

Food Microscopy

(An Annotated Bibliography)

PART II E. MAJOR INGREDIENTS: MILK AND MILK POWDER

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Many papers have been published on the microscopy of milk and milk products, and a large number of techniques have been used, including normal light microscopy (LM), anoptral, interference and phase contrast, fluorescence microscopy, transmission electron microscopy (TEM) and scanning electron microscopy (SEM).

Bacteriological examination of milk can be done by direct microscopic counts or by electron microscopy. Many studies have been made of the size distribution and number of fat globules in bovine, buffalo, goat, human and sow's milk both by LM and EM, and Brownian movement in milks has been investigated. Microscopical studies have been made of the effects of homogenisation, and various homogenisation indices have been suggested. Both the refractive index and interfacial tension of milk fat globules have been measured microscopically.

A considerable literature exists on the crystallisation of bulk milk fat and the phenomenon of polymorphism (multiple melting points). The super-cooling and delayed crystallisation of milk fat in the emulsion state, as in milk, has also been investigated with the help of the polarising microscope. The technique of micro-electrophoresis has been used to measure the mobility of fat globules in milk, and to gain structural information about the outer layers of the globules. The clustering of fat globules and creaming in milk and evaporated milk have been studied microscopically. In recent years there has been a rapidly growing interest in the milk fat globule membrane, and many investigations have been made by electron microscopy and other techniques.

Milk proteins have also been studied extensively by TEM. Casein micelles have been detected by LM, using techniques such as dark field, anoptral contrast and fluorescence microscopy; more extensive studies by TEM have revealed the shape, size distribution and ultrastructure of micelles. The effect of reagents, including mineral salts, on the casein dispersion have been investigated. Crystalline α -lactalbumin and β -lactoglobulin have been studied microscopically. Lactose crystals in condensed milk have also come under scrutiny.

The effects of heating or freezing milk, evaporated milk and whey have been studied, and ultrastructural changes in UHT-sterilised milk and concentrated skim milk have received particular attention in relation to gelation, and the

effects of added salts investigated. Milk deposits on heat-exchange surfaces in UHT pasteurising plant have been examined microscopically. Electron microscopy has been used to study the changes occurring in acid/rennet coagulation of milk. Milk gels (e.g. yoghurt) and carrageenan-milk gels have been explored both by TEM and SEM.

Full cream and skim milk powders and dried whey have been widely investigated by light, fluorescence and phase contrast microscopy, and by electron microscopy. Spray-dried combinations of milk with fruit or vegetables have also been studied. Aspects of milk powders investigated microscopically include particle morphology of freeze, roller and spray-dried powders, particle size distribution, location of fat and protein, crystallinity of the lactose, particle ultrastructure and the effects of processing on ultrastructure, hygroscopicity, wetting phenomena and the reconstitution of dried milk.

The following 100 references are a representative selection from the large amount of literature, and give an introduction to the above aspects.

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