Partial demineralization and concentration of whey permeate by nanofiltration

At-a-Glance

Project purpose:
- **Study lactose rejection over time**

System:
- **5 stage NF 3838**

Feed:
- **UF permeate of whey**

Competitive elements:
- 5 different NF elements in 3838 configuration

Key parameters measured:
- Lactose in permeate via enzyme and HPLC
- Salt passage as ASH
- Permeate flow

Average system conditions

Concentration, brix	11 to 26
Feed pressure, psi	449
Feed flow, l/m	530
Conc. flow l/m	250
CF	2.12
Temperature	58
pH	5.8

Average stage 4 conditions

Loop 4 pressure	490
Concentration, brix	23
Permeate %	27

DOW was invited to participate in a competitive field trial comparing five Dairy nanofiltration elements available on the market.The purpose was to determine which elements provide the best overall performance concentrating and demineralizing lactose over a period of 12 months.The results show that FILMTEC™ NF245 membrane consistently outperformed the other elements and maintained the highest lactose rejection and highest salt permeability. Additionally, FILMTEC NF245 had 16 percent higher permeate flow than the competition.*

Introduction

Removing dairy salts from whey permeate is essential in the production of edible and high quality lactose. It can also reduce evaporator fouling as salts can precipitate as scale. Monovalent salts can be removed efficiently with nanofiltration membranes while simultaneously concentrating the lactose stream. The demineralization and concentration of lactose requires a membrane that has an appropriate molecular weight cut off to reject lactose molecules yet is open enough to allow significant transport of monovalent salts. As with many nanofiltration membranes on the market, high salt passage comes with higher than desirable organic passage and can result in product loss and permeate quality issues such as high BOD. Alternately, nanofiltration membranes that have high organic rejection also have lower salt passage and lower permeate flows resulting in poor desalting efficiency and decreased plant capacity.

FILMTEC NF245 elements are truly unique nanofiltration membranes that have high lactose rejection, high monovalent salt passage as well as high flux. These properties translate into value creation for whey and lactose processors.

- Maintains rejection over time
- Higher product yields by keeping lactose in the concentrate
- Higher capacity and salt passage than membranes with a similar molecular weight cut off
- Lower BOD in permeate resulting from good organic rejection
- Better salt removal that can lead to less scaling in evaporator as well as higher purity lactose

** compared to elements with lactose passage less than 1 percent on a wet basis.*

Experimental details

The competitive field trial took place in a whey plant in Canada. The trial elements were in stage four of a five stage NF system. Each vessel was loaded with four 3838 elements of only one type of element. The feed was UF whey permeate. The permeate for each vessel in the study was analyzed for Lactose, Ash and Total Solids. The permeate flow was also recorded at intervals over the 12 month study. A standard daily CIP of acid, caustic and enzyme was performed daily.

Results

The results show that FILMTEC™ NF245 membrane consistently performed better than the competitors and maintained the highest lactose rejection and the best salt passage.

Out of the five elements that participated in the study, only three were able to maintain a typical target specification of less than 0.2 percent lactose in permeate (by enzyme test, wet basis) during the course of the 12 month study. Out of the three membranes that met the typical target specification, two were FILMTEC membranes. FILMTEC NF245 had the lowest permeate lactose level, the most ash passage and the highest permeate flow. See Graphs 1 through 4 and Table 1.

Figure 1. Schematic of system where field trial took place

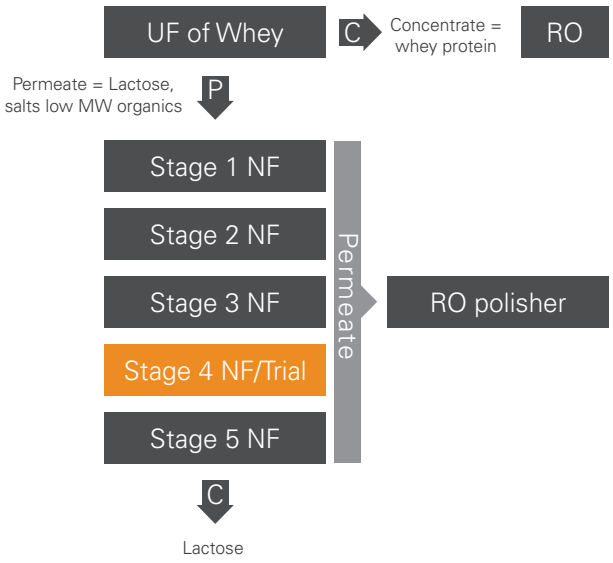
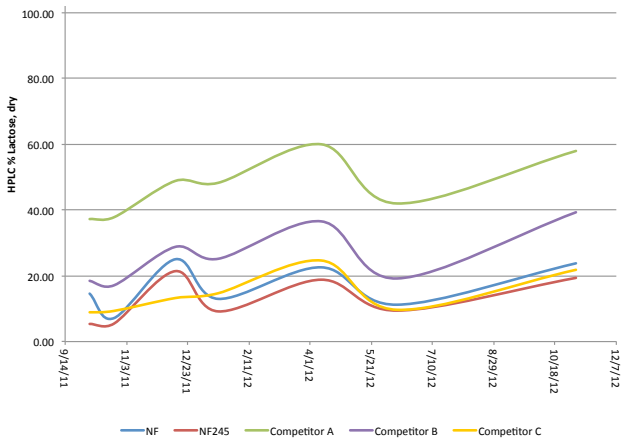


