Abstract

With the growing milk production, dairy plants should take actions to decrease the generation of by-products and increase their circularity. Among main dairy streams considered as by-products the following should be noted: whey, buttermilk and ultrafiltration permeates, which are highly polluting agents when they are incorporated into the wastewater of dairy plants. They are characterized by very high biochemical oxygen demand and chemical oxygen demand. Thus, it is clear that they require an appropriate treatment and their inadequate disposal creates a major environmental issues. Furthermore, the processing in XXI century means following the zero waste principle to maximize the use of all nutrients with maximum profits and minimum costs. Such an approach is justified not only economically, but also ethically and is dedicated by the action resulting from the strategy based on sustainability.

One of the important developments in dairy technology in recent decades has been the fractionation/separation of dairy streams into their principal constituents using membrane processes. However, fouling is still a major factor limiting application of membrane filtration. It changes membrane selectivity and reduces the flux during filtration time.

The objectives of the doctoral dissertation were to assess the fractionation efficiency during ultrafiltration of whey and microfiltration of buttermilk, to indicate major foulants during filtration processes, to model the flux decline of different feed tested with a resistance-in-series model and to determine a time-based evolution of model parameters. Moreover, considering the need to increase the circularity of dairy by-products, the utilization of ultra- and diafiltration permeates in an anaerobic digestion was studied.

The conducted study revealed that the major fouling agents reducing the efficiency of whey ultrafiltration were β-lactoglobulin and α-lactalbumin adsorbed to the membrane surface and to the pore walls. The performance of microfiltration membrane was reduced by the cake layer formed by caseins. A time-based evolution of resistance-in-series model parameters was determined for the first time, when filtering dairy streams obtained at industrial scale. Another novelty introduced was a general equation that accounts for the time-based changes in the mass deposited on the membrane surface during microfiltration of buttermilk. It has also been shown that with use of microfiltration to process buttermilk, which has undergone extensive heat treatment, it is possible to fractionate α-lactalbumin. The study of anaerobic digestion of ultrafiltration and diafiltration permeates has proven that tested permeates are efficient substrates in biomethane production. Based on these results, it has been calculated that for a dairy plant using ultrafiltration and diafiltration, the utilization of permeate in the methane fermentation process can provide enough energy to meet the plant's needs.