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DEPARTMENT

TRAINING IN RURAL POULTRY DEVELOPMENT PROJECT

PRINCIPLES OF POULTRY NUTRITION

prepared for the

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1. INTRODUCTION

The main aim of Animal husbandry is to provide useful products like food, wool, manure, skin, power etc. to man. Poultry,as one of the farm animals provide eggs, meat and also manure.

Poultry, if they are expected to produce optimally, need to be supplied with the necessary nutrients in the appropriate proportions and quantity.

The common sources of feed for poultry include grains and grain by products (wheat, wheat shorts, corn etc); processed slaughter house by products (meat meal,bone meal etc); by-products of oil extraction (Noug Cake, peanut cake etc). Some of these products especially the intact grains can be consumed directly by humans while the others like the oilseed cakes and slaughter-house by-products can't be directly consumed. The aim of animal husbandry (and thus poultry husbandry) is to transform such humanly inedible products to highly desirable and nutritious human food-meat and eggs. Attainment of efficient transformation of these by-products requires knowledge and application of the scientific bases of Animal (poultry)) feeding. We should know the following in order to understand the scientific bases of animal feeding.

1. Plant and animal chemistry (structure and function)
2. Life processes in the animal body: Digestion and metabolism
3. Nutritional value and characteristics of feeds
4. Nutritional needs of animals and the effects of the lack or deficiency of one or more nutrients
5. Feed rationing and feeding practice to attain specified production targets by supplying the right quantities and proportions of nutrients.

1.1 Importance of Good Poultry Nutrition

Good nutrition is a pre-requisite for applying modern methods of poultry production.

Good nutrition reduces production costs-As a rule,feeding accounts for 50 to 70% of the cost of producing broilers or eggs. This percentage may even be higher in countries like ours where labour is usually cheap and housing doesn't have to be very elaborate. There is no doubt, therefore, that efficient food conversion is one of the most important factors in economic poultry production .

Good nutrition saves feed-well balanced rations save feedstuffs by reducing the quantity of feed needed to produce a dozen of eggs or a kilogram of meat. The explanation for this is that the requirements for maintenance are "fixed costs" and are independent of the number of eggs produced.

Good nutrition also increases the resistance of poultry to disease and allows the producer to make maximum use of the genetic potential of his poultry.

1.2 Peculiar Features of Poultry

There are certain peculiarities of poultry and their production system which have implications to their nutrition and these deserve consideration:-

- Poultry have very fast growth rates-body weight of broilers can increase 30 fold in about eight weeks of growth (50 grams at day old to 1500 grams at 8 weeks of age).
- Their body temperature is slightly higher than other farm animals (107^{o}F VS 100^{o}F).
- All the physiological processes are much faster in poultry eg. respiration 40 per minute; blood circulation (heart beats of up to 350 per minute).
- Poultry have no lips or teeth, hence require a more concentrated ration.

- As simple stomached animals, poultry have a comparatively short digestive tract. Digestion is thus quite rapid. It takes about 2 1/2 hours for feed to go from the mouth to the cloaca in a laying hen. this makes the nutritive requirements of poultry more precise.

- Poultry can't tolerate high levels of fibre due to the structure of their digestive tract.

- Poultry depend completely on the dietary source for all the essential amino acids, vitamin B complex etc due to lack of microbial synthesis in the ruminant digestive tract.

- Poultry are normally fed collectively.

1.3 Partitioning of the nutritional needs of poultry

The nutritional needs of poultry can be partitioned into maintenance needs and production needs:

1. **Maintenance** needs: requirements of nutrients for the very existence of the animal. When these needs are met, the body weight and temperature are stabilised and this ensures that all the internal processes of the body run properly.

    - For a one month old chick, 65% of the feed is needed for maintenance
    - For a five month old chicken, 90% of the feed is needed for maintenance
    - For good layers, 70% of the feed is needed for maintenance

2 **Production needs**: the remaining part of the feed fulfils three main objectives:-

- To increase body weight in the young chick i.e growth
- To increase body weight in grown-up chicken i.e fattening
- Reproduction-this function is for egg production.

2. BRIEF OVER VIEW OF THE NATURE AND FUNCTION OF NUTRIENTS

The term NUTRIENT means any chemical substance in feed that has specific functions in the nutritive support of animal life and production .

They are classified according to physical, chemical and biological properties into the following groups:

- Water	- Fats and oils	- Feed additives
- Proteins	- Minerals	
- Carbohydrates	- Vitamins	

2.1 WATER

Water is the nutrient most essential to life. Animals die much faster from thirst than from hunger.

The internal environment of an animal is basically a water medium in which transport of nutrients occurs, metabolic reactions take place and from which wastes can be eliminated. Water makes up 85% of the body weight of day old chicks. This decreases as the chicks grow older, reaching a level of about 55% in mature chicken at 42 weeks of age. The water content of the whole egg is about 65%.

Ordinarily, chickens consume about 2 to 2.5 grams of water for each gram of feed consumed during the starting and growing period and from 1.5-2 grams of water per gram of feed as laying hens. Since an average poultry ration contains no more than 10% water, a good supply of clean drinking water is essential for poultry and egg production. Birds obtain water from three different sources namely:-

1. Drinking water
2. water in feed
3. Metabolic water (about 3% of body weight)

The consumption of water by poultry depends upon:-

1 The quantity of ingested feed-increased intake of feed associated with additional water consumption.

2. Environmental temperature-higher environmental temperature induces increased water consumption. The following relationship between temperature and feed: water ratio exists:

Temperature	Water:Feed ratio
-7	1.5:1
4	1.7:1
15	2:1
26	2.5:1
37	5:1

3. The temperature of the drinking water itself

.......5°C.........10-14°c.......35°c.......

low intake   optimum   low intake

In general, the temperature of water should be slightly below the environmental temperature.

4. Activity and production of the birds: increased activity and/or production increases water intake. in batteries.
5. Management:Poultry raised on litter drink more than those raised in batteries.
6. Feed composition: Composition of feed affects consumption

   - Salt (minerals):-birds should get rid of excess minerals. The kidneys,in order to perform their function properly, require water. The bird, thus tends to drink more water which causes wet droppings kidneys can be affected if enough water is not available

   - Protein % in feed: Excess of proteins or an imbalance of amino acids results in the production of large quantities uric acid which requires increased quantities of water to be excreted.

Shortage of Water can lead to:-

- digestion and assimilation trouble
- a thickening of the blood
- an increase in body temperature and eventual death
- cessation of lay and eventual death in layers

In general, birds are given free access to drinking water:-

- IN PRACTICE WE NEVER RATION WATER;

Consequences of Total water deprivation of water for different periods can have the following:-

- One day without water-Sudden drop in egg production

- Two days without water-birds start moultin on the neck and a mean of 3 weeks of lowered egg production results
- Three days without water-Thine will be complete moulting-4 to 6 weeks of lowered production or total stop of egg production.

Water deprivation is sometimes used as one management tool to induce moulting.

Quality of drinking water

Quality of the drinking water is also an important issue that needs attention. Drinking water should be fresh, clean and free from:

- salt and other inorganic materials;
- Heavy metals like pb,Hg,cd;
- Organic materials like pesticides;
- micro-organisms(presence of coli indicates fecal contamination)

Water is at times used for the administration of medicaments and vaccines Sick animals may stop eating but they will still drink water thus becomes a good medium for administration of medicaments. The following points should be noted in this context:-

- high concentrations of iron i.e. higher than 4mg/litre can make some medicaments inactive. this can be prevented by adding sodium carbonate.

- High iron concentrations can inactivate vaccines prepared from live or attenuated (weakened) viruses. In cases of high concentration, it is advisable to add skim milk if available at about 10% to the drinking water.

Poultry should be given adequate access to water by providing enough trough space. A circular trough for every 100 chicks is required until the chicks are two weeks old. then, a three feet line trough (with possible access on both sides), but still keeping the circular trough a few days more. Then:-

- from 2 to 4 weeks, 1 three feet trough (double access)
- from 4 to 6 weeks, 2 three feet troughs(" ")
- From 6 weeks onwards, 3 three feet troughs(" ")

2.2 THE PROTEINS

Proteins are complex organic substances made of amino acids. Amino acids are chemical compounds containing carbon, oxygen, nitrogen and hydrogen; some amino-acids contain sulphur also.

