ANALYSIS OF THE DIFFERENT FILTRATION PARAMETERS OF WHEY BY TUBULAR AND VIBRATORY FILTRATION SYSTEMS

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ABSTRACT

The largest quantities of by-product of the dairy, namely whey comes from the cheese making. The whey proteins are used by the agriculture in animal nutrition, and by the human nutrition as well; dry soups, infant formulas and supplements. The aim of our experiments was the separation of the lipid fraction of whey. During the measurements 0.05 μm, 0.2 μm and 0.45 μm microfiltration membranes were used in vibrating membrane filtration equipment (VSEP) and in a laboratory tubular membrane module. During the microfiltration, analytical characteristics, the fouling and the retention values were examined. Using the VSEP and the tubular module made possible to compare the effect of vibration, the static mixer and/ the airflow on the separation parameters.

Keywords: whey, vibratory filtration, static mixer, tubular filtration, airflow

1. INTRODUCTION

Liquid whey contains lactose, vitamins, protein, and minerals, along with traces of fat. During the degreasing cream can be skimmed from whey. Whey cream is more salty, tangy, and "cheesy" than ("sweet") cream skimmed from milk, and can be used to make whey butter. The other reason of the degreasing is the further processing of the whey for dry powder/nutritional supplement. The membrane degreasing methods are new ones and the biggest gap of it is the low flux and high resistances. These effects could be mitigated by used membrane modes of us, i.e. static mixer, aeration and vibrating.

Newtonian fluids such as an aqueous solution, - are being turbulent flow in most industrial applications, but within a short pipe section this turbulence is not enough to equalize temperature or concentration in-homogeneities. The use of static stirrers was made better amalgamation than increase the speed or the pressure during the process. The flux is increased and the operating cost is decreased at tubular membranes with static mixer (Krstic et al. 2002). Similar result was obtained with an alternative design equipment to increase turbulence and other type of membranes as well (Bellhouse et al. 2001, Costigan et al. 2002). The fouling of the membranes was possible to decrease at the introduction of gas into the liquid (Laboire et al. 1998, Cabassud et al. 2001, Cui and Wright, 1996). The introduction of a specific gas - in this case air - directly into the fluid created a two-phase gas/liquid flow. The efficiency of the separation is influenced by the position of the membrane (vertical or horizontal) and the direction of the flow (up or down). The aeration method is limited by the gas distribution and the management of this process (Derradji, 2000). During the vibratory shear enhanced process (VSEP), the filtering parameters (flux, retention and resistances) were investigated by the effects of the vibration. This is another solution to decrease fouling (Frappart et al. 2008, Hodúr et al. 2013). The shears strengths at the surface of the membrane can be increased by vary the frequency of the vibratory membrane module. The polarization layer, the resistance values, and the fouling were measured by the effect of vibration, and the evolution of retention values were measured by the effect of increase of vibrational amplitude (Ahmadu et al. 2009, Hodúr et al. 2009, Kertész et al. 2010).

2. MATERIALS AND METHODS

Sweet cheese whey was used for measurement which came from Soma Budapest Ltd. Its basic analytical parameters are: fat content: 0.18 m/m%, protein content: 0.33 m/m%, milk sugar content: 2.61 m/m%, dry materials: 3.72 m/m%, total protein content: 0.47 m/m%. The degreasing process was made by membrane separation. These basic parameters were measured by Bentley milk analyzer equipment.

The air injection and/or static steering method were implemented by tubular and hollow fiber membranes with 0.45, 0.2 microns, 0.05 microns cut off value. The tubular membrane was 250 mm length, and it was included 1 tube which has an internal diameter of 7 mm.. The applied static mixer was a 250 mm length *Helix* type metal static stirrer with a pitch of 0,006 m and an inner radius of the stirrer of 0.0035 m. (KenicsTM, Helix).. The *KenicsTM* type static stirrer (made by plastic material) was used also with a length of 241 mm, and a thickness of 1 mm, a diameter of 6.35 mm. The flux was performed on 100 L/h recirculation flow rate, on 0.2 MPa transmembrane pressures and on 20 L/h air injection rate. In all measurements the initial amount of feed was 2 L of sweet whey. The temperature was a permanent 30°C degree during the tests. The airflow was introduced into the fluid flow before the membrane module.

Vibratory filtration equipment set marketed by New Logic International Corp. and this equipment was used at L-mode (L: laboratory methods: the module comprises one disk-shaped membrane with an active filter surface 503cm2). The VSEP system consists of disk-shaped flat-sheet membranes. This laboratory module attached to a central shaft. The shaft was rotated a short distance at a frequency of 54 Hz. 0.2 µm cut-off values membranes (made of polyethersulfone) were used during the measurements, on a transmembrane pressure at 0.3 MPa. In this equipment the initial amount of feed was 10 L of sweet whey.

