

Technical Memorandum

FoodPro® Cleanline – reduced fouling and increased profitability in the dairy industry



INTRODUCTION

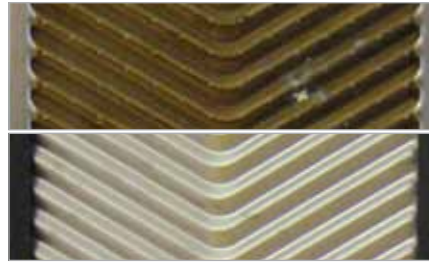
Thermal treatment of milk or milk-based products often causes proteins to denature and, then, precipitate to form undesirable layers on the surface of plate heat exchangers. This causes significant technical and financial problems for the dairy industry.

Full-scale factory trials at several dairy plants have demonstrated that this fouling can be reduced by treating milk with FoodPro® Cleanline, an enzyme developed by Danisco. In addition, milk products benefit from improved emulsion stability and an up to 80% reduction in free cholesterol.

A COMMON CHALLENGE

A plate heat exchanger (PHE) is the typical equipment used for indirect heat treatment of milk. The advantages of using a PHE include high thermo-fluid efficiency, high turbulence for enhanced heat transfer and easy, efficient cleaning, and a compact, space-saving design.

During a normal working cycle, the PHE is subject to a complex phenomenon that results in undesired material



Plates with (top) and without fouling

accumulation along its working surfaces – normally referred to as fouling. Fouling formation increases the pressure drop over the PHE, leading to reduced heat transfer coefficient and, thereby, reduced working efficiency. More production downtime is necessary in order to clean the affected surfaces. From a financial point of view, fouling results in loss of production capacity, higher manpower costs and increased energy and detergent consumption during cleaning.

FoodPro® Cleanline

FoodPro® Cleanline is a new enzyme that acts on milk products by transferring acyl groups from the sn-2 position of phospholipids to cholesterol. The transferase reaction contributes to the formation of

lysophospholipids and cholesterol esters, as shown in figure 1.

Essentially, the transferase reaction controls the formation of lysophospholipids without forming a significant amount of free fatty acids, because the amount of donor substrate – phospholipid – is lower than the amount of acceptor substrate – cholesterol. This secures the reduced fouling effect in the heat exchanger while maintaining the high sensory quality of the enzyme-treated milk.

FoodPro® Cleanline is highly active in milk products. As illustrated in figure 2, the pH of milk is optimal for the activity of the enzyme.

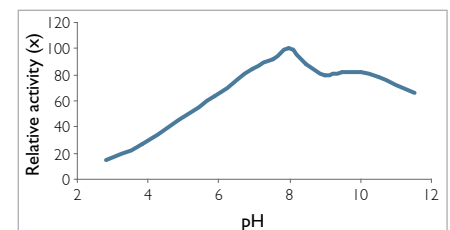


Figure 2. Activity was determined by 10 minutes of enzymation on lecithin substrate (without CaCl_2) at 37°C and various pH (50mM phosphate buffer) and subsequent determination of free fatty acids by the NEFA C method.

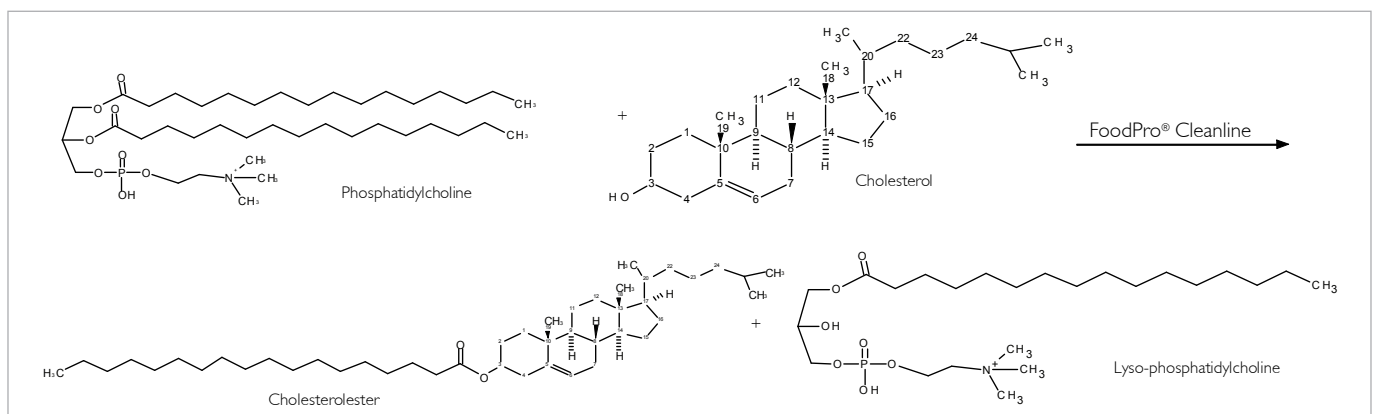


Figure 1. Schematic illustration of transferase reaction by FoodPro® Cleanline. An acyl group in the sn-2 position of phosphatidylcholine is transferred to cholesterol, and lyso-phosphatidylcholine and cholesterol esters are formed.

FoodPro® Cleanline remains fully active up to 50°C. At a higher temperature, the enzyme starts to denature, completely losing its activity at 75°C (see figure 3). The enzyme is also active at lower temperatures down to 5-10°C.

