Performances of skimmed milk crossflow microfiltration: Comparison of ceramic membrane configurations

Nadine Leconte, Fabienne Garnier-Lambrouin, Gaspard Fouillard-Mairesse, Geneviève Gésan-Guiziou

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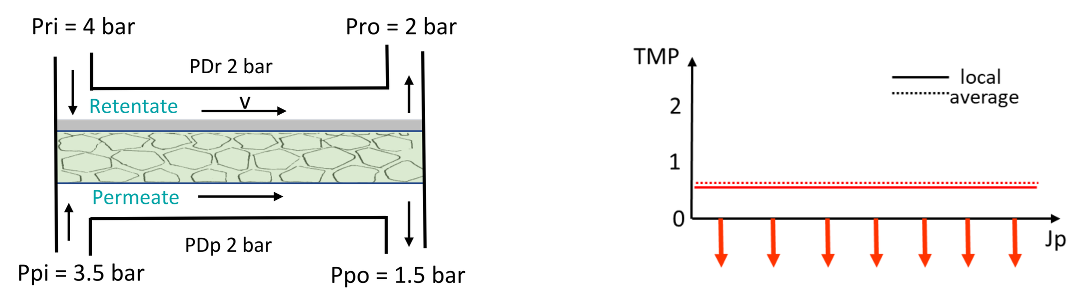
Performance of skimmed milk crossflow microfiltration: Comparison of ceramic membrane configurations

Nadine Leconte, Fabienne Garnier-Lambrouin, Gaspard Fouillard-Mairesse, Geneviève Gésan-Guiziou

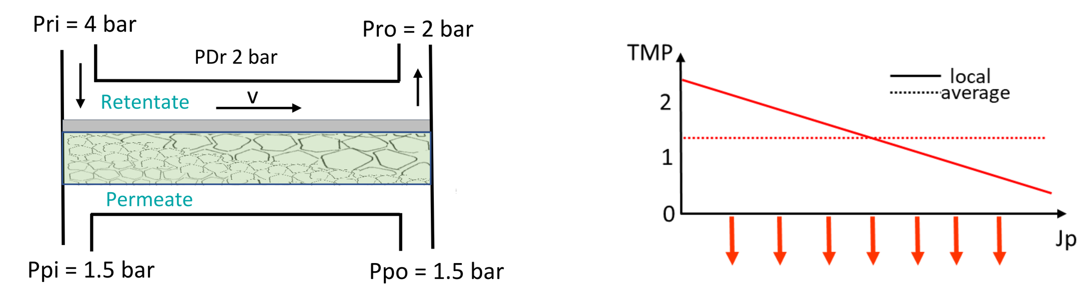
UMR 1253 STLO Science et Technologie du Lait et de l'Œuf, INRAE, Institut Agro Rennes Angers, France

Objective

Microfiltration is largely applied in the food sector for the separation and concentration of proteins. Skimmed milk 0.1 µm microfiltration is implemented in the industry to separate casein micelles (retentate) from serum proteins (filtrate). The efficiency of the process, and especially the serum protein transmission, depends on the accumulation of casein micelles at the membrane surface. To overcome this problem, milk microfiltration is operated with specific ceramic tubular membrane configurations.



The Uniform Transmembrane Pressure (UTP) configuration makes it possible to get a low transmembrane pressure (TMP) along the membrane with an additional pump on the permeate side.



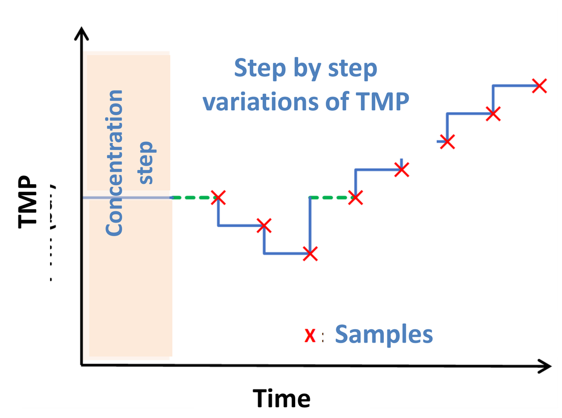
The Graded Permeability (GP) configuration uses a membrane designed to create uniform permeate flux along the membrane (higher hydraulic resistance at the inlet, when TMP is higher).

Pri et Pro : Retentate pressure at the inlet / outlet of the membrane (bar) ; Ppi et Ppo : Permeate pressure at the inlet /oulet of the membrane (bar) ; PDr / PDc: Pression Drop in the retentate / permeate (bar)

➢ **Compare the performances of the UTP and GP configurations in the case of milk 0.1 µm microfiltration operating in feed and bleed mode**