The most characteristic element of the proteins is nitrogen(N). Proteins contain about 16% nitrogen and, therefore, proteins are measured by determining the quantity of nitrogen and then multiplying by 6.25 (100/16=6.25) in order to get the weight of proteins . The factor 6.25 is, thus, called the protein factor.

The protein of feedstuffs as determined in the routine analysis is made up of two component parts; one is the true protein occurring in larger proportions, the other constitutes non-protein nitrogenous compounds. The term crude protein is given to the results of these determinations because nitrogen containing feed constituents that are not true proteins are also included. So, when we express the total nitrogen content in terms of crude protein, we make two assumptions:-

1. All feed protein contains 16 percent nitrogen
2. All the nitrogen of the feed is present as true protein

Both of these assumptions are, however, not correct strictly speaking. Different feed proteins have different nitrogen contents and therefore different factors should be used in the conversion of nitrogen to protein for individual feeds.

The second assumption that the whole of the feed nitrogen is present as protein is also false, since many simple nitrogenous compounds such as amides, free amino acids may be present. From the practical of view, as all ruminants can utilise nitrogen from protein and non-protein equally and hence the two assumptions that are made to calculate CP will not affect the ruminants. In the diet of pigs and Poultry, cereals and oilseed meals predominate, and there is little non-protein nitrogen in these feeds. Hence, in practice there is little to be gained from attempting to distinguish between the two types of nitrogen.

Twenty one amino acids compose most of the proteins, and all of them are essential from the physiological point of view i.e they are necessary for growth and production. Poultry can synthesise some of the amino acids in their system. As far as the other amino acids are concerned, we must ensure that they are included in the feed. These are referred to as essential amino acids to imply the essentiality of including these amino acids in the diet.

The following 11 amino acids constitute the essential amino acids for poultry.

Phenylalanine	Lysine	Methionine
Histidine	Valine	Threonine
Isoleucine	Tryptophan	Glycine
Leucine	Arginine	

There are many possible combinations and sequences for amino acids in the protein molecule and this explains the infinite number of different proteins which can be formed. the arrangement of the amino acids in the protein is specific for every species of plant or animal and it also varies in the different tissues.

When a feed contains all amino acids in proper amount and ratio according to the requirements of the animal, we say that the feed has a high biological value (B.V.). This indicates the N utilised by the body from the amount of N digested: i.e

$$BV = \frac{\text{(N-in feed)-(N-in faces)-(N-in uric acid) X100}}{\text{(N in feed-(N in faeces)}}$$

Biological value can range from 0(no amino acids present) to 100 (no N excreted in the urine from the N-digested).
Animal products have a high biological value, leguminous plants have a reasonably high biological value while cereals have low biological values.

An animal grows or produces until one amino acid is used up. This amino acid is then called the "limiting amino acid". It is the amino acid which is found in relatively lowest quantities in the feed relative to the animal's needs. This amino acid limits performance even if other amino acids are available to the animal. In most cases methionine followed by Lysin are the most limiting amino acids in poultry feeds.

In poultry, the products produced consist mainly of protein. On a dry weight basis the carcass of an eight week old broiler is more than 65% protein and the egg contents are about 50% protein.

The amino acid needs of growing chicken and laying hens are met in practice by feed protein sources of plant and animal origin. It is generally necessary to choose more than one source of dietary protein, (i.e animal and vegetable sources) to meet the amino acid requirement of chicken.

Of the essential amino acids in poultry rations, lysine, methionine, arginine, glycine and tryptophan are referred to as critical amino acids, since these are usually deficient in ordinary practical poultry rations. This is because cereal grains are usually low in the critical amino acids which make up a large proportion of a usual poultry ration. It is thus essential to include a good proportion of animal protein sources in poultry rations to ensure the inclusion of all critical amino acids.

In addition to the role of amino acids as building materials in the body, some amino acids also have specific roles in the body:Thyroxine is a hormone which controls metabolism; tryptophan is used in the synthesis of nicotinic acid (a vitamin).

Animals can use proteins as energy sources if provision is in excess of requirements. Overheating of proteinous feeds can result in the destruction and unavailability of some amino acids, optimal heating may release some amino acids and make them more available.

2.3 ENERGY

Energy is one of the requirements of animals for production and maintenance of life. The energy level of feed is the main factor which determines feed consumption i.e. Poultry normally eat to meat their energy needs. A high energy feed leads to better feed conversion rates in egg and meat production. A low energy feed decreases the fat content of the body and leads low feed conversion rates.

Energy is measured by units called calories or joules. We have seen, before, that poultry eat according to their energy needs and, therefore, there is a link between the energy content of a feed and the other nutrients in the feed. Poultry will eat a lower quantity of a high energy feed.We will have to increase the rate of other nutrients in order to ensure that the birds consume these nutrients in the right quantity.

The main energy producing feed constituents are carbohydrate and fats.

2.3.1 CARBOHYDRATES

There is more carbohydrate material in nature than all other organic substances combined. This is due to the fact that carbohydrates make up most of the organic structure of all plants, as well as being present to some extent in all animals.

All carbohydrates are compounds of carbon, hydrogen and oxygen. Generally, but not always, the hydrogen and oxygen in carbohydrates are present in the proportion of two hydrogen atoms to one Oxygen atom in water (H_2o), from which fact the term "carbohydrates" (carbon hydrate) was derived and thus carbohydrates were originally represented with an empirical formula (Cn ($H2^o$)n.

Today, the name is retained but not bound to the empirical formula. Many substances not carbohydrates contain hydrogen and oxygen in the proportion of H_2o such as acetate (C_2 H_4 O_2) and lactic acids (C_3 H_{10}^{O}4), rhamnose (C_6 H_{12} ^{O}5) do not contain hydrogen and oxygen in the proportion of water.

The chief function of carbohydrates in the animal organism is that of a fuel, the degradation of which to carbon dioxide and water represents a major source of energy. Carbohydrates can also be used as a starting material for the biological synthesis of other types of compounds in the body, such as fatty acids and certain amino acids.

Carbohydrates can be categorized into two categories: crude fibre and nitrogen free extract.

Poultry can't digest crude fibre, a low percentage of crude fibre is thus allowed in poultry rations. Although crude fibre is not digestible, it has some positive effects in the ration:-

1. It activates the peristaltic movement of the intestines, resulting in increased secretion of enzymes

2. It makes the feed bulky and thus gives the animal the feeling of satisfaction (especially broiler parent stock)

3. It creates a medium for microflora to live on, especially in the caeca. The bacteria produce cellulase to break down cellulose into glucose. At the same time, the bacteria produce vitamins such as vitamin B_{12} and vitamin K even though poultry do on take optimal advantage of the microbial fermentation in the caeca.

The nitrogen free extracts contain mainly starch which is the main form of carbohydrates used as an energy source by poultry. Cereal grains and their by-products are excellent sources of starch and constitute a bulk of poultry rations.

2.3.2 FATS

Fats are a sub group of lipids which includes substances extractable from biological materials using organic solvents like ether, benzene, chloroform etc.. The term "ether extract" is used frequently due to the determination of the compositions of these constituents using ether extraction.

The true fats are normally the main constituents of ether extract. Other products dissolved by ether and included in the ether extract include colouring substances (eg. carotene,xanthophyll,chlorophyll) & vitamins A,D,E and K.

Like carbohydrates, the fats contain the elements carbon, hydrogen and oxygen. They are however, much richer in carbon and hydrogen as is shown by the following percentage figures:

	Carbon	Hydrogen	Oxygen
fats	77	12	11
starch	44	6	50

True fats or triglycerides are built up of one molecule of glycerol and three molecules of fatty acids. When the fatty acids attached to the glycerol are a single type of fatty acid, the compound produced is a simple triglyceride.

When more than one type of fatty acids are esterified, then, the resultant product will be a mixed triglyceride. Naturally occurring fats are mixtures of such triglycerides .

From the structure of fats, it is apparent that one molecule of fat will yield three molecules of fatty acids and one molecule of glycerol. This reaction. which can be accelerated by enzymes called Lipases, is the first step in the biological evaluation of fats.

Fatty acids can be classified into two types namely saturated fatty acids with only single bonds in between C-atoms and unsaturated fatty acids with one or more double bonds between C-atoms.

