Fat Crystallisation - Fundamentals

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There are many aspects to consider in the fractionation of fats. This paper will address the principal factors. The crystallisation process comprises two stages. Nucleation involves the coming together of sufficient molecules to form a stable seed crystal. This is followed by crystal growth, in which further molecules are added to the growing crystal surface. Both processes are temperature dependent but may be influenced by stirring and minor components in the oil.

The size and shape of the crystals has a large effect on the ability to separate the solid crystals from the remaining liquid phase, an important consideration in fractionation! Crystal morphology depends on the rate of crystallisation (which is related to the temperature at which crystallisation takes place), the polymorphic form of the solid that is formed and minor components. In addition, aggregation of individual crystals may occur yielding larger particles or, alternatively, crystals may break up (especially if the system is agitated) leading to many small crystals.

The fractionation process is designed to separate the various components of a fat into fractions of different physical properties. To understand what takes place during the crystallisation of a triacylglycerol mixture, as is a natural fat, it is useful to consider the phase behaviour of triacylglycerol mixtures. This is determined by the interactions between the various molecules in the fat and can be explored using phase diagrams (revealing ideal solubility, monotectic and eutectic behaviours). The change in composition of the crystallised solid can be determined by following the relevant line in the diagram. This is helpful in understanding the complexities of the process, but the approach ultimately is limited since it requires thermodynamic equilibrium to have been established. In practice, of course, thermodynamic equilibrium is not attained.

As well as triacylglycerols, natural fats contain varying amounts of other, minor, components, such as free fatty acids, partial acylglycerols (mono- and di-) and oxidised materials. These can have a greater or lesser effect on the crystallisation and crystal morphology. In addition, materials can be deliberately added to control the crystallisation.

Finally, in an attempt to predict the behaviour of real systems, various researchers have applied kinetic models to the crystallisation behaviour. Although many of these have a basis in theory, application to real systems raises questions of interpretation and can lead to workers simply finding the 'best fit' line.

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Natural fats are complex systems and knowledge remains in two, almost separate, spheres: theory and practice. Much is known and understood of the theoretical aspects. Much is known empirically. Little work, however, has successfully brought the two together. Challenges still await us in fully understanding fat crystallisation.

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