Effect of formulation and processing factors on the properties of liquid food foams

C. Balerin a, P. Aymard b, F. Ducept c, S. Vaslin b, G. Cuvelier a,*

a ENSIA, UMR 1211 SCALE, 1 avenue des Olympiades, 91744 Massy Cedex, France
b Danone Vitapole, Technovaleur, Route Départementale 128, 91767 Palaiseau Cedex, France
c ENSIA, UMR GENIAL, 1 avenue des Olympiades, 91744 Massy Cedex, France

Received 19 May 2005; accepted 16 November 2005
Available online 19 January 2006

Abstract

The aim of this work was to determine the phenomena affecting bubble size, according to process conditions (pressure, flow rates, whipping rotation speed) and formulation properties. Model fluids were formulated in order to get simple and well-defined rheology. An instrumented foaming pilot-scale line was built and allowed us to monitor the process and to characterise bubble size under pressure, at the exit of the mixer.

Viscosity and rotation speed of the whipping head are the most influent parameters on foam morphology: interaction between these factors have been highlighted. Experimental measurements obtained were consistent with the critical Weber number since a corrected fluid viscosity is used. It seems indeed that the fluid viscosity is reduced in the whipping head, due to the presence of local heating. These temperature variations consequent to the shear of viscous fluids in a narrow-gap geometry were quantified and modelled as a function of shear rate and fluid viscosity.

© 2005 Elsevier Ltd. All rights reserved.

Keywords: Foam; Processing; Bubble diameter; Weber number; Viscous dissipations

1. Introduction

Foams are the subject of a strong interest in a large number of industries, including textile, building trade, oil industry, personal care, etc... In the food industry, foams are also present in a variety of applications, from dairy products to ice creams, soft doughs, confectionery or meat. Indeed, a number of food products show a porous structure that is created either by chemical (e.g. raising powders in biscuits), biological (yeasts in bread) or mechanical (dairy foams) means. These porous food materials are often referred to as “solid” or “liquid foams”, depending on the mechanical properties of the continuous phase. Liquid foams here refer to suspensions of gas bubbles in a liquid, with moderate volume fractions (up to 50%), such as typically encountered in food products. Within this class of products, bubble size is of major importance for the foam properties, as it influences the texture, the mouth-feel and the stability of the aerated product.

To predict the bubble size resulting from a mechanical treatment, it is usually referred to the so-called Weber number $We$. This dimensionless number stems from the Capillary number $Ca$, defined by Taylor in the small deformations range and at infinite dilutions (Taylor, 1932). It reflects the balance between the viscous forces tending to deform the bubbles over the interfacial forces that tend to maintain the spherical shape

$$We = \frac{\eta \cdot \dot{\gamma} \cdot D_{3.2}^3}{\sigma}$$

In Eq. (1), $D_{3.2}$ is the Sauter diameter defined as a volume surface mean diameter, $\sigma$ is the gas/liquid interfacial tension, $\eta$ is the continuous phase viscosity and $\dot{\gamma}$ the shear...