The types of fatty acids in a fat determine its characteristics. Presence of higher proportions of saturated fatty acids in a fat make this fat firm or solid at room temperature while higher proportion of unsaturated fatty acids make fat liquid (oil) at room temperature. Unsaturated fatty acids are more unstable and oxidize easily This causes rancidity of fats. Rancid fats are spoiled and unpalatable Rancidity can also set fatty acids free. A high percentage of free fatty acids in a product is not desirable because it indicates breakdown of the fat and deterioration not only of the fat but also of the vitamins especially vitamin A and carotene. Antioxidants can be added to feeds to prevent fats and vitamin A from oxidation-eg. tocopherol (vit E), BHT (Beta hydroxy Toluene); Ethoxyguine. Excessive amounts of unsaturated fatty acids in the diet may induce a vitamin E deficiency due to the fact that it is used up in the process.

The type of fatty acids in the ration determine the nature of the body fat. Large proportions of unsaturated fatty acids cause soft body fat. Excess of carbohydrates are deposited as solid fat.

For a long time linoleic, linolenic and arachidonic were considered to be essential fatty acids, but it has been firmly established that arachdonic acid can be synthesised by the body if diets contain enough linoleic acid. Recent work on this subject shows considerable doubt about the essentiality of Linolenic acid. It can thus be said that the truly essential fatty acid is linoleic acid.

Fats make up over 40 percent of the dry egg and about 17 percent of the dry weight of a broiler. Although fats supply concentrated form of energy (2.25) times more energy than carbohydrate and protein) their inclusion as true fats or oils in the ration is seldom practised because of high cost and the risk of rancidity which develops on prolonged exposure to air, heat sunlight, etc.. Most feed ingredients (maize, wheat etc) contain 2-5 percent fat and that is enough for the inclusion of one essential fatty acid (linoleic acid), which must be present in rations of young growing chicks or they will grow poorly, have an accumulation of liver fat and be more susceptible for respiratory infection. Laying hens with diets deficient in linoleic acid will lay very small eggs that will not hatch well.

Older birds digest fats better than young birds. In general, a maximum of 5% fat is recommended in a ration. In order to reach the required high energy content of broiler feed up to 10% fat can be included.

2.4 MINERALS

Minerals are the inorganic fractions of feedstuff and the animal body. The animal body contains about 3% minerals which are constant constituents of animal tissues. Some 30-40 mineral elements occur in the animal body. all tissues contain minerals but these minerals are not uniformly distributed:-

- Bones contain 36% calcium, 17% Phosphorus and 0.8% magnesium
- The egg shell is mostly made of calcium carbonate and the yolk contains a large amount of phosphorus and sulphur;
- Potassium is abundant in muscles, glands and nerves
- sodium is found in blood and lymph

- sulphur is found in some amino acids (methionine,Cystein)
- chlorine is present in the gastric juice
- Iron is found concentrated in blood haemoglobin
- Iodine is found in the hormone thyroxine etc..

The mere presence of minerals in tissues doesn't indicate a role in the animals metabolism. Their presence may be due to their ingestion with feed and water or their inhalation with air during respiration.

The essentiality of any mineral element is known from its metabolic role in the animal body based on the following criteria.

1. It is present in all healthy tissues of all animals
2. Its concentration from animal to animal is fairly constant
3. Its withdrawal from the body induces reproducibly the same structural and physiological abnormalities.
4. Its addition either prevents or reverses these abnormalities .

Purified diet experiments are conducted to know the essentiality of any element. Twenty one such elements have thus far been proved to be essential and there is some evidence that six other elements may also be essential .

Minerals can be classified into two main classes based on the quantities in which they are required by animals.

1. Macro or major minerals: Ca, P,Na,K, Cl,Mg,S.

2. Micro or minor or trace minerals fe,Co, Cu,Mn,Zn,I,Mo,Se,F, Va,Cr,Sn,Ni,Si

All poultry feed ingredients contain minerals, but not always in sufficient quantities always. This, therefore, necessitates addition of concentrated sources of minerals in poultry rations. This is especially true for calcium and phosphorus sources. The rates of inclusion vary based on type of birds eg broiler, layer. Sodium and chlorine are supplied by addition of salt at the rate of 0.25 to 0.50% of the ration. The needs of chicken for other minerals are much lower;

Deficiency of Calcium, Phosphorus or vitamin D causes rickets in young animals, Osteomalacia in order animals and reduced egg production by layers. Mild deficiency could be manifesed in the production of thin shelled or some times even shell-less eggs. Calcium enough for the synthesis of 3-4 eggs can be stored in the marrow of the medullary bone in the form of $Ca_3 (Po_4)_2$. These three nutrients are inter-related in the structure of bones. Vitamin D is for the deposition of calcium and phosphorus in bones.

The lack of iron leads to anaemia i.e. problems in the transport of oxygen to different tissues via the blood. Lack of iodine leads to decreased metabolism. Lack of manganese leads to perosis (because of the slippage of the achilles tendon, the tibia and metatarsus are twisted and bent.)

Cobalt deficiency results in vitamin B_{12} deficiency necessitating supplementation of the diet in poultry feeds.

Many of the essential or non-essential elements may be toxic if their amounts are higher than the usual level which causes disorders in normal metabolism. Selenium is an example of an essential mineral which is toxic at quite low levels in the diet while fluorine is another example of a mineral believed to be essential but results in toxicity in excess amounts.

Presence of any mineral at too high a level may cause a metabolic deficiency of another mineral by inhibiting its absorption. Such is the case where a high level of molybdenum causes conditioned copper deficiency. Thus, mineral supplementation should be done cautiously.

Too much calcium reduces feed intake and prevents poultry from assimilating other minerals and vitamins. This can lead to high death rates of young chicks, delay in growth, bad feathering and reduced rate of lay.

Too much magnesium leads to soft bones, a decrease in laying and eggs with soft shells. This is due to antagonism of magnesium to calcium and the resultant reduction in calcium deposition .

Excess salt consumption (greater than 0.5% salt in the ration) results in excessive water consumption, diarrhea, dehydration and increased mortality. Broiler chicks are most sensitive to high salt levels in the ration.

Sodium and chlorine are supplied by the addition of common salt. Salt must be clean and ground, dry and should not be caked.

Phosphorus and calcium sources: the following constitute common sourced of calcium and phosphorus.

		Ca%	P%
Limestone ($CaCo_3$)	38	-	
Dicalcuim Phosphate($CaHpo_4$)	23	18	
Bonemeal	29	13	
Rock phosphate	32	18(deflourinated)	

The phosphorus in the ration can originate from different sources inorganic P(eg dicalcuim phosphate), animal origin (eg. bone meal) and plant origin. Phosphorus from a plant source is about 1/3 inorganic and 2/3 organic (phytin-p). Poultry do not have the enzyme (phytase) necessary to utilize phytin-P. The organic form of plant phosphorus is not, thus, available to poultry.

P total-Pphytin= Available

P total-2/3Pplant= Available

Non-laying birds require calcium and phosphorus in the ratio of its presence in the bones i.e Ca:P = 1.4:1. Layers require extra calcium for the formation of the egg shell:- Ca:P=4:1

As a general rule, phosphorus is more expensive to supply than calcium. Therefore, the choice of supplements has to be made based on the phosphorus content and not on the calcium. All the products that are used as phosphorus supplements also contain calcium but not vise versa.

2.5 VITAMINS

Vitamins are organic compounds necessary for the normal development and performance of animals. The vitamins have no chemical resemblance to each other, but because of a similar general function in metabolism they are considered together. A substance is categorized as a vitamin if it fulfils the following :_

1. Is an organic component of natural feeds but distinct from carbohydrates, fats, proteins and water
2. Is present in minute amounts
3. Is essential for development of normal tissue and for normal health, growth and maintenance.
4. Causes a specific deficiency disease when absent from the diet or not properly absorbed or utilized
5. Can't be synthesized by the host and therefore must be obtained either from the diet or from synthesis by the micro organisms of the digestive tract.

The later characteristic distinguishes a vitamin from a hormone; it is possible however that a substance may be a vitamin in one species and a hormone in another . Ascorbic acid, for example, is a vitamin for man, monkeys and guinea pigs, but may be called a hormone in all other animals since they are capable of producing it by biosynthesis. Vitamins can be made available to poultry through different ways:-

1. Present in the feed:- The ingredients of a compound feed contain a small quantity of vitamins, which normally are not taken into consideration. In a compound feed the premix contributes the vitamins. Provision through the drinking water is also another way .
2. Provitamins or vitamin precursors which are converted into vitamins, like:- carotene-precursor of vitamin A
3. Synthesis of the vitamins in the body:- vitamin C is synthesized in the body of the animal itself. Vitamins of the B-complex group and K are produced by microflora, especially in the caeca but the bird doesn't take full advantage due to the location of the caeca beyond the sites of major absorption.

