



The effect of citrate on calcium phosphate deposition from simulated milk ultrafiltrate (SMUF) solution

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Abstract

As has been widely reported, different calcium phosphate phases can be formed in solution depending on several physical-chemical aspects like the concentration of free calcium and phosphate ions, pH of the solution, temperature and the presence of interfering ions. The present work aims at studying the effect of pH and of citrates on the precipitation of calcium phosphate in a solution that simulates the mineral composition of milk (SMUF), as well as the subsequent effect on the deposition on stainless steel surfaces. The different calcium phosphate species formed during heating at different pH values and in the presence or absence of citrate were characterized by scanning electron microscopy, X-ray microanalysis and X-ray diffraction. Their fouling behaviour was characterized according to the amount of deposit formed on stainless steel surfaces and to the deposit's resistance to removal by hydrodynamic shear forces. The absence of citrate was responsible for the decrease in the solution pH and for the formation of a crystalline dicalcium phosphate dihydrate structure with a deposited mass which was almost twice the one obtained in the presence of citrate.

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1. Introduction

Fouling in milk processing is a complex process because it involves several simultaneous phenomena associated with protein aggregation and subsequent deposition and mineral salts deposition, the latter mainly caused by calcium phosphate (Jeurnink, Walstra, & deKruif, 1996). It has not yet been clarified whether calcium phosphate fouling is due to deposition of particles which have been formed in the bulk, or due to direct crystallization/precipitation on the surface (Andritsos, Yiantsios, & Karabelas, 2002). Therefore, the fouling process must be analysed not only in terms of deposit

adhesion and growth but also according to what is happening in the bulk solution.

The most widely used test solution in milk mineral deposition studies is called simulated milk ultrafiltrate (SMUF) which was first described by Jenness and Koops (1962). It is a simplified milk system which constitutes, so far, the best way to evaluate the role of the different milk mineral components on the overall milk fouling behaviour. Due to the use of this simplified system more is now known about the mechanisms of fouling of the different milk components but there are still remaining some key scientific problems related to the poor understanding of the role of some interfering ions such as citrate (also present in SMUF) on the precipitation behaviour of calcium phosphate under different pH values.

Calcium phosphate formation by precipitation from solution is determined by two mechanisms which only

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