The Protein in Animal Nutrition

Proteins are complex organic nitrogenous compounds made up of amino acids. All proteins contain carbon, hydrogen, oxygen, nitrogen and generally sulphur, many contains phosphorus. Element such as iodine, iron, copper and zinc are also occasionally present The approximate average elementary composition of protein is as follows:

Elements	Average	percent
Carbon	50	(51-55)
Hydrogen	7	(6.5 -7.3)
Oxygen	23	(21.5- 23.5)
Nitrogen	16	(15.5-18.0)
Sulphur	0-3	(0.5-2.0)
Phosphorus	0-3	(0.0-1.5)

Most proteins contain about 16 percent nitrogen, which means that the weight of protein nitrogen multiplied by 6.25 (100/16 = 6.25) equal the weight of protein. Suppose a feed sample to be analysed yields 1.0 gram of nitrogen by Kjeldahl process, then the weight of protein represented as 1.0 x 6.25 = 6.25g. Milk nitrogen is multiplied by 6.38 because milk protein contains 15.87 percent nitrogen.

Amino acids: Proteins are hydrolyzed by enzymes, acids or alkalies into amino acids. About 20 amino acids are commonly found as components of proteins. Amino acids have a basic amino group and an acidic carboxyl group. So amino acids are amphoteric in nature and exist as dipolar ions or zwitter ions in aqueous solution. A pH value called isoelectric point for a given amino acid at which it is electrically neutral.

Classification of amino acids: Amino acids can be classified into three groups, namely, the aliphatic, aromatic and heterocyclic amino acids.

I. Aliphatic Amino Acids

(a) Mono amino-mono carboxylic acids

1- Glycine
2- Alanine
3- Serine
4- Threonine
5- Valine

6- 6- Leucine

7- Isoleucine

(b) Mono-amino di carboxylic acids (Acidic amino acids)

8. Aspartic acid 9. Glutamic acid

(c) Di-amino mono carboxylic acids (Basic amino acids) •

(d) 10. Lysine

11. Arginine

12. Citrulline

(dj Sulphur containing amino acids

13. Cystine 14-Methionine ... 15-Cysteine

II. *Aromatic Amino Acids* 16. Phenyl alanine

17-Tyrosine

III. *Heterocyclic Amino Acids*

18-Histidine

19. Proline

20. Hydroxyproline

21. Tryptophane

Function of proteins:

1. Proteins form muscles and tissues of the body; hence it is essential for the growth and development of the body.
2. They help in maintaining the loss of body tissues and muscles.
3. They help in the formation of enzymes, hormones, antigen, antibody, digestive juices of the body and regulate body osmotic pressure and acid-base balance.
4. They help in the repair of body cells as well as for the production of new cells.
5. They also supply energy to the body.
6. They are essential for the formation of egg, milk protein, wool and hairs of the animals.
7. They provide the basic cellular matrix within which the bone mineral matter is deposited.
8. Under condition of non-digestion and no-chances for de-naturation, the protein accumulates inside the cells and produce toxicity, i.e. venoms of snakes and insects are infected by biting into the blood.
9. Endorphins (peptide) are found in brain and are involved in the suppression of pain.

Essential amino acid (indispensable amino acid):

An essential amino acid is one needed by the animal that cannot be synthesized by the animal in the amounts needed and so must be present in the protein of the feed as such.

Non-essential amino acid (dispensable amino aicd): A non-essential amino acid is one needed by the animals that can be formed from other amino acids by the animals and so does not have to be present as the particular amino acid in protein of the feed.

S. No.	Essential amino acid	Non-essential amino acids
1.	Arginine	Alanine
2.	Histidine	Aspartic acid
3.	Iso- Leucine	Citrulline
4.	Leucine	Cystine
5.	Lysine	Glutamic acid ^
6.	*Methionine	Glycine
7.	Phenylalanine	Proline
8.	Threonine	Hydroxyproline
9.	Tryptophan	Serine
10.	Valine	Tyrosine

• Methionine may be replaced in part by cystine.

Non protein amino acids: There are many other amino acids, which are never found as constituents of proteins but which either play metabolic roles or occur as natural products, e.g. L- Ornithine, L- Citrulline, P- alanine (in vit. Pantothenic acid), Creatine and g- aminobutyrate (in brain). L- ornithine & L- Citrulline occur in free state in the animal tissues and are metabolic intermediates in the urea cycle.

