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# Sustainable production of protein fractions using microfiltration $0.1\mu\text{m}$ of milk : Impact of skim milk thermal history

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# Sustainable production of protein fractions using microfiltration 0.1 $\mu\text{m}$ of milk : Impact of skim milk thermal history

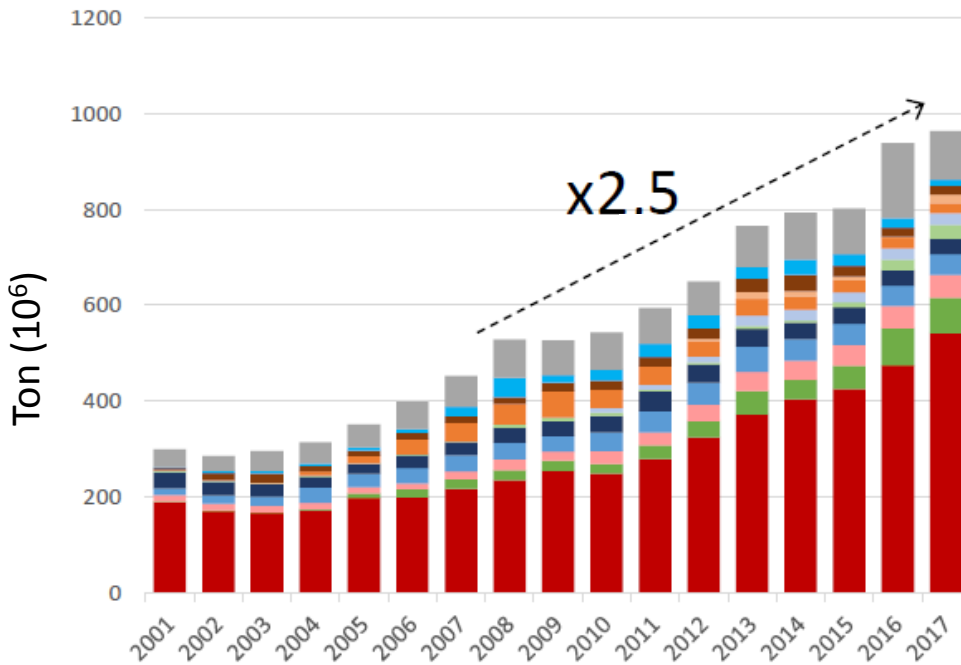
EWM  
April 10<sup>th</sup> 2019



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Françoise LE GOFF • Marieke VAN AUDENHAEGE • Geneviève GESAN-GUIZIOU