Most of the vitamins are unstable substances which are quickly destroyed in the presence of air, light, heat or by the action of oxidizing agents such as rancid oils or metals. Because of this we always give a slight overdose of vitamins as a security measure unless stabilised such as gelatine coating. vitamins.

Excess of many vitamins can be stored in some parts of the body such as the liver or eggs. It is therefore, advisable to add a good margin of excess vitamins for reproducing flocks for good development of the embryos, good hatching rate and chick growth .

The quantity of a vitamin is normally expressed in mg/kg of feed. Exceptions are vitamins A,D and E which are expressed in international units i.e. IU/kg of feed.

The Vitamins are generally divided into two major groups. The fat soluble and water soluble vitamins. The fat soluble Vitamins, which are usually found associated with the lipids of natural feeds, include vitamins A,D,E and K. The vitamins of the B-complex group and vitamin C comprise the water soluble vitamins. The typical differences between the two groups is:-

1. The water soluble vitamins contain only carbon, hydrogen and oxygen while the fat soluble group contans either nitrogen, sulphur or cobalt additionally.
2. Fat soluble vitamins can occur in plant tissue in the form of a provitamin which can be converted into a vitamin in the animal body. No provitamins are known for the water soluble vitamins.
3. Fat soluble vitamins not universally distributed and can be completely absent from some tissues. Water soluble vitamins are distributed in every living tissue.
4. Absorption of fat soluble vitamins from the intestinal tract in the presence of fat and thus related with factors which govern fat absorption. In general, the absorption of water soluble vitamins is a simple process as there is a constant absorption of water from the intestine.
5. Any of the fat soluble vitamins can be stored wherever fat is deposited. Water soluble B-Vitamins not stored in the same way or to the same extent.
6. Fat soluble Vitamins are usually excreted through the feces. The water soluble B-Vitamins may also be present in the feces (though sometimes only because of bacterial synthesis) but their chief pathway of excretion following metabolic use is through the urine.

2.5.1 THE FAT SOLUBLE VITAMINS

2.5.1.1 Vitamin A

Vitamin A is necessary for:

1. Keeping the epithelia especially of the eyes and digestive tract/
2. Formation of the eye pigment.
3. Growth and reproduction.

The deficiency of the Vitamin will lead to:

1. Infection of the epithelia and sensitirty of the skin to microbial agents. a thick fluid appears in the eyes which can lead to blindness.

2. Delayed growth and bad feathering

3. Reduction in egg production

4. Reduction in hatchability and high mortality of chicks. Long term and severe deficiency can also lead to death of adult poultry.

Vitamin A can be derived from a yellow substance called B-carotene (or provitamin A). It is found in green grass, alfalfa meal, yellow maize, liver meal. There is also synthetic vitamin A. The vitamin and B-carotene are rapidly destroyed by heat, light, contact with rancid oil which leads to its oxidation. Vitamin A can be prilled to prevent it from oxidation . This means coating with sugar or gelatin.

Vitamin A is measured in international units. One IU being equivalent to 0.6 microgram of B-carotene or 0.3 microgram of vitamin A.

2.5.1.2 VITAMIN D.

There are two precursors of Vitamin D:-

1. cholesterol (in animal body) <u>UV-light</u> Vitamin D_3 (in animal Products)
2. Ergosterol (in green plants) <u>UV-light</u> vitamin D_2 (in sundried plants)

In poultry, Vitamin D_2 is almost inactive. It is therefore only Vitamin D_3 that is important in poultry nutrition. The D_2 form is active in mammalian species, eg. cattle, sheep etc.

One international unit (IU) Vitamin D for poultry is defined as the activity of 0.025 micrograms of Vitamin D_3 and used to express requirements and allowances of Vitamin D.

The Problem of Vitamin D deficiency arises only in confined flocks. There is no problem of Vitamin D deficiency if poultry are raised freely in the open where they receive ample sun light for Vitamin D_3 synthesis. It is usually recommended to add Vitamin D_3 up to 1/10 of the Vitamin A level in poultry rations.

Vitamin D is necessary for calcium assimilation, growth, egg production and good hatchability. Lack of the Vitamin can lead to:-

1. Rickets: badly developed and soft bones, unable to sustain the weight of the body (the symptoms are the same as the lack of calcium or phosphorus in the ration.
2. Low hatchability due to shortage of the vitamin for the development of the embryos.
3. Low rates of lay and production of thin shelled eggs .

An excess of Vitamin D_3 may lead to calcium deposits in places other than bones. It also results in a drop in egg production and hatchability.

It is only since the discovery of synthetic Vitamin D_3 that confined poultry production could be effectively practised.

2.5.1.3 VITAMIN E

At least eight compounds with vitamin E activity are known. of all these x-tocopherol is the main and most active one. Vitamin E is necessary in reproduction, male fertility and hatchability.

Vitamin E deficiency can lead to:-

a. Encephalomalacia- resulting from haemorrhages and edema in the cerebellum causing nervous disturbances and death.
b. degeneration of muscle fibres
c. exudative diathesis-a severe edema produced by a marked increase in capillary permeability, especially in the muscles.

Vitamin E is found in small quantities in grain by-products (eg. wheat bran), alfalfa meal, vegetable fats. It is found in concentrated form in germinated wheat.

Vitamin E is relatively stable but is damaged by contact with rancid oil or some metals (iron). Synthetic Vitamin E (x-tocopherol acetate) is available.

2.5.1.4 Vitamin K (the anti-haemorrhagic vitamin.)

Vitamin K is necessary for blood coagulation. The Vitamin was given its name from the first letter of the Danish word "Koagulation" lack of this Vitamin will lead to an increase of the coagulation time of blood and poultry may bleed to death if wounded. In Vitamin K deficient chicken we see sign of haemorrhages under the skin and the legs. the same symptoms appear in young chicks when the hens (parents) did not get enough vitamin K in their ration.

Vitamin K is found in alfalfa meal, young green grass, and in fish and meat meals.

A synthetic product "Menadion" has the same effect as Vitamin K and is widely used. Vitamin K is expressed in milligrams(mg).

2.5.2 THE WATER SOLUBLE VITAMINS

2.5.2.1 Thiamin

Thiamin is necessary to stimulate appetite, to form certain enzymes necessary for digestion, and to prevent nervous disorders that culminate in polyneuritis. However, as many feed ingredients carry abundant supplies of this vitamin, the symptoms are seldom seen.

Thiamine is relatively abundant in cereal grains, mill by-products, oil meals, alfalfa meal. Synthetic Thymine is also available.

2.5.2.2 RIBOFLAVIN

This Vitamin is of major importance, not only because of its effect on body processes, but because it is generally inadequate in rations composed of ordinary feedstuffs. Most rations should contain added riboflavin. commercially prepared riboflavin is available .

Although fish meals, alfalfa meal and milk products are relatively high in riboflavin, their limited use in poultry rations means that practically all poultry rations must include supplemental riboflavin. Deficiency of riboflavin results in:-

1. curled toe paralysis: The toes curl and sometimes the legs are affected to produce paralysis
2. Poor hatchability

2.5.2.3 Pantothenic acid.

This Vitamin is associated with many protein molecules and is involved with protein, carbohydrate and fat metabolism. It is relatively unstable. Requirements of young and growing chicks for pantothenic acid are high.

Deficiency of pantothenic acid can cause retarded growth in young chicks, ruffled feathers, granulated and stuck eyelids in young chicks, dermatitis of the feet, lowered egg production and lowered hatchability.

Peanut meal, Milk products, mill by-products and alfalfa meal are good sources of pantothenic acid. Calcium pantothenate is manufactured commercially as a supplement .

2.5.2.4 NIACIN (Nicotinic acid)

This Vitamin is an important part of two enzymes. The amino acid tryptophan is a precursor of niacin, and the ability of the bird to convert tryptophan must be considered when compounding poultry rations. As corn is a poor source of both, high corn diets usually require a niacin supplement.

Requirement of the chick for niacin is relatively high, but it is low for laying birds. Growing embryos have a high requirement .