Materials and methods

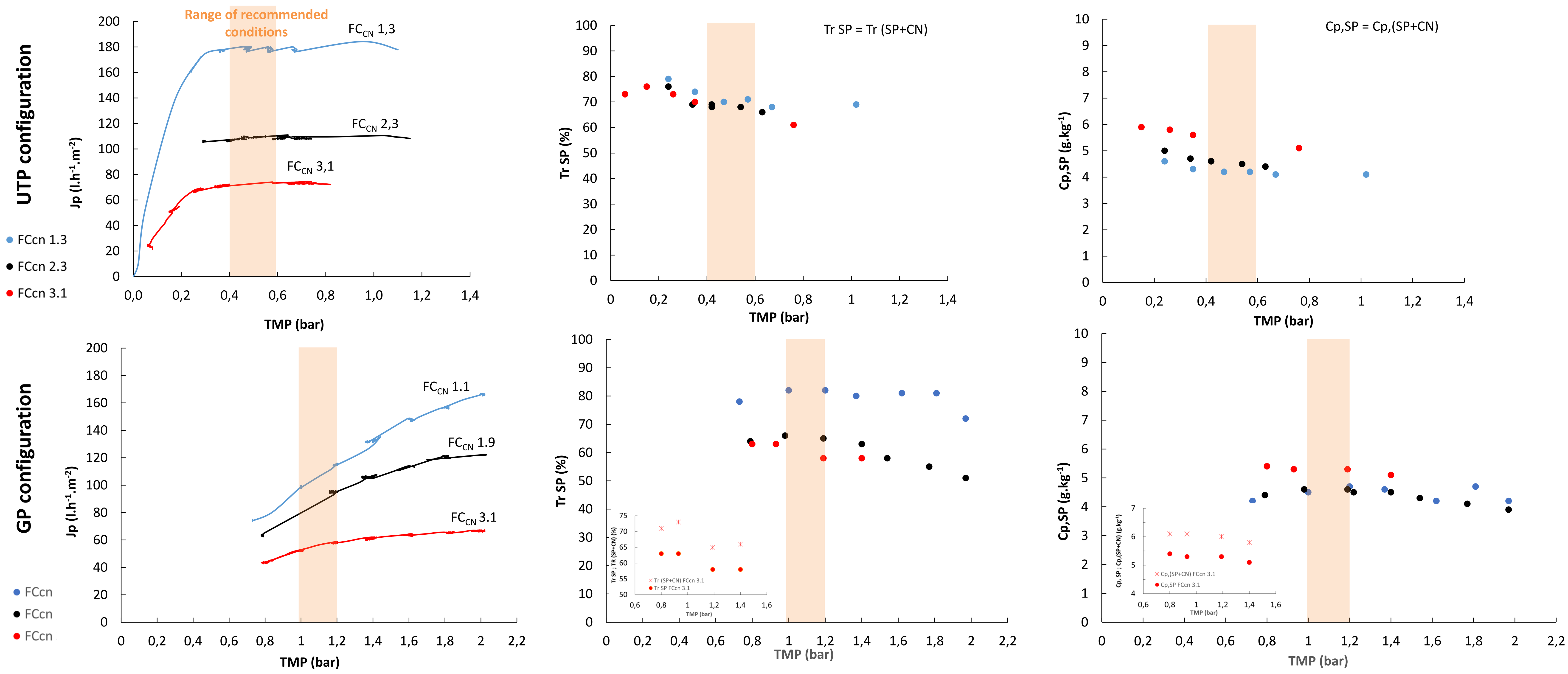
- **Ceramic membranes** Pall 0.1 µm, 7P1940GL, 1.68 m^2 , channel diameter 4 mm: UTP and GP configurations
- **Parametric study**
  - Step by step variations of TMP: 0.2 - 2.0 bar
  - Casein micelles concentration factor (FC_{CN}): 1.0 - 3.1
  - Cross flow conditions:
    - UTP → v= 7.0 $m.s^{-1}$
    - GP → PDr = 2.0 ± 0.1 bar (7.8 – 7.0 $m.s^{-1}$ according to FC_{CN})
  - Temperature: 50 ± 2°C
  - Duplicates of several experiments were shown to be reproducible (< 5%)



- **Performance**
  - Permeation flux (Jp)
  - Serum protein (SP) concentration in permeate (Cp,SP)
    Cp,SP = NCN – NPN (Kjeldahl N x 6.38)
  - Protein concentration in permeate (Cp,(SP+CN), CN : casein)
    Cp,(SP+CN) = TN – NPN (Kjeldahl N x 6.38)
  - Serum protein transmission $\text{Tr SP} = \frac{Cp,SP}{Cr,SP} \times 100$
  - Serum protein+ CN transmission $\text{Tr (SP+CN)} = \frac{Cp,(SP+CN)}{Cr,SP} \times 100$

Results

Permeability | **Protein transmission** | **Permeate concentration**



Under recommended conditions:

- Jp_GP < Jp_UTP regardless of FC_{CN}

- Tr SP_GP > Tr SP_UTP at FC_{CN} ≈1.2 ± 0.1 due to higher cross flow velocity
- Tr SP_GP ≈ TR SP_UTP at 1.9 < FC_{CN} <3.1

- Cp SP_GP ≈ Cp, SP_UTP regardless of FC_{CN}
- Systematic presence of casein in permeate

Main conclusions

Despite the fact that both configurations used membranes with similar filtering layers, the performances of the two ceramic membrane configurations show discrepancies. The optimal performances are not obtained under the industrially recommended conditions, which leaves room for significant improvements of existing filtration plants. Perspectives: investigation of performances at high FC_{CN} 3.0 - 3.5; investigation of cleaning efficiency.

genevieve.gesan-guiziou@inrae.fr
https://www6.rennes.inrae.fr/stlo