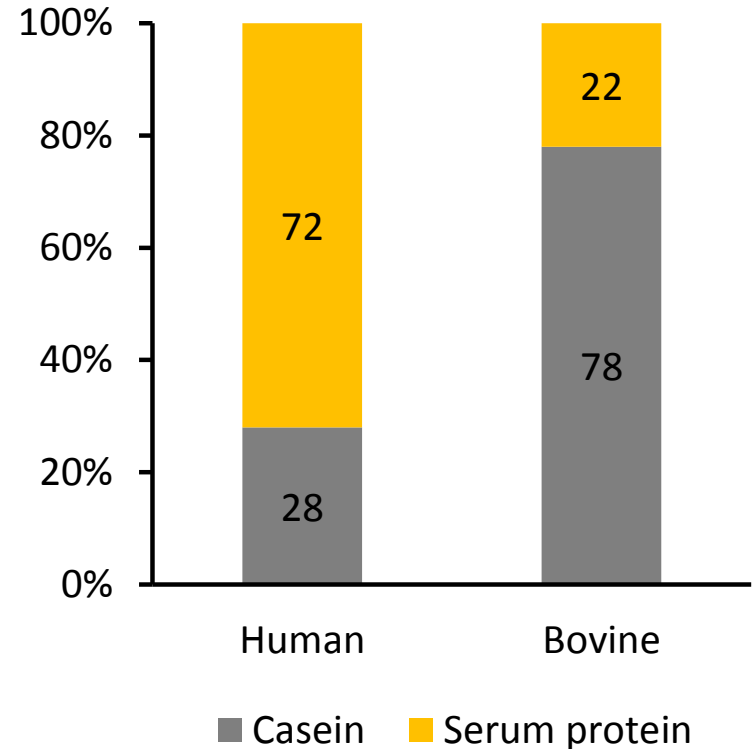
# World Dairy Industry

World infant milk trade



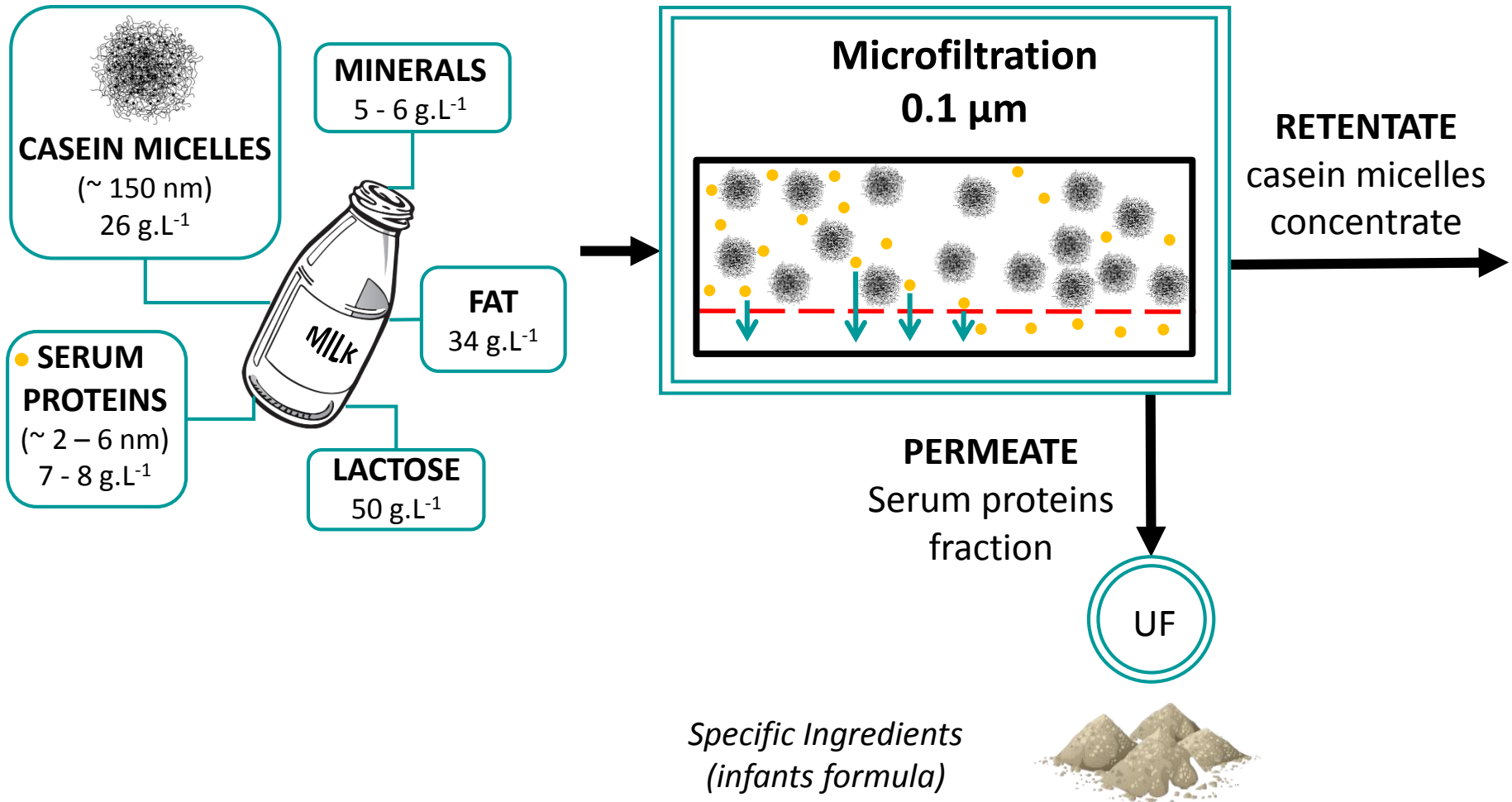
In 10 years, World trade for infant milk has been multiplied by 2.5, EU supplies more than 50 %