Limiting amino acid: Livestock in definite proportions requires the essential amino acids. While the proportion may vary for different functions, it is always quite definite for any given animal performing any given set of functions. The amino acid which is present in a protein in the least amount in relation to be animal's need for that particular amino acids can be used by the animal toward meeting its essential amino add requirement only to the extent that the so-called limiting amino add is present. It will be noted that lysine is the limiting essential amino acid of com.

Structure of proteins: The structure of proteins can be considered under four basic headings:

1. **Primary Structure:** Proteins are built up from amino adds means of a linkage between the a-car boxy 1 of one amino acid and the a -amino group of another acid. This type of linkage is known as the peptide linkage. Large number of amino acids can be jointed together by this means with the elimination of one molecule of water at each linkage to produce poly peptides. The term primary structure refers to the sequence of amino acid along the polypeptide chains of protein.

2. Secondary Structure: In secondary structure the peptide chain exist in the form of a right-handed -helix The spiral is stabilized by hydrogen bonding between the amino (NH) and carbonyl (CO) group of adjacent amino acids.

3. **Tertiary Structure:** It describes how the chains of the secondary structure further interact through the R-groups of amino add residues. These interaction causes folding and bending of the polypeptide chain, the specific manner of the folding giving each protein its characteristics biological activity. The tertiary structure is stabilized by H- bonding, S-bonding (disulphide linkage), self bridge between basic amino acid and acidic amino acids and certain amino adds like alanine, phenylalanine and valine in which R- group is non-polar. If it coiled all non- polar amino acids come in contact to form hydrophobic centre.

4. **Quaternary Structure:** Protein poses quaternary structure if they contain more than one polypeptide chain. IT force that stabilized these is hydrogen bonds and electrostatic or salt bonds formed between residues on the surface of the polypeptide chain.

Classification Of **proteins:** Proteins may be classified into three main groups according to their shape, solubility an chemical composition.

1-Fibrous Proteins: These proteins are insoluble and very resistant to animal digestive enzymes. They are composed of elongated, filamentous chains, which are joined together by cross linkages. They are as follows:

Collagens are the main proteins of connective tissues. I make up about 30 percent of // the total proteins in the mammalian body. Hydroxy proline is the important component / of collagens.

b- Elastin is the protein found in elastic tissues such as tendon and arteries. It is rich in alanine and glycine

c- Keratins are the protein of hair, hoof, nails etc. These proteins are very rich in sulphur containing amino acid, cystiene. Wool protein contains about 4 percent sulphur.

2- Globular Proteins: This group includes all the enzymes, antigens and hormones that are protein.

a- Albumin is water-soluble and heat coagulable and occurs in eggs, milk, blood and many plants.

b- Globulins are present in eggs, milk and blood and are the main reserve protein source in seed.

c- are basic protein, which occur in cell nucleus where they are associated with DNA. They are water-soluble but not heat coagulable, and on hydrolysis yield large quantities of histidine and lysine.

d- Prot amines are basic protein of relatively low molecular weight, which are associated with nucleic acid and are found in large quantities in the nature, germ c^lls of vertebrates. Protamines are rich in arginine.

3 -conjugated Proteins: Conjugated proteins are composed of simple protein combined with some non-protein substances as prosthetic group.

a) Phosphoprotein is the protein which on hydrolysis yields phosphoric acid and amino acids. Casein of milk and phos-vitin of egg yolk are the best known phosphoproteins.

b) Glycoproteins are conjugated proteins with one or more heterosaccharides as prosthetic groups. In most of the glycoproteins, glucosamine or galactosamine or both, in addition galactose and mannose may be present. Glycoproteins are components of mucous secretions which act as lubricants in many parts of the body eg. ovalbumin.

c) Lipoproteins are proteins conjugated with lipid lecithin and cholesterol. They are the main components of cell membranes and play a basic role in lipid transport.

d) Chromoproteins contain pigment as a prosthetic group. Examples are haemoglobin, haemocyanin, cytochrome and flavoproteins.

e) Nucleoproteins are compound of high molecular weight and conjugated with nucleic acid.

f) \ Metalloproteins a large group of enzyme proteins contain metallic elements, such as Fe, Co, Mn, Zn,M Cu, Mg, etc. which are essential part of these proteins.

