

Proteins in foods

Introduction

- Proteins are important in foods, both nutritionally and as functional ingredients.
 - They play an important role in determining the texture of a food.
 - Proteins are made up of sequence of amino acids.
 - There are 20 amino acids present in food proteins.
- 1. Essential amino acids and Nonessential amino acids**
 - The body is able to synthesis about 10 amino acids and these amino acids are called **non-essential or dispensable amino acids** as they can be synthesized in animals from other compounds.
 - They are **glycine, cysteine, alanine, serine, proline, tyrosine, aspartic acid, asparagine, glutamic acid and glutamine.**

- The remaining amino acids are called **essential or non-dispensable** as they cannot be synthesized in animals.
- They are **methionine, tryptophan, threonine, valine, isoleucine, leucine, phenylalanine, lysine, arginine and histidine.**

2. Limiting amino acid

- Proteins of different foods have different proportions of essential amino acids.
- Some of them may contain required amounts of essential amino acid and few of them may not have adequate amounts of one or more of essential amino acids.
- An essential amino acid of a protein which is present much below requirement is called as limiting amino acid. Most of the plant proteins contain limiting amino acid.

- **Examples**

- Tryptophan is the limiting amino acid in maize, bengal gram and red gram proteins.
- Lysine is the limiting amino acid in wheat protein.
- Methionine is the limiting amino acid in peanut protein.
- Due to limiting amino acid quality of protein decreases

- **Effect of limiting amino acid on protein utilization**

- When tissue proteins are synthesized all the essential amino acids must be present in proper proportions in tissues.
- If one essential amino acid is absent in tissues due to lack of dietary supply protein synthesis decreases and nitrogen balance is not maintained.
- More over biological value of a protein with limiting amino acid is low.

Supplementary value of protein

- One way of improving quality of dietary protein with limiting amino acid is by adding another protein containing the missing amino acid.
- Some proteins are poor quality proteins as such due to limiting amino acids.
- But they are complementary in limiting essential amino acid composition i.e., a limiting essential amino acid in one protein is present in excess amounts in another protein and vice versa.
- So they supplement each other and make good quality protein in diet. This is known as **supplementary value of proteins**.

- For example wheat proteins and red gram proteins are complementary proteins and as such both are low quality proteins due to limiting amino acid.
- Wheat protein is limiting in lysine but good source of tryptophan whereas red gram is limiting in tryptophan but a good source of lysine.
- When they are mixed they make up good quality protein in diet by supplementing one another i.e., wheat protein effectively supplement pulse protein and vice versa.
- Therefore chapati and dal combination improves quality of protein in diet.

Structure of Protein

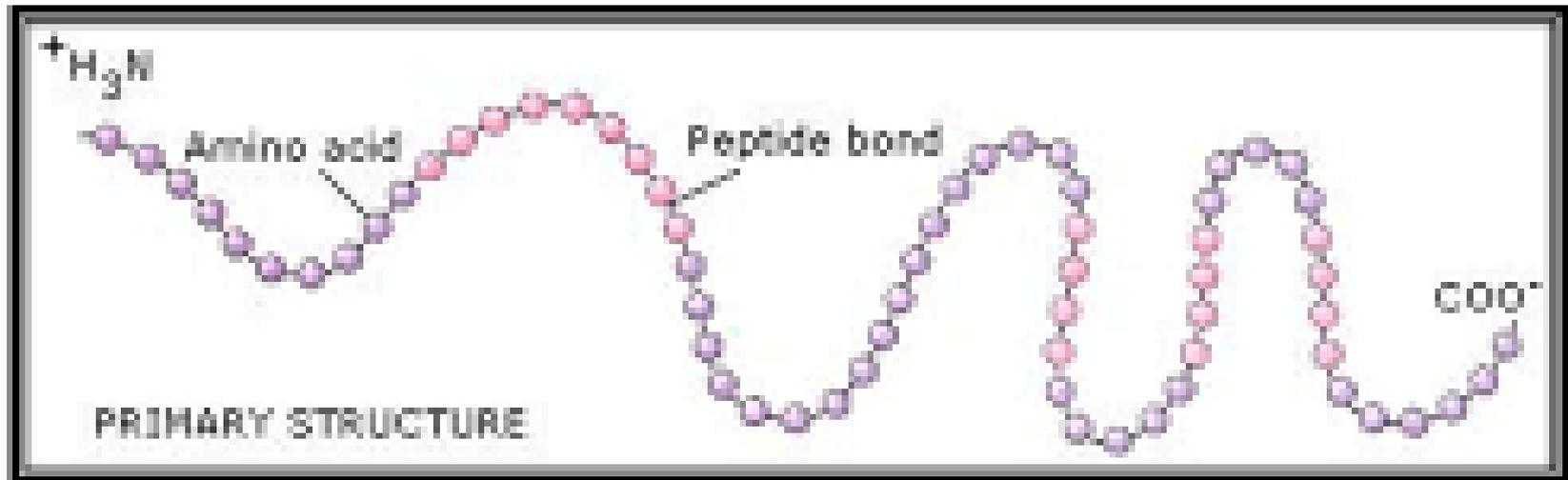
There are four levels in a protein structure:

- Primary,
- Secondary,
- Tertiary
- Quaternary.

