AVIAN NUTRITION

POULTRY, RATITE AND TAMED BIRDS

Nityanand Pathak

2 FEEDS OF POULTRY

feeds are normally the natural organic sources eaten for the supply of nutrients essential for the maintenance of optimum physiological functions of the body.

Main sources of poultry feeds

Poultry birds may be omnivorous and herbivorous. Fowl (Chicken) is the main poultry bird around which commercial farming is flourishing in the country. The other important species of the Indian poultry industry are the duck and quial. Guinea fowl, turkey and recently introduced emu are yet to make a place in production. The later species are mostly grazer and consume considerable quantity of soft and leafy herbages. Thus, the sources of feeds for poultry and ratites may be enumerated in the following groups.

1. Feeds of plant origin
   - (a) Food grains, pulse, oil seeds and their milling by products.
   - (b) Succulent herbages
   - (c) By-products of sugar industry
   - (d) Aquatic plants
   - (e) Fruits and vegetable shortings
2. Feeds of animal origin
   - (a) Meat and offals of mammalian food animals
   - (b) Meat and shortings of aquatic animals like fish, crab, lobster, frog and snail etc.
   - (c) By-products of dairy industry
   - (d) Poultry eggs and carcass processing by products

(e) Silk worm pupae meal

are classified as follows:

1. ENERGY RICH FEEDS

Yellow maize is considered the main feed source around which poultry industry develops. But most of the other food grains are comparable sources of energy. The energy feeds may be further classified into the following sub groups.

A. Cereal grains: Maize, wheat, rice, sorghum, milo, pearl millet, barley, oats, finger millet, paspalum and other minor millets.

B. Cereal grain milling by-products: Wheat bran, rice bran, rice polish, grain shorting's, maize gluten, maize gluten feed, broken rice etc.

C. Sugar: Jaggery and molasses.

D. Root crops and tubers: Beat root, turnip, tapioca, yam, potato, sweet potato, carrot

E. Seeds of fruits and forest like sal seed meal, mahua seed cake, mango seed kernel cake, tamarind seed, nahor seed cake, azar seed cake, karanj cake, castor bean cake, neem seed kernel cake etc.

F. Fats and oils: These are richest sources of dietary energy and used for balancing the dietary energy level of the diets of high laying hens and fast growing broilers.

Mineral supplements

Physiological requirements of most of the dietary essential minerals are not met by the common source of energy and protein feeds and there is need of supplementation of mineral salts for balancing the compounded feeds of different class of poultry. Some of the common sources of different dietary essential minerals are presented in table 2.5 and 2.6.

Vitamin supplements

Vitamins are unrelated chemical compounds required in minute quantity for optimum physiological functions.

National research council (NRC, 1994) of USA has suggested 13 vitamins dietary essential. Some vitamins are synthesized in the birds but products are mostly insufficient to meet optimum requirement due to which dietary supplementation is required. Vitamin D is utilized for the production of D3 form or 1, 25- dihydroxycholecalciferol required for the absorption and metabolism of calcium. Vitamin E is a very effective antioxidant in tissues. The other vitamins are mostly a co-factor in enzymic reactions in the body. Choline is not a metabolic catalyst. It is a source of methyl group (CH3) and a constituent of phospholipids responsible for neurotransmission. Niacin is synthesized from tryptophan in liver and vitamin D3 is synthesized from 7-dehydrocholesterol in the skim exposed to light. Some vitamin of B-complex group, say folic acid and B12 are synthesized by normal microorganisms in the caeca and large intestine but these vitamins are available to scavenging birds through coprophagy. Absorption of these vitamins through the walls of caeca and large intestine is not yet clear and needs further exploration. Requirement of vitamin E is increases on the feeding of polyunsaturated fatty acids. Mostly synthetic vitamin sources are used for supplementing the compounded poultry feeds (Table 2.7).

3 NUTRIENTS

Table 3.1: Classification and sources of common carbohydrates.

Carbohydrates		Monosaccharide constituents	Main sources
A.	**Monosaccharides**		
1.	Pentoses ($C_5H_{10}O_5$)	Arabinose Xylose Ribose	Pectic
B.	**Disaccharides ($2C_6H_{12}O_6$)-H_2O or ($C_{12}H_{22}O_{11}$)**		
	Sucrose sugar	Glucose+fructose	Cane sugar, beet
C.	**Trisaccharides ($3C_6H_{12}O_6$)-$3H_2O$) or ($C_{18}H_{30}O_{15}$)**		
	Raffinose	Glucose+fructose+galactose	Cotton Seeds, sugar beets, eucalyptus
D.	**Tetra saccharides ($4C_6H_{12}O_6$)-$4H_2O$ or ($C_{24}H_{40}O_{20}$)**		
	Stachyose	Polymerized raffinose (galactose + glucose + fructose)	Plants

Disaccharides, trisaccharides and tetrasaccharides together are called oligosaccharides.

E. Polysaccharides; These are complex carbohydrates of big molucue and non sugar in taste

(a)	Pentosans $(C_5H\text{-}_8O_4)n$	Pentose	Pentose polymers

F. Derived carbohydrates

1.	Amino sugars Galactosamine	Glucosamine Galactose, CH_3 N	Glucose, CH_3 N Chitin Cartilage

Functions of carbohydrates in the body

1. Carbohydrates are the major source of dietary metabolizable energy for poultry production.
2. Glycans are universally distributed and found in the cells and inter cellular space. These transmits biochemical signals into the cell and amongst the cells.
3. Contribution of energy from plant carbohydrates is small in carnivorous avian species like owls, hawks and vulturs etc.
4. Carbohydrates are not essential for chicken and they can survive on a dietary energy of lipids and proteins provided protein: energy (ME) ratio is optimum and the sources
   of fat are triglycerides. In the absence of triglycerides gluconeogenesis from amino acids fails due to non availability of glycerol a product of hydrolysis of triglycerides.
5. Blood glucose level should be maintained for normal body functions. The source may be glucogenesis from food or gluconeogenesis from fat and/or protein.
6. Participates in cell functions for protein and vitamins synthesis.
7. Indigestible fibrous carbohydrates are hygroscopic and facilitate defaecation.

Role of soluble non-starch polysaccharides (NSPs)

Higher concentration of soluble non starch polysaccharides is not desirable in the diets of poultry due to following reasons:

1. Soluble non starch polysaccharides like pentosans increase viscosity of digesta resulting in higher rate of passage and lowering of digestion of nutrients and duration of absorption of nutrients.
2. These are indigestible in poultry and occupy the space of digestible constituents of the feedstuffs.
3. The performances of birds decrease due to reduced availability of nutrients.
4. These are, therefore, considered anti nutritional factors.

PROTEINS

Proteins are the constitutional tissues responsible for the development of characteristic shape and size of body in conjunction with minerals. Proteins constitute major part of body and their concentration is maximum in muscles, glands and body fluids. These are complex compounds made of carbon, oxygen, hydrogen and nitrogen. Sulphur and some other substances are also required for the synthesis of special proteins. Proteins are synthesized in all living cells and participate in all activities of cells necessary for the maintenance of life.

