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INVESTIGATIONS ON THE COMPATIBILITY OF FATS USING POLARIZED LIGHT THERMOMICROSCOPY

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SUMMARY

The study of the compatibility of a lauric fat with several milk fat fractions via polarized light thermomicroscopy is described. Thereby former results obtained by investigations via differential scanning calorimetry (DSC) are confirmed. The thermomicroscopic system is supplied with evaporating nitrogen to crystallize the molten fat samples by constant cooling rates. The compatible fat blends show typical microscopic pictures with characteristic triglyceride crystal agglomerations. Noncompatible fat blends solidify more or less amorphously. The thermoanalytic results allow to differentiate the milk fat fractions in their compatibility with the lauric fat. Further completions are reached by investigations via X-ray diffraction.

INTRODUCTION

As it is well known the compatibility or noncompatibility of fats among one another can be proved by a possible depression in melting point, a reduced hardness, or a decreased solid fat content of the fat blends (refs. 1,2).

On the occasion of our examinations of compatibility of a lauric fat with several milk fat fractions we presented a DSC method (refs. 3,4). We aimed at finding the particular milk fat fractions and their amounts which can be added to the lauric fat without altering the crystallization of the resulting blends considerably.

Therefore the measured crystallization enthalpy values of the fat samples are compared to corresponding values which are calculated for an "ideal blend".

A noncompatibility of the fats is shown by negative differences. Less crystallization enthalpy can be measured than expected because of a disturbed triglyceride crystal lattice. Positive differences indicate that the added milk fat can contribute to a re-

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alization of a closer and more stable triglyceride crystal lattice of the fat blends.

The studies by the previously used methods, i.g. melting point depression or "Iso-Solid-Diagrams", do not give significant results to differentiate the milk fat fractions in their compatibility with the lauric fat (refs. 1,5-7).

However, a confirmation of our former investigations succeeds by polarized light thermomicroscopy. Some aspects about studies via X-ray diffraction are mentioned at the end of this article.

METHODS

Polarized Light Thermomicroscopy

With the aid of thermomicroscopy samples can be observed during a cooling or heating process (ref. 8). The schematic picture given in Fig. 1 shows the used thermomicroscopic system for a cooling process.

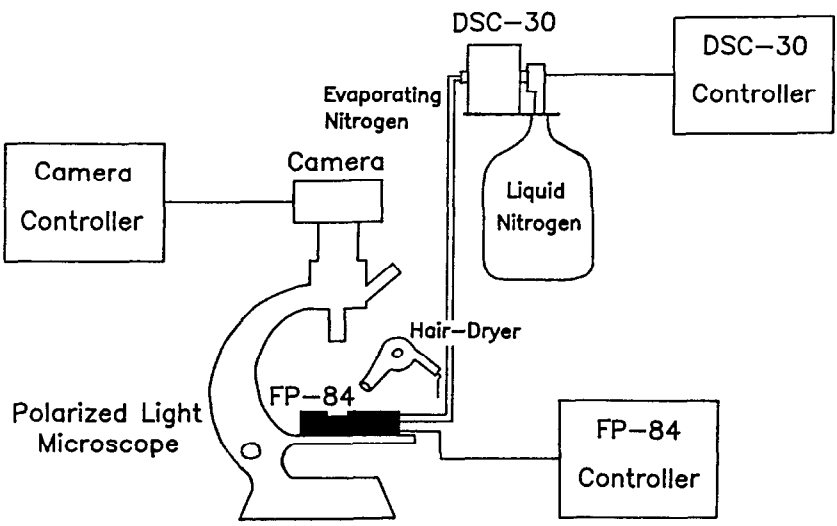

Fig. 1 Thermomicroscopic System

The molten fat samples (about 1 mg; 60 °C) are cooled under defined conditions. Therefore the hot/cold stage FP-84 (METTLER) is used. Its flat bed furnace is surrounded by evaporating nitrogen. The supply with nitrogen is ensured by the DSC-30 system (METTLER).

The condensation of water on the FP-84-outside can be avoided by a hair-dryer.

With this thermoanalytic system constant cooling rates up to 12 °C/min can be reached, so that the same conditions are guaranteed as in the former DSC studies.

The solidified fat samples are examined microscopically and photographed at the temperature of -15 °C. No change can be seen in the microscopic picture by further cooling.