Deficiency of Niacin can result in swollen hocks, reduced growth inflamed tongue and mouth (black tongue), scaly skin and feet, ruffled feathers, reduced feed consumption.

Yeast, fish meal, distillers solubles are good sources. A synthetic supplement is also available.

2.5.2.5 PYRIDOXINE

This Vitamin is a growth stimulator in chicks and is abundant in most feedstuffs. It forms a part of several enzymes. Most practical diets do not produce deficiencies. Most feed ingredients contain pyridoxine, so, deficiencies uncommon .

2.5.2.6 CHOLINE

The chicks demand for choline is very high. At times it may be synthesized by the chick, but the amounts derived from this source are usually inadequate. The older the bird gets the better the synthesis.

The vitamin has many functions in the body: it helps in fat movement in the body; it has a sparing action on methionine, aids in growth; prevents a type of slipped tendon; helps to reduce excessive fat deposits in the liver.

Deficiency of choline can cause perosis, fatty liver, retarded growth.

Fish meal, yeast, liver meal, soybean meal, distillers solubles are good sources. synthetic form of choline (choline chloride) available.

2.5.2.7 BIOTIN

Biotin seems adequate in the diet when the composition of normal feedstuffs is concerned, but only about half is available to the chicken. Thus, it is possible that deficiencies may occur.

Symptoms of biotin deficiency include:scaly dermatitis, mild perosis, retarded growth, reduced hatchability.

Good sources are alfalfa meal, yeast, liver meal and soybean meal.

2.5.2.8 FOLIC ACID

Folic acid is a complicated chemical compound necessary for many physiological functions: growth, muscle formation, blood formation and feather growth. Diets are seldom low in this Vitamin .

Deficiency causes depressed growth, poor feathering with feathers lacking pigment, anaemia, increased embryonic mortality. good sources are alfalfa meal, yeast, soybean meal.

2.5.2.9 Vitamin B_{12} (Cobalamin)

This Vitamin is associated with feeds of animal origin plant products contain little or no vitamin B_{12} . It is synthesized by micro organisms of the intestinal tract as a cobalt-containing compound. However, the process is inadequate to supply the amount needed by most chickens. The birds own droppings are a source of vitamin B_{12} Therefore, birds raised in cages are more likely to show a deficiency than those kept on a litter floor. Deficiency of vitamin B_{12} causes: anaemia, reduced growth, poor hatchabitity and fatty liver.

Sources:- Meat meal, fish meal, poultry manure.

2.5.2.10 ASCORBIC ACID (VITAMIN C)

In all probability vitamin c is not required in the feed of Chicken for birds synthesize an adequate amount. Ascorbic acid helps embryo growth, aids bone development in young chicks and stabilizes body fat.

2.6 UNIDENTIFIED GROWTH FACTORS

In spite of the knowledge of the basic feed ingredients, there are occasions when some natural feedstuff seem to improve the growth of chicks when added to purified diets containing all the known nutritive requirements in ample supply. At present there seem to be two unidentified factors in this group. Sources containing a good quantity of these factors are known even though the factors have not been identified.

These two factors are:

1. WHEY FACTOR : Sources are whey, distillers dried solubles and yeast.
2. FISH FACTOR : Sources are fish meal, and fermentation products.

2.7 FEED ADDITIVES

Additives are products usually included in the feed mixture in very small quantities to obtain some special effect.

Additives available for inclusion in animal feeds together with details of the preslaughter withdrawal times (i.e. the time before the slaughter of the animal when ingredient should be withdrawn from its ration to avoid the possible danger that traces of the ingredient might appear in edible tissues and hence in food for human consumption).

These "nutritional additives do not have a part to play in the metabolic processes of the animal. What they do is to make the processes more effective in some way, either by counteracting some growth depressant in the system, by modifying hormonal balances or by improving the appeal or quality of the feed mixture on offer and there by the bird's consumption.

The use of additives should only be considered when there is evidence that their inclusion in the mixture will lead to some such advantage and that the advantage will be economical. Their use should be very carefully controlled at all times in case there should be effects which will be counter-productive. Priority should be given to proper formulation of rations. Effect of additives is not a substitute for good animal husbandry. They are used for fine tuning only.

Additives are included in a feed mixture in very small quantities and, in view of this, special consideration must be given to the manner in which they are mixed, in order to ensure that the additive is evenly distributed throughout the mixture.

The most satisfactory method of mixing is to incorporate the additives in a 'premix' or 'carrier' before they are added to the main bulk of the ingredients in the mixer. The premix might 'bulk up' the additive in this way so that it may be added at the rate of, say, 3 kg per ton of ration. Considerable care is necessary when calculating the actual quantity of the additive that has to be included in the ration. The inclusion of incorrect amounts may lead to unexpected, perhaps, unfortunate results.

The possible effect of one additive upon another must always be considered. In some cases additives may be antagonistic to one another whereas, in others, they may be complementary. The combined value of two additives used at the same time may on occasion be greater than the sum of their individual values, and this phenomenon is known as a synergistic effect.

Feed additives can most conveniently be discussed under the following categories: additives intended to overcome some limit to growth; additives intended to modify the hormonal balance; additives intended to improve the acceptability of the ration and additives intended to improve the acceptability of the ration and additives intended to improve the appearance of the final product.

a. Additives intended to overcome some limit to growth.

Antibiotics may be used for improving rate of growth and feed efficiency as well as for the prevention and treatment of disease. The so-called nutritional levels of inclusion are 4g per ton of the narrow-spectrum antibiotics, and 10g per ton of the broad-spectrum types.

Suitable antibiotics, could neutralize any unsuitable bacteria or other toxic organisms, thus rendering further nutrients available and, at the same time, stimulate some of the useful intestinal micro-organisms thus allowing the greater production of certain nutrients.Generally, the higher the standards of hygiene and general management are, the lower the response. The greatest benefit occurs in young, fast growing animals.

b. Additives intended to modify the hormone balance

Hormones are substances produced by the endocrine or ductless glands of the body. They pass directly into the blood stream and play a vital part in the well being of poultry, being concerned as regulator in most body processes. Synthetic hormone preparations can be used in the form of implants or injections.

c. Additives intended to improve the acceptability of the ration Antioxidants.

Antioxidants increase the stability and storage life of certain nutrients especially vitamins and fats which are prone to loss of value due to oxidation. Antioxidants are used to give protection to fats and oils which might become rancid in the feed mixture, to fat, soluble vitamins which would break down and lose their potency and to the xanthophyll (used for improving the color of egg yolks and broiler flesh), which might lose their pigmenting value.

d. Additives intended to improve the appearance of the final product

Pigments may be added to the rations for broiler chickens and to those for laying hens when a deeply pigmented skin in the broiler, or richly coloured egg yolks from the layer, are required. This will be most likely when feed mixtures low in yellow maize or green feed (grass or lucerne) have to be used. Colouring in naturally yellow-skinned birds is dependent upon the level of deposit in the fat, skin, shank and beak of pigment known as xanthophyll.

In a similar manner the degree of pigmentation of the yolks of eggs laid by all species of fowls is dependent upon the level of carotenoid pigments in the diet.

Fresh and dried green feed are the main natural sources of xanthophyll and in addition, carry quantities of the carotenoid precursor of vitamin A. In view of this, it is often considered that dark-yellow colored egg yolks are also rich in vitamin A, but this may not be the case. Vitamin A itself is an almost colourless substance and although dark colored yolks may also be rich in vitamin A they are not necessarily so.

Alfalfa meal is commonly used as a source of xanthophyll. It is highest in its xanthophyll content in the fresh form. It is thus normally hung in the middle of the poultry house from which the birds can pick at will. Dried alfalfa meal will have lost most of its xanthophyll and carotene.

Synthetic colouring agents are also commercially available.

3. DIGESTION IN POULTRY

Many of the organic components of feeds are in the form of large insoluble molecules which have to be broken down into simpler compounds before they can pass through the mucous membrane of the alimentary canal into the blood and lymph. The breaking down process is termed digestion.

Within certain sections of the digestive tract, chemicals are produced to facilitate the digestive process. These are known as enzymes. Each of the several types has a specific function in producing the necessary chemical reaction. Enzymes are catalysts produced by living cells to aid certain chemical reactions without entering into them All enzymes are conjugated proteins.