Protein content in body

Total protein content in the body of animals including birds ranges from 15 to 20 per cent. Body protein content on fat free basis is almost constant which is 21.6 per cent. The ratio of protein in the body decreases with the increase in body fat proportion. In case of poultry larger part of protein is utilized for the synthesis of feathers.

Constituents of proteins

Amino acids are the units required for the synthesis of proteins. Body protein is made of amino acids. Of the 20 amino acids involved in the synthesis of body tissue 10 were found dietary essential because animals are unable to synthesize these amino acids or can synthesize few in very small quantity, much less than the optimum requirements. These amino acids are essential dietary supply and called essential amino acids (EAA) or non- dispensable amino acids.

Classification of proteins

Proteins are broadly classified into three groups on the basis of their physical, chemical and functional properties (Table 3.3).

Table 3.3: Classification of proteins

Globular proteins	Fibrous proteins	Conjugated proteins
Albumin	Collagen	Glycoproteins
Globulins	Elastin	Lipoproteins
Histones	Keratin	Mucoproteins
		Nucleoproteins
		Phosphoproteins
		Protamines

Amino acids

Amino acids required by poultry or any other animal are differentiated into two main groups of non-essential or dispensable amino acids and essential or indispensable amino acids. Dispensable amino acids are synthesized in the cells to meet the physiological requirements of the body on the availability of nitrogenous moiety. Dietary supplementation of essential amino acids is must for the optimum physiological functions. Protein nutrition is very sensitive in poultry production and deficiency or imbalance of few essential amino acids can disturb the production performances of the birds. The essential amino acids of poultry are further distinguished into critical amino acids and limiting amino acids (Table 3.4).

Table 3.4: Amino acids in poultry nutrition

Non essential amino acids	Essential or indispensable amino acids		
	All amino acids	**Critical amino acids**	**Limiting amino acids**
Alanine Aspartic Acid Glutamic acid Hydrooxyprolin Proline Glycine Serine Citrulline	Lysine Methionine or Methionine+Cystine Tryptophane Threonine Arginine Isolencine Leucine, Valine Histidine, Phenylalanine or Pheylalanine + tyrosine		

Part of methionine requirement can be supplied by cystine and that of pheylalinie by tyrosine.

LIPIDS

Lipids are organic components of plants and animals constituted of fat and fat soluble subestances. These are either insoluble or sparingly soluble in water but highly soluble in organic solvents. Some of the lipids are essential for many biochemical reactions and physiological functions of the living body. Fat and oils are the richest sources of dietary energy for the animals including poultry.

Constituents of lipids

The main basic constituents of lipids are the carbon, hydrogen and relatively small amount of oxygen. These constitute the major part of the body lipids. Some of the lipids contain substances other than triglycerides or triacyglycerols. These are compound and derived lipids and contain different kinds of organic and inorganic substances.

Characteristics of lipids

1. Specific density of lipids is ligher than the water due to which they form top layer on mixing with water.
2. Lipids are soluble in organic solvents like ether, hexane and chloroform etc.
3. Lipids are normally insoluble in water except some sparingly soluble derived lipids.
4. These are condensed sources of energy for the animals. Some of the fatty acids are essential for the normal physiological function of the animal body.

Classification of lipids

Lipids are classified into three broad classes of simple lipids, compound lipids and derived lipids.

1. **Simple lipids:** These are esters of fatty acids with glycerol and other alcohols. Simple lipids were earlier classified into fats, oils and waxes but later on fats and oils were merged together being similar in chemical constituents and called fats.
   Fat: These are the esters of fatty acid with glycerol only. In common non scientic terms the triglyceride compounds in solid form at room temperature are fats and other present in fluid forms are oils. However, there are other confusing situations encountered in normal practice like fats of coconut, mahua seed and salseed are solid at room temperature are called oils due to their vegetable origin. Actually the ratios of unsaturated and saturated fatty acids in the triglycerides are responsible for the solid

or liquid state at room temperature (20°C). In order to avoid this confusion all pure triglycerides are now called fats.

Waxes: These are also simple lipids and esters of fatty acids with alcohol other than glycerol.

2. **Compound lipids:** These are esters of fatty acids with alcohols which also contain non lipid and proteins. These compound lipids are further named on the basis of non- lipid constituent of the compound like phospholipids, glycolipids, and aminolipids or lipoprotein.

   Phospholipids: The lipids containing phosphorus and nitrogen are phospholipids. Examples are phosphoglycerides or phosphatids. Common phospholipids found in the body are lecithin and cephalin. In lecithin's phosphoric acid combines with the nitrogenous base choline and the term phosphadylcholines is more specific for the compounds. In cephalins phosphoric acid combines with ethanolamine and the compounds are also called phosphatidyl ethanolamines.

   Sphingomyelins are different than the lecithins and cephalins. In place of glycerol the constituent is sphingosine. The terminal hydroxyl group joins with phosphoric acid and not a sugar residue. In sphingomyelines, amino groups link with carboxyl group and long chain fatty acids are formed by linkage with peptide bonds.

3. **Derived lipids:** The lipid fractions and other compounds produced from the hydrolysis of simple and compound lipids are know as derived lipids.

Pseudolipids or lipids like substances

These are generally substances extracted with lipids by organic solvents but these are not fats. Such substances are pigments, strols, terpenes and prostaglandins.

Saturated and unsaturated fatty acids

The fatty acids without double bond in molecular structure are known as saturated fatty acids. Unsaturated fatty acids contain one or more number of double bonds in their molecular structure and the degree of unsaturation is determined by the number of double bonds in the molecular structure.

Omega-3 and omega-6 fatty acids

The polyunsaturated fatty acids (PUFA) containing 3 and 6 number of double bonds in their molecular structure are known as omega-3 and omega-6 fatty acids respectively. Linolenic (18 carbons and 3 double bonds) is an omega 3 fatty acid and docosahexaenoic acid (22 carbons and 6 double bonds) is omega-6 fatty acids. These are found plenty in fish oil and some of the vegetable oils. These are protective substances for heart and in recent years have acquired important place in nutrition and dietary managements.

Essential fatty acids

The polyunsaturated fatty asids essential for the normal physiological functions in poultry birds and not synthesized in the body are known as essential fatty acids. The essential fatty acids to be supplied in the diets of poultry are linoleic acid, gama-linoleic acid and arachidonic acid. In true sense linoleic acid is the only essential fatty acid required to be supplied in the diet and it is converted into arachidonic acid from the linoleic acid ingested in the diet.

