WEEK EIGHT

NUTRIENT REQUIREMENTS FOR MAINTANANCE AND PRODUCTION

For a given no of animal species, the G I T very largely determines the types of food that will be nutritionally adequate, consequently, the Avian species with the relatively short intestinal tract would require food that is highly digestible in the same way, ruminants are better adapted to utilizing foods or feeds of lower digestibility than poultry this is an account of the extensive G I T which facilitates the microbial degradation of dietary fiber. There are also some animal species like the horse which may neither be considered ruminant or monogastric, they do, however, have extensive caecum wherein considerable fibre degradation occurs. Carnivorous animals have a relatively short alimentary canal while herbivores have an extensive G I T.

The relationship of the length of body to the digestive tract for wide range of animals usually provides a useful guide in the dietary formulation. Such a relationship length to length is about 1:4 for cat and chicken, 1:6 for dogs 1:27 for sheep and goat and 1:14 for swine. It follows therefore that the type of food most useful for chicken closely resembles those for cat and dog rather than for cattle and sheep.

The absence of lips and teeth both of which, are replaced by a horny-mandible. The tongue in the chicken and turkeys is shaped like the barb end of an arrow with the point directed in such a way as will help the movement into the oesophagus. Salivary glands secret mucus saliva which lubricates the feed as it passes into the oesoghagus. The crop is a pouch which forms an enlarged specialized area of the oesophagus, little digestion takes place in the crop as it’s function is largely that of storage. Posterior to the crop is an acid secretory section of the G I T of the bird called the PROVENTRICULUS; it is similar to the stomach of such animals as pigs, dogs and cat. The stomach usually opens up into the small intestine (SI) but in the chicken the proventriculus leads into the gizzard which in turn opens into the duodenum. Hcl and pepsin which aid the digestion of protein are secreted by the wall of proventriculus. No rennin secreted since no milk is produced by the bird. Food usually spends a short time in the proventriculus hence little digestion takes place in the proventriculus. Lying between the proventriculus and the duodenum is an oval shaped organ the GIZZARD; it comprises two pairs of red powerful organ, covered internally with a thick horny epithelium. The chief function of the organ is to grind coarse food particle. The process of grinding is aided by the ingested grit or gravel. With properly ground ration the role of gizzard is diminishing. Immediately after the gizzard, the small intestine is folded into a loop called the duodenum and in between the duodenal loop we have the pancreas supplied with numerous ducts which lead into the duodenum. The pancreatic juice is slightly alkaline and neutralizes acid secreted by the proventriculus. The pancreatic secretion contains enzymes which hydrolyze protein, CHO, and fats. The bile is a pigment secreted by the liver and it is important for proper absorption of fat in the small intestine. The bile is conveyed to the lower end of the duodenum via the duct. The duct from the right loop of the liver is enlarged to form the gall-bladder in which bile is stored and concentrated. The elaboration of the bile is triggered off by the presence of food in the S.I. The S.I consists of 2 distinct parts i.e. the duodenum and lower intestines. The enzymes of lower small intestine complete the digestion process started or initiated by the pancreatic enzymes. Here the peptides are broken down into amino acids, fats to glyceride and fatty-acid, disaccharides into simple sugars.

Since there is no specialized area in the G I T of the chicken for bacteria to aid the break-down of food stuffs only feed materials which can be digested by enzyme secreted by the chicken are useful as food for the chicken.

The epithelial lining of the S.I. has a tremendous surface area, which makes rapid absorption of nutriment possible. The chicken can digest and absorb a full meal in 3 hours. The caecum (a) is represented by 2 blind pouches giving off from either sides of the junction between the lower intestine and large intestine It is about a few “cm” in length usually filled with faecal matter. With highly digestible ration the caecum has little functions in digestion, however, in adult birds fed highly with fibrous ration, some digestion of fibre may occur in the caecum due to microbial action. Since this microbial fermentation takes place at sites posterior to the absorption area of G I T, the significance of short chain volatile fatty acid so produced is still questionable. Large intestine in the avian specie is usually short and consists of a short rectum which leads to the cloaca (which is a chamber common to digestion, urinary, reproductive which opens external through a vent and the urinary is discharged in this chamber and excreted with feaces.

