Troubleshooting in the Production of Croissants: Characterisation of an Appropriate Fat System

Rachel Kelly, Maria Lundmark, Annika Sahlström and Katarina Wikström

Nestlé R&D Center Bjuv AB,
Box 250, 26725 Bjuv, Sweden

ABSTRACT

A controlled stress rheometer was used to characterise the melting profiles of different fat systems used in laminated dough applications at a Nestlé factory. The information enabled the factory to avoid the critical temperatures for fat melting, which previously resulted in fat leakage during production. The results were verified by rheological measurements on a laminated dough.

INTRODUCTION

A Nestlé factory was to switch from margarine-based croissants to butter-based. This switch resulted in big production problems caused by delamination of the dough due to fat melting. Temperatures on a factory production line can vary during the day and since fats are temperature sensitive this was an important factor to consider.

On testing butters from different suppliers large production variations were noted. It was decided that a more scientific approach was needed to understand and overcome the variations. Knowledge of the relationship between temperature, melting behaviour and rheology would enable the selection of the best ingredients and to optimise the processing parameters.

MATERIALS AND METHODS

A Reologica StressTech controlled stress rheometer with parallel plate geometry (diameter 45 mm, upper plate of polycarbonate, lower plate of standard stainless steel) was used to characterise the different fat systems and the resulting laminated dough (prepared by the Scotch method. Main ingredients were flour, fat and water). Temperature sweeps were performed under the oscillation mode with a frequency of 1Hz. The stress selected was extracted from the linear viscoelastic region of the stress sweep performed prior to the oscillation tests. The temperature was ramped in steps of 2°C/minute. Measurements on the different fats was performed with a stress of 100 Pa, a gap setting of 2mm and a temperature range from 4°C to 40°C. The corresponding values for the laminated dough was a stress of 600 Pa, a gap of 3 mm and a temperature range from 8°C to 40°C. The dough was protected with an inert oil to prevent it from drying. Samples were loaded onto the tempered rheometer base plate immediately on being removed from a 4°C (8°C) refrigerator.

Three butters, called A (80% fat), B (80% fat), and C (100% fat), together with two margarines, called A (84% fat) and B (100% fat), from different suppliers were included in the study. For comparison rheological measurements were made on a laminated dough prepared with butter C.

RESULTS

The change in the elastic parameter, G', with temperature for the different fats is shown in Figures 1-5 below. The change in G' illustrates the melting behaviour with increasing temperature and the melting temperature is determined as phase angle, δ, equal to 45°. The replicates of each trial are shown on the graphs in order to illustrate the reproducibility of each fat's melting behaviour.

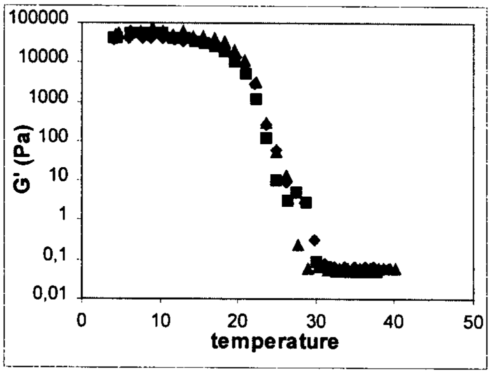

Figure 1. The melting profile of butter A.

Butter samples A and C (Fig. 1 and Fig. 3) show very precise and reproducible melting behaviour over a well-defined temperature range. The melting temperatures of these butters are at $23.5^{\circ}C$ and $25.5^{\circ}C$ for A and C respectively. However this is not the case with butter sample B (Fig. 2) which show a very wide range of melting curves, in some cases more representative of the margarine samples. For butter B it is difficult to calculate a mean melting temperature since it varies from as low as $20^{\circ}C$ up to $33^{\circ}C$, with a mean value in the mid-$20^{\circ}C$'s.

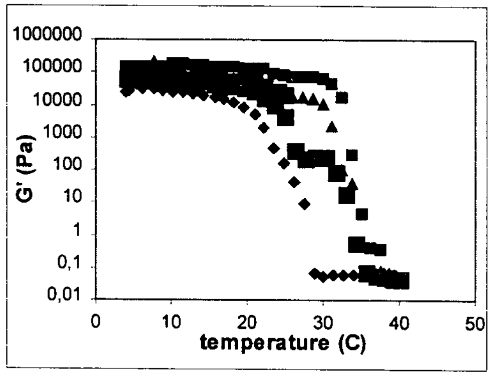

Figure 2. The melting profile of butter B.