The samples were taken at different intervals during the measurement from retentate and also from permeate.

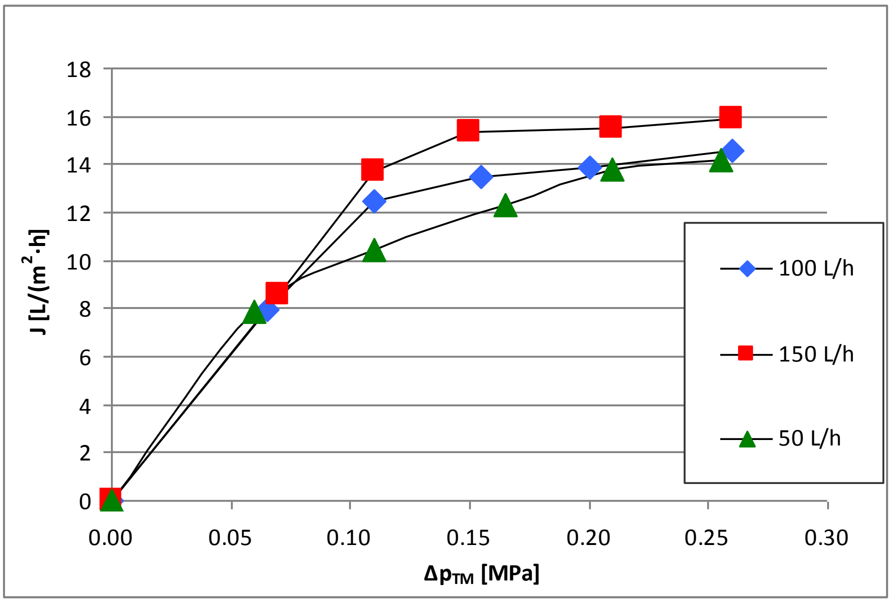
3. RESULTS AND DISCUSSION

The tubular membranes were used during the measurement at a pore size of 0.2 microns. The retention of the fat component was important in our research programme, and we were able to retain more than 50% at low pressure with using static mixer.

The flux values were measured at 0.2 MPa transmembrane pressures and at 100 L/h recirculation flow rate by a 0.45 µm tubular membrane. The flux values are started at 60 L/m^2h. The flux values were showed 17-18 L/m^2h values during the normal filtration process, and with combined the air injection, the flux was decreased slight by the air flow on a 0.2 µm membrane. When the *Helix* static mixer element was used in the filtration process, the flux values were increased two times greater extent, from 18 L/m^2h to 40 L/m^2h when the *Helix* static mixer was used with air injection.

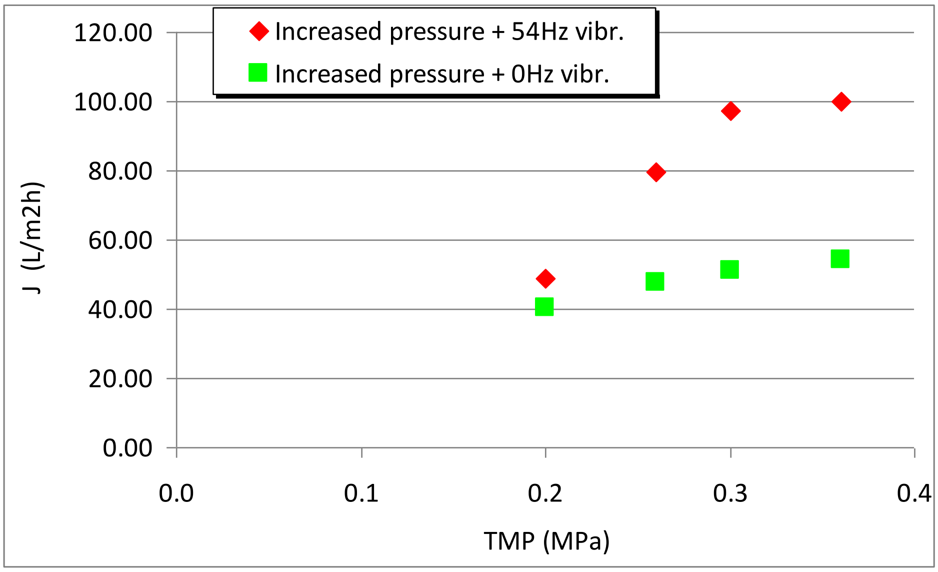
The increase of the flux is holding until the 0.2 MPa transmembrane pressures; because on higher pressure values this increase of the flux is started to show a strong deceleration (1. Figure). When the air injection process was used alone, the flux values remained very low;

therefore the air injection method itself is not a recommended method for whey processing. When the *Helix* static mixer was used alone in the equipment under the same parameters, the flux values were showed higher values than the experiments with air injection, but above 0.2 MPa transmembrane pressures values, the flux was strongly decreased, therefore it was justified to use the lower transmembrane pressure.