Functions of lipids

1. Minimum true fat is essential for the absorption of fat soluble vitamins in the body.
2. Fat is also essential for the absorption of carotenoids necessary for the supply of vitamin A activity and imparting yellow colour to egg yolk.
3. Phospholipids in lipoproteins complex are essential for the functions of cell membranes.
4. Glycolipids are the components of brain and nervous system.
5. Adipose tissues are the store houses of energy in condensed form for energy supply. Depot fats are metabolized for blood glucose supply by gluconeogenesis.
6. Dietary fat reduces heat increment in the body.
7. Cholesterol is essential for the normal functions of cells. Production of 7-dehydrocholesterol is essential for the synthesis of active form of vitamin D, i.e., cholecalciferol.
8. Cholesterol is utilized for the synthesis of bile acids necessary for fat digestion and absorption.
9. Essential fatty acids are important for the maintenance of skin health and function of cell membranes and play role in immune modulation.
10. Maintenance of normal reproductive functions like spermatogenesis in male bird and hatchability of eggs in female birds.

ENERGY

Energy is the fuel for the normal physiological functions of the body. In biological terms energy is the chemical constituents of the body yielding calorie through biological oxidation for the vital functions. The heat liberated from the oxidation of glucose is the ultimate form necessary for body functions.

Sources of energy in the body

1. Glucose in the body fluid specially the blood glucose.
2. Glycogen (animal starch) present in the muscles and liver.
3. Adipose tissue in the body.
4. Muscles of the body.

Sources of dietary energy

The sources of dietary energy are carbohydrates, fats and proteins. These are available from food grains, tubers, roots, fats and animal tissues (muscles and fatty tissues). The foods are digested, metabolized and utilized for the maintenance, growth and egg production in poultry.

Units of energy used in poultry nutrition

Generally big calorie or kilocalorie (kcal) or mega calorie (mcal) and joule, kilo joule (kj) and mega joule (mj) are used in different countries for the feeding of poultry birds. A small calorie is the amount of heat required to increase the temperature of 1 g water from 14.5° to 15.5°C. The heat generated from the foods is measured with the help of a bomb calorimeter. Joule is smaller unit than the caloric and in nutrition including poultry nutrition kilocalorie (kcal) or, kilo joule (kj) is mostly used for the expression of energy. For the conversion of calorie to joule the calorie value is multiplied by 4.1854 and joule is divided by 4.1854 to get calorie.

Functions of energy

1. Maintenance of life through the maintenance of normal vital functions of the body.
2. Utilization of nutrients for growth production.
3. Energy supply for metabolism.
4. Energy supply for essential physical activities.
5. Optimum reproductive performances.
6. To provide protection.

Storage of energy

In addition to normal production of skeleton, muscle, skin and feather etc, the excess intake of energy is stored in the chemical form of fat in adipose tissue.

Gross energy (GE)

The total amount of heat produced from complete oxidation or burning of organic matter of a food or other organic substance is known as gross energy. It is also called heat of combustion.

Metabolizable energy (ME)

Since faeces and urine are voided together in the birds, it is more useful and easy to determine metabolizable energy (ME) for practical feeding. Metabolizable energy is the part of gross energy intake minus the gross energy voided in excreta.

Digestible energy (DE)

A study of digestible energy is a subject of academic interest and has little practical utility in poultry production. Sturkie made experimental models with the help of surgery. The ureters were separated from the urodium of the cloaca and joined near the vent for independent excretion of urine. However, it is very expansive and labour intensive to maintain such models.

The other method is on the basis of assumption that grayish white cap on the poultry excreta is urine and faeces can be obtained by its separation. This method is also not free from error.

MINERALS

These are main components of structural frame work of the body besides playing important roles in various physiological functions as constituents, cofactors and activators. The list of nutritionally essential elements has increased from 13 up to 1960 to mere than 20 by this time. However, there is no change in the list of macro or major 7 elements, calcium (Ca), phosphorus (P), magnesium (Mg), sodium (Na), potassium (K), chlorine (Cl) and sulphur (S) but the list of micro minerals or trace minerals is increasing and exceeded 13 from the earlier 6 trace elements comprising of iron, iodine, copper, cobalt, manganese and zinc. It is expected that some more trace elements may be found involved in some physiological functions in the animal body. The present status of micro minerals is presented in table.3.8.

VITAMINS

These are essential micro nutrients of organic composition but mostly unrelated chemical nature. These are dietary requirements in traces and deficiency results in occurrence of health problems and conspicuous drop in production. The terminology "Vitamin" was adopted due to its historical importance. The name vitamin was given by Funk(1912) to certain minute organic constituents of foods capable of preventing diseases like beri-beri, pellagra etc. Exact date of discovery is not yet known. As early as 1753 a British doctor of navy named Lind observed that inclusion of juicy fruits and salads in the diets prevented the occurrence of scurvy. Studies of ancient literatures and the literatures of Vedic and pre- historic period of India may unveil many important informations on the role of micronutrients like vitamins.

Vitamins are classified into two main groups of fat soluble vitamins and the water soluble vitamins.

Fat soluble vitamins: These are soluble in fat and the organic solvents dissolving the fats. The precursors of vitamins are also soluble in fat and organic solvents. The fat soluble vitamins may be present in more than one chemical form in the feed sources but active form useful in the body is mostly one. However, most of the other forms ingested in feeds

are converted into biological active form in the digestive system. The members of fat soluble vitamins are A, D, E and K.

Water soluble vitamins: These are B-complex vitamins and vitamin C. All are soluble in water and mostly highly unstable. Regular dietary supplementation is required. Most of the members of vitamin B complex group are coenzymes or prosthetic group required at different stages in the metabolism of various nutrients and energy utilization for body vital functions. The members of vitamin B – complex group are thiamine (B_1), riboflavine (B_2), biotin, nicotinamide, pyridoxine (Vitamin B6), folic acid, pantothenic acid, choline, vitamin B12 and vitamin C or Ascorbic acid.

Sources of vitamins

Vitamins are available to poultry both from the plant and animal sources, either in the active forms or in the form of precursors which are transformed into active form in the gastro-intestinal tract.

ENZYMES

Enzymes are not considered as nutrients but these are essential for the availability of nutrients for the normal functions of body. These are compounds required to act as catalyst for the storage as well as release of the energy as per the physiological requirements in the body. Various chemical reactions are necessary for the change of energy from storage form to functional form and vice versa. On the basis of functions the enzymes may be grouped in to the following categories.

A. The oxido-reductases: These are actively involved in the transfer of hydrogen, oxygen or electrons from one molecule to another in the body. Following are the various groups of enzymes of oxido-reductase category.

