Crystallization Mechanisms of Cream during Butter Manufacturing

Patrizia Buldo & Lars Wiking
patrizia.buldo@agrsci.dk, Aarhus University, Department of Food Science, Blichers Allé 20, P. O. Box 50, 8830 Tjele, Denmark

Introduction

• Tempering and ripening of cream are the production time consuming steps in butter production. These steps vary during the year based on the fatty acid composition of the cream.
• A better understanding of the mechanisms leading to partial coalescence, such as fat crystallization during butter manufacturing, will contribute to optimization of the production process.

Aim

To examine the mechanisms of cream crystallization during churning, including the effect of ripening time and thereby understand how churning time and partial coalescence are affected.

Results

Fig. 1: Viscosity during churning of cream ripened at 10°C for 5, 1, 0.5, and 0 hours (a). Coalesced milk fat globule size during ripening for 5h (b), 1h (c), and 0h (d) and churning.

• During ripening, no changes in viscosity nor in milk fat globule size were observed
• A ripening time of 5 hours leads to the highest viscosity and shortest churning time (=15min), while, when no ripening treatment was applied to the cream, the churning time was 23 min, and the final viscosity was significantly lower
• Coalescence of milk fat globules begins right after that the churn starts
• The final size of coalescence of milk fat globules was approximately 100µm (5h), 70µm (1h), 60µm (30min) and 53µm (0min)

Materials & Methods

• Butter manufacturing in a lab scale (Rheometer- starch cell): pasteurized milk cream (38% fat) was supplied by ARLA FOODS (DK). After having the crystal history of the cream by heat treatment, the cream was ripened at 10°C for 5, 1, 0.5 and 0 hours, respectively. After that, the cream was churned at 13°C, at 100 rad/sec, until required.
• Oscillation Rheology: during the entire butter processing, the viscosity was followed as function of ripening and churning time by a rheometer (AR-G2, TA Instrument) supplied with a starch cell geometry.
• Milk fat globule size: coalesced milk fat globule size was investigated as function of ripening and churning time by a laser light scattering (Malvern Hydro 2000S; Malvern Instrument, UK).
• Melting profile of cream during butter processing: the melting profile was analyzed as function of ripening and churning time by Q 2000 Differential Scanning Calorimeter (DSC; TA Instrument, US-based). The cream samples were heated to 60°C at 5°C/min.

Conclusions

• Viscosity measurements can be used to monitor partial coalescence (formation of butter grains) during churning in a starch cell
• Ripening time influences both the churning time and final viscosity
• Longer ripening time results in larger butter grains
• Crystallization behavior changes just before butter grain aggregation occurs

Fig. 2: Melting behavior during ripening and churning of cream.

• The first milk fat fraction to be crystallized during ripening is the high melting fraction (HMF)
• During churning the HMF melting peak shifts from 33.5°C to 38.9°C, and its area increases as the churning proceeds
• A new HMF crystallized just before butter grain aggregation occurs

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