Table 1: Data generated from 12 month field trial.

	Average permeate flow Flow, lph	Average TS % dry	Average ASH % dry	Average lactose HPLC % dry
Feed		22.7	6.5	84.0
Permeate (avg)				
FILMTEC NF	308	1.2	58.6	16.8
FILMTEC NF245	328	1.1	63.6	12.7
Competitor A	376	2.7	31.8	47.5
Competitor B	274	1.6	50.0	26.4
Competitor C	275	1.0	59.0	14.6

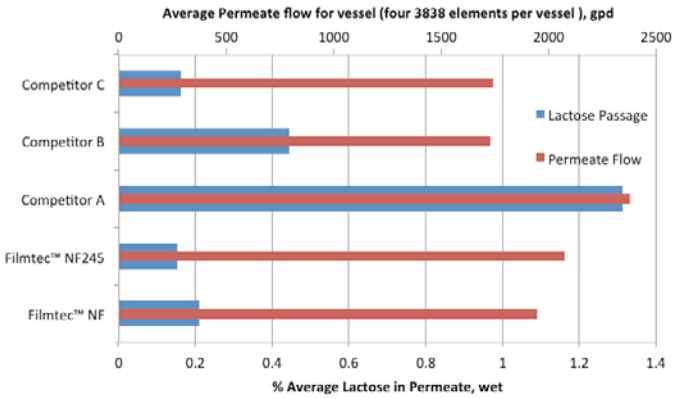
Graph 1: Average amount of Lactose in the permeate over the 12 month field trial. Results are from HPLC on a dry basis. The fluctuations in the curves could be due to changing flow conditions or feed compositions. Since DOW was not involved in test work, the exact cause is unknown.

% Lactose in Permeate (dry) by HPLC Lactose Passage Over Time



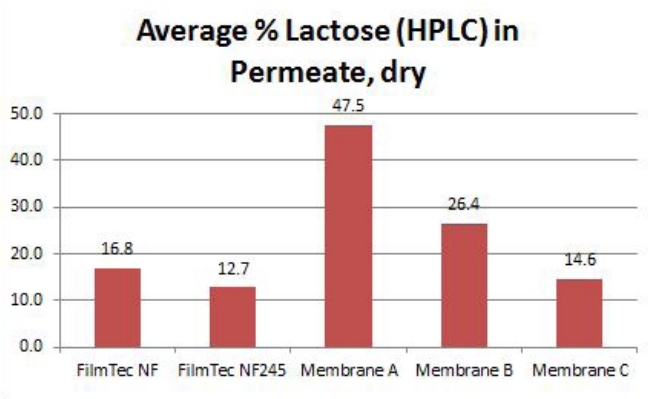
Graph 2: Comparison of the average amount of lactose in permeate and average permeate flow for four elements each over the 12 month trial

Flow and Rejection Performance



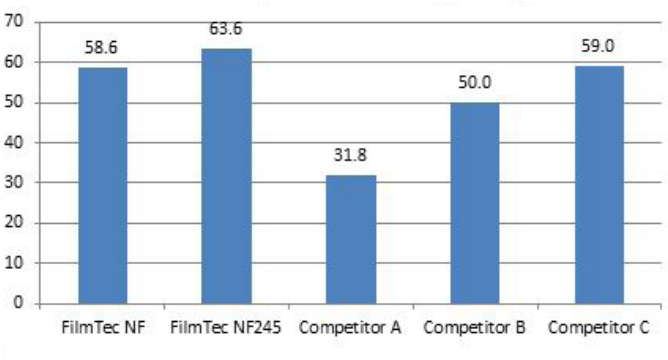
Graph 3: Average amount of Lactose in the permeate over the 12 month field trial. Results are from the HPLC on a dry basis.

Average % lactose (HPLC) in permeate, dry



Graph 4: Desalting Efficiency. FILMTEC NF 245 showed the best salt passage. Note that salt passage is not indicative of organic passage. FILMTEC NF245 also had the least lactose passage (Graph 3).

% Average Ash Passage, dry



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