Improving dairy processing eco-efficiency using an integrated approach to dairy fluid concentration

Duration: 2019-2022

Highlights

- Milk contains more than 88% water. Milk composition does not change significantly when used to produce drinking milk (other than as a result of the standardization of its fat content) as opposed to milk used for cheesemaking where 90% of its volume is found in whey.
- Filtering milk to extract water and concentrate proteins is a widespread practice in dairy technology. It makes the production of a host of foods possible, in addition to making processing more eco-efficient. To do so, "baromembrane" processes are used, including reverse osmosis and ultrafiltration, which is garnering a growing amount of interest. The result is a concentrate that is rich in proteins, and the creation of whey, a liquid by-product.
- The residue from reverse osmosis presents a composition that is very close to water and can be used in dairy plants to reduce the consumption of potable water, whereas the whey obtained through ultrafiltration contains lactose and mineral salts that make it difficult to use.
- The idea of pre-concentrating dairy fluids (RO) to reduce transportation costs and the environmental impact (GHG) is attracting attention a context of eco-efficiency (EE).
- This project will measure the energy gains obtained by applying these new practices to cheese processing and the valorization of whey in an industrial context. It will draw on the knowledge and simulation software recently developed by the NSERC-Novalait Industrial Research Chair on Process Efficiency in Dairy Technology.
- The results will then be used to complete an initial evaluation of the potential of using whey obtained through ultrafiltration on dairy farms.

Objectives

The main objective of this project is to develop knowledge that will allow dairy processors to integrate the use of dairy concentrates obtained through RO or UF.

More specifically, the objectives are to:

1) Optimize cheese production conditions using dairy concentrates obtained through RO and UF;
2) Quantify the eco-efficiency gains obtained through the generation of cow water through RO in cheese-making;
3) Optimize the use of concentrates to improve material flow in the dairy processing industry.

Results and potential benefits

Objective 1: **New approaches** to correcting production defects resulting from the **use of reverse osmosis concentrates in cheesemaking** are being developed.

- The **addition of sodium to a reverse osmosis concentrate** shifts the mineral balance to milk's soluble phase and demineralizes the casein micelle.
- The work in progress aims to determine how this approach **improves the cheesemaking performance** of reverse osmosis concentrates.

Objective 2: A first **water recovery simulation (Chamberland et al, 2020)[a] on the industrial scale for a plant processing 1000 m³ of milk/day into milk protein concentrates (MPC-56)** demonstrated that:

- the pre-concentration of skim milk through RO prior to UF **reduced water and electricity consumption by 35% and 10%, respectively**, compared to the traditional process; and
- reductions in water and electricity consumption directly resulted in a **smaller environmental footprint of the MPC-56 production process** which improves eco-efficiency.

A simulation on the **impact of concentration through membrane processes in an industrial cheese plant** was completed. (Benoit et al, 2020)[b]

Objective 3: The research results will also **generate preliminary data** on the **impact of preconcentration of whey through RO** prior to transport. The simulations will help determine the scale (volume of whey), the volume concentration factor (VCF), and the transport distance (km) where pre-transport concentration becomes economically viable.

The project will produce significant benefits with respect to the use of milk components (including water) and reducing the environmental footprint of dairy transportation and milk processing processes.

Innovative aspects

- New approaches to correcting production defects resulting from the use of reverse osmosis concentrates in cheesemaking.
- First simulations:
  - water recovery simulation on the industrial scale for a plant processing milk into milk protein concentrates.
  - impact of integrating concentration through membrane processes on cheese plants' eco-efficiency
  - economic and environmental benefits related to the pre-concentration of whey prior to transport.

Professionals trained

- **Marie-Pier B. Vigneux**, PhD candidate.
- **Scott Benoit**, Postdoctoral fellow, Université Laval

For further information

The research results will be able to be quickly transferred to the dairy industry through diverse means, including the STELA Colloquium, the Novalait Forum Techno and different scientific conferences. Other communications activities (articles and presentations) are planned for collaborating users.

Financial contributions

Special call for proposals in dairy production and processing (2016–2021):

- Natural Sciences and Engineering Research Council of Canada (NSERC)
- Quebec consortium for industrial bioprocess research and innovation (CRIBIQ)
- Novalait

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a. Chamberland, J. Bouyer, A., Provault, C., Bérubé, A., Doyen, A., Pouliot, Y. (2020) Efficiency assessment of water reclamation processes by reverse osmosis in milk protein concentrate manufacturing plants: a predictive analysis. J. Food Eng. 272:109811.

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