Infant milk proteins ratio

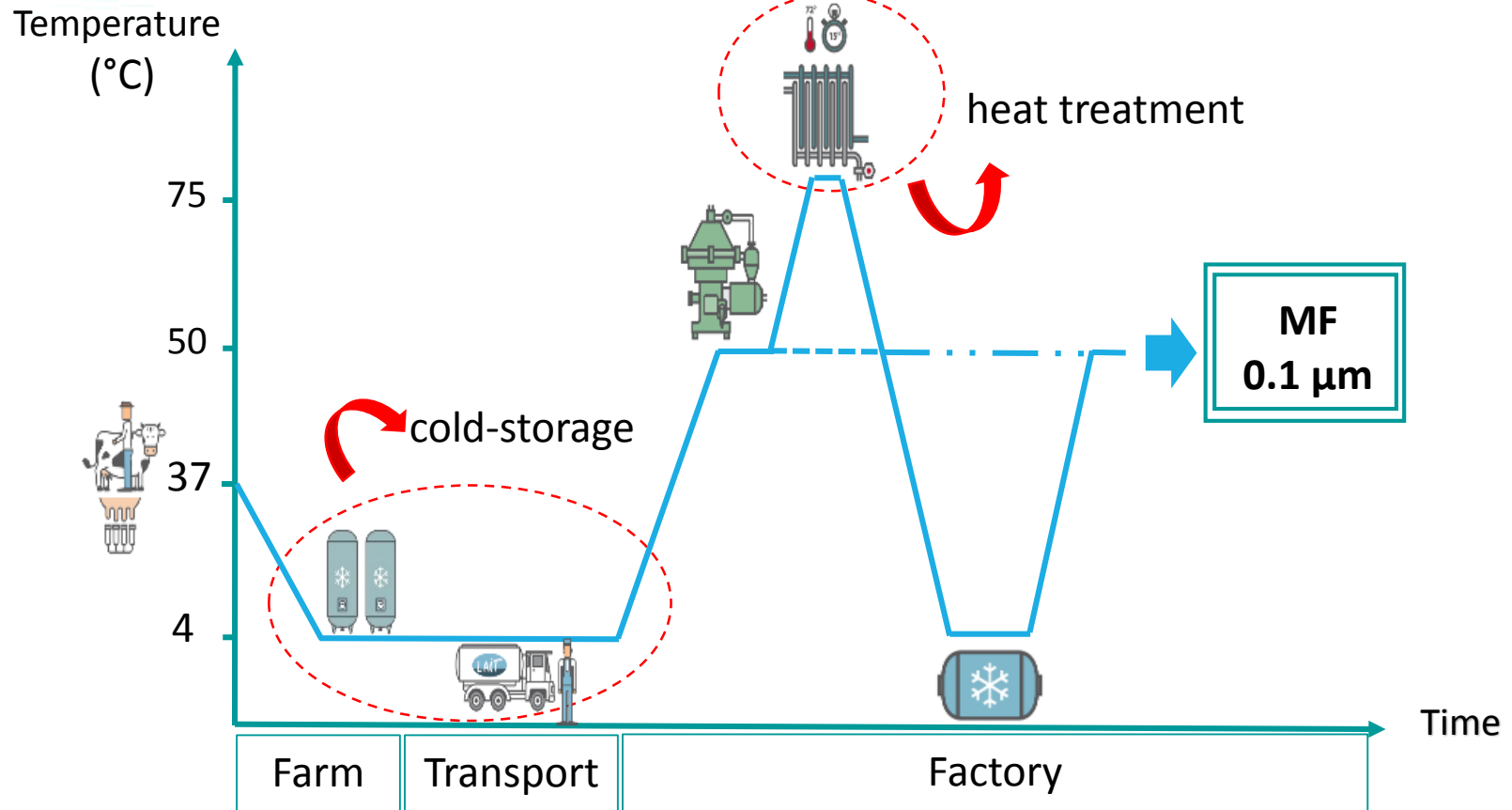


CN/SP ratio has to be change  
 → fractionation of bovine milk proteins

# Microfiltration of skimmed milk



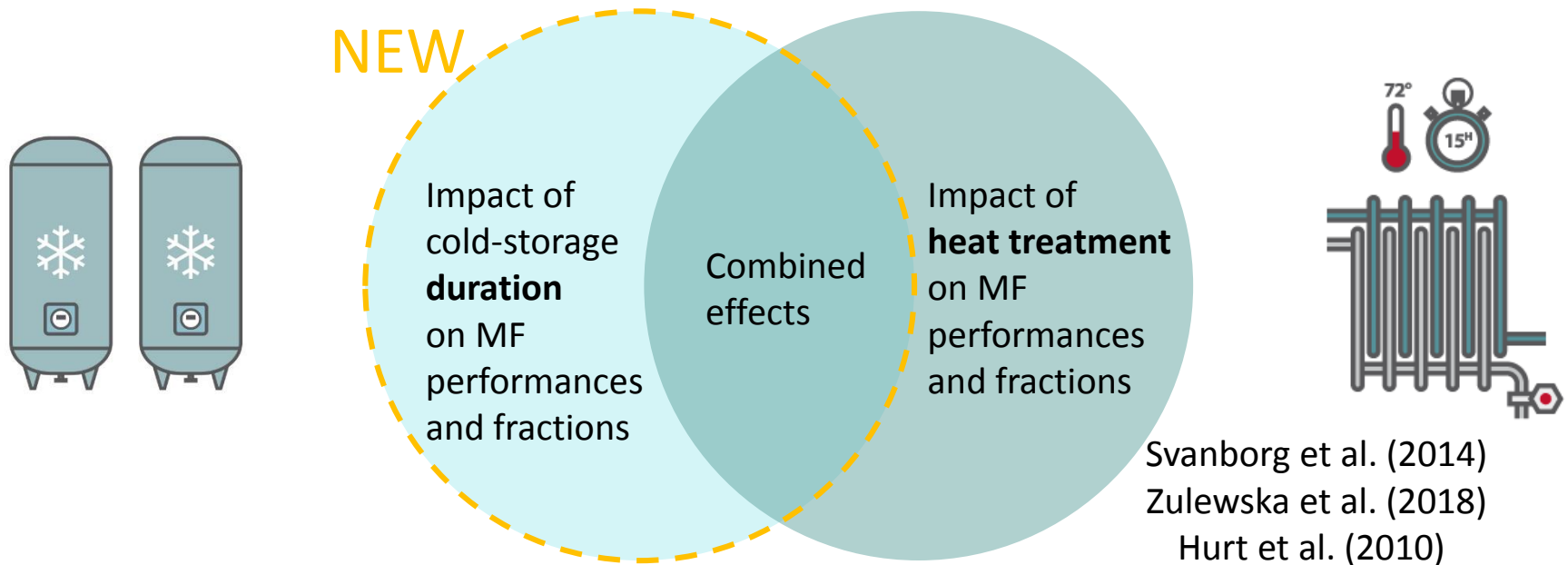
# Pre-processing steps prior to MF



Lack of knowledge about how the thermal history of milk (cold-storage and heat treatment) affects the MF performances (productivity and fractions characteristics)