Because of the relative high hot/cold stage only magnifying factors up to 1 : 25 can be reached. A separately made sample prepared in the DSC-30 system makes magnifying factors up to 1 : 100 possible. During the microscopic examination a slide and the glass crucible with the solidified fat are put on an aluminium plate which was cooled beforehand with evaporating nitrogen.

X-Ray Diffraction

The molten fat samples are cooled at different cooling rates under vacuum ($1.3 \cdot 10^2$ Pasc) using the diffractometer systems MPD-1880 (PHILIPS) with temperature attachment for low temperatures (N_2)-TTK (PAAR) and D-500 with low temperature attachment (SIEMENS).

RESULTS AND DISCUSSION

The microscopic fat sample photographs can be characterized as follows:

In contrast to the molten fat, the fat or triglyceride crystals or crystal agglomerations, respectively, are anisotropic and thereby optical activity is given (ref. 9). They can be differentiated easily as bright crystal bodies.

The Fig. 2a shows the photograph of the used lauric fat. Accumulations of bright round crystal agglomerations, so-called spherulites, can be observed (ref. 9).

The photograph of a low melting milk fat fraction, MF-28, is illustrated in Fig. 2b. The crystal agglomerations seem to be of a elongated form. Both fats as well as the fat blends have been pre-

pared under a cooling rate of 5 °C/min.

The Fig. 2c shows the photograph of a corresponding fat blend (lauric fat : MF-28, 60 : 40) which was proved as noncompatible by the DSC investigations. This fat sample solidifies more or less amorphously. It is not comparable with the two "pure" fats, MF-28 and lauric fat.

On the contrary, the Fig. 2d shows the photograph of a fat blend (lauric fat : MF-28, 80 : 20) which has been proved as compatible earlier. As in the photograph of the lauric fat, spherulites can be observed; their form, their size, as well as their arrangement are in good agreement with those of the lauric fat.

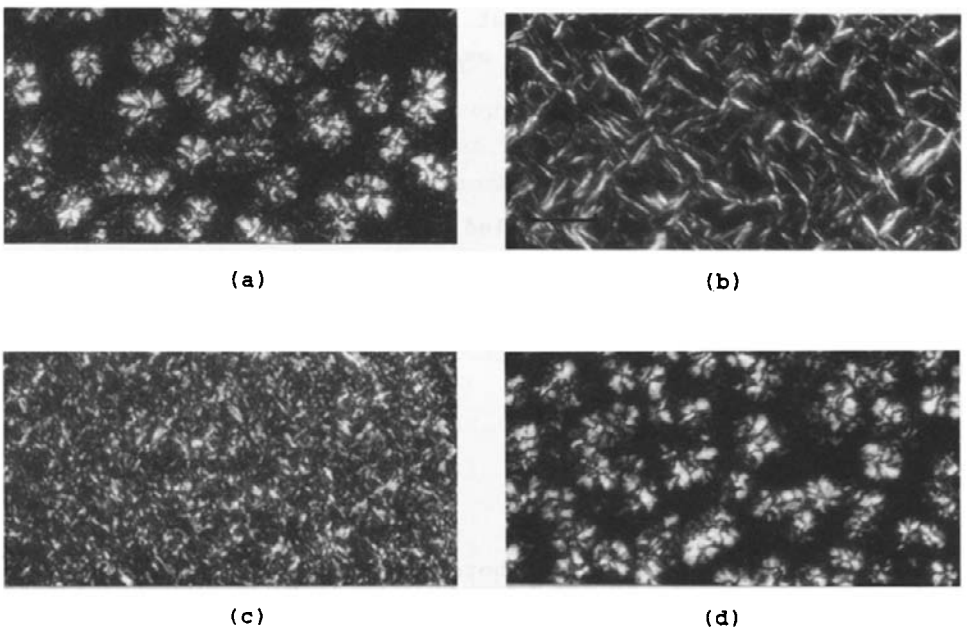

Fig. 2 Microscopic Photographs of Fats and Fat Blends (— 20 µm)

This observation confirms the already described findings that a certain fat amount can be integrated in a dominating triglyceride crystal lattice of another fat (ref. 10). In our case, this typical crystal structure will be destroyed with increasing milk fat amount. Our previously results are completed by the following findings:

The fat compatibility decreases with increasing cooling rate as was expected and proved by our DSC investigations. The correspond-

ing thermomicroscopic results are summarized in Fig. 3.

