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Review Article

Effect of Food Processing on Protein and Its Functionality

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Abstract

The demand for processed foods with high content of protein is increasing globally. Food processing affects physical, chemical as well as functional properties of nutrients. In the present review article, certain changes like proteolysis, protein cross-linking, amino acid racemization and Maillard reaction that occur during food processing and storage affecting the textural and nutritional qualities of protein-rich foods have been outlined.

Keywords: Protein; Proteolysis; Racemization; Functional Properties

Introduction

Protein is a highly complex macronutrient made up of amino acid residues joined by Peptide bonds. In human body proteins play vital role in growth and maintenance of tissues, formation of essential body components, regulation of water balance maintenance of pH, and as source of energy. It is a well-recognized fact that protein-rich foods contribute to healthy-ageing. During the prevalence of Covid-19, the demand of protein-rich food is gaining an increasing trend. Due to the socio-economic changes caused by several reasons like increase in population, increased urbanization, rise in income, and ageing population the demand for protein in diet will continue to rise.

Effect of processing on protein

Processing of food includes the mixing of protein with other food components and their derivatives in conditions like with physical treatments such as milling or heat, biological treatments such as fermentation or enzymatic reactions, or chemical treatments such as use of oxidizing agents or alkali [1]. Some major effects seen in protein due to processing are discussed below.

Proteolysis

It is caused by the endogenous enzymes present in the raw materials or due to commercial enzyme used in food processing. The proteolytic enzymes have an effect on texture of protein as they hydrolyze it into amino acids and cause ageing and spoilage.

Protein cross linking

It refers to the formation of covalent bond between polypeptide chains either within a protein or between the proteins [14]. Protein cross-linking occurs during processing due to high temp extreme pH, exposure to oxidizing agents which leads to subsequent chang-

es in its structure and further leads to functional and nutritional changes [2,5]. It also leads to indigestibility of protein, as the aggregated protein is less digestible [15]. The protein cross linking due to heat treatment is sometime desirable as it leads to gelling of come foods like in milk, eggs, meats, soybeans.

Amino acid racemization

Racemization means the conversion of L-amino acid to D amino acid. It occurs when food undergo heat treatment or treated in non-neutral pH (mostly alkali conditions) or during proteolysis [2,5]. Racemization leads to reduction in digestibility of protein up to 2-7% in particular of cysteine 16-26% and aspartic and 07-11% [2]. It is seen in wide variety of food like in alcoholic beverages, bake products, meat and meat products, yeast extracts etc.

Oxidative reactions

Proteins are highly susceptible to the oxidative damage caused by reactive oxygen species so during oxidative reaction these are modified to several amino acid residues [2,16]. The functional properties like emulsification, binding water, and gelation decrease due to these oxidative reactions of the protein. In some cases, these reactions lead to protein cross linking which leads to the decrease in nutritive value of protein.

Reactions induced by heat and high pressure

Heating is one of the most common methods for food processing. During certain processing method like extrusion, high temp and high pressure is applied to the food. These high temp and pressure leads to the breakage of the peptide chain (strong and bind amino acids covalently) and causes denaturation [8,10]. In some instances, this leads to decreased nutritive value of protein.

The Maillard reaction

The reaction is started when a free amino group reacts with carbonyl group of reducing sugar. The first reaction gives Schiff's base. This undergoes a rearrangement to form Amadori product. The reactions are accelerated in conditions like pH, water content, temperature and other molecules present in the food. The Maillard reaction is responsible for color and flavor development in many foods.

Denaturation of protein

Denaturation is a process where the native state of protein which is mostly very stable is partially or totally altered and results in the bioactivity loss. It leads to decrease in solubility, increase in viscosity, alteration of functional properties, loss of enzymatic activity, and sometime increase in digestibility of proteins [3]. Some of the important factors that cause protein denaturation

- **pH:** It accelerate protein denaturation by breaking the ionic bond and affecting the salt bridge of protein [2,8]
- **Temperature:** High temp destabilizes the non-covalent bonds. When high temperature introduced to protein food, the hydrogen bond breaks first followed by the ionic bond [8].
- **Metal ions:** The metal ions break the salt bridge and make the protein insoluble. Also, the heavy metals disrupt the disulfide bond (that gives structural conformation and stability) and causes denaturation [6].
- High pressure and oxidation also cause protein denaturation [10-12].

Some processing conditions and their effect on Protein

- Heat treatment causes protein denaturation, racemization.
- High pressure causes protein denaturation, pH change solubilization of protein.
- Enzymatic reaction - causes oxidation of amino acids through lipid or polyphenol oxidation [2].
- Fermentation - causes racemization increase bioavailability.
- Milling (friction and shear forces) causes protein denaturation and aggregation [7].

Functional properties of protein

The physical and chemical properties that affect the department of a nutrient in food systems during its storage, cooking or processing and consumption, is known to be the functional properties of that particular nutrients.

Solubility

The solubility of proteins is regarded as the proportion of nitrogen present in protein, are in soluble state under specific conditions. It is affected by the balance of hydrophobic (ex-valine, leucine, isoleucine, methionine etc) and the hydrophilic (Lysine, arginine, threonine) amino acids on its surface. The proteins are least soluble at their isoelectric point (pI - the PH of a solution at which the net charge of a protein becomes zero) [5]. When the pH of the solution increases or decreases from the isoelectric point,

protein become soluble. At low salt concentration, protein solubility increases and when there is high salt concentration it decreases. Processing of protein in a very high or low temp also lowers the solubility of protein.

Gelation

Gelation occurs when proteins denatured by the application of heat, pH, pressure or shear action [4,11,12]. A gel is a continuous 3D network which is formed when the protein denatures or coagulates and tangles the fluid [13]. The protein prevents the flowing away of liquid/fluid and the fluid keeps the protein away from collapsing.

Emulsification

Emulsion is a mixture of two or more immiscible liquids, one dispersed in another. Proteins contain both hydrophilic and hydrophobic amino acid on their surface, so they can act as good emulsifiers [7]. If there are more hydrophobic amino acids present in the surface, then the emulsifying property as well as solubility of protein increases.

Foaming

When a protein-based food is mechanically agitated for example whipped, through which gas/air enters into it, foam is formed. When the salt concentration is increased, the charges get neutralized due to which proteins loose solubility and the foaming increases. This property is similar to emulsifying property.

Some other functional properties of protein are

- **Cohesion:** Adhesion -It is the property where the protein acts as an adhesive material and this can be seen in meats, sausages, baked goods and pasta products.
- **Viscosity:** It is the property where protein helps in thickening and is used in soups and gravies.
- **Elasticity:** The hydrophobic bonding in gluten and disulfide links in gels gives elasticity in bakery goods and meats.

Conclusion

Processing affects the nutritional and functional quality of protein. Since the intake of protein is essential for our body, it is important to consider the impact of food processing so that the protein in the food gets affected little and the body derives maximum nutrition from the food we eat.

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