Primary Structure:

- The primary structure of a protein refers to the linear sequence formed by the amino acids linked by peptide bond formed by the condensation of the α -carboxyl group of one amino acid with the α -amino group of the next amino acid.

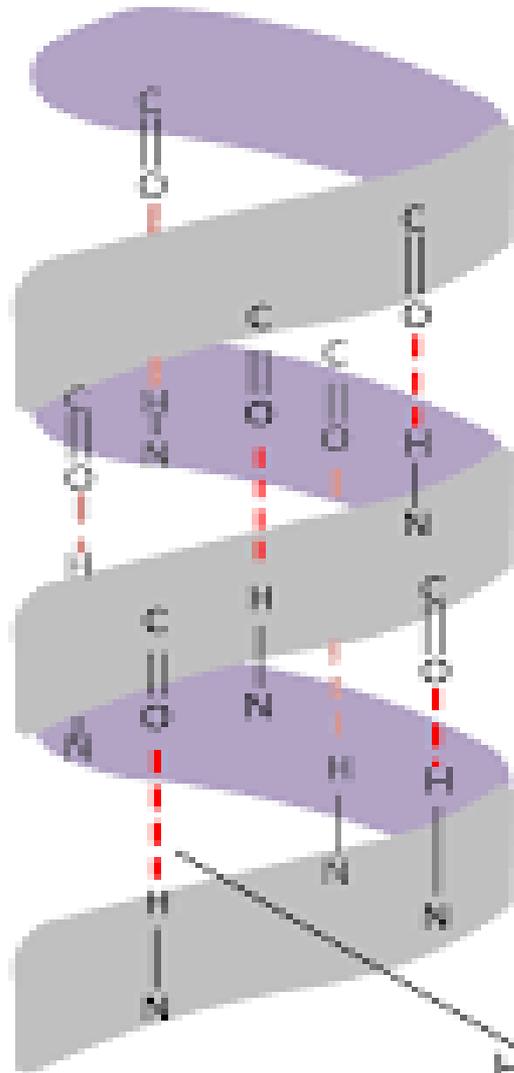
Fig: Primary Structure Of Proteins



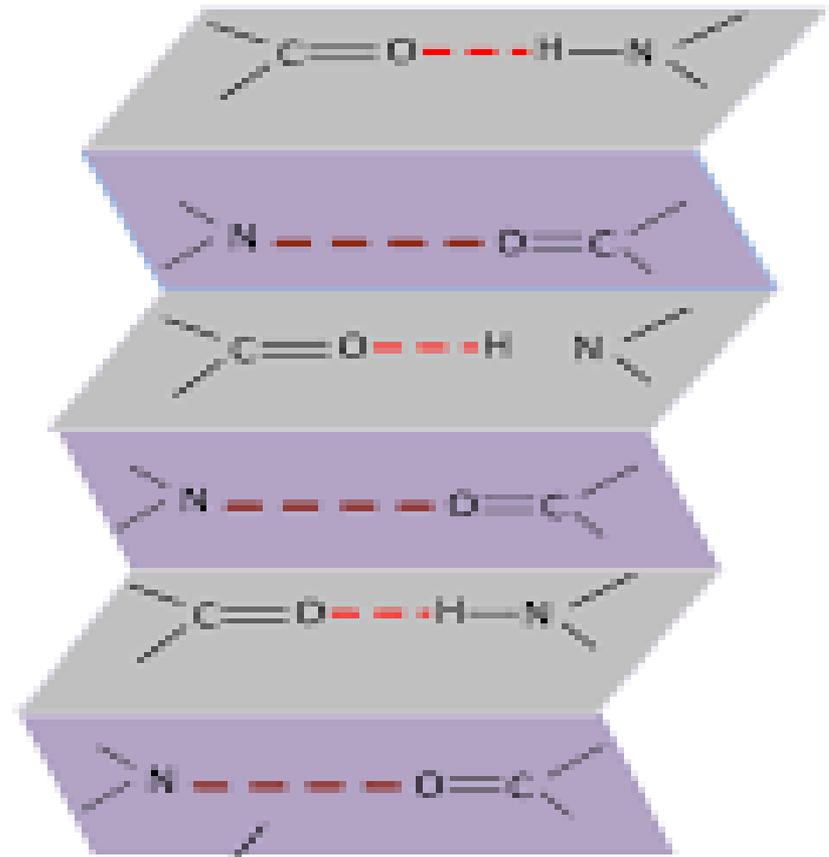
Secondary Structure:

- Secondary structure refers to the spatial arrangement of amino acid residues of the polypeptide chain.
- Two forms of secondary structures are found in proteins: α -helix and β -pleated structure.
- α -helix is the major form found in proteins.
- The α -helix is stabilized by hydrogen bond.
- The β -pleated structure is formed by hydrogen bonds between two strands of the same molecule forming a sheet like structure known as β -pleated sheet.

α -helix



β -Sheet



Hydrogen Bond

Tertiary structure:

- Tertiary structure refers to the spatial arrangement formed when a linear protein chain with secondary segments folds further into a compact three dimensional form.

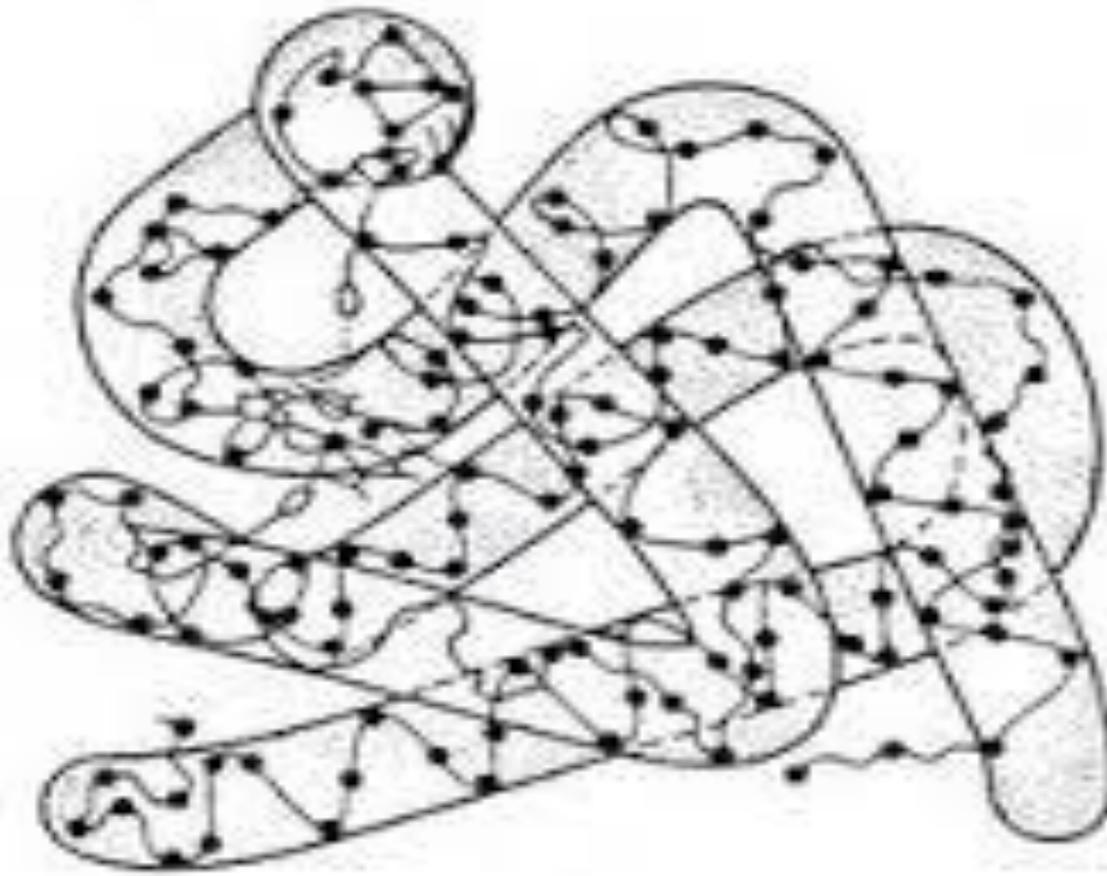
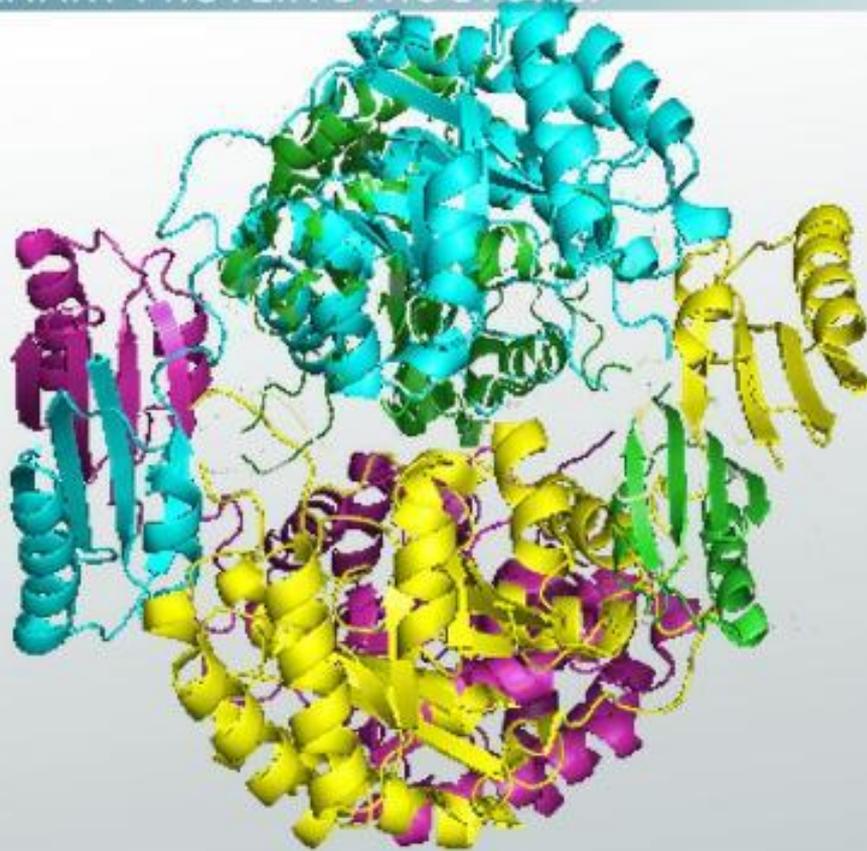


