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Emulsifying salt and Cheddar cheese age: functionality in cheese powder production

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In cheese powder production, cheese is melted with water and emulsifying salt creating an emulsion, cheese feed, remaining stable for spray drying. The aim of this study was to investigate how cheddar cheese of different age (1, 6, 12 and 18 months) influences stability of feed without emulsifying salt. Confocal laser scanning microscopy showed that the protein of feeds with emulsifying salt formed a continuous network whereas in feeds without emulsifying salt, protein occurred as lumpy aggregates, less able to emulsify the fat. The viscosity of feeds decreased more than one order of magnitude when removing emulsifying salt and the flow properties changed from shear-thinning to almost Newtonian behavior. Without emulsifying salt, feed prepared from 18 month old Cheddar was most unstable and had the lowest viscosity, indicating an effect of extent of protein degradation. Effect of cheese of different age differed between feeds with and without emulsifying salt.
EMULSIFYING SALT AND CHEDDAR CHEESE AGE: FUNCTIONALITY IN CHEESE POWDER PRODUCTION

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Objective
To study how the technology, stability and microstructure of hot cheese emulsions for cheese powder production are affected by
- Cheddar cheese age
- Presence of emulsifying salt

Introduction
Cheese powders are used in the food industry as natural functional and flavouring ingredients in applications such as biscuits, savoury snacks, bakery products, sauces, dressings, ready meals and processed cheese.

Cheese powder is produced from cheese, which are mixed with water and emulsifying salts (primarily sodium phosphates) and subsequently melted to form a hot cheese emulsion (cheese feed). The cheese feed is heat treated and finally spray dried.

Currently there is an increased focus on reducing additives in food as well as a health based desire to reduce the general intake of sodium and phosphates. A need for production of cheese powder without the use of emulsifying salts has therefore emerged. In order to make this possible, however, more knowledge about the functionality of emulsifying salts in stabilization of cheese feed is needed.

Emulsifying salts are added to aid creation of an emulsion that remains stable until spray drying and also to ensure a final powder with good storage quality.

Besides addition of emulsifying salt, the stability of cheese feed may also be affected by the characteristics of the cheeses used, addition of other dairy ingredients and processing parameters.

Results and discussion
Stability
Cheese feed containing emulsifying salt showed no separation during the applied centrifugation analysis, whereas cheese feed prepared without emulsifying salt separated into three phases.

Cheddar cheese age did affect stability, the onset of separation was delayed and total separation was slightly lower when the 6 months old cheddar was used, whereas higher levels of separation was observed in all steps of the analysis when the 18 months old cheddar was used (data not shown).

Rheological properties
Cheese feed with and without emulsifying salt exhibited markedly different rheological properties and furthermore, an effect of cheddar cheese age was observed. For cheese feed with emulsifying salt, a shear-thinning behaviour was observed in the flow curves (Figure 1 A). Cheese feed without emulsifying salt showed a nearly Newtonian behaviour (Figure 1 B).

The rheology of cheddar cheese age are different for cheese feed with and without emulsifying salt (Figure 1), indicating that both the maturation itself and the interplay between the emulsifying salt and the maturation of the cheeses influence the rheological properties of the feed.

Comparing the shear stress values for the cheese feed with and without emulsifying salt reveals a difference of more one order of magnitude, with the lowest values for the cheese feed without emulsifying salt (Figure 1). The big difference observed in flow behaviour and in measured shear stress indicates that emulsifying salt aid in creating structure in the cheese feed, a structure that develops further during a holding time at high temperature (data not shown). These observations are in accordance with those of Lee et al. (2003) made on processed cheese.

Microstructure
The CLSM images reveal that cheese feed produced with emulsifying salt contain a large number of widely distributed fat particles of varying size (Figure 2 A-C). The protein forms a continuous and compact network. The fat globules appear embedded in the protein matrix with protein absorbed onto the fat globule surface, indicating that the fat has been emulsified. Increasing cheese age seems to produce cheese feed with a larger fat globule size, indicating that the fat is less emulsified (Figure 2 A-C).

In the CLSM images of cheese feed without emulsifying salt the protein occur as lumpy non-continuous aggregates (Figure 2 D). The fat is less associated with the protein matrix and the fat globules are located in the serum phase. This indicates risk of sedimentation of protein particles and formation of free fat. Increasing cheese age appear to produce cheese feed with smaller protein aggregate sizes (Figure 2 D).

Materials and methods
Cheese feed was prepared in a Stephan Cooker (Stephan UMC5 electronic, Stephan u. Ehne GmbH) by heating cheddar cheese (age 1, 6, 12, or 18 months; 300 g), soft white cheese (200 g) and water (140/160 g, without/with emulsifying salt). All kinds of cheese feed were prepared both with and without emulsifying salt (dissodium hydrogen phosphate equivalent to 15 g/kg feed). Cheese feed without emulsifying salt were added potassium hydroxide for pH adjustment. The ingredients were mixed in the Stephan cooker at 1500 rpm for 5 minutes and heated by applying direct steam for 45 seconds under continuous mixing.

All kinds of cheese feed were prepared at least in duplicate. The feed pH value was 6.74 ± 0.03.

Stability of the cheese feeds was analysed by centrifugation for 5-1 minute at 1500 rpm at 40°C (SL 16R, Thermo Scientific, Karlsruhe, Germany). Each measurement consisted of a flow curve (taken approx. 15 min after production) using shear rates (up and down sweep) ranging from 1 s⁻¹ to 300 s⁻¹.

The rheological properties of the cheese feeds at 60°C were analysed using a HAAKE R5 6000 meter (Thermo Scientific, Karlsruhe, Germany). Each measurement consisted of a flow curve (taken approx. 15 min after production) using shear rates (up and down sweep) ranging from 1 s⁻¹ to 300 s⁻¹.

The microstructure of the cheese feeds was visualized using confocal laser scanning microscopy (CLSM, Inverted Planar Scanning Confocal SP5 II, Leica Microsystems, Germany) after staining the fat with Nile red and the protein with FITC.

Reference
Lee et al. (2003): Lebensm.-Wiss. -U.-Technol. 36, 339-345

Figure 1: Flow curves for cheese feed produced from cheddar cheeses of different ages with and without emulsifying salt measured approx. 15 min after production.
A: Cheese feeds with emulsifying salt. B: Cheese feeds without emulsifying salt.

Figure 2: CLSM micrographs of cheese feeds produced from 1 and 18 month cheddar cheeses with, and without emulsifying salt. Green indicates protein, red indicates fat.
A: 1 month with emulsifying salt. B: 1 month without emulsifying salt. C: 18 months with emulsifying salt. D: 18 months without emulsifying salt. Scale bar, 20 μm.