THE RUMINANT GIT &PHYSIOLOGY OF RUMINATION

The ruminant animals such as the sheep, goat and cattle are characterized by possession of complex digestive tract being an anatomical adaptation to their dietary habit. The ruminant animals handle a considerable amount of digestive fibre and therefore require considerable and prolong physiological processes before being broken down into utilizable form.

The various compartments of the ruminant stomach are:

I Rumen – 1st or fore- stomach.

Ii Reticulum

Iii Omasum

1v Abomasum

The rumen and the reticulum are contiguous and hence communicate freely with each other. The rumen represents the most extensive portion of the ruminant stomach and it is endowed with numerous muscular folds which aids the mixing up of ingested food substances. The reticulo-rumen serves as the initial storage units where the food substances are initially reduced in size by various digestive processes.

The reticulum and omasum communicate by means of reticulo-masal orifice. In the young ruminant animal, there is a development of an esophageal tube or grove that enables the liquid diet of the young animal to enter directly into the abomasum without passing through the reticulo-rumen. A rather oval organ which lies to the right of the reticulum is the omasum, which is filled with a no of laminae (finger- like processes), the omasum is linked with the abomasum by means of a grove called sulcus-omasi. The abomasum or true stomach is analogous in no of respect to the small stomach of the canivores.

The abomasum is linked with duodenum by the pylorus. It must be emphasized that a matured rumen is richly supplied by a no of tongue-like projection called papillae which give the rumen its fur-like appearance. The S.I of the ruminant animals is similar to that of the monogastric animal and terminates at its Ileo-caecal junction. The caecum a blind sac-like out- grow of the large intestine where in some food may first enter for some degrees of digestion although the actual function is still largely speculative.

RUMINATION

In the ruminant animal both the rumen & the reticulum serve as fermentation vat while both omasum & abomasum serve to prepare food for gastric digestion by enhancing the removal of excess water and facilitating the normal acid-enzymes digestion in the glandular stomach. The rumen harbors millions of micro-organisms whose functions are not only to break down cellulose into digestible poly-saccharide but also synthesize a host of other chemical substances which will serve as ruminant food. The chief product of ruminal fermentation are the short chained fatty acids which include acetic acid 60%, prop ionic acid 20%, butyric acid < 20% and others such as methane. These short chained fatty acids are usually absorbed through the ruminal wall. These volatile fatty acids provide energy sources and may also be synthesized into fatty acid and ketone bodies. Propionic acid is of great importance in ruminant nutrition because it's configurations $CH_3CH_2C=0$ makes it highly glucogenic within the liver cell and thus provide about 50% of the glucose that enters the ruminant metabolic system. Butyric acid or butyrate may be glucogenic as well as ketogenic and therefore less useful nutritionally as propionic acid.

The cow and most other ruminants are endowed with the ability to synthesize protein from fatty acid owing chiefly to symbiotic activities of the ruminal micro-organisms; this represents a marked contrast to the metabolism of non-ruminant mammals that lack such specialization. It must be emphasized that the ability to effectively utilize dietary fibre is not to be found in the ruminal animal at birth thus a young calf feeding on the mother's milk metabolizes in much the same way as monogastric animal until it is about 4 months when the rumen would have sufficiently developed to assumes its full nutritional responsibilities. Although several advantages accrue to the ruminant digestive system as far as food is concerned, the process of fermentation generates so much gas which needs to be eliminated through belching. Any interference with the mechanism of elimination of gas in the rumen produces a spectacular syndrome called BLOAT and it is a disease condition usually associated with cattle grazing on lush legume pastures. Another defect of ruminant metabolism is the formation of ketones body which is a specific disease of ruminant. Ketosis is believed to be caused by liver inability to detoxify or metabolize short chain fatty acids in the blood stream due to increase stress brought about by lactation and pregnancy.

NUTRIENTS FOR BODY MAINTENANCE AND PRODUCTION.

Nutrients for Maintenance

Maintenance can be defined as that state in which there is neither gain nor loss of a nutrient by the body. Maintenance requirements are estimates of the amounts of nutrients needed to achieve such equilibrium states. Whether an animal is being fed for growth, fattening, milk secretion etc, a substantial part of its food is used for supporting body processes which must go on.

Maintenance Requirement

The term requirement implies the minimum amount of a given nutrient needed to promote a given body function to the optimum in a perfectly balanced ration.
Note – such a minimum value will not be the same for any two individual.