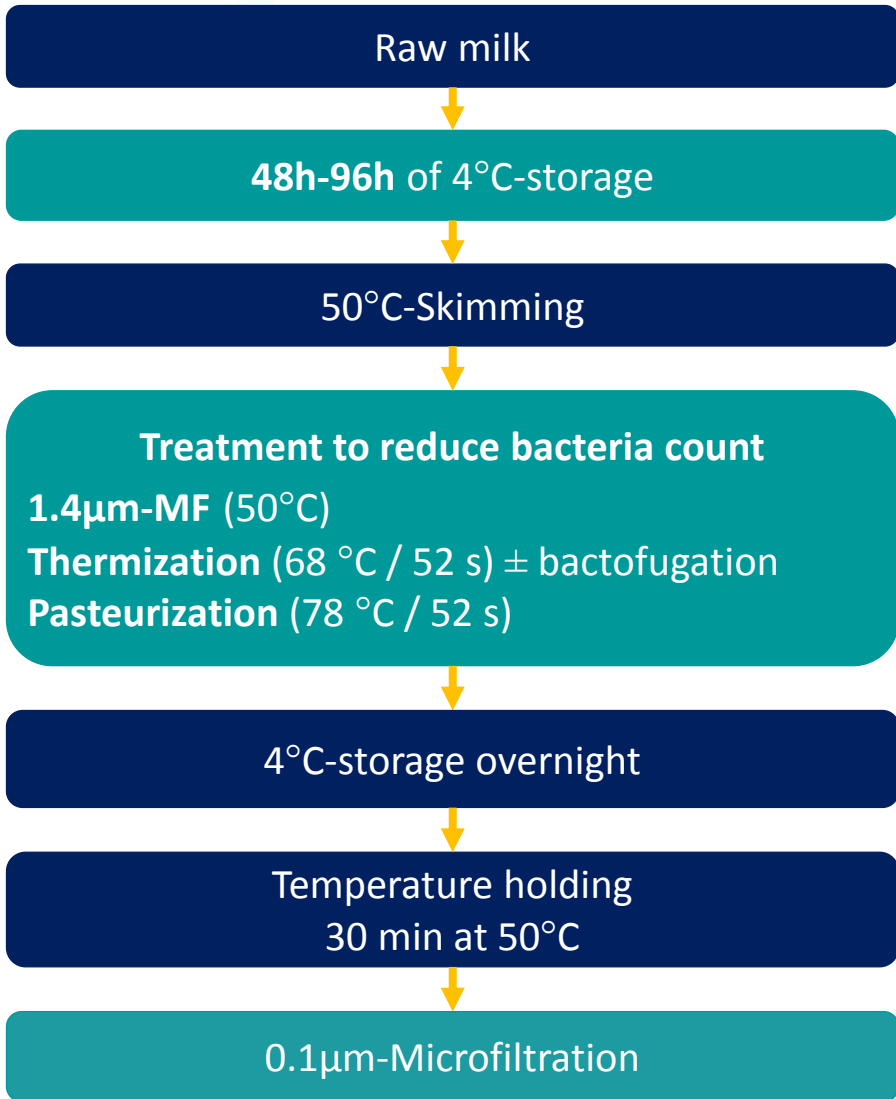
# Objectives & Strategy

Investigating the **impact of pre-processing steps** (cold-storage & heat treatment) on the **MF efficiency**



To adapt the **stabilization** step to the **cold-storage history** of milk and provide a **sustainable production** of fractions.

# Processing steps



Ceramic  
membrane (Pall)

0.1 µm pore size

Uniform  
Transmembrane  
Pressure system

$T = 50 \pm 2^\circ\text{C}$

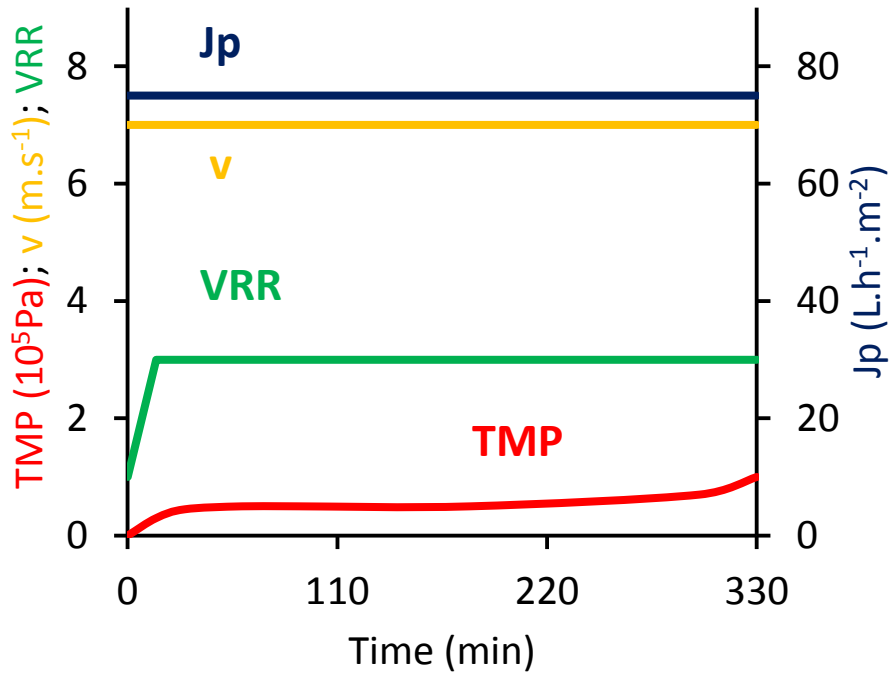
$J_p = 75 \pm 1 \text{ L}\cdot\text{h}^{-1}\cdot\text{m}^{-2}$

$v = 7.0 \pm 0.3 \text{ m}\cdot\text{s}^{-1}$

$\text{VRR} = 3.0 \pm 0.1$

Feed-and-bleed  
mode of operation: 330min

# Performances indicators and fluids characteristics



**TMP = f(t)**

**Serum protein recovery ratio in permeate:**

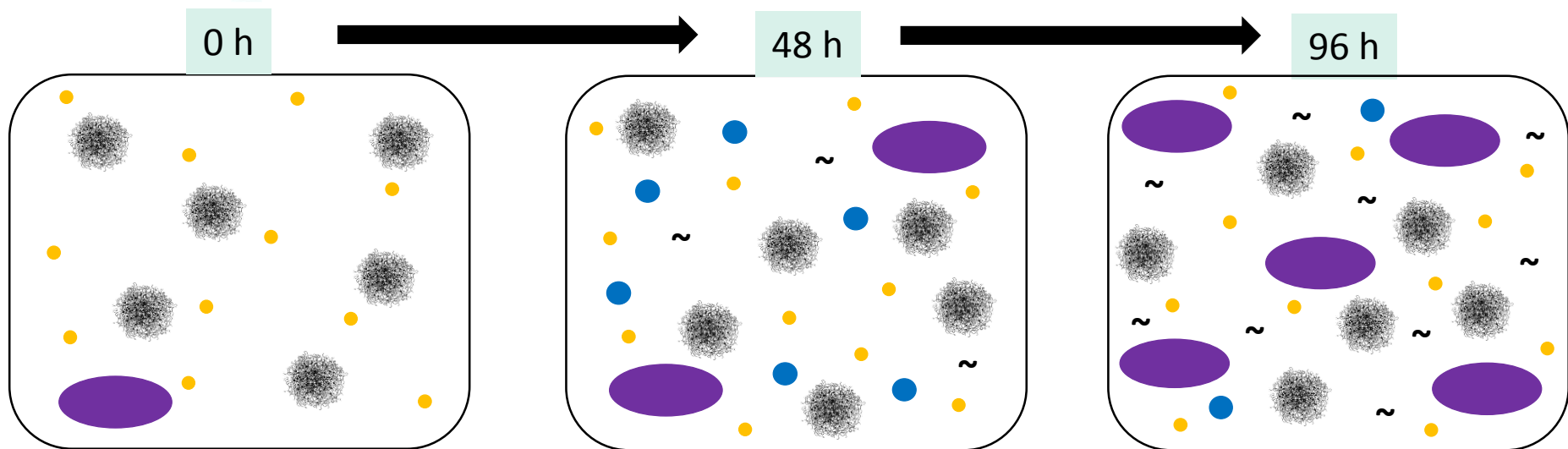
$$(SP \text{ recovery}) (t) = \frac{[SP]_{permeate} (t)}{[SP]_{Milk}} * \frac{VRR - 1}{VRR}$$






