Fouling of milk concentrates on membranes

Subheading: Improved control of filtration processes by understanding fouling formation

Summary
Optimization of the filtration process is currently mainly experienced-based and often focuses solely on the yield without considering the impact on the final product quality. This project will focus on the production of casein-enriched concentrate to understand how process parameters such as transmembrane pressure and diafiltration impact fouling formation during filtration and how this impacts the functional properties of the final products. The expected outcome of this research is the evaluation of principles that lead to improved process control. Ideally, these principles will enable the prediction of potential variations in casein-enriched concentrates caused by different fouling structures and compositions.



BY MILENA CORREDIG, PROFESSOR AND CENTER LEADER CIFOOD AARHUS UNIVERSITY, FOOD SCIENCE
BEHNAZ RAZI PARJIKOLAEI, CHIEF R&D SCIENTIST, ARLA FOODS INGREDIENTS R&D, VIDEBAEK, DK
FREJA MARDAL, INDUSTRIAL PHD STUDENT, ARLA FOODS INGREDIENTS & FOOD SCIENCE, AARHUS UNIVERSITY

How Understanding Membrane Filtration Adds Value to the Dairy Industry Today

Filtration, used for the separation and concentration of milk, has become a widely adopted practice within the dairy industry. An example is the separation of whey proteins from caseins (Figure 1) applying microfiltration. This process has been optimized to improve protein yield and improving filtration based on experience and research within the field.

One effective approach to enhance whey protein yield involves incorporating a washing step also known as diafiltration. This step involves the use of substances like water to dilute the milk, thereby increasing the yield of whey proteins. Despite these advancements, we do not know much about how altering process parameters impact the formation of fouling layers on the membrane during the filtration, the filtration performance and as important the functionality of the final products.

A preceding project 'FILTRATE', supported by the Danish Dairy Research Foundation DDRF, has yielded valuable insights into the impact of diafiltration and concentration on concentrate functionality by minimizing fouling layers. This ongoing work seeks to build upon these findings by additionally investigating the influence of fouling on filtration performance and the functionality of the concentrates.

Exploring Fouling at the Laboratory Scale

Fouling of the membranes will occur over time during filtration of proteins. This phenomenon may be familiar from everyday experiences in the kitchen, such as when draining yogurt to make tzatziki using a coffee filter or cheesecloth. In these cases, the whey passing through the filter gradually slows down as the filter's "pores" become clogged. In membrane filtration, we refer to the flow of whey through the filter as the flux.

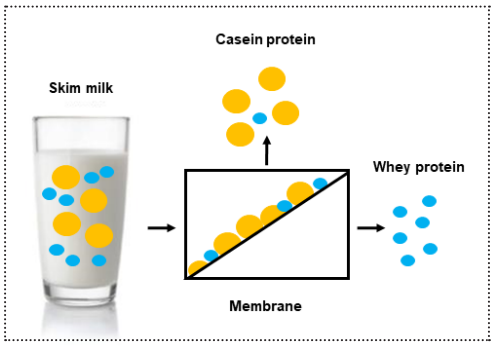

Figure 1: The main principle of membrane filtration

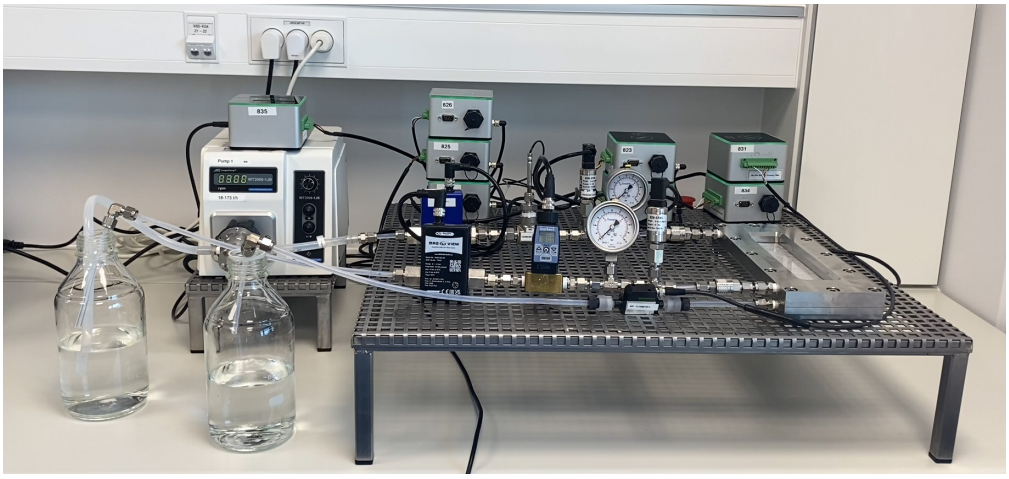

Figure 2: The lab-scale filtration unit which will be applied to better understand the filtration process.

This is inherent difficult to study at realistic conditions. To better mimic production conditions and investigate fouling and flux, a custom-built filtration system has been constructed within the R&D laboratory of Arla Foods Ingredients. This system comprises two stainless steel plates with membranes sandwiched between them. Notably, one of the steel plates features a sight window that faces the feed side of the membrane, enabling real-time observation of fouling during the filtration process. Analysis of the filtration membrane will sheds light on whether the pore blockages are predominantly due to proteins or minerals.

Samples of casein-rich concentrates can then be assessed to determine whether changes in process parameters impact the functionality of the final product. Functional aspects cover properties like the acid gelation properties compared to skim milk, which are of great importance in yogurt production, or how the concentrates respond to heat treatment.

Subsequently, samples of concentrates and membranes will be gathered from the production plant to verify the findings established within the laboratory environment.

How This Project Can Benefit the Dairy Industry

Knowing how process parameters affect the filtration performance is crucial for optimizing filtration processes, but it is just as important to know how the changes affect the final product quality and functionality.

This research holds the potential to provide insights into these questions for the selection of specific process parameters which shapes both the final product and its performance. By doing so, it can allow plant operators to make informed decisions based on a foundation of knowledge.

Furthermore, a deeper understanding of fouling composition has the potential to drive optimization in filtration performance. This understanding might lead to strategies that minimize fouling or even contribute to the development of improved cleaning procedures.

The main objective of this research is to assist the dairy industry in producing high-quality ingredients with consistent composition on every occasion.

Projects related to the Danish Dairy Research Foundation

This project will combine expertise in casein micelle functionality and structure from Aarhus University with ingredient and process knowledge from Arla Foods Ingredients, a solid foundation is established to gain a deeper understanding of the fouling impact on casein functionality. This endeavor is supported by funding from DDRF.

PROJECT FACTS

Title: SURFMILK – Effect of Membrane surface properties on fractionation of milk casein concentrates and their functionality
Project Manager: Professor Milena Corredig, Department of Food Science, Aarhus University
Partners: Aarhus University & Arla Foods Ingredients
Time period: May 2022 - May 2025
Objectives: To describe how selected process parameters impact the fouling development and product functionality during microfiltration of skim milk
Project participants: Milena Corredig, Professor and center leader CIFOOD Aarhus University, Food Science, Behnaz Razi Parjikolaei, Chief R&D Scientist, Arla Foods Ingredients R&D, Videbaek, DK, Freja Mardal, Industrial Phd Student, Arla Foods Ingredients & Food Science, Aarhus University
Ozgenur Coskun, Postdoc Fellow, Food Science, Aarhus University