1. Figure The changes of whey flux (J) as a function of trasnmembrane pressure at different recirculation flow rate

The 0.2 microns membrane was used with *Kenics* type static mixer in second period of our research programmes. The flux values (J = 45 L/m^{2}h) were increased by the *Kenics* static mixer, but the increasing was not as high as using the *Helix*-type static mixer (J = 53 L/m^{2}h). Our experiments were continued by a 0.05 microns pore size tubular membrane to comparing the received data with the other tubular membranes different data. The flux was increased 50-80% during the filtration process by using a 0.05 microns pore size tubular membrane with a *Kinetics* static mixer. The flux was decreased strongly after 0.3 MPa transmembrane pressures. The vibratory shear enhanced membrane filtration was examined by a 0.2 µm pore size microfiltration membrane, on 0.3 MPa transmembrane pressures with using vibration at 54 Hz vibrational frequency and without using vibration (Figure 2.).

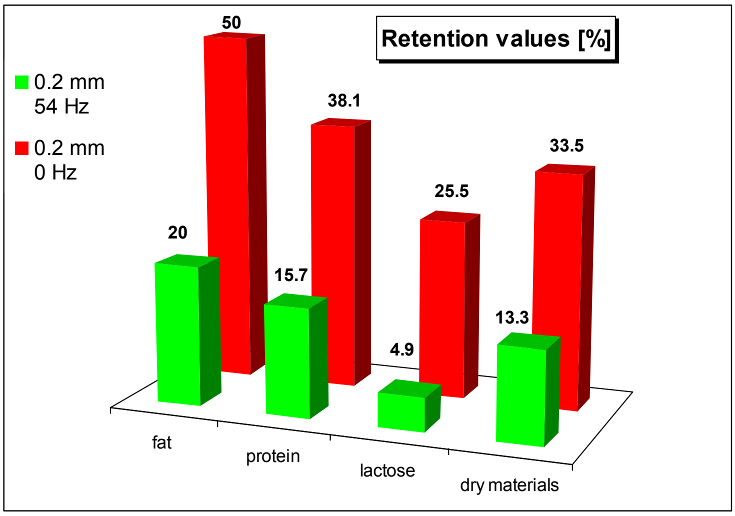


2. Figure The changes of whey flux (J) as a function of trasnmembrane pressure at vibrated (54 Hz) and non vibrated methods

The retention values were measured only from the fat molecules. The examination of the resistance values was showed that the gel layer and the membrane resistance values showed the same magnitude values. The fouling resistance was showed an order of magnitude lower value than the two other determinative resistance values before.

In non-vibrating mode, not only the total resistance value was showed differences, but its structure and distribution as well. Without using vibration during the separation process, the flux values were showed four times lower; the total resistance value was showed one order of magnitude higher; and the fouling resistance values were showed two orders of magnitude higher values.

The drag resistance values were decreased by the vibration, therefore this change was allowed the fat molecules to move and accumulate on the membrane surface (3. Figure) The flexible fat molecules were moved into the capillaries of the membrane under pressure and without vibration, where due to their sizes (3.5 microns), these molecules were fouled inside the membrane capillaries. The increased retention values and their absolute magnitude were been significant by fat content. The retention values of the small components were increased by the fouled pores.



3. Figure The retention value of most important components of whey

4. CONCLUSION

The experiences showed that the 0.45 microns pore size membrane could slightly hold back the fat molecules, due to their larger pore size. The desired filtration results were achieved by the measurements of 0.2 MPa and 100 L/h.

The 45 % higher flux values were measured by Helix static stirrer against the normal filtration process, but the combination of the static stirrer and the air injection were made the highest flux values (30 % higher than the filtration process by the Helix static stirrer) under the same conditions. Comparing the two different static stirrers, it was found, that the 15 % higher flux values were measured by Helix static stirrer than the Kenics stirrer. This means that the separation of the fat content was easier and more effective by using the combination of static stirrer and air injection.

The vibratory shear enhanced process was showed that not only the retention values of the fat content were increased without vibration, but the other elements retention values too. 300 % higher flux values were measured by 54 Hz vibration than without vibration.

5. ACKNOWLEDGEMENTS

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