Catalases

B. The transferases: These are enzymes responsible for the transfer of functional groups like acetyl group, amino group and phosphate group from one molecule to another. The various transferases are

Acyl transferase

C. The Hydrolases: The enzymes catalyzing the hydrolytic division of molecules in the body are hydrolases. The hydrolytic enzymes are specific for the cleavage of fat

molecules and protein molecules. Various type of hydrolases are:

Amidases

D. The lyases: These enzymes are responsible for non-hydrolytic cleavage and removal of certain groups from the molecule like removal of carbon dioxide (CO_2) in decarboxylation reaction and amino group ($-NH_2$) in deamination reaction. Some of the enzymes of this category are:

Aldolases

E. The Isomerases: These are enzymes responsible for catalyzing reactions for the rearrangements of position of elements or groups within the molecule. The various groups of enzymes are:

Isomeras
es

F. The Ligases: The enzymes catalyzing the formation of new molecules from two molecules are the ligases. The reaction receives energy from the break up of ATP to AMP in case of production of Acetyl-CoA from the reaction of acetic acid and co enzyme A.

4 FUNCTIONS OF NUTRIENTS

Growth

1. **Maintenance of life with the help of blood and blood circulation for**
   (i) Gaseous exchange, i.e. supply of oxygen to each cell of the body and collection of carbon dioxide from each cell for expulsion out of the body by expiration.
   (ii) Transportation of nutrients to each organ and cells of the body.
   (iii) Maintenance of acid-base balance, osmotic pressure and homoestasis.
2. **Reproduction:** This includes birth of off springs and their maintenance till they become capable of surviving on non-maternal foods like milk in mammals and eggs in aves, reptiles and pisces.

All these functions in living body are accomplished by reconstitution of dietary
nutrients in the body in different organs, particularly the glands (liver, pancreas, spleen, kidneys) and tissues.

1. WATER

Water is the most important constituent of body and survival is not possible without water. More than two-third of animal body is water and its proportion in youngs is more than 70 percent of body mass.

Functions of water in the body

1. Maintenance of equilibrium among the fluid compartments (blood, lymph, interstitial fluid and intracellular fluid). The function is known as homoeostasis.
2. It is an essential medium for the optimum digestion because effective action of enzymes needs adequate water.3. Exchange of nutrients and metabolites upto cellular level.
4. Lubricant.
5. Constituent of products, viz. chicken egg contains about 67% water and meat contains 75% water in broilers but less (about 70%) in culled birds.
6. Maintenance of body temperature.

Symptoms of deficiency

1. Loss of appetite resulting in lowered feed intake; complete cessation causing decreased growth and egg production.
2. Dehydration and ruffled feathers.
3. Death on loss of more than 20 percent water from the body in most of the species.

2. CARBOHYDRATES

1. Staple food constituting more than 50 percent of daily diets.
2. Main source of metabolizable energy and productive energy.

Functions

1. Energy supply for life and production.
2. Feeling of satiety.
3. Maintenance of blood sugar level.
4. Soluble non starch polysaccharides (NSPs) like pectins, arabinoxylans, beta-glucons, xylans and hemicellulose are indigestible and also interfere in the digestion of other nutrients. However, these absorb water and help smooth passage of ingesta and digesta.
5. Storage of energy in the form of glycogen in liver and muscles and also considerable increase in blood glucose (130-270 mg/dl) level.
6. Formation of ribose essential for AMP, ADP, ATP, RNA and DNA.

7. Essential for metabolism of protein and fat. In case of hypoglycemia fat metabolism is incomplete and ketone bodies accumulate.

3. PROTEINS AND AMINO ACIDS

Proteins are the polymers of essential and non-essential amino acids required for the formation of body tissues. There are also free circulating proteins particularly conjugated proteins and other responsible for the management of vital functions in the body. The properties and functions of proteins depend on the length of peptide chain, structural arrangements of the amino acids and incorporation of other nutrients or elements in the protein structure (Conjugated proteins like lipoproteins, glycoproteins and metaloproteins etc.).

Functions of proteins

1. Formation of cells and tissues including gametogenesis.
2. Connective tissues like ligaments and tendons composed of fibrous proteins (collagen and elastin) responsible for movement and also the formation of skin and feathers.
3. Glycoproteins and lipoproteins are the constituents of cell membrane and responsible for the maintenance of homoeostasis and osmotic pressure by controlled movements of fluids, nutrients and metabolites across the membranes.
4. Blood proteins fibrin and thrombin with other factors are responsible for blood clotting.
5. Gaseous exchange, haemoglobin in blood and myoglobin in muscles are responsible for transportation of oxygen upto cells and removal of carbon dioxide from cells to lungs for expulsion in expired gas.
6. Transportation of nutrients to target organs for growth, repair, replacement and storage etc.
7. Transmission of genetic materials in gametes (eggs and sperms) and nutrients supply for gametes.
8. All enzymes and most of the hormones are proteins. These are essential for metabolism and vital functions.
9. Antibodies providing protection against diseases are proteins.
10. Provides metabolizable energy by gluconeogenesis in deficit glucose supply from deficit intake of carbohydrates and fats.

4. FATS

The proportion of fats is highly variable and depends on the species, breed, age, sex, level of nutrition, composisiton of diets and production level (Egg production). For normal physiological functions the level of body fat in birds should be more than 2 percent. Body fat content in non producing obese bird may be upto 50 per cent, although such high level is a rare incidence.

Functions

1. Condensed source of energy. About 2.25 times more than the available energy from carbohydrates or proteins.
2. Carrier of fatsoluble vitamins and also the precursors of vitamin like carotenoids that impart yellow color of egg yolk. It shows that all dietary carotenoids ingested in feeds are not converted to vitamin A activity (Retinol) in intestinal mucosa and liver parenchymal cells.
3. Structural and functional components of cell membranes
4. Storage of energy in fat depots.

Essential fatty acids

Although three fatty acids, i.e., linoleic, linolenic and arachidonic acid have been identified as essential fatty acids for the animals but for the birds only linoleic acid is strictly essential. Vegetable oils are rich sources of linoleic acid.

Unsaturated fatty acids

The fatty acids containing double bond (s) in their structure are known as unsaturated fatty acids. A fatty acid with single double bond in molecule is known as mono- unsaturated fatty acid (MUFA) and those with two or more double bonds in the molecule are polyunsaturated fatty acids (PUFA). These are considered better than the saturated fatty acids.

Blood lipids

The sources of blood or plasma lipids are:

1. Absorbed from the digested feeds.
2. Lipids synthesized in the liver.
3. Lipids mobilized from fat depots in the body.

The plasma lipids are found in the following chemical forms:

1. Chylomicrons

2. Lipoproteins: These are very low density lipoproteins (VLDL), low density lipo-proteins (LDL) and high density lipo-protein (HDL).

Symptoms of deficiency

1. Poor growth
2. Reduction in production and size of eggs.
3. Reduced fertility in both sexes
4. Poor hatchability

Symptoms of excess fat intake

1. Development of obesity
2. Occurrence of cardio-vascular disorders.

VLDL and LDL are claimed to be more harmful

5. ENERGY

Energy is the heat generated from the metabolism of organic nutrients-carbohydrates, lipids and proteins. Survival is not possible without energy supply as all vital functions need energy.