VRR : volume reduction ratio

**Bacterial counts**  
 pH/ Dornic grade  
**Proteins (SP & CN)**  
 Dry matter  
 Fat  
**SP/DM in permeate**



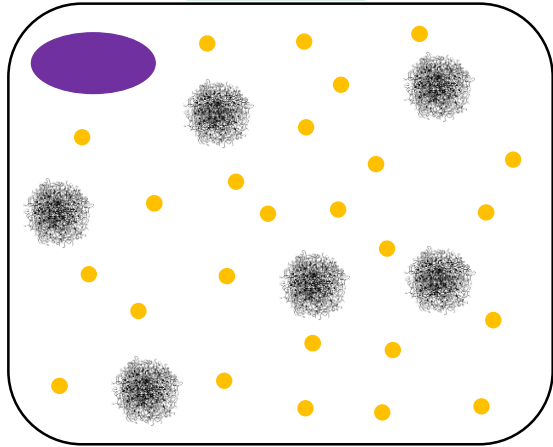
# Effect of 4°C-storage on raw milk composition



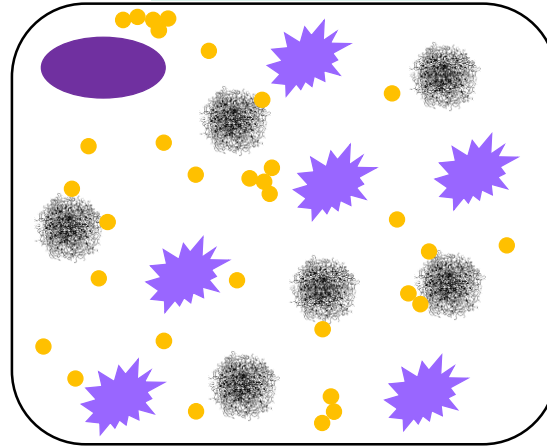
	Casein micelles
	Serum proteins
	Psychrotrophic bacteria
	$\beta$ casein
	Proteose peptone

# Effect of treatment on skimmed milk composition

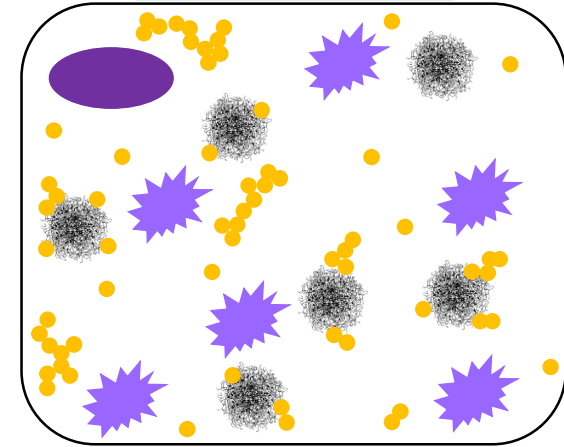
1.4-MF  
50 °C



Thermization  
68°C / 52 s



Pasteurization  
78°C / 52 s



Same viable psychrotrophic bacteria count



Fragments & cells of bacteria




< 1 %

2 - 5 %

8 -13 %

SP denaturation

 Casein micelles  
 Serum proteins

 Psychrotrophic bacteria  
 Fragment/cell of bacteria  
 Aggregate of SP

# Hydraulic performances of 0.1 $\mu$ m-MF

	48h		96h	
	$\Delta$ TMP (10 <sup>5</sup> Pa)	% of TMP <sub>i</sub>	$\Delta$ TMP (10 <sup>5</sup> Pa)	% of TMP <sub>i</sub>
<b>1.4<math>\mu</math>m-microfiltrated SM</b>	0.03 $\pm$ 0.08	+ 6 %	0.03 $\pm$ 0.08	+ 6 %
<b>Thermized SM</b>	0.04 $\pm$ 0.08	+ 7 %	0.13 $\pm$ 0.08	+ 23 %
<b>Pasteurized SM 1</b>	0.03 $\pm$ 0.08	+ 6 %	0.14 $\pm$ 0.08	+ 25 %
<b>Pasteurized SM 2</b>	0.04 $\pm$ 0.08	+ 8 %	0.07 $\pm$ 0.08	+ 15 %

Pasteurized SM 1: 

Pasteurized SM 2: 

- 1.4-MF SM: no evolution of TMP regardless of the 4°C-storage duration
- Heat-treated SM: increase of TMP on the course of filtration when milk is cold-stored 96 h
- Presence of a bactofugation step has no impact on MF hydraulic performances

# Hydraulic performances of 0.1 $\mu$ m-MF

	48h		96h	
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Pasteurized SM 1: 

Pasteurized SM 2: 

