

FUNCTIONAL PROPERTIES OF WHEY PROTEINS



- The general behavior of whey proteins indicate that they are highly soluble over a wide range of pH, especially acid pH, able to produce firm gels on heating, exhibit good fat and water binding properties, especially on denaturation and good aerating agents.
- Whey proteins play an important role in controlling the texture of many food products.
- In this respect, the rheological and gelling behavior of whey protein are important.

Solubility

- Whey proteins are unique among the milk proteins used in food applications since in their native conformation they are soluble at low ionic strength over the entire pH range required for food applications.
- Solubility is an important functional property of WPCs; complete solubility of the proteins is a requisite for optimum functionality in foams, emulsions, beverages, and similar applications.
- Macromolecules are not soluble in the same manner as small molecules are.
- However, the amino acid side chains in the proteins can interact with water and proteins can be suspended in water.
- This property is often used as an indicator of whey denaturation.
- Protein solubility is a function of temperature, pH, presence of other ions, and the values obtained for solubility are highly dependent on the methods used to achieve the solubility.

- Proteins are least soluble at the isoelectric point but whey proteins are soluble over a wide range of pH values.
- This property of whey proteins makes it desirable for use in beverages.
- In some cases, whey proteins may be soluble in a non-aggregated state, so that they can thoroughly mix with the other ingredients of formulation or orient at the interface of emulsions or foams.
- In order to accomplish this in food systems throughout the pH range of 3 to 8 and in the presence of calcium ions, it is essential that proteins be in undenatured state, otherwise they will aggregate and precipitate when incorporated into such food systems and fail to provide adequate functionality.
- However, being globular proteins, their solubility decreases at high salt concentrations due to salting out and they are susceptible to thermal denaturation at temperature $> 70^{\circ}\text{C}$.

- Solubility at pH 4.6 is widely used as an index of the extent of denaturation caused by processing and storage of protein-rich whey products.
- The level of denaturation and subsequent insolubility at pH 4.6 depends on heating temperature and time, whey pH and ionic calcium concentration.
- Whey ingredients have good dispersibility, instantized forms of WPC and WPI are available for applications that require whey ingredients to dissolve quickly and without an excessive amount of agitation.

Hydration/Water Binding Properties

- Bound water is defined as the water retained by protein containing slurries following filtration or application of either mild pressure or centrifugal force.
- Water binding or hydration is defined as the g of water associated with or occluded by 1 g dry protein.
- Hydration values determined for individual native whey proteins range from 0.32 to 0.60 g H₂O/g, depending on the assay method used.
- Water binding is especially important when whey proteins are used in viscous food products viz. beverages soups, sausages and custards.
- Moreover, the water binding and associated properties (i. e. swelling, gelation and viscosity) of proteins are the major determinants of texture in a number of food products.

- However, when whey protein solutions of sufficient protein content and suitable solution conditions (pH, ions, etc.) are heated, gels are formed and the water holding capacity of such gels make significant contributions to the texture and rheology of a number of processed foods.
- Heat denatured whey protein (lactalbumin) absorbs more water than undenatured whey protein.
- Practical uses of whey protein concentrates, in which water-protein interactions are utilized include yoghurt drinks, hard pack ice cream, low fat ice cream, non fat ice cream, and soft serve ice cream, yoghurt, sour cream, and coffee whiteners.
- In cheese sauces, low fat cream soups, creamy salad dressings, refrigerated pasta and orange marmalade, viscosity and the ability of whey proteins to bind water are useful.

Viscosity

- Viscosity which results from water-protein interactions have been discussed extensively by de Wit (1989).
- The relative viscosity of whey decreases between 30 and 65°C. Above 65°C, this relative viscosity increases as a result of protein denaturation and above 85°C a further increase is observed as a consequence of protein aggregation.
- The viscosity of whey protein concentrates (WPC) in the range 25-39% TS depends strongly on the composition and pre-heat treatment of the whey due to the rate of crystallization of the lactose in the concentrate.

- Due to their compact globular shapes, solutions of undenatured whey proteins are much less viscous than caseinate solutions.
- They exhibit minimum viscosity around the isoelectric point (pH 4.5) and relative to water, their viscosity decreases between 30 and 65°C, but increases thereafter owing to protein denaturation.
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- Solutions of WPC containing 4-12% (w/v) protein were reported to exhibit Newtonian flow while at higher concentrations flow became more pseudoplastic.

Heat Gelation

- Gelation is formation of three-dimensional structures capable of entrapping sufficient water to produce gel.
- One worker defined gelation as a protein aggregation phenomenon in which polymer–polymer and polymer solvent interactions are so balanced that a tertiary network or matrix is formed.
- Whey proteins, in undenatured soluble form, as in WPC prepared by UF process, have ability to form heat induced irreversible gels at appropriate protein concentration, pH and ionic conditions.
- At about 5% concentration and above, whey proteins are able to produce firm gels on heating, Optimum gel strengths are formed between 10–15% protein concentration.
- Gel characteristics depend on the protein concentration, the pH of the solution, and the calcium and sodium ion concentration.

- The process of gelation is a two-stage one involving: an initial denaturation or unfolding of a protein molecule followed by subsequent aggregation.
- Whey proteins form thermo-irreversible gels. Whey proteins form irreversible gels by restructuring into extended three-dimensional networks that have the capability to entrap fat and water.
- A strong gel network helps hold this water and prevents moisture loss, which assists in controlling syneresis.
- The gelation characteristics of whey protein systems can be improved by dialysis to remove interfering components and adding calcium salt just before heat.
- Heating whey proteins to temperatures above 70°C can cause denaturation and polymerization, resulting in gel formation.
- Heating skim milk with 0.5% added WPC's produce gelation.

Emulsification and Foaming Properties

- Whey proteins have both hydrophilic and hydrophobic groups, which allow the proteins to adsorb and unfold rapidly at the oil-water interface and form a layer that stabilizes the oil droplets and prevents flocculation and/or coalescence.
- The hydrophilic sites of the whey protein molecule bind water while the hydrophobic sites encapsulate the fat, resulting in stabilization of the system.
- Whey protein adsorbs at the interfaces at a slower rate than other proteins like β -casein. Factors affecting whey protein emulsions include pH and ionic strength.
- Around their isoelectric point whey protein forms poor unstable emulsions.
- If the milk used for cheese making is pasteurized or if the whey resulting from the cheese making is pasteurized the emulsification properties of the whey proteins are not adversely affected.

- Pasteurization of the retentate greatly diminished the emulsion capacity of the proteins.
- Whey proteins do help in emulsification in infant formula, meal replacement beverages, soups and gravies and coffee whiteners.
- They are used in conjunction with low molecular weight emulsifier. Whey protein-enriched products are widely used in foaming applications in foods and factors such as protein concentration, level of denaturation, ionic environment, pre-heat treatment and the presence of lipids all influence whipping properties.
- Whey proteins have low emulsion capacities than casein. A number of compositional and processing conditions such as pH, redox potential, heat denaturation, enzymic hydrolysis, polyphosphate, residual lipids, phospholipids, sodium lauryl sulphate affect foaming properties.
- This is may be due to the inherent hydrophobic–hydrophilic nature of the amino acid side chains, which the whey protein molecules orient to the air liquid interface.
- Heating increases the foaming properties because heat unfolds protein molecules, to expose buried and alter their effective hydrophobic–hydrophilic balance.