Other chemicals are secreted to alter the acidity or alkalinity of the tract so that the chemical reactions may be expedited. All in all the digestive process in poultry is quick, continuous and constant for the most part, the processes are the same in a young chick as they are in a laying hen.

The fowl is omnivorous, as monogastric, but with a digestive tract differing in a number of respects from typical monogastric animals (eg. pigs)

Fig 1. Structure of the digestive tract of poultry

3.1 FUNCTIONS OF PARTS OF THE DIGESTIVE TRACT

MOUTH (BEAK) : In the fowl, the lips and cheeks are replaced by the beak, the teeth being absent. Saliva which is slightly alkaline is produced. Contains some enzymes. The enzyme (ptyalin) X-amylase has the capacity to hydrolyse starch and convert it to sugars. However, feed is held just a short time in the month of chicken and the hydrolysis here is minimal.

OESOPHAGUS : is a dilatable tube with a function of transporting feed from beak to the crop. No enzyme production.

CROP : or diverticulum or expanded part of the oesophagus. It serves as a reservoir for storage. The feed remains here for varying lengths of time depending on its particle size, on the amount consumed and on the amount of material in the gizzard (the next organ). In the crop, the feed particles are softened and amylase from the month continues to hydrolyze the starch. No enzyme produced here.

PROVENTRICULUS : The oesophagus terminates at the proventriculus or glandular stomach which leads into the stomach. It is here that the gastric enzyme, pepsin, is produced, along with hydrochloric acid. The hydrochloric acid changes the contents of the digestive tract from alkaline to acid and aids in protein digestion. The proventriculus is small and holds little feed material; feed passes quickly through it to the gizzard. Because feed is held in the proventriculus for such a short time, little or no actual digestion takes place here.

GIZZARD: this is unique to birds. It is a highly muscular portion of the alimentary tract and is capable of exerting pressures of up to several hundred pounds per square inch. It is here that large particles of feed material undergo mechanical grinding . Usually in the presence of "grit" in the form of sand, or other abrasives to help facilitate the process. Although highly variable, the contents comprise about 50% water when in the gizzard. No enzymes are secreted in the gizzard, but digestion continues as a result of the secretions of the proventriculus. The presence of grit in the gizzard, although not essential, has been shown to increase the breakdown of whole grains by about 10%.

THE SMALL INTESTINE:

The foremost portion of the small intestine is known as the duodenum. It takes the form of a loop known as the duodenal loop; imbedded within the loop is the pancreas, which empties its secretions into the intestine . The pancreas produces pancreatic juice which contains amylase, lipase and trypsin. These, along with other enzymes, continue the process of digestion in the duodenum, although most of the absorption takes place in the next section of the small intestine, the jejunum. The third section is the ileum where enzymes are produced.

Bile is secreted by the liver and flows into the duodenum as a thick, green material. It does not contain enzymes, but has the following functions:

- Emulsification of fats;
- Activating peristaltic movement of the intestines;
- neutralising the contents of the intestines.

Comparatively speaking, little digestion takes place until the feed reaches the small intestine. Here, most of it is completed.

THE LARGE INTESTINE

Some of the processes of digestion may cantinue in the large intestine, although no enzymes are secreted here; any digestion is a continuation of processes initiated in the small intestine.

Water moves in and out of the large intestine, but outward transfer predominates to bring the intestinal contents into a more solid state. This movement of water is related to conditions associated with dehydration and edema of the tissues. Dehydration is a condition produced as a result of loss of sodium and/or potassium from the muscle cells. Retention of water produces edema, a condition arising when too much salt is consumed, and the body tries to dilute the salt in the cells of the tissues and in the space between the cells by osmosis. Both dehydration and edema of the tissues affect the transfer of water through the walls of the large intestine.

The large intestine in poultry is very short. Faeces can be stored for a short period of time.

CECA.

At the juncture of the small and large intestines are two pouches called ceca. Formentation takes place here to a limited extent. Some absorption can also take place. This organ is not essential to the fowl since surgical removal causes no harmful effects.

CLOACA

A common site (chamber) for the digestive tract as well as the urinary and reproductive systems. End products of digestion from the digestive tract and end products of the metabolism from the urinary tract are thus voided together in poultry.

3.2 CHEMICAL DIGESTION OF NUTRIENTS

3.2.1 CARBOHYDRATES

Carbohydrates are complex chemical structures composed of starches, cellulose, pentosans, some sugars and other forms. The carbohydrates undergo hydrolysis during the course of digestion, reducing the complex structures of starch by the action of amylase to maltose and ultimately to glucose by the action of maltase.

Saccharose (sucrose) will be degraded by sucrase to glucose and fructose. The fowl lacks the enzyme lactase. Birds can't, thus, make use of lactose (milk sugar). Some fermentation of crude fibre especially hemicellulose can occur in the ceca and large intestines by action of microorganisms. However, for all practical purposes, crude fibre in feeds is not utilised by chicken.

3.2.2 FATS

Fats can't be absorbed unless they are at least partially soluble in water. Digestion includes the formation of fatty acids and glycerol through the action of lipases. The bile is helpful in facilitating this action.

3.2.3 PROTEINS

Proteins must be broken down into amino acids inorder to pass the intestinal wall. A number of enzymes are involved in the degradation of proteins. The digestion starts by the action of pepsin in the stomach (proventriculus). Many enzymes:- Trypsin, carboxypeptidase, aminopeptidase, dipeptidases act on proteins and accomplish their specific duties until the proteins are totally transformed to amino acids.

Proteins not only vary in the combination of the amino acid constituents but also in their digestibility. For instance, fish protein is more digestible than protein from blood.

3.2.4 VITAMINS

Many Vitamins occur in combinations that prevent absorption through the intestinal wall; they must undergo a type of digestion, or at least change, to enable them to pass into the blood stream .

3.2.5 MINERALS

Minerals can't be said to undergo digestion; they are absorbed from the intestinal tract in the same form as they are fed; but solubility is related to their absorption.

4. ABSORPTION OF DIGESTED NUTRIENTS

The main organ for absorption of dietary nutrients is the small intestine. This part of the tract is especially adapted for absorption because its inner surface area is increased by folding and the presence of velli.

Absorption of a nutrient from the lumen of the intestine can take place by passive transport, involving simple diffusion, provided there is a high concentration of the nutrient outside the cell and a low concentration inside. An alternative and faster process is by active transport which involves a specific carrier. Absorption of sugars and amino acids is mainly by this method. The carrier has two specific binding sites and the organic nutrient is attached to one of these while the other site picks up sodium. the loaded carrier moves across the intestinal membrane and deposits the organic nutrient and the sodium inside the cell. The empty carrier then returns back across the membrane free to pick up more nutrients . The sodium which enters the cell is actively pumped back into the lumen where it is available for attachment to another carrier site. A number of carriers are thought to exist although some may carry more than one nutrient; for example xylose can be bound by the same carrier as glucose.

The third method of absorption is by pinocytosis ("cell drinking") in which cells have the capacity to engulf large molecules in solution or suspension. Such a process is particularly important in many newborn suckling mammals, in which immunoglobulin present in colostrum are absorbed intact.

4.1 CARBOHYDRATES:

Carbohydrates are absorbed as monosaccharides. Formation of these simple sugars from disaccharides takes place on the surface of the microvillus membrane. The monosaccharides are actively transported across the cell after attachment to the specific carrier and carried by the portal blood circulation to the liver.

The rates of absorption of various sugars differ. At equal concentrations, galactose, glucose, fructose manose,xylose or arabinose are absorbed in decreasing order.

4.2 FATS

Fats after digestion are found in the form of mixed micelles. the pattern of absorption of these micelles is into the mucosal cells of the jejunum by passive diffusion. Following absorption, there is resynthesis of triacylglycerols into chylomicrons (minute fat droplets), which then pass into the lacteals of the Villi, enter the thoracic duct and join the general circulation. In fowls the lymphatic system is negligible and most of the fat is transported in the portal blood as low density lipoproteins.

4.3 PROTEINS

The products of protein digestion in the lumen of the intestine are free amino acids. The amino acids which pass into the portal blood and then to the liver, are absorbed from the small intestine by an active transport mechanism which in most cases is sodium dependent.