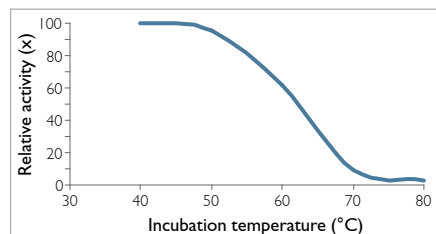


Figure 3. After 30 minutes of incubation in 50mM HEPES buffer; pH 7 at 2.9 LATU/ml and various temperatures, activity was determined by subsequent 10 minutes of enzymation on lecithin substrate at 37°C and pH 7.0. Free fatty acids were determined by the NEFA C method.

FUNCTIONALITY AND APPLICATIONS

The antifouling effect of FoodPro® Cleanline can be explained by two mechanisms.

First of all, FoodPro® Cleanline produces lysophospholipids, which are known to be water dispersible and have a high surface activity. Laboratory experiments have shown that milk treated with FoodPro® Cleanline has a lower surface tension measured against a stainless steel surface than non-treated milk (see figure 4). The reduction in surface tension indicates that enzymation results in the creation of surface and interfacially active components, which reduces the proteins' ability to form a deposit or settle on the surface of the heat exchanger.

The second mechanism is the conversion of free cholesterol into cholesterol esters. It is known that free cholesterol is located at the surface of milk fat globules.

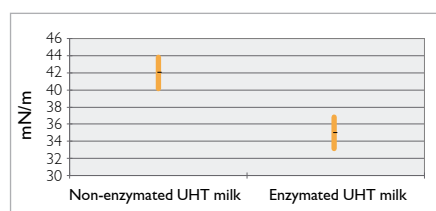


Figure 4. Surface tension of UHT milk.

By treating milk with FoodPro® Cleanline, 80-90% of the cholesterol can be converted into cholesterol esters (figure 5), which are more lipophilic than cholesterol and, thus, are present in the core of milk fat globules rather than in the membrane. This phenomenon typically improves the incorporation of trans-membrane proteins in the membrane structure, leaving less denatured protein with free hydrophobic regions in the continuous phase. It is believed that this also contributes to reduced fouling.

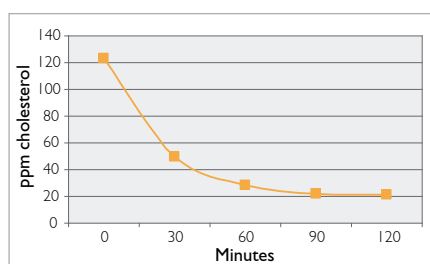


Figure 5. Recombined full-fat milk treated with 0.005U/g FoodPro® Cleanline at 40°C.

Generally, it is possible to detect the fouling of plate heat exchanger surfaces through a linear evolution of pressure drop and the overall heat transfer coefficient. Most commonly, UHT plants monitor the development of pressure drop in order to determine when it is necessary to run an intermediate cleaning cycle (CIP).

Figure 6 shows the development of pressure drop during actual, full-scale factory trials carried out over a longer period. Data averages were collected.

The full-scale trial shows the run time for a UHT plant can be increased by several hours, optimising processing capacity and generating significant cost savings in

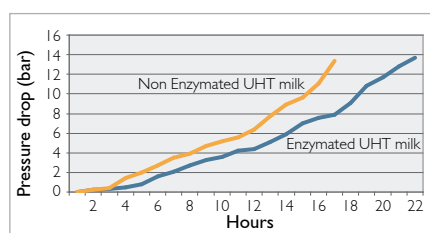


Figure 6. Development of pressure drop in UHT plant.

detergents, energy and manpower for cleaning.

An additional beneficial effect of using FoodPro® Cleanline is the improved emulsion stability of UHT milk.

Figure 7 shows the improvement in emulsion stability when milk is treated with FoodPro® Cleanline prior to processing into a wide range of dairy products. Samples of UHT milk, enzyme-treated and non- treated respectively, were analysed by Turbiscan measurement. From these measurements, it is clear that the creaming effect over time is greatly reduced in enzyme-treated milk compared to standard UHT milk.

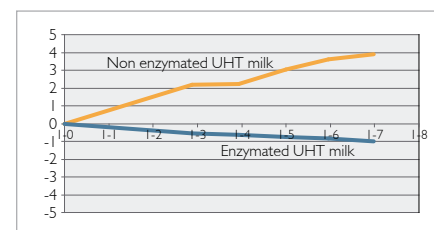


Figure 7. Turbiscan measurement of UHT milk (top 5mm 20°C, Backscatter Relativ).

ENZYME DOSAGE

FoodPro® Cleanline is in liquid form and is added to milk during agitation to ensure good distribution.

The enzyme dosage depends on the process time and temperature.

It is recommended that the enzyme is added at 40-50°C and allowed to react for 15-30 minutes (or add the enzyme during milk recombination). This should be followed by pasteurisation, which deactivates the enzyme, and subsequent cooling to 5°C. If this method is used, the enzyme dosage should be 5-10ppm.

Alternatively, the enzyme may be added to cold milk at 5-10°C and enzyme treatment run for up to 20 hours prior to UHT treatment. Then the enzyme dosage is typically 10-30ppm.

ENZYME INACTIVATION

During UHT treatment of milk, FoodPro® Cleanline is completely deactivated by the high temperature, and no enzyme activity is found in the final product. In the

EU and US today, it is common practice to regard enzymes as processing aids, and as such they do not need to be labelled on the final product. Authorities in the EU and US are striving to enforce new legislation by which only enzymes with prior registration and GRAS status will be permitted. FoodPro® Cleanline has obtained GRAS status in the US.

STORAGE AND HANDLING

FoodPro® Cleanline should be stored dry and cool (below 10°C/50°F). Under these conditions, the enzyme will remain stable for at least 6 months. In processing plants, the enzyme should not be kept at 30°C for more than two weeks.



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