. **Spiking mortality**

    Young broiler chickens develop hypoglycemia and become blind. Particularly, one should give due consideration to other stress factors like periods of poor or marginal feed availability, bird panting and or heat exhaustion during extreme hot weather.

15. **Ascites** (Right ventricular hypertrophy, Pulmonary hypertension syndrome, Water belly) occurs in broiler chicken, turkeys and duck due to cold climatic condition in fast growing birds.

HORSE

The term **Developmental orthopedic disease** (DOD) was first coined in 1986 to encompass all orthopedic problems seen in the growing horse and therefore encompasses all general growth disturbances of horses. Occur due to over feeding in foals led to fast growth.

Miller's disease / Bran disease/ NSHP/ Big Head disease

Foals fed excessive amounts of phosphorus (e.g. four times NRC recommendations, with limited exercise) tended to show lesions of dyschondroplasia, although there may be no clinical signs of **nutritional secondary hyperparathyroidism** provided adequate calcium levels are fed. Bran is rich in Phosphorus when fed to foal, affect calcium absorption led to hypocalcemia stimulates parathyroid gland which led to hyper trophy.

Laminitis /Grain overload

Laminitis is the local manifestation of a serious systemic metabolic disturbance. Laminitis is perhaps most commonly associated with certain feeding and management factors that will increase the likelihood of a potential attack whatever the type or breed of horse. Grain overload for example, whether by accident or deliberately induced, increases the risk of developing laminitis. Turning certain ponies out onto lush pastures in the spring and autumn/fall is a common triggering factor for the development of laminitis. High levels of water-soluble carbohydrates (which include the simple sugars as well as the more complex storage carbohydrate fructans) may be involved in this process.

Equine rhabdomyolysis syndrome (**Tying up, azoturia, Monday morning sickness, exertional rhabdomyolysis)**

Affects primarily the muscles of horses of apparently any age, breed or gender and results in the partial or complete inability to move. The most common cause of azoturia is over-feeding an active horse during times of rest, such as feeding the same amount of food to a horse that is being stalled for a day or two instead of cutting rations to accommodate the lack of activity. Too many carbohydrates can cause the muscles to have an acid base imbalance and can cause muscle damage if severe enough.

Symptoms like Unwilling to walk, Taking short steps, Unsteady or stiff on hindquarters, Muscles feel hard or hot to the touch in the hindquarters, Cannot move, muscles seized up Unable to stand or collapses when trying to move, Distressed behavior such as excessive head throwing or pawing the ground, Raised pulse rate, **Reddish-brown or dark chocolate colored urine**, Frequent urination or frequent attempts to urinate, Slight elevation in body temperature.

PET ANIMALS

Rickets

Any disturbance in the mineral metabolism that results in defective or abnormal calcification, or hardening, of growing bones is usually termed rickets. The clinical indications of rickets include lethargy and listlessness, arched neck, crouched stance, knobby and deformed joints, bowed legs, and flabby muscles. The changes characteristic of defective calcification in the young animal are most marked in the zones of growth of the long bones of the legs—at the junction of the end (epiphysis) and shaft—and at the cartilaginous junction of the ribs.

The specific treatment of rickets consists in the administration of vitamin D in addition to an adequate supply of calcium and phosphorus. The best sources of vitamin D are fish-liver oils, irradiated ergosterol, irradiated foods, and the action of sunlight on the skin, which enables the animal to manufacture its own vitamin D. Bone meal at a level of 1 or 2 percent of the ration will usually provide sufficient supplementary calcium and phosphorus for puppies of small breeds. Puppies of the larger breeds should have bones and milk in addition.

Eclampsia / Tetany of parturition

It occurs sometimes in female dogs and cats shortly before, during, or after the delivery of young. It is apparently the result of a calcium deficiency, possibly associated with a vitamin D deficiency. It is most common in females nursing large litters, in which case the demands of the mother for calcium for milk production are heavy. The symptoms vary in severity from nervousness and mild convulsions to severe attacks which may terminate in coma and death. It has been found that the seizuires can be controlled by the administration of calcium, and recurrence is prevented by additions of readily utilized calcium and vitamin D to the diet.

Scurvy

Efforts to produce experimental scurvy in the dog with vitamin C-deficient rations have been unsuccessful, and the evidence is that dogs normally synthesize their own vitamin C. Nevertheless, there are occasional reports of a spontaneously occurring condition resembling scurvy which is relieved by the administration of ascorbic acid (vitamin C) or some vitamin C-rich substance such as lemon juice.

Nutritional anemia

Nutritional anemias occur as a result of diets inadequate in the quantity of the constituents that function in the production of hemoglobin. They are most commonly associated with a deficiency of iron or copper or of the B vitamins, or with long-continued underfeeding of proteins essential for the formation of red blood cells. Copper itself is not a constituent of the hemoglobin molecule, but it is required by the canine as well as by some other species for the utilization of iron, which is essential in hemoglobin formation.

Diabetes

Diabetes Insipidus is a metabolic disorder that prevents the kidneys from functioning correctly. This causes poor fluid regulation, which can lead to dehydration, inhibited immune system function and circulation of toxins throughout the body, leading to poisoning. Diabetes Mellitus comes in two forms, type 1 and type 2. The symptoms of both forms are similar to Diabetes Insipidus, but the causes are different. Type 1 is caused by a congenital absence of certain pancreatic cells, resulting in abnormal insulin levels. This causes improper kidney function. Type 2 is caused by incorrectly functioning insulin receptors. Insulin levels are normal, but the kidney doesn't recognize this.

Hypothyroidism

Hypothyroidism is caused by abnormally low production of thyroid hormones, leading to a number of abnormal metabolic functions. Weight gain without increased food intake, lethargy, inability to exercise, greasy skin, dry coat and pimples are some of the common symptoms. A "puffy" face is typically the defining physical symptom of this condition. Large breeds and spayed females of any breed are at increased risk of hypothyroidism.

Obesity

Obesity and being generally overweight has long been linked to insulin resistance and weight gain. Obesity isn't "random:" it's the over-accumulation of fat in cells.

Metabolically, when dogs eat high-carbohydrate kibble, they process carbohydrates as glucose and store fat instead of using fat-for-fuel through Ketosis. When dogs are eating highly-inappropriate, nutrient-deficient, and high-carbohydrate kibble, there is a huge increased risk for weight gain and thus obesity. Given obesity's roots at the metabolic level, this disease can be classified as a **metabolic disease.**