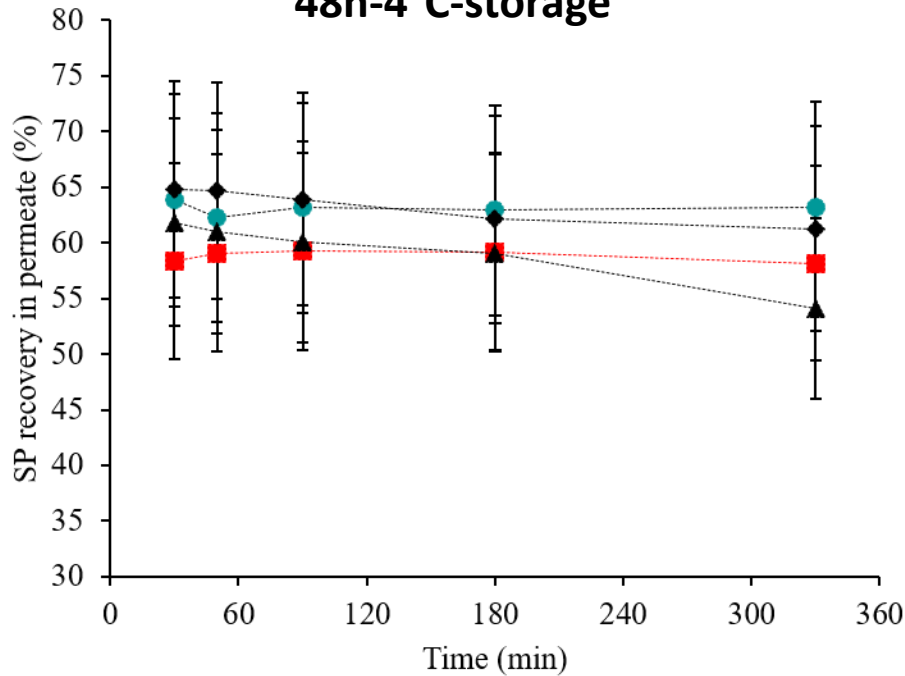
## Assumptions:

- Bacteria are partly responsible for fouling
- 1.4-MF: high retention of bacteria, somatic cells and residual fat globules
- Heat treatment: accumulation of bacteria, somatic cells and residual fat globules

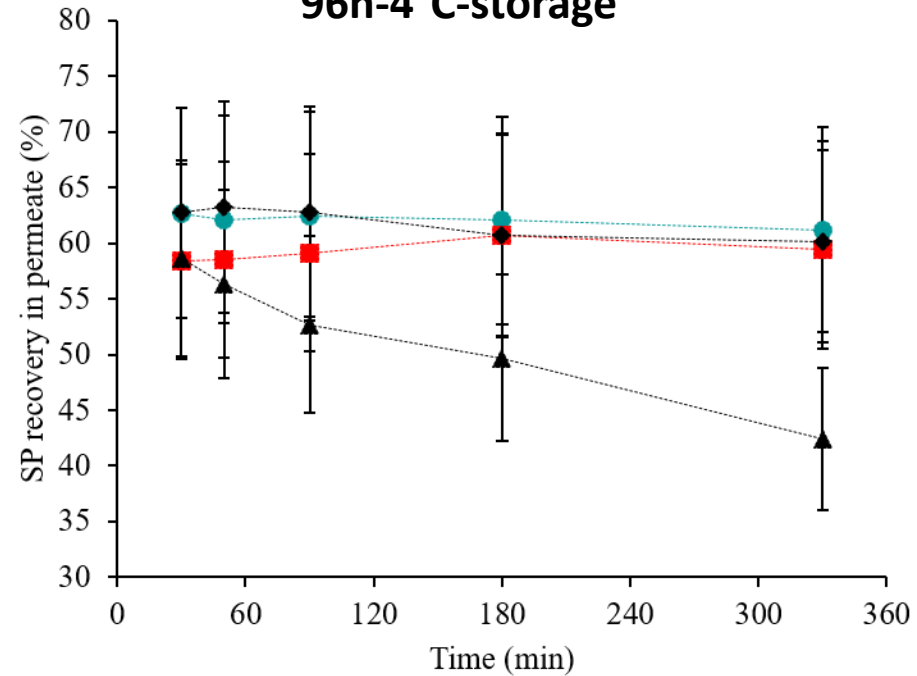
# SP recovery during 0.1 $\mu$ m-MF

- 1.4 $\mu$ m-microfiltrated SM
- Thermized SM
- ▲ Pasteurized SM 1
- ◆ Pasteurized SM 2

### 48h-4°C-storage



### 96h-4°C-storage

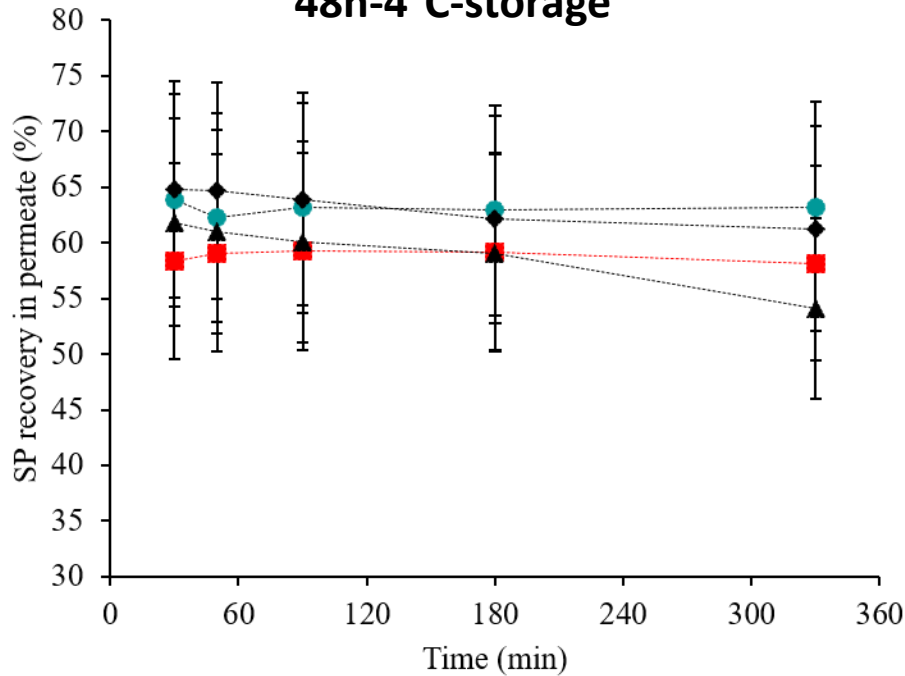


- 1.4-MF SM & thermized SM:
  - SP recovery in permeate is stable during MF regardless of the cold-storage duration
- Pasteurized SM :
  - SP recovery in permeate declines over the time of operation
  - decline of SP recovery is all the higher than the cold-storage of raw milk is long

