The role of mixing temperature on microstructure and rheological properties of butter blends

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Introduction

- Butter blends are made by mixing vegetable oil and butter after the churning and working processes.
- Blending milk fat with vegetable oils is used to modify the physical properties of the blended systems. Furthermore, it enhances the nutritional properties of butter and increases the buttery flavour of vegetable fats.
- The texture of fat blends depends on: level of solid fat content (SFC), microstructure and crystal polymorphism. These properties are related to the processing and storage conditions and to the composition of the materials.

Aim

To examine the effect of different concentrations of rapeseed oil and different mixing temperatures on the microstructure and rheological properties of butter blends.

Materials & Methods

- **Preparation of butter blends:** Unsalted butter (ARLA FOODS) was mixed with 0, 10 or 25%, respectively, of rapeseed oil (RO, DLG Food Oil-Dk). Blends were mixed at three different temperatures 13, 18 and 23 °C, respectively. The final products were stored at 5 °C until analysis.
- **Rheological oscillation analysis of butter blends:** Frequency sweep tests were performed on a rheometer (AR-G2, TA Instrument) using 40 mm parallel plate geometry.
- **Microstructure analysis of butter blends:** Imaging was performed using an inverted confocal scanning laser microscope (CLSM; Leica TCS SP2, Germany). Nile red (Sigma) and FITC (Merck) were used as the fluorescence stains for fat and proteins.
- **Melting profile of butter blends:** The melting profile was analysed for each blend by Q 2000 Differential Scanning Calorimeter (DSC; TA Instrument, US-based).
- **SFC determination:** SFC of butter blends was measured at 0 and 5 °C with a low field nuclear magnetic resonance (NMR; Resonance Maran Ultra UK).

Conclusions

- ❑ Rheological properties of butter blends can be modified by both mixing temperatures and content of RO.
- ❑ The microstructure of the fat crystal network mainly explains the rheological properties of butter blends.
- ❑ Interaction between RO concentration and mixing temperature affects the fractionated crystallization.

Results

1 Oscillatory rheology analysis

Fig. 1: Complex modulus of butter blends with 10% (a) and 25% (b) of RO as a function of angular frequency. The analyses were performed after storage of the samples at 5 °C.

- Blends mixed at 23 °C obtained the lowest $|G^*|$ value, independently of the percentage of RO added to butter.

2 Prediction of melting point and level of SFC

Fig. 2: Counter plots for prediction of melting point (a) and level of SFC (b) as function of percentage of RO added to butter and of mixing temperature.

- Melting point of the butter blends is solely affected by RO concentration until 12 wt% RO. At higher concentrations, interaction between mixing temperature and RO concentration explains the melting point (Fig. 2a).
- SFC is linearly affected by concentration of RO and mixing temperature (Fig. 2b).

3 CLSM images

- CLSM images explain the results obtained from the oscillatory analysis (Fig. 1).
- A less dense crystal network was obtained by increasing the content of RO and at a temperature of 23 °C.

Figure 2: CLSM images of butter blends 10% RO and 25% RO. The black shadow on the image background represents the crystal network of the samples. The red area is the liquid fat of the system, and green spots are protein and water phases.

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