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Interfacial, foaming and emulsifying characteristics of sodium caseinate as influenced by protein concentration in solution

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Abstract

The foaming and emulsifying characteristics of proteins are important attributes during the production stage, storage, transport, and consumer perception of quality (appearance) of food dispersions (emulsions and foams). In this contribution, we are concerned with the analysis of interfacial, foaming, and emulsifying characteristics of a typical milk protein (sodium caseinate) as a function of protein concentration in aqueous solution (C, % w/w). We have observed that there exists close relationships between foaming (power of foaming, foam capacity, foam density, and foam conductivity) and the rate of diffusion (slope of π vs. $t^{1/2}$) of caseinate to the air–water interface. The foam stability (quantified by the relaxation time (t) due to drainage and disproportionation/collapse) correlates linearly with the equilibrium surface pressure (π_e) of aqueous solutions of caseinate. At surface pressures lower than that of monolayer saturation (at $C<1\times10^{-3}$%, w/w) the foaming is zero. The emulsifying capacity (quantified by the droplet size and the specific surface area) was correlated with the protein concentration in solution (surface pressure at equilibrium). Coalescence was observed only at the lower caseinate concentration in solution ($C<0.1$%, w/w). As a coherent protein layer (multilayer) saturates the interface, at higher protein concentrations, the emulsion instability is due to flocculation and/or creaming. The coalescence and creaming rates correlate well with the protein concentration in solution (thus with the surface pressure and/or surface dilatational modulus).

Keywords: Foam; Emulsion; Food dispersion; Protein; Caseinate; Food colloids; Adsorption; Air–water interface

1. Introduction

Food dispersions often take the form of emulsions and foams. The foaming and emulsifying characteristics are important attributes during the production stage of such dispersions. In addition, stability is an important property of food dispersions, since consumer perception of quality is influenced by appearance. These dispersions are thermodynamically unstable, and their relative stability is affected by factors such as flocculation of aggregated dispersed particles, usually followed by creaming (sedimentation), partial or total coalescence of dispersed particles and/or Ostwald ripening (disproportionation), resulting in final dispersion breakdown (Dickinson, 1992; McClements, 1999). Foaming and emulsifying characteristics and the stability of the resulting dispersion depend on the properties of the surface-active components in the system. The most important surface-active components in foods are proteins and low-molecular weight emulsifiers (lipids, phospholipids, surfactants, etc.).

Among food proteins, caseins are distinguished by their good foaming and emulsifying properties, and for these reasons they are widely used in food formulations (Dalgleish, 1997; Damodaran, 1997). All of the individual caseins, except κ-casein, show a strong tendency to adsorb the fluid interfaces (air–water and oil–water), and thus they find an important use in the manufacture of stable emulsions (i.e. ice cream, cream liqueurs, whipped toppings, coffee whiteners, products for infant nutrition, etc.), where long-term emulsion stability is essential. The foaming and emulsifying properties of caseinate arise from the structures of the four proteins found in bovine milk (β-casein, α_{s1}-casein, κ-casein, and α_{s2}-casein). In foams and emulsions made of incorporating caseinate the individual caseins seem to be adsorbed at fluid interfaces in proportion to their incorporation in solution (Hunt & Dalgleish, 1994).

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