Symptoms of deficiency

1. Unthriftness
2. Loss of body weight.
3. Reduction in metabolism and other body functions.
4. Fall in egg production.
5. Deformity in phenotypic appearance.

Symptoms of high excess

1. Development of obesity.

2. Occurrence of other deficiency disorders caused by the imbalance of nutrients ingested.

6. MINERALS

General functions of minerals.

1. Development and maintenance of skeletal system.
2. Maintenance of acid-base balance by maintaining the ratios of anions (chloride, iodide, phosphates) and cations (Calcium, Magnesium, Potassium, Sodium, Iron, Mangenese and Zinc).
3. Cellular respiration with the help of haemoglobin and myoglobin.
4. Immunomodulator.
5. Catalyst/cofactor in enzyme and hormones activities.

Minerals constitute about 4 percent dry matter in the body. All dietary minerals involved in various physiological functions are exogenous and essential because these can not be produced in the body. Seven minerals constituting more than 0.1 per cent are called major or macro minerals and include calcium, phosphorus, magnesium, sodium, potassium, chloride and sulphur.

The minerals requirement less than 0.1 per cent in the body are known as micro minerals or trace elements. The nutritional relationship among the minerals is very important because it is synergistic as well as antagonistic among different dietary essential minerals. Likewise there are certain minerals that are nutritionally essential in traces but turn harmful or even toxic on increasing the concentration beyond the maximum tolerance level. Therefore, it is essential to maintain concentration as well as ratio among the nutritional minerals.

Calcium and phosphorus

In the animal body calcium (Ca) and phosphorus (P) are required in the ratio of 1:1 to 2:1 and vitamin D3 for optimum utilization.

1. Largest quantity of calcium and phosphorus are used for skeletal development.
2. Common feeds (grains, oilseed etc.) of plant origin are deficient in calcium, phosphorus and many other minerals and required supplementation of richer sources.
3. For optimum utilization dietary ratio of Ca:P should range from 1;1 to 2:1 preferably 2:1, but in feeds of laying hens this ratio changes to about 5:1 due to continuous turn over of the large quantity of calcium for the formation of egg shell.

4. Apparently the quantity of P in feeds of plant sources may be considered reasonably adequate for adult birds but it is not available due to presence in phytate form. Liberation of phytate-P (PP) requires the enzyme phytase which is not produced in the birds.
5. The phosphorus found in the feeds of animal sources like bone meal, bone ash, fish meal and meat-cum bone meal are non-phytic phosphorus (NPP) which are readily available to birds and other animals.
6. Supplementation of not only Ca and P but many other essential minerals is necessary for the balancing of diets.

Functions of Calcium (Ca)

1. Skeletal development and maintenance (bone contains almost 99% Ca) in all birds.
2. Egg shell formation in laying birds. Egg shell contains 3-4% calcium.
3. Maintenance of egg shell permeability.
4. Neuro-muscular excitability depends on Ca level.
5. Active role in blood clotting.
6. Co-factor in enzyme systems.

Functions of phosphorus (P)

1. Bone formation, almost 80 percent absorbed P is used for bone formation.
2. Functional constituents, viz. phosphoproteins, phospholipids and nucleoproteins. Phosphorus is essential for the functions of cells.
3. Essential for energy metabolism particularly the release of energy for body functions and also storage of excess energy as body reserve.
4. Cell formation and repair of wear and tear.

Deficiency symptoms of Ca and P

1. Decreased feed intake due to inappetence.
2. Loss of body weight and weakness.
3. Rickets in growing chicks.
4. Lowered egg production.
5. Reduction in egg weight.
6. Thin shell formation.

7. Shellless egg laying in extreme cases.
8. Mottled egg yolk.
9. Decreased hatchability in breeding flock.
10. Weak chicks are hatched. Post hatching chick mortality is high and performance of survivers is poor.

- Sodium or Natrium (Na) Chloride
- Salt toxicity
- Potassium or Kalium (K)
- Magnesium (Mg)
- Sulphur (S)

7. MINOR OR TRACE MINERALS

Iron, copper, manganese, zinc, iodine, selenium, fluorine and cobalt receive more attention in ration formulation of poultry.

- **Iron or ferrous (Fe)**
- **Copper or cuprum (Cu)**
- **Manganese (Mn)**
- **Zinc (Zn)**

Zinc is a dietary essential trace mineral and integrated part of several metalloenzymes. It is also activator of many other enzymes. Cereal grains and oil seed cakes are generally deficient in zinc.

Functions

1. Zinc is component of many metalloenzymes like carbonic anhydrase, carboxypeptidase A and B, alkaline phosphatase, DNA polymerase, ribonuclease and many dehydrogenases.
2. It is activator for some of the enzymes.
3. It is associated with the roles of some hormones like insulin, testosterone and steroids.
4. Maintenance of immune system.
5. Required for protein synthesis.
6. Maintenance of water level (homoeostasis) in the body.
7. Antioxidant and protection of cell membranes.

Deficiency symptoms

1. Weak chicks and high early mortality.
2. Enlarged hocks, shortened legs and growth retardation.
3. Lowered weight of thymus, spleen and bursa fabricius.
4. Rough feather and scaly skin.
5. Reduced hatchability and deformed embryonic development, viz. fusion of lumbar vertebrae, missing toe and shortened legs etc.
6. Hatched chicks are weak and unable to stand and walk. Breathing difficulties and death of most chicks due to various degree of starvation.
7. Incomplete and slow feather growth and failure of feather growth in extreme cases.
8. In surviving chicks feed intake is lowered which causes delayed maturity and less egg production.

- **Iodine**
- **Cobalt (Co)**
- **Selenium (Se)**

Toxic minerals found essential for poultry

Some of the minerals found toxic for poultry are the salts of aluminium, barium, bromine, cadmium, chromium, fluorine, lead, mercury, molybdenum etc.

- **Molybdenum (Mo)**
- **Silicon (Si)**
- **Arsenic (As)**
- **Nickel (Ni)**
- **Vanadium (V)**

Suspected essential trace elements

Some more elements like tin (stanus, Sn), barium (Ba), bromine (Br), Cesium (Cs) and rubidium are suspected for playing some role in metabolism. Extensive studies are required before consideration of these elements for their essentiality.

8. VITAMINS

Classification of vitamins

Vitamins are classified into two main groups of fat soluble and water soluble substances.

A. Fat soluble vitamins: Four fat soluble vitamins are A,D,E and K. Each vitamin is found in different forms and variable functions efficiency. Fat soluble vitamins are dietary essential but do not require daily supplementation because these can be stored in body fats for several days or much longer period.

B. Water soluble vitamins: These are not stored in the body except vitamin B12 and daily supply is required. Common feeds of poultry are satisfactory sources
of many water soluble vitamins. The water soluble vitamins are thiamin (B1), riboflavin (B2), niacin or nicotinic acid, pantothenic acid, Vitamin B6 (Pyridoxine, pyridoxal and pyridoxamine), Vitamin B12 and folacin of the B- complex group and vitamin C or ascorbic acid.

