Thermophiles and Fouling Deposits in Milk Powder Plants

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To my loving wife Lisa, for
her help, support,
encouragement and
acceptance of long hours
and stressful times.

Abstract

Fouling deposits were suspected of playing a pivotal role in the thermophile contamination problem experienced in the dairy industry during milk powder manufacture. The objective of this work was to investigate thermophile growth and develop an understanding of how fouling deposits affect thermophile contamination in milk powder plants.

Pilot plant and laboratory scale studies were carried out investigating:

- The release of thermophiles from fouled and un-fouled surfaces;
- The survival of thermophiles in fouling during cleaning;
- The rate of re-contamination of thermal equipment after incomplete cleaning;
- and the adhesion of thermophiles to fouled and clean stainless steel.

Thermophile contamination from the pilot plant equipment was also modelled mathematically.

The bulk milk thermophile contamination from sanitised fouled and un-fouled surfaces was found to be not significantly different, showing that fouling deposits by themselves do not increase the steady state amount of bulk contamination and that the more important factor is the amount of surface area available for colonisation within the temperature growth range of the thermophiles.

Milk fouling layers provided much greater protection against cleaning than that of biofilms alone. Thermophiles that survive cleaning or greater initial thermophile concentrations in the raw milk were shown to reduce the plant production time available before concentrations of thermophiles in the bulk milk became excessive ($>1x10^6$ cfu.ml^{-1}).

Therefore, cleaning procedures in milk powder plants need to remove or destroy all traces of thermophiles to allow the maximum possible run length. It is similarly important to obtain raw milk with the lowest possible thermophile load before processing.

During adhesion studies, the number of thermophilic bacteria adhering to stainless steel surfaces increased with bulk cell concentration and increasing contact time for adhesion. The adhesion rate of thermophiles to whole milk fouling layers was found to be around ten times higher than the adhesion rate to stainless steel.

Steady state modelling provided a quick estimate of the level of bulk milk contamination that can be expected, however it was dependent on obtaining accurate measurements of the surface numbers. Since surface numbers were underestimated by approximately a decade using techniques that dislodged but did not enumerate loosely adhered cells, the model under predicted the bulk milk contamination.

Unsteady state modelling predicted the trends observed in the experimental data and provided reasonable estimates of the bulk contamination that can be expected over time from the pilot plant. Predictions from the model after changes in key parameters provide an insight to the magnitude of any reduction in contamination that can be made.

The results of this work have demonstrated that thermopile contamination during dairy processing can be minimised through:

- Re/design operating equipment to minimise the residence time of the product in the range of 40-70°C.
- Minimising the contact surface area of thermal equipment by use of alternative direct heating technologies.
- Minimising fouling by management of milk quality, optimising processing conditions, hygienic design of the plant equipment and ensuring the product mix is suited to the plant.
- Ensuring that the plant is thoroughly clean at the commencement of each run through attention to equipment design and optimisation of cleaning procedures.

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