How much can I squeeze milk proteins?

Understanding critical processing parameters to design improved functional milk protein concentrates.

Creating value through flow

Many dairy plants today utilize membrane filtration technologies to process milk, so while milk is flowing through, we can standardize its composition, gently concentrate or fractionate different components to ultimately add value to the streams. In this gentle, pressure driven process, milk is pumped through and runs parallel to a membrane surface, and part of the liquid transmits through the pores and is collected as a second stream. This stream is called "permeate". Depending on the size of the pores, the permeate has a different composition. With the largest pore configuration, the milk is pumped through a membrane with pores just about the size of bacteria and fat, thus creating a barrier for them. This system can be used to skim whey after cheese making or to remove bacteria and their spores without the need of high temperature treatment. In the smallest pore configuration, the permeate may contain only water (in reverse osmosis systems, such as those used to desalinate water and make it fit for drinking). In the case of ultrafiltration, a very common process in dairy plants, proteins are concentrated in the feed tank, while lactose, minerals and very small components can pass in the permeate stream. The result is a feed higher in proteins, but with very different properties depending on the conditions. On the other hand, with the help of diafiltration with water or ultrafiltration permeate, milk can be concentrated more and more while mineral balance is controlled or not. Therefore, even all these streams are called "milk concentrates" but, they are not all the same.

Membrane filtration processes have many advantages, for example, the decrease in amount of volume to be transported, a gentler concentration than with






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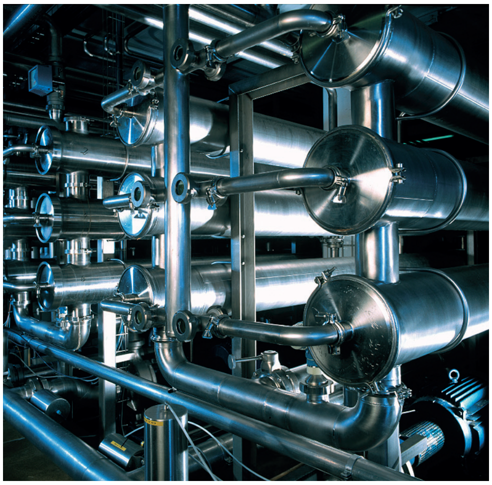
How will this help the dairy industry?

There is an increasing variety of milk protein concentrates in the market and they all are optimized for particular applications. These concentrates are upstaging commodities such as skim milk and whey. They are currently being used in a wide range of products including nutritional and ready-to-drink beverages, and fermented products. Furthermore, membrane filtration is often added as an upstream technology to a plant to standardize or modify the milk composition up front and improve quality and sustainability of the final product. A good knowledge of the details of the process of making them and how their characteristics are linked to their behavior in a product will increase the value of the ingredient. Furthermore, it will allow for a better control of the quality of the process or the ingredient used and ensure consistent products in the marketplace.



Projectinfo

Title: Understanding critical processing parameters to design improved functional milk protein concentrates (FILTRATE)
Project Manager: Professor Milena Corredig, Department of Food Science, Aarhus University
Partners: Aarhus University & Arla Foods
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evaporation and the ability to concentrate at cold temperatures, all advantages contributing to improved sustainability of the dairy value chain. Another important advantage of this process is that we can control compositions and components better, really "fine-tuning" the downstream processes. All in all, membrane filtration is a technology that has changed the milk ingredients' landscape.

Different process configurations give different compositions, from high to low lactose, for example, or with more or less amount of minerals. So, how many ingredients can we obtain with membrane filtration? In the past decade, we have seen a huge drive to develop a variety of milk protein concentrates as ingredients, and this without counting the variety of processes used upstream in factories, before making dairy products.

When engineering meets physics and chemistry

But is it all just about the composition? Proteins in milk are not only important because of their nutritional value, but also because of their ability to perform technologically, and over centuries we have learned to process milk in different ways to obtain the perfect structure and texture for a multitude of different products. For a few years, we have worked with the assumption that by using membrane filtration we just changed its composition, and we needed just to adjust processes in the factories and obtain either exactly the same or improved dairy products. However, as we started to use more and more such technologies and the ingredients derived from these technologies, we have come to the conclusion that this is not only an engineering problem, but we need to really look at the physical and chemical details of what is happening during filtration. Milk proteins are present in untreated milk in structures that are like sponges, aggregates of sizes larger than the molecules alone. We call these "self assemblies" of minerals and proteins that are not randomly structured, but aggregated, according to the laws of thermodynamics. When we use membrane filtration, we modify the solution around the sponge structures, as well as their mineral environment, and this may affect them so much to modify their core, as well as the outer surface, with obvious impact on their ability to react during processing. Our previous work have brought some evidence of these changes. Further to this, how many sponges can we squeeze together during concentration, before they start to merge into one large, gelled structure? Our research project aims at answering these questions, by providing us with the details necessary to suggest better process controls.

The research behind FILTRATE

This project, funded by the Danish Dairy Research Foundation and a close collaboration between Aarhus University and Arla Foods Innovation, is set to understand and better control the process of membrane filtration. We are proposing to study the changes in physical and chemical structure of the proteins present in milk during its concentration, by taking "snapshots" during the process using a small-scale filtration system, which can reach very high concentrations, up to the point when the proteins are so packed together that they no longer behave like a liquid. We will identify which critical processing steps modify the protein ability to form gel structures or to be stable during heating and pasteurization.

Our ambition is to develop a comprehensive road map of which changes we are causing and what are the process parameters to watch for. ●

Summary

It is ambition of this project to understand the molecular and physical details of the changes occurring to proteins during concentration using membrane filtration, a very widespread unit operation in the industry, which has revolutionized the processing landscape in the past decade. This project, a close collaboration between the Aarhus University team and Arla Foods, and under the auspices of the Danish Dairy Research Foundation, has two main objectives: to describe in detail the effect of concentration and environmental conditions during process on the milk structures present in the feed, and then to see how these changes are related to changes in the feed processability.