A. FAT SOLUBLE VITAMINS

1. Vitamin A

Both preformed and precursors are available in nature and later forms are converted into vitamin A activity in the intestinal mucosa and liver. The rate of conversion of carotenoids into vitamin A activity is not similar in different species.

Vitamin A occurs in three forms.

(i) Alcohal form or retinol.
(ii) Aldehyde form or retinal
(iii) Acid form or retinoic acid or esterified form with a fatty acid.

All the three forms of active vitamin A are called retinoids and retinol is the most active form of Vitamin A.

Carotenoids or precurs of vitamin A are variable in vitamin A activity. Maximum conversion of carotenoids into vitamin A activity occurs in the intestinal mucosa followed by liver cells. Considerable proportions of carotenoids (mostly yellow to yellow orange in colour) remain unchanged and deposited in body fat. The carotenoids are carried in circulating fat and fatty acids. Egg yolk fat has high affinity for the carotenoids which impart yellow colour. Intensity of yellow colour of yolk depends on the source of concentration of carotenoids transfered from feeds into body of the laying birds. So far more than 500 types of carotenoids have been identified in plants. Till to day not a single plant has been found to possess active form of vitamin A. Largest proportion of absorbed carotenoids are stored in the liver and transported to ovary in blood circulation where greater amount is retained in the yolk of developing follicles during oogenesis.

Functions

1. One of the most important function of vitamin A is the formation of rhodopsin or visual puple essential for sight. Lack of rhodopsin formation in the absence of vitamin A causes night blindness (xerophthalmia) leading to total blindness on prolonged deficiency.
2. Required for the maintenance of integrity of the epithelial cells.
3. It is essential for normal skeletal growth by maintaining the functions of osteoblasts (bone forming cells) and osteoclasts (bone phagocytes).
4. It is required for normal cellular metabolism, protein synthesis and gene expression. Two proteins actively involved are the cytosolic retinoid binding protein (CRBP) and cytosolic retinoic acid binding protein (CRABP).
5. Maintenance of normal reproduction.
6. Regulation of immune system.
7. Protection from cancer.

Sources of vitamin and its precursors

1. Fish oil like cod liver oil, shark liver oil etc.
2. Fish meal and fish trash.
3. Green and yellow leafy vegetables, carrot, pumpkin etc are rich in carotenoids.

2. Vitamin D

Synonyms of vitamin D are anti-rachitic vitamin, sun shine vitamin or sterol vitamins. Many sterols have been found to have vitamin D activity but only two forms are more useful. These are ergosterol or calciferol (D2) and 7-dehydrocholesterol (D3). Efficiency of utilization of vitamin D2 is very low in poultry and should be considered only when vitamin D3 is not available for supplementation. Vitmain D_2 is present in plants and D3 in animals.

Functions

1. It is essential for the intestinal absorption of calcium and phosphorus.
2. Maintenance of high Ca and P levels in plasma essential for normal skeletal growth.
3. Prevention of Ca deficiency tetany by mobilizing Ca to maintain plasma level. This occurs due to associated action of parathyroid hormone (PTH).
4. It is associated with the maintenance of immune system.

Sources

1. Exposure to sun light. One can observe foraging birds spreading their wings frequently for solar exposure. Some birds lie on back for some time.
2. Eating insects, snails and fish meal.
3. Supplementation of commercial vitamin D3 in feeds

3. Vitamin E

Vitamin E is an excellent anti-oxidant available from different common feeds of poultry. It is fat soluble oxygen scavenger and protects fats and fatty acids from oxidation. Chemically it is tocoferols found in different forms like alpha, beta and

gamma etc. Alpha-tocoferol is most potent among the all forms. Some functions of vitamin E are also done by selenium but complete replacement with selenium is not possible.

Functions

1. As potent biological anti-oxidant inhibits production of free radicals from the oxidation of fatty acids and protects the damage of biological membranes.
2. It is associated with the synthesis of many specific proteins.
3. Synthesis of phospholipids necessary for the maintenance of cell membrane.
4. Provides protection to leukocytes and macrophages during infection and enhances disease resistance.
5. Maintenance and regularization of cell membrane permeability.
6. Increases antibody production for protection against diseases.
7. Harmful function is the increased toxic effects of heavy metals like cadmium and mercury.

Sources of vitamin E

1. Vegetable oils
2. Oil of cereal grains and their by-products.

4. Vitamin K

It is group of fat soluble compounds essential for prevention of bleeding by blood clotting. The two important compounds are phylloquinone (K1) and menaquinone

(K2). Vitamin K1 is found in green plants and K2 is synthesized by enteric bacteria. All forms of absorbed vitamin K are converted into K2 or active form by liver.

Functions

Synthesis of prothrombin or blood clotting factor II in liver, which is essential for blood clotting.

Common sources

1. Cereal grains and their oil containing by products.
2. Oil containing cakes also contain small amount of vitamin K.
3. Liver meal and fish meal.
4. Coprophagy in foraging birds.

B. WATER SOLUBLE VITAMINS

The vitamins of B complex group and ascorbic acid (Vitamin C) are water soluble and dietary essential because these are neither synthesized nor stored in the body.

1. **Thiamin (Vitamin B_1)**
2. **Riboflavin (Vitamin B_2)**
3. **Niacin or Nicotinic acid**
4. **Pantothenic acid**
5. **Biotin (Vitamin H)**
6. **Vitamin B6**
7. **Folacin**
8. **Vitamin B_{12} (Cyanocobalamin)**
9. **Choline**
10. **Ascorbic acid (Vitamin C)**

The unknown factor in lemon and orange that cured scurvy centuries back was named vitamin C. The 'C' was derived from citrus. Later on it was found to be ascorbic acid. This is water soluble vitamin. It is found in two chemical forms, reduced form or ascorbic acid and oxidized form or dehydroascorbic acid.

Ascorbic acid is synthesized in the body of poultry and many other birds except the red vent bulbul and yellow vent bulbul. There is remote chances of vitamin C deficiency even in the bulbuls due to opportunity of feeding on citrus fruits.

Functions

1. It is component of enzymes involved as a catalyst in many oxidation-reduction reactions in the body.
2. It is a reducing agent.
3. Associated with electron transfer in cells.
4. It is essential for conversion of tetrahydrofolic acid from folacin and utilization of vitamin B12. These are necessary for the maintenance of haemoglobin and prevention of anaemia.
5. Stimulates phagocytosis and antibodies production.
6. Alongwith ATP it is involved in incorporation of plasma iron into ferritin.
7. It is associated with normal bone development.
8. Essential for steroids synthesis.
9. Facilitates absorption, transportation and distribution of metal ions in the body.
10. Required for the synthesis of carnitine used for the fat metabolism.

5 FEED ADDITIVES

Different kinds of feed additives

Different kinds of feed additives with beneficial claims in poultry production are available in the market. These feed additives including neutraceuticals may be classified into the following groups.