Fig. 9.27. Diagrammatic representation of the tertiary structure of a protein (sperm whale myoglobin).

Quaternary structure

- Quaternary structure refers to the spatial arrangement of a protein when it contains more than one polypeptide chain. Many biologically active proteins exist as dimmers, trimers, tetramers etc. These structures are formed by specific protein-protein interactions. Eg. Haemoglobin

WHAT IS A QUATERNARY PROTEIN STRUCTURE?



Nature of proteins

- Proteins play an important role in biological systems. Proteins are synthesized in ribosomes.
- After synthesis some amino acids are modified by cytoplasmic enzymes.
- Proteins that are not modified thus are called homoproteins and that are modified or complexed with nonprotein parts are called heteroproteins or conjugated proteins

Type	Examples
Nucleoprotein	Ribosomes, Histones
Glycoprotein	Ovalbumin, k-casein
Phosphoproteins	α , and β caseins, phosphorylases
Lipoproteins	Proteins of egg yolk, plasma proteins
Metalloproteins	Hemoglobin, myoglobin and enzymes

Milk proteins

- Protein represents 3-4% of the composition of milk. Casein is the primary protein of milk, comprising approximately 80% of the milk protein.
- Milk proteins are of two types: casein (24-28g/L) and whey proteins(5-7g/L).
- Milk proteins have found various applications in formulated foods and as meat extenders, initially only casein was used.
- Milk proteins have high nutritional value due to amino acid composition and have higher content of phosphoryl serine and proline.
- Several milk proteins have antibacterial properties.
- The whey protein lactoferrin, beta lactoglobulin, lactalbumin, α - casein, β -casein are biologically active peptides

Egg proteins

- Eggs provide nutritive value and culinary variety to food.
- The egg white is made up of albumin.
- Protein in the egg yolk is primarily vitellin. Egg albumen is used various food formulations because of its foaming properties and heat gelling ability, while egg yolk serves as an emulsifying agent.

