MILK PROTEINS

What are Proteins?

Proteins are essential part of our diet & when eat then they are broken down into simple compounds through digestive system. Then these compounds are conveyed to the cells of body where they are used to construct body parts, maintenance & other physiological activities.

The majority of chemical & biochemical reactions are controlled by the enzymes which are protein in nature. A protein molecule contains one or more than one inter-linked chains of amino acids, where these amino acids are arranged in a specific order.

Usually a protein molecule contains about 100-200 linked amino acids but smaller & larger no. of amino acids can also constituent a protein molecule.

All of the major milk proteins (except serum albumin and immunoglobulins) are synthesized by epithelial cells in the mammary gland from amino acids (AA's) extracted from the blood.

What are Amino Acids (AAs)?

As amino acids are building blocks of proteins. Each amino acid contains one amino group (--NH_2) & one carboxyl group (--COOH). The proteins are formed from a specific type of amino acids which are called alpha amino acids (α-amino acids). α – amino acids are those, in which both, the carboxyl group & the amino group are attached to the same carbon atom (α- carbon). All amino acids of milk protein are α-amino acids.

The amino acids are the group of chemical compounds that can emit hydrogen ions in alkaline solution & can absorb hydrogen ions in acidic solution. Such compounds are called *Ampholytes/Amphotery Electrolytes or Amphoteric Electrolytes*

Thus these amino acids can appear in three different stages as following;

1. –ve charges in alkaline solution,
2. +ve charge in acidic solution, 3. Neutral in neutral solution

There are 20 different amino acids which build the protein. Among these 20, 18 are present in milk protein. Normally amino acids are divided in to two groups as;

1. Essential amino acids: An essential amino acid or indispensable amino acid is an amino acid that cannot be synthesized by the organism (usually referring to humans), and therefore must be supplied in the diet. Eight amino acids are generally regarded as essential for humans: phenylalanine, valine, threonine, tryptophan, isoleucine, methionine, leucine, and lysine. As Systeine is also considered as essential amoino acid for infants.
2. Non-essential amino acids are amino acids that can be produced in our body. Their uses and functions in our body are equally as important as the limiting amino acids. The difference is that those kinds of amino acids can be found in our food. 12 amino acids are generally regarded as non-essential amino acids. These are Alanine, Cysteine, Cystine, Glutamine, Glutathione, Glycine, Histidine, Serine, Taurine, Threonine, Asparagine, Apartic acid, Proline.

All the essential amino acids are present in milk. The type & order of amino acids in protein molecules determine the nature of the protein. 18 amino acids are present in the milk.

The amino acids within protein chains can bond across the chain and fold to form 3-dimensional structures. Proteins can be relatively straight or form tightly compacted globules or be somewhere in between. The term “denatured” is used when proteins unfold from their native chain or globular shape. Denaturing proteins is beneficial in some instances, such as allowing easy access to the protein chain by enzymes for digestion, or for increasing the ability of the whey proteins to bind water and provide a desirable texture in yogurt production.

The possible no. of combinations of 18 amino acids in a protein molecule containing 100-200 amino acids is almost unlimited. So the no. of proteins with different properties is unlimited.

Amino acids contain both slightly basic amino group & slightly acidic amino group. These both are attached to a carbon atom which further links to a side chain which behaves like functional group.

If the side is Polar then water attracting properties of acidic & basic groups in addition to the side chain will normally dominate & the whole amino acid will attract water. So this type of amino acids is readily dissolved in water. Such amino acids are called as Hydrophilic (water loving) Amino Acids.

On the other hand if side chain is non-polar, then the properties of this chain will dominate the properties of basic & acidic group. So the whole amino acid will become water repelling & will be less soluble or insoluble in water. Such amino acids are called as Hydrophobic (water hating) Amino Acids.

Electric Status of Milk Protein:

Iso-electric point of milk is 4.6 (pH). The chains of amino acids in milk proteins carry an electric charge which is influenced by pH of the milk. When the pH is changed by the addition of an acid or an alkali, then charge distribution of protein is also changed. At normal pH of the milk (6.8), a protein molecule has a slight net –ve charge, & the protein molecules remain separated because similar charges repel each other.

If acids (Hydrogen ions) are added in the milk, they are absorbed by the protein molecules. At a pH where +ve charge of the protein is equal to –ve charge, then the net charge of the protein will be zero. The +ve charge of the one molecule will link up with the –ve charge of neighboring molecule & ultimately protein will form large clusters. If more hydrogen ions are added the protein molecules acquire the net +ve charge & start to repel each other, so these will scatter in the milk.

On the other hand if in normal milk alkaline solution or OH^{-} is added then the –ve charge on the protein molecules will be stronger, they repel each other & will completely dissolved in milk.

Iso-Electric Point of Protein:

The pH at which the net –ve & net +ve charges on the protein molecules is zero is called the iso-electric point of protein. This is 4.6 pH of the milk.

Classification/Types of Milk Protein:

According to old classification, milk protein is divided into three categories as;

1. Casein,
2. Albumin,
3. Globulin

According to modern classification there are two (2) main proteins as:

1. Casein,
2. Whey,
3. Fat Globule Membrane Protein is a minor protein. It is 1.2% of total protein.

1/. Casein Protein:

The casein family contains phosphorus and will coagulate or precipitate at pH 4.6. The casein family of protein consists of several types of caseins as:

1. α_{S-1}, (30.6%)
2. α_{S-2}, (8%)
3. Beta casein – ß-casein, (30.8%)
4. Kappa casein – κ- casein. (10.1%)

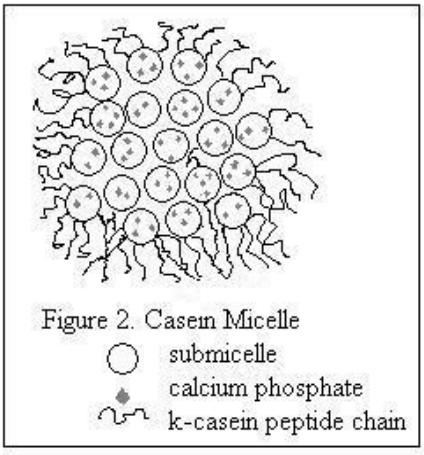

Figure 2. Casein Micelle

The caseins are suspended in milk in a complex called a micelle. The caseins have a relatively random, open structure due to the amino acid composition (high proline content). The high phosphate content of the casein family allows it to associate with calcium and form calcium phosphate salts. The abundance of phosphate allows milk to contain much more calcium than would be possible if all the calcium were dissolved in solution, thus casein proteins provide a good source of calcium for milk consumers.

Micelles are ~140 nanometers in diameter. They are composed of alpha-s-, beta-, and kappa-caseins. The destabilization of the casein micelle structure and partial hydrolysis of casein decreases the quality of fluid milk and the yield of cheese from milk. Conversely, the destabilization of the casein micelle by proteases is part of the mechanism involved in milk

digestion in the stomach and intestine. Controlled hydrolysis of casein is also the means of producing cheeses and other cultured milk products.

2/. Whey Proteins:

The serum (whey) proteins do not contain phosphorus, and these proteins remain in solution in milk at pH 4.6. The whey family consists of several types of whey proteins as:

1. α-Lactalbumin, (3.7%)
2. ß-lactoglobulin, (9.8)
3. Blood Serum albumin, (1.2%)
4. Immunoglobulin, (2.1%)
5. Miscellaneous Whey proteins i.e., Lactoferrin, ß2-Microglobulin etc. (2.4%)