1. Antibiotics
2. Anti-coccidials
3. Anti-oxidants
4. Anti-caking substances
5. Aromatic compounds or flavour producing substances
6. Arsenicals
7. Adsorbants
8. Colouring agents
9. Emulsifier
10. Enzymes
11. Grits for gizzard health
12. Herbal products
13. Hormones and phytohormones
14. Mould inhibitors
15. Prebiotics like mannan, oligosaccharides
16. Probiotics
17. Synbiotics
18. Proteinates and mineral chelates
19. Synthetic amino acids
20. Essential fatty acids

Herbal products

Many herbs and herbal products have been found to increase palatability causing increased feed intake more nutrients availability and resultant higher production. The other merits are antioxidant and immunogenic nature. Use of herbs and herbal preparations for the protection of health and enhancement of productivity is considered safe, economical, easily available and eco-friendly. Advantages of herbal feed additives may be listed as follows:

(a) Increases feed intake and nutrients utilization efficiency.
(b) Quantitative as well as qualitative improvement in production.
(c) Maintenance of good health and protection to liver from harmful substances
(d) Protection of renal system against nephrotoxins.
(e) Alleviation of stress.
(f) Immunomodulation
(g) Antioxidant effect due to presence of phenolics.
(h) Phenolic compounds are antibacterial and provide protection against respiratory infections. Phenols increase cell permeability resulting in increased water imbalance and bacterial cell death. This phenomenon does not allow development of resistance against phenolic compounds.
(i) Some herbal products have coccidiostatic effect: Some of the herbal products used as such or after extraction of active principles are aloe, cinnamon, cardamom, basil, garlic, ginger, mint, thyme, sage, cumin and clove etc. Mixtures of some of such ingredients are also available. However, more information generation is necessary for identification of specific benefits.

2. Prebiotic or Mannan oligosachharides (MOS)

Certain non starch polysaccharides (NSPs) present in common poultry feeds have been claimed beneficial for poultry production. These NSPs are indigestible in chicken. These NSPs reach caeca and lower tract unaltered and increase multiplication rate of one or more useful bacteria in the large intestines. This helps improvement of gut health as well as host health. These non-starch polysaccharides are also called prebiotics and mannan oligopolysaccharides (MOS) are more effective. Others are galacto oligosaccharides, fructo-oligosaccharides and lactose derivatives. Sources of different oligosaccharides are given in table 5.2. Some useful oligosaccharides are also manufactured and marketed for use as prebiotics in the diets of simple stomached animals.

3. Probiotics

Probiotics are beneficial live microorganisms that modify gut microflora for favouring multiplication of useful strains or species of gut microbiota by suppressing the growth of low priority microorganisms. The alimentary canal of avian species under normal conditions is sterile at hatching but acquire certain species of microorganisms from other birds and surroundings. These microorganisms become integral member and inhabit generally in the lower gut. These microflora play complementary role by synthesizing digestive enzymes under normal conditions. Now it has been observed that introduction and establishment of selected beneficial live microorganisms encourage the prolification of beneficial strains of the gut and had additive effects on the availability of nutrients and productivity of the poultry. Increased nutrients availability is the effects of higher digestion and absorption of the digested nutrients.

4. Synbiotics

These are synergistic combinations of prebiotics and probiotics used for enhancing the production performance and maintenance of good health. Synbiotics are still in the process of development and in future definition may be further elaborated.

6 ANTI-NUTRITIONAL FACTORS IN POULTRY FEED INGREDIENTS

The natural constituent(s) in a feed ingredient producing adverse effects on feed intake, digestibility, absorption and assimilation are anti-nutritional factors. Most of the nitrogenous and saccharid feeds of plant contain one or more anti-nutritional constituents.

Characteristics of anti-nutritional factors in feed ingredients

Different kinds of anti-nutritional factors are found even in the common feed ingredients of poultry and other farm animals. The chemical composition and properties of these substances are highly variable and may be acidic, alkaline or neutral in nature.

1. These substances had adverse effects on voluntary intake, digestibility, absorption and metabolism.
2. Some factors produce anti nutritional effects and in some feeds their metabolites produce harmful or even toxic effects.
3. Many anti-nutritional factors are unstable and either destroyed or inactivated by simple processing techniques like drying, boiling, roasting, pressure cooking, soaking and fermentation etc.
4. Few factors turn toxic during digestion due to change in chemical composition viz. Feed nitrates are reduced to nitrites which are toxic and may be fatal on crossing threshold. The nitrites bind with the hemoglobin of erythrocytes and converts ferrous form of iron in haemoglobin to ferric form in brownish methaemoglobin. Methaenoglobin is not capable of transporting oxygen to different tissues causing anoxia and death. Scope of nitrate/nitrite poisoning in poultry is difficult from feed sources.

Different kinds of anti-nutritional factors in feeds

Different kinds of anti-nutritional constituents of the various feedstuffs and also the adulterants of feeds like mixing of argemone seeds with rape sees-mustard have been identified and listed in Table. 6.1

Table 6.1: Anti-nutrient factors in conventional and non-conventional feeds.

S.No.	Anti-nutrient factors	Feed sources
1.	Protease inhibitors (eg. Trypsin inhibitor)	Leguminous seeds- soybeans, cluster bean seeds, field bean, peas, lentil
2.	Phenols	Cotton seed and cotton seed cake.
	(i) Gossypol (ii) Tannins	mustard-rape seed cake sal seed meal, mango seed, babool seed, black bery (jamum) seed, sorghum, etc.
3.	Phytates	All feeds of plant origin.
4.	Oxalates	Sesame seed meal, many plant and animal feeds.
5.	Nimbidins	Neem seed and neem seed meal.
6.	Nitrates and nitrites	Immature plants, chemical contamination.
7.	Non-starch polysaccharides (NSPs)	Cereal grains, brans and vegetable proteins.
8.	Mimosine	Leucaena (koobabul / subabul) leaf meal.
9.	Glycosides	
a.	Cynogenic	Linseed meal, tapioca root.
b.	Glucocynolates	Mustard-rape seed meal
c.	Oestrogens	Soyabean meal, kidney been.
d.	Saponins	Soyabean meal, lucorne leaf meal, mahua seed meal.
10.	Haemagglutinins or lectins	Castor beans, cluster bean meal
11.	Erucic acid	Mustard-rape seed.
12.	Argemone	Adultrant in mustard-rape seed meal.
13.	Antivitamin factors	
a.	Antivitamin A	Soyabean seed (Lipoxygenase enzyme)
b.	Antivitamin D	Soyabeans
c.	Antivitamin E	Kidney bean
d.	Antivitamin K	Dicumarol (false vitamins K synthesis) in sweet clover
e.	Anti-vitamin B1 or Antithiamyne	Linseed meal
f.	Antipyridoxine	Linseed (linamarin)

Harmful effects of various anti-nutritional factor

The informations about the various anti-nutritional factors naturally occurring as constituents of many common feed resources and their deleterious effects on the health and production of poultry are important. These informations are used for the selection of suitable feed stuffs and also application of suitable treatmens for the inactivation / detoxification of such feeds. Deleterious effects of different anti- nutritional factors on the health and production of poultry birds need attention during selection of feeds and formulation of compounded diets.