Energy requirement for maintenance.

The energy required for maintenance is the minimum amount needed to keep the animal in energy equilibrium i.e. to prevent any loss from its tissue.
Therefore, an intake sufficient to offset the loss represented or cause by the fasting metabolism would be the requirement for any given animals. It is usually expressed as Net Energy. The maintenance energy consists of 2 parts.

1. The basal metabolism – which is defined as a state of minimum energy expenditure by the animal in the post absorptive condition. The basal metabolic rate (BMR) is a direct and constant function of the metabolic size of the animal.

$$BMR^{24hrs} = 70\ (W\ kg^{0.75})\ Kcal.$$

2. Metabolizable Energy – This is used for maintenance or sustenance of certain unavoidable activities by the animals that are not using energy for work or production of any tissue or product. With most animal including human, basal metabolic rate represent 75% of ME used for maintenance. Maintenance energy requirement can be computed as BM increased by 1/3 .
:. $BM = 1.33\ (70)\ W\ kg^{3/4})$ Kcal.

Protein requirement for maintenance

The absorbed protein required for maintenance needs must make good the endogenous urinary losses and the metabolic feacal losses incident to the digestion of the ration in question and also provide for **“adult growth”-** this refers to the growth and renewal of hair, nails, feathers etc, a process which continues throughout life. Generally speaking, the amount of protein required for adult growth is very small compare to the over all need.

Theoretically, the minimum required for absorbed protein might be met by supplying the amounts needed for the above mentioned functions in an otherwise adequate diet.

Mineral and vitamins needs for maintenance

Many of the mineral elements undergo active metabolism in connection with various processes which are essential for the normal functioning of the body on maintenance. Different from the energy and protein metabolism, they are not necessarily used up and excreted in the process. For example, the Iron (Fe) released from the constant breakdown of red cells is re-utilized for haemoglobin synthesis, also chlorine (Cl) which is secreted in the gastric juice to provide for digestion can be reabsorbed from the digestive tract and reutilized.

PROTEIN AND ENERGY REQUIREMENTS FOR GROWTH

The total requirement for a given nutrient during growth must include the amount needed for in maintenance as well as the amount required for the new tissue formed of the various nutrient needs for growth. The requirement for energy is by far the largest and primarily governs the total food allowance. The maintenance component of the total energy requirement during growth increases regularly with body size, but the additional demand for the growth itself varies with the rate and with the composition of the tissue formed. Per unit of body weight, the amount of energy represented by the growth tissue formed decreases with age, but the amount of energy store per unit of body increases becomes larger with age. Also, the energy requirement per unit of body gain increases in accordance with its fat contents.

Tissue growth in young animal is largely protein in nature hence protein ration of growing animals. The protein content of the ration of a growing animal will be affected by the size of the animal and by the rate at which new protein tissues are being synthesized. It has been established that the energy and protein requirement being a definite relation to each other for adult animal in a situation which could be true for growing animals. It has been established that at physiologically equivalent age the requirement for protein, Ca, S, P are similar for various specie if expressed as % of TDN. By expressing the digestible protein as % of the TDN requirement, a generalized recommendation for protein applicable to most specie of animal could be arrived at.

Mineral/vitamin requirement for growth

They are organic compound not synthesized by the body and needed in the smallest amount in the diet. There are no of major structural component of the body which they most commonly function as co-enzymes or regulation of metabolism. Birds for example have an absolute requirement for about 13 vitamins, this includes fat soluble vitamin A,D,E,K, water soluble vitamins such as thiamine, riboflavin, choline, vitamin B6, B12 etc. More is known about the vitamin requirement for growth than for other phases of the life cycle. This is because deficiencies are more frequent or pronounced in rapidly growing animals. According to Guilbert *et al.* (1940) vitamin A requirement for growth and freedom from night blindness is proportional to body weight rather than metabolic size. Vitamin D plays a critical role in normal bone growth and development. Most animals that have access to sunlight daily do not need a dietary supply of vitamin D, because of the activation of vitamin precursors in the skin by ultra violet light. Vitamin E is a dietary essential for young nursing lambs and calves.

PROTEIN REQUIREMENT FOR LACTATION

It is somewhere more easily computed than that of growth because lactation represent a direct loss of protein to the body which needs to be replaced and the extent of this loss can be computed in a relatively straight forward manner .

