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Interfacial adsorption and shear flow properties of gum arabic-sodium caseinate mixtures

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Abstract

This work discusses rheological and physicochemical properties of sodium caseinate and gum arabic, in aqueous media (25°C). All the systems showed low viscosity values and Newtonian behaviour in the shear rate range studied. From particle size distribution, a limited thermodynamic compatibility was observed since hydrocolloids mixtures showed particles size between the values from the systems alone. Interfacial tension measurements at equilibrium at the air-water interface, revealed that the binding affinity of arabic to the air water interface is very low compared to that of caseinate. The adsorption critical concentration could be deduced as a function of aqueous solutions composition. In competitive adsorption experiments involving simultaneous adsorption of the hydrocolloids from a bulk mixture, sodium caseinate displaced gum arabic from the interface at both polysaccharide concentrations, changing the adsorption critical concentration.

Keywords: Emulsion; sodium caseinate; whey concentrate; rheology; stability

1. Introduction

Protein/polysaccharide mixtures are commonly found in the food industry as thickeners for low fat food. Within of applications, these biopolymers are used to formulate emulsion-based food systems. Products like ice cream, milk shakes, milk desserts, salad dressing and mayonnaise are some examples. Interactions between proteins and polysaccharides play an important role in the structure and stability of processed foods; control or manipulation of these macromolecular interactions is a key factor in the development of novel food processes and products [1].

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Because proteins are amphiphilic and exhibit a high tendency to adsorb to air-water and oil-water interfaces, they primarily function as emulsifiers in foods [2]. On the other hand, hydrocolloids, which are hydrophilic random coil-type high molecular weight polymers, are primarily used as thickening agents in foams and emulsions. However, it has been reported that some polysaccharides have interfacial properties [3].

Caseinates are in particular demand as functional food ingredients, due mainly to their surface properties [4], these proteins are currently used in a variety of products, including those of low pH such as imitation cheeses and yoghurt. Commercial sodium caseinate is a variable multicomponent mixture containing four major constituents, α_{s1}, α_{s2}, β, and κ-casein, in the proportion 3:0.8:3:1 by weight [5].

Gum arabic is a heteropolysaccharide containing a small amount of proteinaceous material (around 2%) [6], the carbohydrate part has highly branched structure consisting of a 1,3-linked β-D-galactose core with extensive branching through 3- and 6-linked galactose and 3-linked arabinose. A feature of gum arabic is its ability to form an adsorbed film at the oil-water interface whose surface viscoelasticity is rather insensitive to dilution of the aqueous phase [7].

It is known that proteins and polysaccharides exhibit limited thermodynamical compatibility and undergo phase separation; thus, in systems containing both proteins and hydrocolloids to make up an interface, it is conceivable that these surface-active macromolecules may compete for adsorption. In this work we studied the shear flow, the particle size distribution and the interfacial adsorption of gum arabic at two different concentrations, alone and in mixture with 2% sodium caseinate, to elucidate about competitive adsorption at the air-water interface.

2. Materials & Methods

2.1 Materials

Sodium caseinate (Lactoprot, Germany), ≈96% dry matter, and gum arabic (Coloides naturals de México), ≈94% dry matter, were used without any pretreatment. All concentrations are given as a weight percentage. Caseinate systems (2%) an arabic samples were prepared at room temperature, by stirring for 60 minutes. Blends for protein-polysaccharide were made by mixing equal parts of duplicate aqueous solutions of individual components.

2.2 Flow properties

A stress rheometer (LS100, Paar Physica) with a double gap concentric cylinder (DG10, 48 and 50 mm internal and external diameter, respectively, 36 mm length and radii ratio of 1.0417 was used. Flow curves were obtained by using two up-down step programs. The temperature was maintained at 25 ± 1°C.

2.3 Particle size

Particle size distribution of the samples was measured using a Malvern Zetasizer Nano (Malvern Instruments Ltd.). Protein and polysaccharide systems yield satisfactory photon counts without dilution.

2.4 Interfacial tension

A pendant drop tensiometer PAT-1 (Sinterface Technologies) was used to measure the air-water interfacial tension. Normally, a pendant drop of oil is formed at the tip of a capillary. The silhouette of the drop is cast onto a CCD camera and digitized. The digital images of the drop are recorder over time and