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EMULSIFYING SALT AND CHEDDAR CHEESE AGE: FUNCTIONALITY IN CHEESE POWDER PRODUCTION

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Objective

To study how the rheology, stability and microstructure of hot cheese emulsions for cheese powder production are affected by

- Cheddar cheese age
- Addition /removal of emulsifying salt

Introduction

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

Cheese powder is produced from cheeses, 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. However, in order to make this possible, 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.

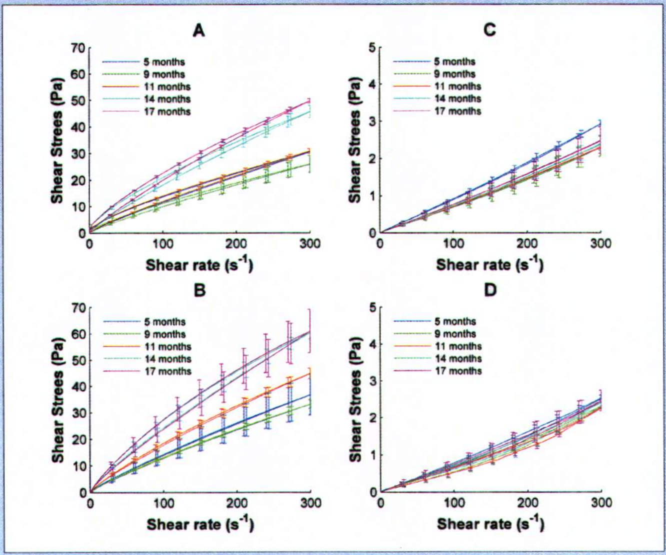

Figure 1: Flow curves for cheese feed produced from cheddar cheeses of different ages with and without emulsifying salt. A: Cheese feed with emulsifying salt measured approx. 15 min after production. B: Cheese feed with emulsifying salt measured approx. 60 min after production. C: Cheese feed without emulsifying salt measured approx. 15 min after production. D: Cheese feed without emulsifying salt measured approx. 60 min after production.

Results and discussion

Stability

Cheese feeds containing emulsifying salt showed no separation during the applied centrifugation analysis, whereas cheese feeds prepared without emulsifying salt separated into three phases. Cheddar cheese age did not affect stability significantly, except for a tendency for slightly less separation observed in the cheese feed prepared without emulsifying salt from the youngest cheese (data not shown).

Rheological properties

Cheese feeds with and without emulsifying salt exhibited markedly different rheological properties and furthermore, an effect of cheddar cheese age was observed, primarily in cheese feeds containing emulsifying salt. For cheese feeds with emulsifying salt, a shear-thinning behavior was observed in the flow curves measured both 15 min and 60 min after production. Furthermore, an increase in shear stress values was seen during storage of the cheese feed. Increased age of the cheddar cheese also resulted in an increase in the measured shear stress (Figure 1 A,B). Cheese feeds without emulsifying salt showed a nearly Newtonian behavior after 15 min of holding, the behavior changed to slightly shear-thickening after 60 min holding. The age of the cheddar cheese did not affect the flow behavior significantly (Figure 1 C,D).

Comparing the shear stress values for the cheese feeds with and without emulsifying salt reveals a difference of more than one order of magnitude, with the lowest values for the cheese feeds without emulsifying salt (Figure 1). The big difference observed in flow behavior and in measured shear stress indicates that emulsifying salt aid in creating structure in the cheese feed, a structure that develops further during the holding time. The apparent viscosity of the cheese feeds measured during steady shear applied during holding also increased with time for cheese feeds containing emulsifying salt, indicating structural build-up (data not shown). These observations are in accordance with those of Lee *et al.* (2003) made on processed cheese. For cheese feeds without emulsifying salt no change or a slight decrease in apparent viscosity was seen during holding (data not shown).

The increase in shear stress values with increasing age of the cheddar cheese indicates that maturation degree and protein degradation in combination with the emulsifying salt affect the properties of cheese feed. Surprisingly, higher shear stress values were obtained from older cheeses that are more degraded.

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). 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.

In the CLSM image of cheese feed without emulsifying salt, the fat droplets are fewer, larger and more spherical. The protein occurs as lumpy non-continuous aggregates (Figure 2 B). 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.

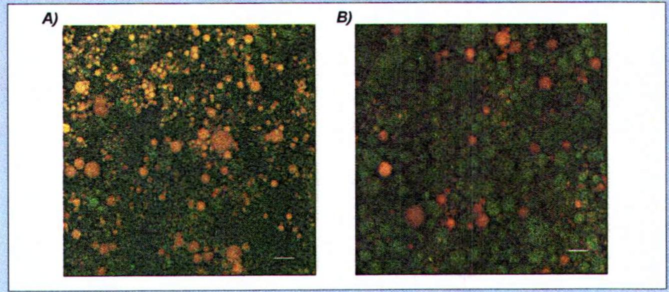

Figure 2: CLSM micrographs of cheese feeds produced from 14 months cheddar cheeses (A) with, and (B) without emulsifying salt. Green indicates protein, red indicates fat. Scale bar, 20 µm.

Conclusion

Not including emulsifying salt in cheese feeds for cheese powder production prepared from cheddar cheeses of different ages combined with soft white cheese led to a decrease in the stability and marked changes in the rheological properties of the cheese feeds. Cheese feed without added emulsifying salt lacked the ability to build internal structure, which may be necessary in order to obtain stability.

Materials and methods

Cheese feeds were prepared in a Stephan Cooker (Stephan UMC5 electronic, Stephan u. Söhne GmbH) by mixing cheddar cheese (age 5, 9, 11, 14 or 17 months; 300 g), soft white cheese (200 g), and water (140/160 g, without/with emulsifying salt). All feeds were prepared both with and without emulsifying salt (disodium hydrogen phosphate equivalent to 15 g/kg feed). Cheese, water (and emulsifying salt) was mixed in the Stephan cooker at 1500 rpm for 5 minutes and heated by applying direct steam for 45 seconds while continuously mixing.

All cheese feeds were prepared at least in duplicate.

Stability of the cheese feeds was analyzed by centrifugation for 5×1 minute at 1500 rpm at 40°C (SL 16R, Thermo Scientific, Karlsruhe, Germany).

The **rheological properties** of the cheese feeds at 60°C were analyzed using a Haake RS 600 rheometer (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}, this was followed by 35 minutes of steady shear (apparent shear viscosity measured at 15 s^{-1}), and finalized with a flow curve (approx. 60 min after production) using the same parameters as for the initial flow curve.

The **microstructure** of the cheese feeds was visualized using confocal laser scanning microscopy (CLSM) (Inverted Point 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

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