4- Derived Proteins: This class of proteins includes those substances formed from simple and conjugated proteins.

a) Primary derived proteins: If there is a slight change in the proteins molecules such as metaproteins and coagulated proteins, they are called primary derived proteins.

b) Secondary derived proteins: If there is a large change in protein structure, they are called secondary derived proteins. They are precipitated by phosphotungstic acid. The examples are proteoses, peptones and peptides.

Non-protein Nitrogenous compounds: Nitrogenous compounds, which are not classed as proteins occur in plants and animals called as non-protein nitrogenous compounds. Amino acids lik^glutamic acid, aspartic add, alanine, serine, glydne and proline forms the main parts of the non-protein nitrogenous fraction in plants, Other compounds are nitrogenous lipids, amines, amides, purines, pyrimidines, nitrates and alkaloids. In addition many members of the vitamin B-complex contain nitrogen in their structure.

Nucleic acid: Nucleic acids are high molecular weight compounds which, on hydrolysis, yield a mixture of basic nitrogenous compound (purines and pyrimidines) a pentose (ribose and deoxyribose) and phosphoric acid. They play a fundamental role in living organism as a store of genetic information and synthesis of proteins. Nucleotide containing ribose is termed as ribonucleic acid (RNA) while those containing deoxyribose are referred as deoxyribonucleic acids (DNA).

Nucleosides and Nucleotides: They are carbohydrates derivatives in which purines and pyrimidines found in nucleic acids are linked to a sugar in a fi-N-glycosyl bond. The sugar is either D-ribose or deoxyribose in the naturally occurring nucleoside. If the nucleosides such as adenosine are esterified with phosphoric acid, they form nucleotides. Naturally occurring nucleotides are adinosine monophosphate (AMP), adinosine di phosphate (ADP) and adinosine tri phosphate (ATP).

Digestion Of **protein in non-ruminante** There is no digestion of protein in the ? mouth because saliva has no proteolytic enzyme. But saliva softens the food particles, which is helpful for ingestion of protein.

Digestion of proteins in the stomach: The digestion of protein start in, the stomach by the action of peptic enzymes. Pepsin and gastricin are the most important peptic enzymes of the stomach. Both enzymes are most active at about pH 2 to 3, and completely inactive at pH above 5. Gastric glands secrete hydrochloric acid at a pH of about 0.8, but by the time it's mixed with the stomach contents, the pH ranges around 2-3, a high favourable for peptic enzyme activity. These enzymes are capable of digesting protein, collagen and nucleo proteins into proteoses, peptones and polypeptides.

Digestion of proteins in the intestine:

1-Digestion of proteins by pancreatic secretions:

When the proteins leave the stomach they ordinarily are in the forms of proteoses, peptones, large polypeptides and amino acids. Immediately upon entering the duodenum the partial breakdown products are attacked by the pancreatic enzymes trypsin, chymotrypsin and carboxpolypeptidases. These enzymes are capable of hydrolyzing all the partial breakdown products of proteins to polypeptides and amino adds.

2- Digestion of polypeptides by the epithelial enzymes of the small intestine:

The epithelial cells of the intestine contain several different enzymes for hydrolyzing the final peptide linkages of the different dipeptides into amino acids. So the end product of protein digestion is various amino acids.