4.4 MINERALS

Absorption of mineral elements is either by simple diffusion or by carrier mediated transport. The exact mechanism for all minerals have not been established, but the absorption of calcium for example, is regulated by 1,25 dehydroxychole calciferol. Low alimentary P^H favours calcium absorption but it is inhibited by a number of dietary factors such as the presence of oxalates and phytates. An excess of either calcium or phosphorus interferes with the absorption of the other. The absorption of calcium is also influenced by the requirement of the animal. For example, the absorption of calcium from the digestive tract of laying hens is much greater when shell formation is in progress than when the shell gland is inactive.

The absorption of iron is to a large extent independent of the dietary source. The animal can regulate iron absorption to prevent excessive amounts entering the body.

Zinc resembles iron in being poorly absorbed from the alimentary canal. Calcium is believed to inhibit zinc absorption.

4.5 VITAMINS

The fat soluble vitamins (A,D,E,K) pass through the intestinal mucusa mainly by simple diffusion. Vitamin A is more readily absorbed than the precursor carotene. It is generally considered that unless ergosterol has been irradiated to vitamin D_2 before ingestion, it can not be absorbed from the tract in any quantity. Water soluble vitamins are believed to be absorbed both by simple diffusion and by carrier mediated transport which is sodium dependent.

5. NUTRIENT METABOLISM

Metabolism is a term used to denote those chemical changes in feed components that occur after digestion and absorption. For the tissues of the body to be able to utilise the simpler compounds carried to them by the blood circulation, further chemical reactions must take place. By these additional processes energy is developed, fat is stored, heat is liberated and many end products not of value are eliminated through the kidneys.

5.1 CARBOHYDRATE METABOLISM

A portion of the simple sugars entering the blood stream is used to produce energy. During the process, body heat is generated. The procedure is relatively quick; there is a close correlation between feed consumption and energy produced. The bulk of the glucose and a few other simple sugars are first converted to glycogen by the liver and stored. The storage capacity for glycogen reaches its maximum, additional glucose in the blood stream is quickly converted to fat to keep the blood at its tolerance level;

5.2 FAT METABOLISM

The metabolism of fats is a process by which the fatty acids are converted and used for energy, egg production or stored as body fat. Stored fats are species specific; that is, the consistency, as indicated by their texture, melting point, etc; varies according to the bird or animal.

Unlike some other nutrients, fat is not excreted either in an original form or as a by-product. Excesses can only be deposited in the fat cells. If the carbohydrate or fat consumed is greater than that required by the bird, deposits of fat continue,If the energy of the diet is lowered below the amount necessary for body processes, the stored fat will be called upon to make up the difference, and the fat deposits decrease.

5.3 PROTEIN METABOLISM

Once the amino acids enter the blood stream they are transferd to the various tissues of the body. Here the cells use them in various ways such as for the repair of tissue structure, formation of new tissues, egg production, etc. and for the rebuilding of various protein structures. However, all the amino acids entering the blood stream may not be necessary to manufacture a type of protein for a particular bird at a particular time. Excess of amino acids may be used for energy through deamination, which splits off the nitrogen from the molecule,after which the nitrogen is excreted by the kidneys most generally in the from of uric acid;

5.4 MINERAL METABOLISM

Minerals are not metabolised in the strict sense, rather, they are incorporated as a part of certain protein or enzyme molecules. In some instances, chemical reactions which produce these molecules can't take place without the mineral. Therefore, many minerals are an important part of the metabolic process, although sometimes indirectly. In some cases a small amount of a trace mineral is absolutely essential, but an excess leads to difficulties,as with selenium.

6. FEED CONSUMPTION IN POULTRY

The lack of satiety (fullness) in certain sections of the alimentary tract induces the primary need for feed. Chicken are continuous nibblers compared to most animals which resort to eating a meal, then rest while the meal digests. But even then chicken do not eat every minute the light is ample for them to find the feed trough. They fill their gizzard to capacity, then wait until some feed leaves these organs before they eat again. The process will be repeated many times a day if feed is present.

Nutritionists have taken advantage of the above regulatory phenomenon by increasing the density of a feed so that birds will eat more before they feel "full". Rations high in energy (less bulk) and compressed feeds (pellets) are typical examples.

Satiety may be the explanation why birds visit the feeder often during a day, or even on a short-time basis, but there is a more powerful regulatory mechanism operating over long periods. Although several theories have been advanced, all involve the hypothalamus, the regulator that turns feed eating on and off as the needs of the birds change.

Many things affect the set points which regulate feed consumption. A few of the important ones among the group are strain of birds,genetics, size, sex, age, degree of egg production, egg size, feather cover, activity, type of housing, feed palatability, energy content of the feed, quality of feed ingredients water consumption, body temperature, body fat content and degree of stress. Of these factors, some deserve a little bit of further discussion.

BODY WEIGHT

Heavy birds consume more feed than light birds. The control of feed intake of light bodied laying hens is very precise and they adjust to considerable variation in the energy levels in the diets and will maintain their daily intake of energy at a constant level. Heavy birds, on the other hand, will consume more energy on a high energy diet than a low energy one and become obese .

RATE OF GAIN

Birds that grow faster than the average normally consume more feed than the average. Faster growth means better feed conversion, because a greater proportion of the feed is used for production. At a given weight, immature birds of broiler strains consume more feed than birds of an egg laying strain.

OUTPUT OF EGGS

The intake of dietary energy by laying hens is related to their rate of egg production. A 1% increase in egg production is associated with a 2% increase in feed intake. Feed intake is greater when active egg formation is taking place and there are large differences in intake by hens between egg forming days and other days. Laying birds have been shown to consume 20% more feed on egg forming days than days when eggs are not formed. Feed intake increases markedly when birds go through the hormonal change two weeks prior to the onset of egg production.

DIETARY EFFECTS

The major dietary factor which affects feed intake is the concentration of energy in the diet. An increase in dietary energy results in a decrease in feed intake. The concentration of nutrients other than energy in the diet does not influence appetite so long as the level does not go outside the range which is acceptable for normal health and production. If the diet is deficient in one or more essential nutrients, appetite is depressed and this is associated with a decline in growth or reproductive performance. In the case of a marginal deficiency of an amino acid, for example methionine, both hens and chicks will sometimes consume extra feed to restore their intake of the limiting amino acid to an adequate level. In this case an appetite for the amino acid overrides the appetite for energy. The effect is a small one and occurs only when the concentration of the amino acid in the diet is just below the level needed for maximum performance.

The intae of pelleted feed can be up to 8% greater than the intae of the samle feed presented as a meal. This is partly an effect of partial cooking of the feed and partly because the pellets are more convenient to consume. This high intake of pellets is desirable in young birds since it promotes growth rate, but in the adult it can lead to increased fat deposition and obesity.

OTHER FACTORS

Light intensity has some effect on voluntary feed intake. With chicks, light has a more direct effect upon feed intake by regulating behaviour patterns and extending feeding activity. Maximum feed intake and growth rate are obtained when chicks are reared in continuous light. With broilers too much light may increase activity and therefore reduce efficiency of feed utilisation.

Feed intake by laying hens has been shown to decline as environmental temperature is increased. The decline in intake is curvilinear resulting in a reduction of approximately 1.5% in appetite per degree between 21°c and 30°c and 4.6% per degree between 32°c and 38°c.

7. THE NUTRIENT REQUIREMENTS OF POULTRY

Nutrient requirements are known more precisely for poultry than for any other species of animal. This has come about because the chick is an excellent experimental subject for nutrition studies. Proper poultry rations can be devised only by application of the nutritional information known about the class of poultry to be fed. The application of this information to poultry feeding requires knowledge of the nutrients, the feedstuffs available to supply these nutrients, and the amount of nutrient needed for the particular productive purpose .

7.1 ENERGY REQUIREMENT

The largest single dietary need of an animal is for a source of energy. Energy is required for all physiological processes in the animal-movement, respiration, circulation, absorption, excretion, the nervous system, reproduction, temperature regulation-in short all the processes of life.

7.1.1 Maintenance requirements

Animals kept for productive purposes must be fed to maintain life whether they are producing or not. A considerable part of the feed consumed by all classes of poultry must be used for maintenance .

The maintenance requirement for energy includes the need for basal metabolism and normal activity. Pasal metabolism is the minimum energy expenditure or heat production under conditions when the influence of feed, environmental temperature, and voluntary activity are removed. The basal heat production varies with the size of the animal, and in general, as size increases, basal heat production per unit of body weight decreases. the minimum heat production of day-old chicks is about 5.5 small calories per gram of live weight per hour, whereas the figure for adult hens is about half of this.