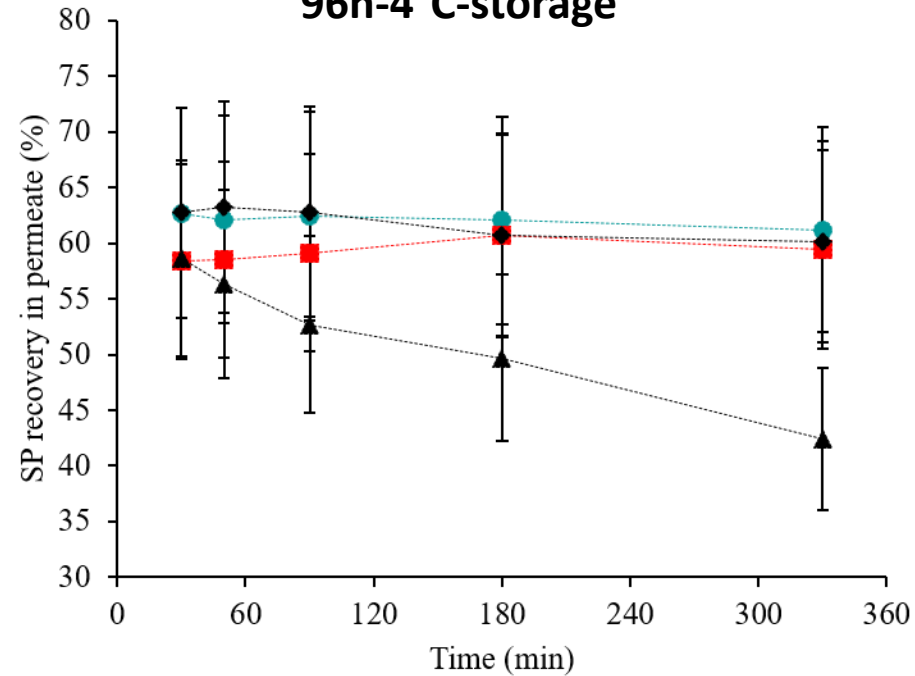
# SP recovery during 0.1 $\mu$ m-MF

- 1.4 $\mu$ m-microfiltrated SM
- Thermized SM
- ▲ Pasteurized SM 1
- ◆ Pasteurized SM 2