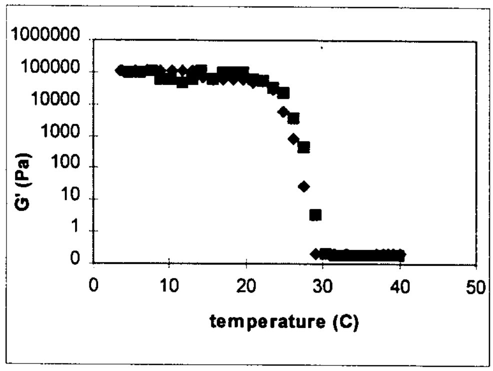

Figure 3. The melting profile of butter C.

The margarine samples show a clear and reproducible melting behaviour shifted to higher temperatures of $33^{\circ}C$ and $30^{\circ}C$ for margarine A (Fig. 4) and B (Fig. 5) respectively.

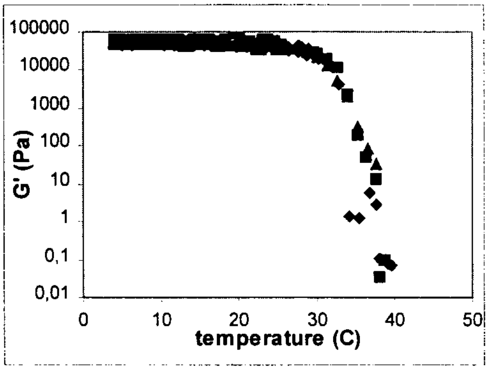

Figure 4. The melting profile of margarine A

Fig. 6 illustrates the change in G' with temperature for butter C compared with a laminated dough made with the same fat. The behaviour of the dough is the same as for the fat.

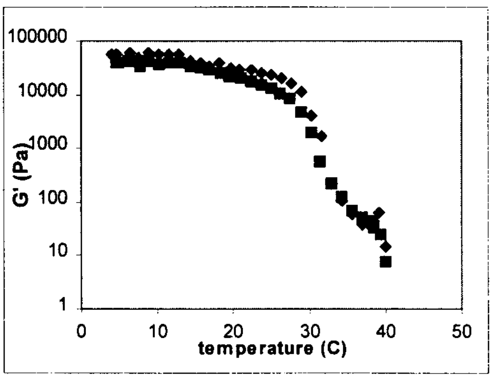

Figure 5. The melting profile of margarine B.

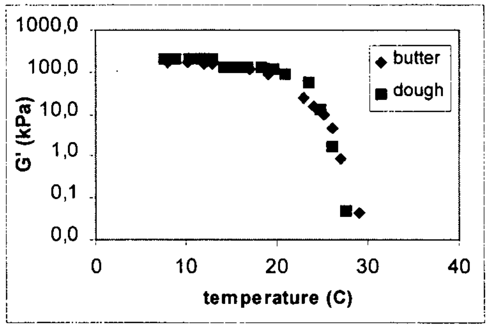

Figure 6. The change in G' with temperature for butter C compared with the dough made from butter C

DISCUSSION

An oscillatory motion applied to a sample measures the viscoelasticity of the sample. This sort of test minimises damage to the sample and therefore allows measurement on the sample "intact". For products, like fats and dough, having a high degree of structure this is important.

The temperature sweep was performed in order to show how the texture of each product changed as it was heated. Essentially this tells us at what temperature or in what temperature range we can expect the sample to melt. Taking the parameter G' (the elasticity or solid-like nature of the sample) the different melting transitions of margarines and butters can be clearly seen; the butters generally melting at lower temperatures (23.5 - 25 °C) than the margarines (30 - 33 °C). Butter A and C show a very distinct and reproducible melting behaviour, whereas butter B shows a large spread between replicates; this butter may consist of a combination of fats with different melting points.

Margarine B differs from margarine A by having an initial slow decrease in G' with temperature.

These differences in melting behaviour between fats may be explained as differences in size and shape distribution of the fat crystals. A fat with crystals that are small, even and uniform in size will melt in a narrow temperature interval. This would rheologically result in a well-defined linear region before melting, which is the case with butter A,C and margarine A. On the other hand, if the fat crystals have a broad size and shape distribution the melting will take place in a broad temperature interval resulting in a shorter, less well-defined linear region. This behaviour is seen for butter B and margarine B.

The overall difference in melting temperature between butters and margarines can be accounted for on the well-known differences in chain length of the constituent fatty acids.

The rheological behaviour of the pure fat was almost identical to the behaviour of the laminated dough, which indicates that the rheological properties of the fat dominate over the properties of the dough.

CONCLUSIONS

The physical properties of a fat system are critical to its application. By using fundamental rheological measurements as a tool, simulating real conditions of the resulting product system, real information about texture properties can be gained in the laboratory rather than during production. This will save much time and money and in the same time bring scientific understanding. The knowledge gained is then a powerful tool in product development changing direction from trial and error to a systematic approach and recipe formulation.

ACKNOWLEDGEMENT

We hereby express our gratitude to Mr Lennart Edmund, our very experienced baker, for serving us with laminated doughs.