The photographs show a crystallized fat blend (lauric fat : medium melting milk fat fraction MF-35, 60 : 40) which was cooled at 5 °C/min (a) and 10 °C/min (b), respectively.

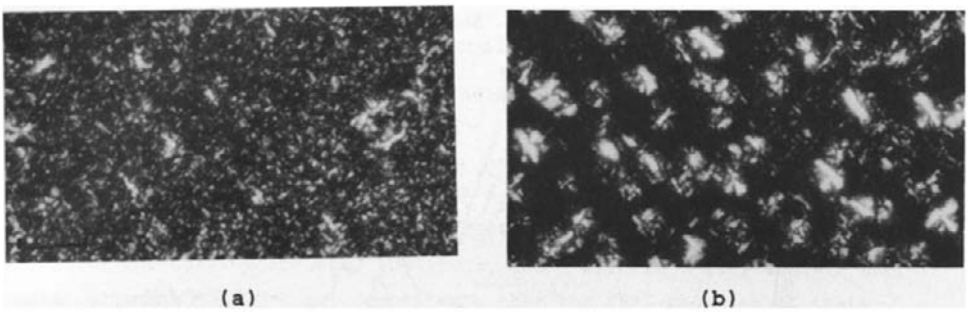

Fig. 3 Microscopic Photographs of a Fat Blend Prepared at Different Conditions (— 20 µm)

If prepared at moderate conditions (5 °C/min), the fat blend shows the characteristic crystal forms of compatibility. The well recognizable noncompatibility of the same sample under rapid cooling (10 °C/min) is expected because only a less accommodated arrangement of the triglyceride molecules can follow. The defect rate in the crystal lattice is increased (ref. 3).

Furthermore, these results show that it is possible to differentiate the milk fat fractions in their compatibility with the lauric fat. This aspect becomes evident by comparing the photographs in Fig. 2c and 3a. Both fat blends were prepared under the same cooling condition and contain the same amount of a milk fat fraction (40 wt.-%).

The fat blend containing the low melting fraction MF-28 (Fig. 2c) is noncompatible, whereas the corresponding blend containing MF-35 shows the characteristical microscopic picture for compatibility (Fig. 3a).

This difference of the two milk fat fractions is obviously caused by the higher oleic acid amount in fraction MF-28. Thereby, only a less stable crystal lattice with the triglyceride molecules of the lauric fat can be constructed (ref. 11). The lauric fat hardly contains unsaturated fatty acids.

These thermoanalytic results can in addition be verified for

other fat samples. A further confirmation succeeds by studies via X-ray diffraction. The diffractograms obtained can be interpreted especially by the "short spacing"-peaks (see Fig. 4).

The increase in marked peak intensity indicates that a closer and more stable triglyceride crystal lattice is obtained.

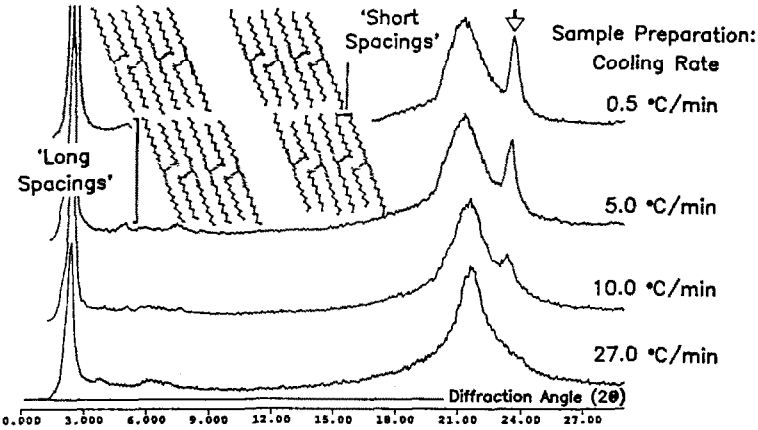

Fig. 4 Diffractograms of a Fat Blend

X-ray diffractic results of the same kind are obtained for the investigations of fat compatibility dependent on cooling rate as well as mixing proportion.

ACKNOWDLEGEMENT

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