Stomach *Protein. Collagen, Nucicoprotnn*

Pepsin, Cutncin

Proteoms, Peptones, Polypeptides

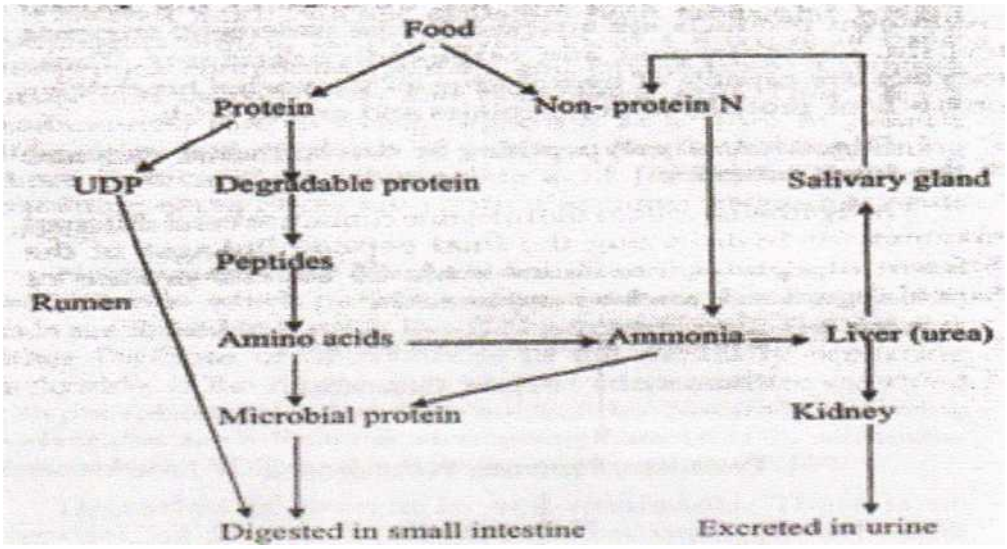
Duodenum

Ttypsin.
Ch>tno»r>twin.
Polypeptides ♦

esuboxy polypeptidases
Ammo acids

Ammo
polypeptidase
r>«fxrpt, daw
acid

Digestion Of **protein in Ruminants:** The digestion and metabolism of proteins in ruminants are different than non-ruminants. The biological success of the ruminant in utilizing crude proteins and non-protein nitrogenous (NPN) substances seems to be dependent upon the physiological regulation of rumen environment as microbial habitat As the microbes multiply, they synthesize protein to construct their own bodies by utilizing dietary protein and NPN substances. This microbial protein is available to the host for subsequent digestion in the lower part of the gut.



Digestion and metabolism of protein and NPN compound:

Proteolysis: The proteins available to the ruminants are digested by the process of proteolysis in the rumen and are converted to peptides and amino acids. These are further fermented, by deamination to carbon dioxide, ammonia and short chain fatty adds. Ruminal proteases are mainly cell bound but may be located on the surface of the ce\\ where the substrate is freely accessible to the enzymes. These proteolytic enzymes are rather non-specific in their character, since their ability to ferment a range of proteins is not influenced by changes in the microflora brought about by different rations. It appears that for the bacterial proteases to act efficiently the protein must be in solution farm. Different proteins are proteolysed at different rates and rate of digestion of a particular protein is fairly constant The rate of proteolysis is closely related to solubility of proteins in the water and in salt solution resembling rumen fluid.

In spite of a strong proteolytic activity in the rumen, the amino add concentration in rumen fluid is low because of the presence of microbial deaminases, the activity of which increases with increasing protein content of the ration. The enzyme is directly responsible for the process of deamination.

Ammonia production: The ammonia in rumen liquor is the key intermediate in the microbial degradation and synthesis of protein. Parts of the ammonia produced in the rumen liquor is utilized by the rumen bacteria along with carbon moiety to synthesize the microbial proteins, and excess of ammonia is absorbed into the blood, carried to the liver and converted to urea. Some of this urea may be returned to the rumen via the saliva, and also directly through the rumen wall, but the larger part is excreted in the urine and thus wasted out. The rumen fluid has a pronounced urease activity so that urea entering it is rapidly hydrolysed to ammonia and carbon dioxide. Increased quantity of readily fermentable sugars decrease the concentration of ammonia in the rumen thereby helping better utilization of proteins and non-protein nitrogen.

Fate of ammonia: Rumen microbes for their rapid Implication utilize considerable protein and utilize ammonia d fix it as excellent body protein composing of essential and n-essential amino acids in presence of soluble carbohydrates, ticularty starch. The rumen microbes continuously passes to the abomasum and small intestine, their cell proteins are then digested by usual gastric enzymes of the abomasum and are absorbed as units of amino acids mostly in the region of the small intestine. A portion of the total ammonia of the rumen is absorbed in to the systemic blood and converted into urea in the liver.

Urea recycling: It is now well established that blood urea enter back into the rumen directly by transfusion through rumen wall and also indirectly through saliva. The process would be of great value to animals on low nitrogen intake.

Microbial protein synthesis: Microbes in the rumen degrade large proportion of dietary proteins and utilize some of the degradation products for their own protein synthesis. These microbes can also make use of NPN compound and can upgrade the dietary protein of low biological values into microbial proteins of high biological values. Therefore, it would be advantageous to feed poor quality protein and NPN compound to the ruminants.