1. **Protease inhibitors (Trypsin inhibitors):** These are harmful constituents present in many vegetable feeds. So far about six protease inhibitors have been found. The important ones are the Bownem–Birk chymotrypsin inhibitor and the Kunitz anti trypsin factor. Protease inhibitors reduce availability of protein by reducing digestion and absorption. In an attempt to neutralize the harmful effects of protease inhibitors the pancreas attempt to increase protease secretion that results in the hypertrophy of the pancreas. This reaction is harmful for health.

   Protease inhibitors are also heat labile proteins and destroyed by heat treatment of feeds. Both dry and moist heat treatments are effective. The potent sources of protease inhibitor are seeds of soyabean, cluster bean, jaek bean and many leguminous seeds.

   Protease inhibitor reduces digestibility of protein causing deficiency of amino acids resulting in reduced growths and egg production. Requirement of methionine is increased due to endogenous losses.

   Common methods of destruction of protease inhibitor in feed ingredient are toasting, autoclaving or pressure flowing hot steam through the feeds.
2. **Phenolic compounds in feeds:** Two common phenotic compounds in feeds of plant origin are gossypol and tannins.
   a. **Gossypol:** It is a toxic phenolic compound of yellow colour found in cotton seeds. The content varies in different varieties and may range from

      0.03 to 2.0 % in dry matter. It is an aldehyde in chemical property. Gossypol is antioxidant and inhibits polymerization reactions.

      Total gossypol in cotton seed/cotton seed cake is present in bound and free forms and the later causes toxic effects. The proportion of free gossypol is greater but variable and may be upto 70% of the total gossypol. The concentration of gossypol in cotton seed meals depends on the methods used for oil extraction. Free gossypol content in hydraulic pressed, screw pressed, solvent extracted and pre-pressed, solvent extracted cotton seed meals may be in range of 0.4 – 1.0 %, 0.2-0.5%, 0.2 to 0.7% and 0.2-0.3 % on dry matter basis respectively. During the process of oil extraction greater proportion of free gossypol binds with protein to form almost undegradable protein complex. This has negative effect on protein digestibility and lysine availability.

      Incorporation of cotton seed meals for protein supply in composite

poultry feeds should not be more than 10% to limit the concentration of free gossypol below 0.1 % which is considered the tolerance level for poultry. For the neutralization of higher gossypol content in compounded feeds ferrous sulphate can be mixed. The amount of ferrous sulphate may be upto 4 times of gossypol.

Concentration of more than 0.1% gossypol produces adverse effects on the performance and health of poultry birds. Prolonged use of cotton seed meal in the diets of poultry may be fatal. The clinical symptoms in growing chicks are loss of appetite, laboured breathing, cardiac disorders and decreased growth rate. In laying hens even small quantity causes greenish discolouration of egg yolk. Fall in oxygen transportation capacity of red blood cells results in hypoxia of tissues and associated pathological changes.

b. Tannins: These are complex polyphenolic compounds and constituents of many feeds of plant origin i.e. seeds, cereal grains and extractions. The two main forms of tannins in feeds are the condensed tannins and hydrolysable tannins. Small quantity of tannins may be beneficial but considerable concentration is antinutritional because tannins bind proteins and carbohydrates and render them indigestible. These also inhibit the activities of digestive enzymes (proteases, amylase and lipase etc.). More than 0.5% tannins in the composite diets of poultry reduces digestibility of proteins and carbohydrates and rate of decrease is more or less proportional to concentration of tannins but beyond 4% level may be even fatal due to drastic fall in feed intake and availability of nutrients from such feeds. Lower tannins content in feeds decreases availability of nutrients resulting in lowered growth rate in chicks and fall in egg production of layers.

Tannins containing common feeds of poultry are sorghum, milo, rape-seed- mustard seed cake and lucerne leaf meal. Non conventional feeds like deoiled sal seed meal, mangoseed kernel, tamarind seed, mahua seed kernel cake are rich in tannins. Tannins content in these feeds are very high and requires laborious and expansive technologies for nutritional improvement. Therefore, use of non-conventional feeds containing more than 2-3% tannins can not be recommended. Total concentration of tannins should not exceed 0.5% of dry matter.

7

HARMFUL AND TOXIC FUNGI IN FOODS (MYCOTOXICOSIS AND MYCOSES)

Conditions for growth of toxin producing moulds

1. Hot-humid climate of tropical and sub tropical zones is most favorable.
2. Almost all kinds of natural organic matters-live, dead and decaying are substrates for moulds and other fungi.
3. Invisible organic matter in soils are also substrates for fungi.
4. Wilting and dehydration of green/wet crops favour mycotic growth. This may be observed during drought.
5. Damage of crops by insects and other factors predispose fungal

contamination, multiplication and mycotoxins production.

6. Handling, shipping and storage increase fungal contamination, growth and mycotoxins production.

Effects of mycotoxins on poultry products

1. High mycotoxins content in poultry feeds may cause only one stage economic loss due to mortality of flock.
2. Gradual intake of low levels of mycotoins is more hazardous for the birds causing drop in feed intake, lowered growth, lowered egg production, prolonged sickness and death.
3. Consumption of eggs and meat from poultry birds fed mycotoxins contaminated feeds are highly hazardous for humans eating such eggs and meat. The most dangerous effect is carcinogenesis.

8

PHYSICAL QUALITY ASSAY OF FEEDS

Physical properties of feeds

The knowledge of physical properties of feed ingredients and compounded feeds is essential for the differentiation and grading of feeds. The physical characteristics of feeds are assessed on the basis of soundness (shape, size and density) of food grains, moisture content or dampness of the feeds, colour of the feeds, taste, odour, presence of insects and fungi and cake formation in stacked feeds.

Physical methods of feed assay

The first step of quality control is the physical assay of feed ingredients and compounded feeds. The techniques of physical assay of feeds should be easy and feasible without much instrumentation and can be done by following methods.

1. **Visual inspection:** Satisfactory assortment of many feeds particularly the whole grains, seeds and kernels is quite simple for the farmer and traders of food grains, pulses and oil seeds. Visual inspection of feeds color, shape, size and detection of adulteration with physically comparable materials.
   (i) Color:
   (ii) Size:
   (iii) Shape:
   (iv) Detection of adulterants:
   (v) Presence of insects

2. **Touch and hand manipulation of lots**
3. **Odour(Smell):**

4. **Taste:**
5. **Sound:**
6. **Effect of hammering:**

Some physical spot tests for physical evaluation of feeds

- **Sieving:**
- **Weighing:**

a.