FOAM STABILITY AS AFFECTED BY THE PRESENCE OF SMALL SPREADING PARTICLES

A. Prins

Department of Food Science
Laboratory of Dairying and Food Physics
Agricultural University
Bomenweg 2, 6703 HD Wageningen, The Netherlands

It is well known fact that the foam stability of aqueous systems is decreased when particles are present from which surface active material can spread over the air/water surface. Examples are the poor foaming behaviour of whole milk with respect to skim milk, the foam depressing effect of egg yolk on egg white, and the strong depressing effect of milk fat on beer foam.

A quantitative theory is developed which is based on the mechanism that as a result of the spreading of material from the particle over the film surface, the film liquid is squeezed away from the particle, forming a thin spot in the film. When this process proceeds far enough, which depends on various factors, the film becomes so thin that it collapses spontaneously as a result of thermal motion. Assuming that the spreading phenomenon can be described quantitatively by the propagation of a longitudinal wave over the film surface, the amount of liquid squeezed away by the spreading surface layer can be estimated. Comparing the amount of liquid with the amount originally present in the film, a criterion can be formulated for the occurrence of film collapse as a result of spreading. From this it can be predicted how the particle size and the total amount of spreading particles affect the foam stability in a quantitative way.

Because the spreading process is a dilational surface phenomenon, dilational properties of the surface play an important role to a degree which in a semi-quantitative way can be predicted from the longitudinal wave theory.

The results of these theoretical considerations are discussed in view of the measured foaming behaviour and dilational surface properties of aqueous protein solutions to which various oil-in-water emulsions were added.
INTRODUCTION

The general experience with aqueous foams is that their stability can be decreased considerably by the presence of fatty particles. Examples are the poor foaming behaviour of whole milk with respect to skim milk and the destabilizing effect of milk fat on beer foam.

One of the mechanisms that can account for this effect is the spreading of material from the fatty particles over the surface of the thin foam films. Due to this radial movement of the film surface away from the spreading particle, also the film liquid close to that surface is squeezed away in a radial way. Because the amount of liquid in a thin foam film is only limited, spreading from the particle causes a local thinning of the foam film. When this thinning proceeds far enough, the foam film will break.

Up to now no quantitative theory is available for this physical process. The ultimate purpose of the present investigation is to try and analyse this process in such a way that the amount of liquid which is squeezed away by the spreading particle can be calculated. When this amount exceeds the amount of liquid originally present in that part of the film, the film will break.

THEORETICAL

Spreading of material from a particle over an aqueous surface is governed by the values of the surface and interfacial tensions involved in the process: the surface tension of the aqueous solution $\gamma_{AG}$ has to exceed the sum of the surface tension of the spreading layer $\gamma_{OG}$ and the interfacial tension between the spreading layer and the aqueous solution $\gamma_{OA}$: (see Fig. 1)

$$\gamma_{AG} > \gamma_{OG} + \gamma_{OA} \quad (1)$$

![Figure 1](image)

*Figure 1* Schematic representation of the equilibrium between the interfacial tension $\gamma_{OA}$ and the surface tensions $\gamma_{OG}$ and $\gamma_{AG}$ at the contact line between an oil droplet and an aqueous surface.