### 48h-4°C-storage



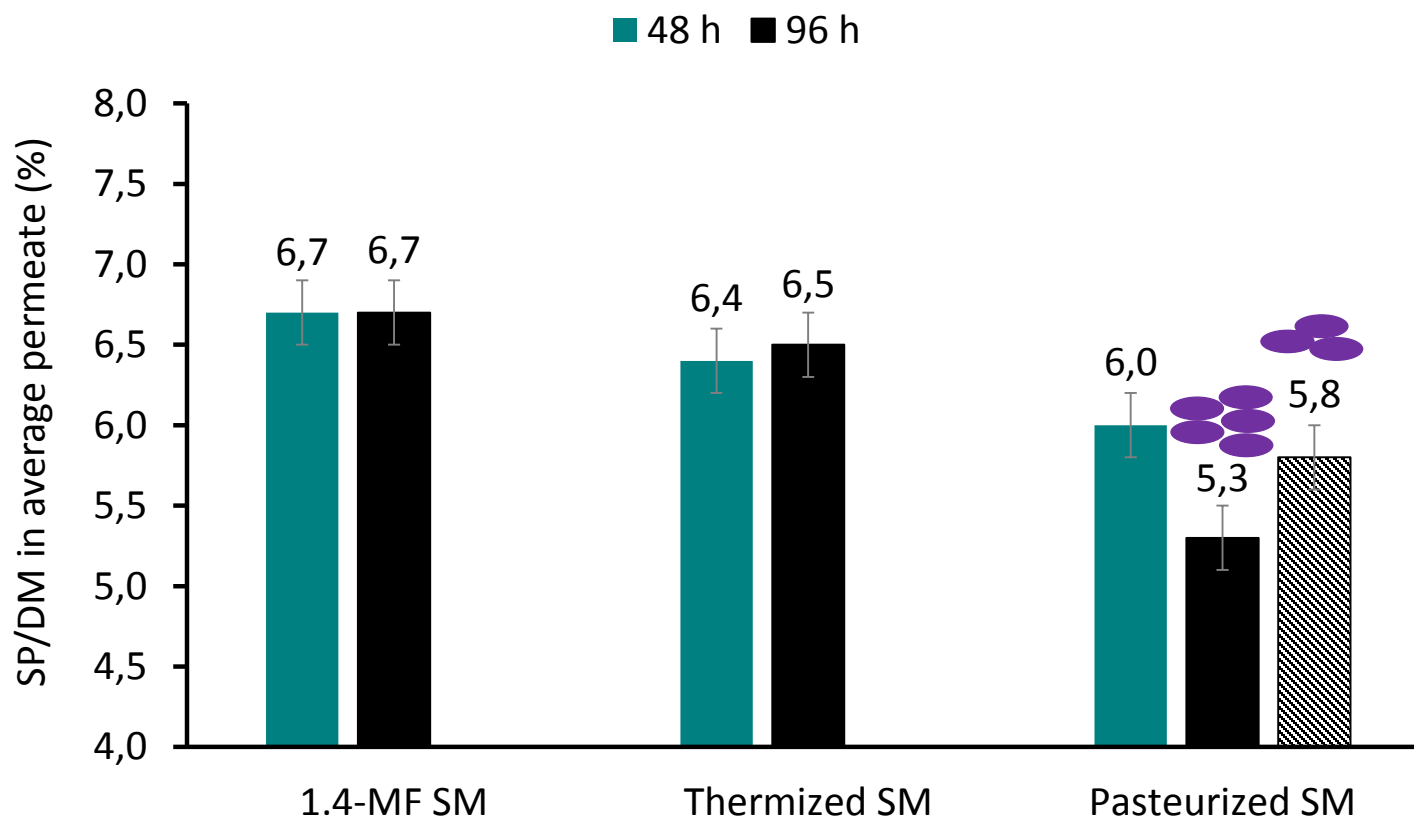
### 96h-4°C-storage



## Assumptions:

denaturation of serum proteins and modifications of interactions between proteins participate in the deposit layer and add up to the fouling effect of bacteria

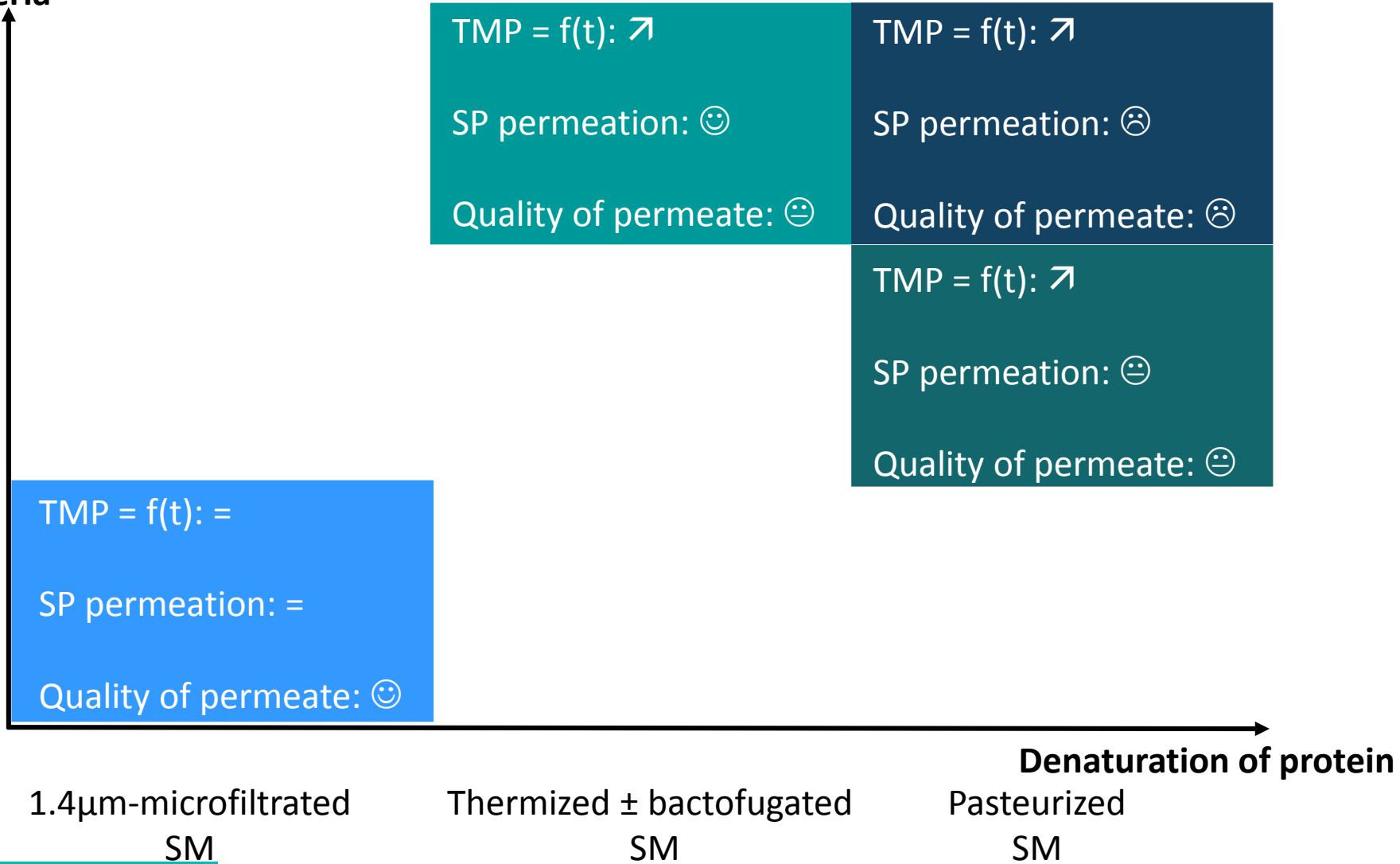
# Quality & value of average permeate



- 1.4 $\mu$ m-MF SM: high SP/DM in permeate regardless of the milk-storage duration
- Thermized SM: intermediate SP/DM in permeate regardless of the milk-storage duration
- Pasteurized SM:
  - low SP/DM in permeate
  - SP/DM even lower than initial psychrotrophic bacteria count in milk is high

# Summary of 0.1μm-MF performances

Bacteria





# Take home messages

- Skimmed milk thermal history (storage duration and heat treatment) has an impact on 0.1 $\mu$ m-MF performances
- Effects of milk modifications induced by thermal history before 0.1 $\mu$ m-MF are cumulative
- Pre-processing by 1.4 $\mu$ m-MF results in good performances of 0.1 $\mu$ m-MF and high recovery of SP in permeate regardless of the milk-storage duration
- If heat-treatment is unavoidable, thermization had to be favored to insure satisfactory serum proteins recovery in permeate



***THANK YOU FOR  
YOUR ATTENTION***