Protein content of egg

Item	%
Whole egg	11.8
egg white	11
egg yolk	17.5

Legume/Pulse Proteins

- i. **Pulses:** Pulses are important food crops due to their high protein and essential amino acid content
 - Pulses are 20 to 25% protein by weight, which is double the protein content of wheat and three times that of rice. While pulses are generally high in protein, and the digestibility of that protein is also high, they often are relatively poor in the essential amino acid methionine, although Indian cuisine includes sesame seeds, which contain high levels of methionine. Grains (which are themselves deficient in lysine) are commonly consumed along with pulses to form a complete diet of protein.

ii. Green pea

- Peas are high in fiber, protein, vitamins, minerals, and lutein. On dry weight basis peas contain 14.8% protein, 7.2% carbohydrates, and dietary fiber 30%.

iii. Dry Beans

- Beans are high in protein (20-30%), complex carbohydrates (8%), folate and iron. They also have significant amounts of fiber and soluble fiber

iv. Soyproteins

- Soybean contains about 43 percent high quality protein and 20 percent oil. It is rich in valuable amino acid lysine (5%) in which is deficient in most of the cereals.
- Soyproteins are used in a variety of traditional products such as soymilk or fermented items, defatted flour, grits, concentrates or isolates.
- The traditional products are prepared by water extraction, cooking, coagulation of the proteinaceous curd, roasting and fermentation often with other products.

v. **Peanuts:** Peanuts contain about 20% protein. They are a good source of niacin, folate, fiber, magnesium, vitaminE, manganese and phosphorus. They are free of trans-fats and sodium

Cereal proteins

- Cereals are important source of proteins because they contain 7.5 to 14% proteins depending upon the type.
- They are used in foods mainly as flour used for the preparation of breads, noodles, cakes, and other commodities by baking.
- The biological value of cereal proteins is significantly lower because of the deficiency of lysine

Native Protein

- Proteins found in living tissues (within the cell and in the fluids) of animals and plants are called native proteins.
- The formation of a unique three dimensional protein structure is the net result of various repulsive and attractive covalent and non-covalent interactions.
- They are stabilized by the following
 - All colloidal particles have similar charge on the molecules. Like charges repel each other and the particles remain dispersed. Protein macromolecules are hydrophilic colloids and are stabilized by a layer of water. This acts as insulation and prevents bonding. Some amino acids with a ring structure and carbon chains (-C-C-C-C-C-) are hydrophobic while the acidic group (COOH group) is hydrophilic.

- The free amino and carboxyl groups in a protein molecule have an electric charge depending on the pH of the medium in which the protein is found. Proteins are said to be amphoteric, i.e., they can react with acids and bases.
- Hence, they act as buffers in food preparations. In the presence of an acid, (the amino group neutralizes the acid) the protein molecules are drawn towards the cathode as a result of the net positive charge on them.
- In the presence of an alkali, (the carboxyl group neutralizes the alkali) the protein molecule migrates towards the anode because of the net negative charge on them. This migration of proteins in an electric field at a definite pH is called electrophoresis. It depends on: charge on the molecule, size of the molecule, and shape of the molecule.

- At the isoelectric point (IEP) the charge on the protein molecule is neutralized and they show no movement in an electric field. Proteins at the IEP are called zwitterions.
- When a fluid food containing protein is brought to its IEP, curdling is likely to occur (addition of acid while curdling milk) as there is no charge which keeps protein dispersed.

Denaturation of Protein

- Denaturation is defined as any non-proteolytic modification in the original structure of the native proteins, giving rise to definite changes in physical, chemical, and biological properties.
- The native structure of protein is the net result of various attractive and repulsive forces intramolecular as well as interaction with surrounding water medium.
- Any change in the environment, such as temperature, pH, ionic strength, solvent composition etc. will force the molecule to assume a new stable structure if the change does not drastically alter the molecular architecture.

- But major changes in the secondary, tertiary and quaternary structures without cleavage of peptide bonds are called as **denaturation**.
- It may be a major change in which there is an increase or decrease in the α -helix and β -sheet.
- But in many cases, denaturation involves a loss of ordered structure. In a denatured protein the globular proteins become a random coil.

(i) Changes in protein during denaturation

- Denaturation is brought about by the following: (1) Denaturing agents, such as acids, alkalis, salts, (2) Increase in temperature

(ii) Stages of denaturation

- 1st stage: Unfolding of helix of the protein molecules as the cross-links holding the helix is disrupted. R groups are exposed. Rebonding takes place between adjacent R groups of protein molecules leading to aggregation of the molecules, bringing about increased viscosity. This is the first change in denaturation which involves structural alteration.

- **2nd stage:** When sufficient proteins have united, the protein molecules are no longer dispersed as a 'sol'. At this stage the protein is said to have coagulated, i.e., water is held in the capillary spaces formed by united protein molecules and the coagulated proteins form a 'gel'.
- **3rd stage:** If the liquid separates from the coagulated protein, the protein is said to be, 'precipitated' or 'flocculated', i.e., 'curdling' takes place. These stages can be observed while cooking scrambled eggs. If it is overcooked, liquid separates out.