The energy required for activity can vary considerably but is usually estimated as about 50% of the basal metabolism. This is probably influenced by housing conditions as well as breed of chicken used . Housing in cages where activity is greatly restricted may result in lower energy expenditure for activity compared with the less restricted conditions prevailing in floor pens.

Inspite of the fact that larger animals require less energy per unit size for maintenance, the total energy required by larger animals is more than by smaller ones. From the practical stand point, this means that the smallest body size for a laying hen consistent with good production, egg size, and livability will be the most efficient for converting feed to product due to a low energy expenditure for maintenance. For broiler production, the animal that reaches market weight in the shortest possible time is the most efficient in converting feed to product because the longer an animal must be fed to reach market weight, the greater the maintenance cost.

In terms of amount of feed required to produce a dozen eggs, high production is more efficient than low production because the maintenance feed is spread over more eggs. The same principle applies to broiler production. Broilers that reach market weight in 8 weeks require considerably less feed per unit weight than those requiring 12 weeks to reach the same weight. Each increment of growth must be maintained longer in slow growing birds.

7.1.2 GROWTH REQUIREMENT

Energy requirements can't be stated as precisely as amino acid, Vitamin and mineral requirements. Good growth rate can be achieved with a wide range of energy levels because of the ability of the chick to adjust the amount of feed consumed to maintain a fairly constant energy intake. broilers are usually fed rations higher in energy content than are replacement pullets. In broiler production, maximum growth rate is usually essential so that broilers can reach market weight in the shortest time; with replacement pullets rapid growth rate is less critical

7.1.3 REQUIREMENT FOR EGG PRODUCTION

The net energy required by a high producing hen consists of energy expended for the basal metabolic rate, activity requirements, and energy stored in the egg. If the basal metabolic rate is estimated as 68 kilocalorie/kg 0.75 , the activity increment is considered as 50% of the basal metabolism, and a large egg contains 90 kilocalorie of energy. A 1.8 kg hen in a comfortable environment, producing an egg a day, would have a net requirement of 250 Kilocalorie of energy per day. The efficiency of using dietary metabolizable energy for these purposes is about 75%, so that the ME intake required to supply the energy needed would be about 330 kilocalorie (100/75 x 250 of metabolisable energy per day. When a hen produces an egg only 8 out of every 10 days, the energy put into an egg will be reduced to 72 kilocalorie per day and correspondingly less for lower rates of production.

Because of the capacity of hens to alter consumption of feed in response to the energy content of a ration, the energy requirement of hens can't be expressed in terms of a specific number of kilocalorie of ME per kg of ration. However, the minimum level of ME/kg to ensure maximum rate of egg production should not be less than 2650. The level of energy actually used in a ration will depend to a large degree on price of feed ingredients available.

7.2 PROTEIN REQUIREMENT

Protein requirements for maintenance are relatively low, and therefore, the requirement depends primarily on the amounts needed for productive purposes. To meet the protein requirement, the essential amino acids must be supplied in the proper amounts, and the total level of nitrogen in the diet must be high enough and in the proper form to permit synthesis of the non-essential amino acids.

Once the minimum amount of protein required to support maximum growth rate or egg production is supplied, additional protein is oxidized for energy. Protein is not stored in the body in appreciable amounts.

7.2.1 Growth requirement

Protein and amino acid requirements for young growing chicks are particularly critical. The largest portion of the dry matter increase with growth is protein. Deficiency of either total protein or an essential amino acid will reduce growth rate. Protein synthesis requires that all the amino acids needed to make up the protein be present in the body at nearly the same time. When an essential amino acid that can't be efficiently used for protein synthesis are converted to carbohydrates or fat that can be readily oxidized for immediate energy needs or stored in adipose tissue. the carcasses of animals fed rations deficient in protein or amino acids usually contain more fat than those from animals fed adequate amounts of a well balanced protein containing ration.

Much of our present day knowledge of amino acid requirements of growing chicks has been obtained from experiments in which individual crystalline amino acids have been used to formulate amino acid mixtures adequate to support rapid growth.

The most important consideration in expressing amino acid requirements is the amount of feed consumed. A fixed amount of total dietary protein and essential amino acids is needed to support a given rate of gain of body tissue of constant composition. However, when the protein requirement is expressed as a constant percentage of the diet, the absolute daily intake of protein will depend on feed consumption . Thus, requirements expressed as a percentage of the diet are usually related to the energy content of the diet.

As broilers grow, they require increasing amounts of energy and protein .However, as the energy needed for maintenance increases as the broiler grows, less protein is required per unit of energy in the diet. This results in a steady reduction in the grams of protein required per 100 Kilocalorie of ME.

Estimated gains, ME needs and protein required

Per day during growth

Age(weeks)	Average wt of male broiler(gm)s	ME required(kcal/ broiler/day)	PROTEIN REQUIRED	
			gm/day/broiler	gm/100kcal ME
2	250	83	6.17	7.43
3	460	150	10.94	7.29
4	700	200	14.25	7.12
5.	960	247	16.95	6.86
6.	1300	320	20.19	6.30
7.	1670	380	23.37	6.15
8.	2060	445	25.48	5.72

The protein required as a percentage of a diet for any stage of growth can be calculated from these data if the energy content of the diet is known. Assume, for example, that a broiler starting ration contains 3200 Kcal of ME/kg. The protein needed for 2-week-old male broilers is 7.43gm/100 kcal of ME. Therefore, the ration must contain 7.43x32=238 gm of protein per kg of diet, or 23.8%. To obtain 83 Kcal of ME (the daily energy required), a 2-week-old broiler would need to consume 26 gms of this feed (83/3200 x 1000). If the feed contained 23:8% protein, 6.2 gms would be consumed. This is the daily protein required. Relating dietary protein to the energy content of the diet is a key principle used in formulating poultry rations.

7.2.2 Protein Requirements of Laying hens

With each large egg laid, a hen produces about 6.7 gms of protein. This is equivalent to the amount of protein deposited daily by a growing broiler gaining at the rate of about 37 gms per day. Although in a typical flock, egg production would be expected to begin at 22 weeks of age when body weight is only 1.6 kg. During the next few weeks, egg production rises rapidly to a maxim, while body weight continues to increase as the hen completes her body growth. As the production year advances and mature weight is reached, rate of egg production begins to fall gradually.

During the early stages of egg production, hens are gainingweight and depositing protein in their bodies as well as laying eggs. Later, protein needs for weight gain are reduced, but egg size is increased . To be able to produce large eggs at a maximum rate, hens must consume about 17 gms per day of a well balanced protein. the actual amount of protein required in the diet will depend on feed consumption. Suggested energy and protein relationships for white leghorn hens in warm climates are shown below:

ME in diet (Kcal/kg)	Protein required/day	Feed/hen/day(gms)
2600	16.5	105
2750	17.0	100
2900	18.0	95
3050	19.0	90

7.3 VITAMIN AND MINERAL REQUIREMENTS

Most requirements of poultry for Vitamins and minerals are precisely known, particularly for those Vitamins and mineral elements likely to be deficient in practical rations. Unlike protein, vitamins and trace mineral elements are usually supplied to poultry feeds in excess of their minimum requirements. Thus, requirements for these nutrients are usually not stated in terms of expected rate of feed consumption or energy content of the diet, since sufficient amounts over the minimum are usually included in diets for poultry.

A major nutritional need in the diet of laying hens is calcium. For every large egg a hen lays she must use about 2 gms of calcium in the formation of the egg shell. A hen that lays 250 eggs per year deposits roughly 500 gms of calcium in the formation of the egg shell. A hen that lays 250 eggs per year deposits roughly 500 gms of calcium in her eggs, primarily in the form of calcium carbonate. This represents approximately 1300 gms of calcium carbonate deposited by the hen in the shells of the eggs. Calcium is not efficiently used by the laying hen and probably only 50 to 60% of the calcium consumed is actually retained and deposited in the eggs.

Feed consumption is important in determining calcium requirements when expressed as a percentage of the diet, for the same reasons discussed previously for protein requirements. It is possible for young pullets in the early stages of production to make good use of their dietany calcium and manufacture satisfactory egg shells when the calcium content of the diet is less than 3% . Under other conditions, particularly for rations for old hens in hot weather, the calcium content of a laying mash may be raised to as high as 4 to 5% in an effort to improve eggshell quality.