Animal Science 270
Foods of Animal Origin
Food Composition Part IV.
Proteins

Introduction

Proteins are the most diverse molecules in food systems. Proteins have a wide range in molecular weight (one meat protein, titin, has a molecular weight of approximately 3,000,000 daltons), solubility (water soluble, salt soluble, insoluble), and physical properties (globular, fibrous). This diversity is due to the many different functions proteins have in living cells. Some proteins contribute to maintenance of metabolism; some contribute structural integrity to the cell.

Proteins in animal products are, as a whole, considered to be of high nutritional quality. This is because they contain all of the essential amino acids in relative amounts equivalent to human dietary requirements. The contribution of essential amino acids to the diet defines the biological value of foods.

Proteins contribute to a broad array of properties of foods. Variations in tenderness of fresh beef, pork, and lamb have been tied to differences in structural and contractile proteins in meat. The meat pigment myoglobin contributes greatly to the color of meat products. Egg proteins contribute to many foods as thickening agents. The diversity of food proteins make them topic of much interest in food product development research.

Protein Structure

Proteins contain carbon, hydrogen, oxygen, nitrogen and to a lesser extent sulfur atoms. The nitrogen content is the major component that sets protein apart from carbohydrates from a strictly composition viewpoint. Amino acids are organic compounds containing amino groups ($-NH_2$) and carboxyl groups (COOH). Proteins are composed of many amino acids bound together peptide bonds (linkage from amino group to carboxyl group of another amino acid). The number of amino acids can vary greatly, depending on the function of the protein. The amino acid sequence is the foundation for these functions. The sequence of amino acids is termed the **primary structure** of a protein. The secondary structure relates to the orientation of the amino acid chain (α-helix, pleated sheet, etc.). The tertiary structure relates to the 3 dimensional shape of the protein.

Globular proteins are spherical in configuration of their tertiary structure. Globular proteins are rather soluble at low ionic strength. Myoglobin (pigment in meat from skeletal muscle) and albumins from egg and milk are globular proteins.

Fibrous proteins are classified together because of their elongated structure and general insolubility at low ionic strength. Contractile proteins in muscle (myofibrillar proteins) are soluble only above 0.6 M sodium chloride. It is important for these proteins to not be soluble within the muscle cell because contraction of myofibrils must translate into locomotion. Connective tissue proteins (collagen, elastin) are very insoluble and can contribute to toughness of meat products. We will discuss classification of proteins in more detail in each of the product units.

Isoelectric point

Several amino acid residues (side chains of the amino acid not involved in the peptide linkage) have the potential to be charged electrically (positive or negative) depending on the pH of the product. The amino acid composition dictates the charge of a protein at a given pH. The **isoelectric point (pI)** of a protein is defined as the pH that the protein has no net charge. As pH increases from the isoelectric point, the net negative charge of the protein increases. As pH decreases (becomes more acid) from the isoelectric point, the net positive charge of the protein increases. When a protein has no net charge it is less likely to interact with water or with other charged molecules such as other proteins or carbohydrates. Proteins are likely to precipitate when pH is adjusted to their isoelectric point.

The significance of the understanding the concept of the influence of pI on food systems is illustrated by the following examples. Casein (the major protein in curds) can be separated from fluid milk by adjusting the pH to 4.6 (isoelectric point of casein). At the isoelectric point for meat proteins (pH 5.1) we expect to see very low water holding capacity of meat because there is less protein interaction with water.

Denaturation

Large complex proteins undergo changes in structure in response to a number of different conditions that are commonly applied during food processing. When a protein molecule "unfolds", but remains intact (all of the peptide linkages are maintained), the protein is **denatured.** Denatured proteins have a different structure and often impart this change to a change in the physical property of foods. Coagulation is a term we use to describe some of the later stages of denaturation where denatured proteins bind together to form a gel matrix. A common example of this change in structure is the transition from a fluid to a liquid that is observed during the cooking of egg whites. Heating, mechanical stress, change in acidity and concentration of mineral salts all can cause denaturation.

Degradation

Enzymes called proteases have the capacity to break peptide linkages to **degrade** proteins. Degradation of proteins is distinctly different than denaturation in that the protein is separated along the amino acid backbone, yielding two peptides. Hydrolysis of the peptide bonds in some meat proteins results in an improvement in tenderness of beef, pork and lamb.

Biological Value

The balance of essential amino acids in a particular food defines the biological value of protein in that food. Essential amino acids are defined as those that must be consumed because they cannot be synthesized. Eight amino acids are considered to be nutritionally essential for maintenance in the adult human. These are phenylalanine, valine, threonine, tryptophan, isoleucine, methionine, leucine and lysine. Two amino acids are often considered essential for infants: histidine and arginine.

Foods of animal origin contain these amino acids in the proper amounts and balance to classify as having a high biological value. Vegetable sources of protein are often lacking in one or more of the essential amino acids. Cereals and legumes are more valuable in the diet if they are consumed with protein from an animal source.

As a rule, animal proteins are considered to be of superior to proteins from plant sources. The following table does show that some plant proteins have high biological value as well.

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Relative Biological Values of Common Proteins

Protein	Source	Biological Value
Casein	Dairy	High
Lactalbumin	Dairy	High
Ovovitellin	Egg yolk	High
Ovoalbumin	Egg White	High
Myosin	Lean Meat	High
Gliadin	Wheat	Low
Glutenin	Corn	High
Zein	Corn	Low
Glycinin	Soybean	High
Legumelin	Soybean	Low

Terms

Primary Structure
Secondary Structure
Tertiary Structure
Isoelectric point
Denaturation
Degradation
Biological Value