Utilization of non-protein nitrogen compound:

Ruminants can utilize non-protein nitrogenous compound as a source of protein through the microorganisms. The compound which are commercially available are urea and biuret etc. as a source of NPN compounds for ruminants.

Urea is very common and now it has been accepted that urea can replace about 30 to 40 percent of DCP requirement

When Urea entering the rumen is rapidly hydrolyzed to ammonia and carbon dioxide by bacterial urease enzyme. This ammonia is used as a nitrogen source by the rumen microorganisms for synthesis of microbial protein along with the carbon skeleton coming from the carbohydrates/proteins. Efficient utilization of ammonia for microbial protein synthesis requires the optimum initial ammonia concentration and a readily available source of energy for protein synthesis.

Urea toxicity symptoms: Nervousness, muscle tremors, Artieulty in respiration, excessive salivation, bloat tetany, convulsions and death within 2 to 3 hours are the symptoms of urea toxicity. The severity of symptoms depends upon the dose of urea intake. The drenching of glacial acetic acid cold water is the line of treatment in urea toxicity. To avoid urea toxicity, urea should be mixed properly in the feed and level of urea should be 3 percent in the concentrate mixture or 1 percent in the sole ration of ruminants. Whereas BIS recommended 1 percent of urea in the concentrate mixture of ruminants.

Utilization of NPN substance by non-ruminants:

Non-ruminants are also able to utilize NPN compound for the synthesis of non-essential amino acids and the optimum level is 0.3 percent of the diet. But NPN substances are of little practical value for non-ruminants. It is ineffective for swine but used to some extent by mature horses on low protein diet and by hen fed diets well balanced in the essential amino acid

Protein metabolism: Dietary proteins are digested through the action of proteolytic enzymes to amino acids. These amino acids are absorbed through the small intestine into the portal blood. Major site of absorption of amino acids is proximal 2/3rd of small intestine. Absorption :can active type in which transport of sodium is involved. Tri peptides are absorbed more rapidly than di peptides, which are in turn faster than free amino acids. There is a competition for absorption within groups of free amino acids, viz, acidic, basic, neutral and amino acids but no competition between groups which suggests that slightly different mechanisms of transport exist for different chemical configurations. They are transported to the liver and then to the systemic blood circulation. Amino acid of the blood pool serves as a major source for tissue protein synthesis. Excess of amino acids, which are not required for synthesis of tissue protein, hormones, enzymes etc. are catabolized in the liver tissues. The catabolism of amino acid involves deamination whereby ammonia and a-keto-acid are formed. The released ammonia is converted into urea or may be utilized by a-keto acid to form amino acid.

Protein deficiency Symptoms: It includes reduced feed intake and utilization, reduced growth rate, infertility, reduced serum protein concentration, accumulation of fat in the liver and carcass, reduced synthesis of certain enzymes and hormones resulting depression of most metabolic activities which may lead even to early death.

The classical d'cease of **protein** malnutrition of the young is kwashiorkar. The marasmus is a calorie deficient state. The general term for both the conditions in protein/calorie malnutrition (PCM) which is characterised by low blood protein level, poor digestion, lethargic patient and depressed immune system.

Amino acid deficiency: it is a condition in which the dietary supply of one or more of the essential amino acids is less than that ʳcquⁱʳed for the efficient utilization cf ether amino adds and other nutrients Diets are in general unlikely to he completely devoid of any one or more amino acids but may be deficient in respect cf required it*. The •— .... ᵣ..... ... . uwH vi uiv uiwwioucal iequirement, is

Amino acid imbalance: This term is normallv restricted to circumstances where the composition of essential amino acids in **the diet** **in a further iw- ™** animal performance than would be expected in case of amino acid deficiency where the effect depends on the extent of iimiting amino acids. Imba'anor :sr produced by the addition to a diet lev.' :r. tele! p.ctclr. ef .It!... t!.c limiting amino acid, or more usually a

gffpnt on norfAIttV^n*)**.. kfikw r«*. tr.n.f ^ r.t#.l!^^ *i i ic auvci 06*

Amii'iO aciu antagonism: Certain amino acid interferes the metabolism of other am.ln.c **acids** eg. **Lycir.c !r. eueecc ir.crccccc «.c** OA-eretion of Arginine. Excess lysine