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Journal of Food Engineering 77 (2006) 14–26
JOURNAL OF FOOD ENGINEERING
www.elsevier.com/locate/jfoodeng

Continuous manufacturing of a light-textured foamed fresh cheese by dispersion of a gas phase. II. Influence of formulation

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Received 25 January 2005; accepted 5 June 2005
Available online 8 August 2005

Abstract

The continuous process developed in "Part I. Influence of process parameters" was used to investigate the influence of ingredients on the manufacturing of a light-textured foamed fresh cheese. The role of ingredients was analyzed using overrun, stability of the dispersed gas phase over time, cheese texture and visual aspect as indicators. Using cream and skim milk as a reference, fresh cheese formulation has been modified by replacing cream with milk fat fractions or incorporating whey protein concentrates (WPC) and emulsifiers, such as phospholipids (PhL) and mono–diglycerides (MDG). Experiments have shown that the foamability and the stability are enhanced by WPC addition and high-melting point fat fractions, but also that the simultaneous addition of WPC and PhL provides softer textures, whereas MDG present always a negative impact on foamability. The best results are obtained when WPC are incorporated before curd homogenization.

Keywords: Fresh cheese; Continuous process; Foamability; Foam stability; Formulation; Food processing; Gas dispersion; Texture

1. Introduction

In spite of the large number of cheese varieties (see, e.g., Olson, 1995), cheese industry is continuously looking for new technologies and ingredients in order to improve shelf-life, appearance, body, texture, mouthfeel and taste by using innovative ingredients and/or technologies. As an illustration, ultrafiltration (UF) has been used since the 70s as a key technology for improving cheese characteristics (Maubois, Mocquot, & Vassal, 1975; Shell, 1986). This operation has enabled the integration of whey proteins into the cheese matrix along with the normal casein and fat components in order to improve cheese nutrient value as well as the economic effectiveness of cheese production (Hinrichs, 2001).

Nevertheless, it appears clearly that innovative technologies have still to be found, not only for improving again cheese yield, but also for changing cheese texture, flavour, ripening and melting. In a previous work, a process for the continuous manufacturing of a more spoonable and spreadable fresh acid cheese was suggested and developed by Vial, Thakur, Djelveh, and Picgirard (2005). By dispersing a gas phase under high-shear conditions, the presence of gas was shown to affect both the mechanical properties (consistency, firmness, etc.) and the visual aspect of the raw material, which results in a lighter texture, an increased spreadability, as well as a more homogeneous appearance. This could lead to sensory and marketing advantages over conventional acid fresh cheeses. In their work, the final product had to contain at least 15% (v/v) of gas (18% overrun) with moisture between 60% and 70% (w/w); additionally, it had to be stable for more than 21 days, but without needing the addition of non-dairy stabilizers (gelatin,

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0260-8774/$ - see front matter
doi:10.1016/j.jfoodeng.2005.06.016

Nomenclature

a_i	main effect of parameter x_i
a_{ij}	interaction between parameters x_i and x_j
AMF	anhydrous milk fat
AS	absolute stability of the gas phase
d_{32}	Sauter mean diameter (m)
DM	dry matter
Eff	foaming effectiveness
FDM	% of fat in dry matter
FPM	fat-to-protein mass ratio
G	gas flow rate ($m^3 s^{-1}$)
G'	shear storage modulus (curd) (Pa)
G'_m	shear loss modulus (foamed cheese) (Pa)
L	liquid flow rate ($m^3 s^{-1}$)
MDG	mono- and diglycerides
N	rotation speed (s^{-1})
O	overrun
PhL	phospholipids
tan(δ)	tangent loss (curd)
tan(δ_m)	tangent loss (foamed cheese)
WPC	whey protein concentrates
WPCah	whey protein concentrates added after homogenization
WPCbh	whey protein concentrates added before homogenization
x_i	parameter

Greeks

ε	gas volume fraction
ε_{+7}	gas volume fraction after 7 days
ε_{max}	maximum gas volume fraction under steady-state conditions
ρ_F	foam density ($kg\,m^{-3}$)
ρ_{F+7}	foam density after 7 days ($kg\,m^{-3}$)
ρ_G	gas density s ($kg\,m^{-3}$)
ρ_L	curd density ($kg\,m^{-3}$)

starch, etc.) that are incompatible with French regulations for "traditional" cheese products.

The processing methods for elaborating an aerated acid fresh cheese that have been described and optimized previously have been used (Vial et al., 2005). The scope is now to understand the respective role of cheese ingredients on the foamability of acid fresh cheese (which corresponds to its ability to form a foam structure), but also on the texture and stability over time of the aerated structure. In a fresh cheese, more than 80% dry matter is constituted by milk fat and caseins. Only caseins present a foaming capacity. However, these proteins are poor foaming agents when the pH is too close to the pI of milk (Franzen & Kinsella, 1976; Vial et al., 2005). This is the reason why the addition of whey protein concentrates (WPC) to traditional ingredients will be investigated in this work to enhance cheese foamability. Whey proteins are known indeed to have a good foaming ability that is less pH-dependant than that of caseins, but WPC may act also on cheese microstructure: they may complex with casein micelles, form aggregates or have a gelling effect after heat-induced denaturation (Hinrichs, 2001; Livney, Corredig, & Dalgleish, 2003). The controlled addition of whey proteins has already been considered as a convenient way to create innovative cheese products with soft and creamy structures and has been used successfully in the manufacture of soft cheeses like Camembert (Hinrichs, 2001). Moreover, WPC addition may be carried out before and after homogenization. In the first case, whey proteins may become part of fat globule membranes, while most of them will probably remain in the bulk in the second case. Both situations will be investigated in this work.

Conversely, milk fat cannot act directly as a foaming agent. However, it may contribute to an increase in total solids and therefore in cheese viscoelasticity. This may play a role in the stabilization of gas cells, as high viscosity levels are known to help foam stabilization. Additionally, the membrane material of fat globules can also take part in bubble stabilization by spreading over gas–liquid interfaces during foaming operation. For example, globules can become attached to gas cells, especially when they contain fat crystals (Walstra, Geurts, Noomen, Jellema, & van Boekel, 1999). In many emulsified foods, it is clear that solid fat crystals are known to be necessary for microstructure stabilization (Rousseau, 2000). This ability depends however strongly on morphology and polymorphism. The melting point of milk fat is therefore one of the key parameters of cheese formulation that will be investigated in this work by comparing anhydrous milk fat fractions with different slip melting points.

Another opportunity to act on cheese formulation consists in increasing the amount of non-triglyceride lipids. In milk, mono- and diglycerides play only a secondary role, but phospholipids are of utmost importance in fat membrane stabilization. These ingredients are known for their emulsifying properties, but their influence is generally neglected in cheese manufacturing because it is overshadowed by the large amount of proteins available, especially when pressure homogenization is applied. However, if their content was increased, they might influence gas dispersion and cheese texture: it has already been pointed out that combinations of proteins and emulsifiers are likely to produce new functional foods with novel structural