Foam stability and interfacial properties of milk protein–surfactant systems

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Abstract

Interfacial properties like shear behaviour of commercial milk proteins and food emulsifiers were studied, at both air-water and n-dodecane–water interfaces. Whey proteins form a protein network at interfaces. The film exhibits high elasticity, whatever the interface. On the contrary, micellar caseins and emulsifiers do not exhibit any viscoelastic behaviour at interfaces. Competitive adsorption of proteins with surfactants was clearly identified, both via rheological and tensiometrical measurements. The addition of an emulsifier to an elastic protein film, even at very small amounts, leads to a significant decrease of the interfacial elasticity, depending on the type of emulsifier and on the emulsifier/protein ratio. Water-soluble surfactants (like sucrose ester) are indeed more effective than oil-soluble surfactants in displacing protein molecules from our model interfaces. Most of our results on commercial samples do confirm but also extend what was already described in the literature with purified products. Our major contribution links these interfacial parameters to the stability of model foams. Foaming trials were performed by incorporating air in a sucrose syrup/water mixture, containing protein or emulsifier molecules (previously characterised) for stabilisation. In protein aerated systems, a high surface elasticity is required to prevent quick foam destabilisation: interfacial layers are quite deformable, their rupture and the bubbles’ coalescence are limited. In the presence of low-molecular-weight surfactants, the formation and stabilisation mechanisms are quite different. Therefore mixed protein–surfactant systems offer a simple way for optimising foam ability and stability.

Keywords: Interfacial shear rheology; Surface tension; Protein; Emulsifier; Competition; Foam stability

1. Introduction

Emulsions and foams are dispersed systems often present in foodstuffs. Proteins (milk proteins in particular) and emulsifiers are widely used as functional ingredients for the formation and stabilisation of these systems. These molecules contain simultaneously polar and non-polar regions, which give them surface-active properties. During the emulsification or foaming processes, they rapidly adsorb and form a film at the surface of the oil droplets or gas bubbles. The systems are thus stabilised and protected against destabilisation. The bulk properties (especially its viscosity) also play a key role in the stabilisation of a dispersed system.

A good knowledge of the structure and the mechanical properties of the interfacial films seems essential for controlling the behaviour of such systems. This work is part of a project aiming at a better and systematic understanding of the functionalities of surface-active agents, in order to optimise their use in industrial processes.

It is well known that the surface-activity of proteins is an essential attribute. However, lowering the surface tension of the phases is important during the formation of emulsions and foams, but the decrease does not explain the stability of the films. Proteins enable the fluid interfaces to resist tangential stresses from the adjoining flowing liquids (Lucassen-Reynders & Benjamins, 1999). Therefore surface rheological properties of adsorbed protein layers have been studied extensively. As examples, whey proteins and caseins form different films and do not show the same behaviour. Proteins and low-molecular-weight surfactants have different behaviours too.

The aim of our study is to check if some links can be established between the behaviour of simple aqueous foams (in particular regarding their stability) and the interfacial