There is ample indication that animals can adjust themselves to lactation over a relatively long period with ranges of protein intake. It is believed that if enough protein is added to the maintenance requirement to replace that loss to the body in the milk produced plus about 25%, the minimum requirement for lactation would have been met.

Requirement for minerals (poultry production)

The mineral elements for poultry are Ca, P, Na ,K, Mg, Cl, I, Fe, Mn, Mb, Co, Cu and Zn. Ca, P, Na, K, Mg, & Cl are usually designated as major elements since they must be present in relatively large amount of the diet. Ca can be up to 1% of the diet for growing chicks or over 3% or layers. Mg could be up to 0.03-0.05% of diet. Although, the remaining minerals are required in diet in trace amount, it must be emphasized that their deficiency could just be as detrimental to the animal as the deficiency of the major ones.

Requirement for Ca,P,& Mg

The 3 elements are important in bone formation as they are important bone constituents. The Ash or bone contains-25% Ca

-12% P

-0.5% Mg.

Insufficiency of these elements or mineral could result in poor bone mineralization and general condition of rickets. The major mineral needed in the diet of a laying hen is calcium for every larger egg the hen lays it must use about 2g calcium for egg shell formation. A hen that lays 250 eggs per year for example deposits about 500grams calcium in the egg primarily as $CaCO_3$.This amount represents about 1,300grams $CaCo_3$ deposit in the egg annually per hen. Ca is not efficiently utilized in laying hens and probably only about 50-60% of the Ca consumed is actually absorbed and retained and deposited in the egg. To produce egg shell required, thus, hens have to consume 2,600 grams $CaCo_3$ during the laying year an amount considerably in excess of the body weight.

The magnitude of Ca metabolism in the laying hen is considerably greater than any other specie of farm animals. Eggs quality characteristics are largely influenced by dietary calcium level. Eggs laid at the end of the production tend to have thinning shell than those laid at the beginning of the production year

High temperature causes the deposition of thinner egg shell but the most important cause of thin egg shell is Ca deficiency.

Feed consumption is also important in determining Ca requirement when expressed as % of the diet. For old layer in hot weather 4- 4.5% Ca is recommended for good egg shell quality. In addition to their structural roles, Ca and P have other functions in the animal body. For example P is essential for energy metabolism as it is constituent of nucleic acid and plays major roles in several enzymic systems. Ca is also important in blood clotting and muscles contraction. Much of the Mg is found in the bone and it is also an important activator of a number of enzymes involved in energy metabolism

Inter-relationship between Ca and P-:

Chicks are especially sensitive to imbalances in Ca, P ratio. In any ration it should be 1.5:1- 2:1.

1. An imbalance could result in poor utilization of either Ca or P.

2 Vitamin D must be present in adequate amount for the proper utilization of dietary Ca and P.

Requirement for Na, Cl, K

Na, Cl, and K are principally in-organic ion of body fluid. Na is found in the extra-cellular fluid while K occurs mainly in the inter-cellular fluid. These mineral are important in the maintenance of acid- base fluid balance in the body tissue.

Cl is an important component of HCL found in the proventriculus.

Deficiency of any of these, result in poor growth, dehydration or death while excess may result in excessive retention of body fluid.

Trace minerals

Generally, the trace minerals are component or activators of a series of enzymes system found in the animal body. Examples are Cu, Zn, Fe, Mo, etc. Fe is an important constituent of blood in form of haemoglobin. It is also present in muscles as Myoglobin and also in cytochrome system.

ENERGY AND PROTEIN REQUIREMENT FOR REPRODUCTION

The energy requirement for production consists of the energy stored in the new tissue formed plus the energy expended in the process. In practice, most pregnant animals must be given a sufficient energy allowance to enable them gain some weight during the period as a whole with special attention given to the last quarters when the specific needs are substantial.

Low protein diet has been shown to cause a cessation of estrus and that, if fertilization occurs, foetal resorptions or the birth of premature, dead or weak offspring results, therefore, quality as well as the quantity of protein is important. Rations that are adequate in protein for maintenance and for growth should be adequate also for conception and the initiation of foetal growth. Since, the products of a conception arises largely of protein, it is evident that there is an increased need as foetal growth proceeds. It has been shown that pregnancy in sow and cow increases the need for protein much more than for energy.