Membrane processes in the food industry

From dairy to egg processing

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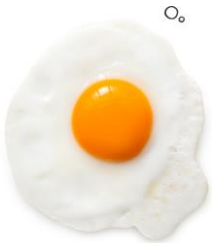
Overview

- Introdoction
- Dairy applications
- Fruit juice processing
- Egg processing
- Fouling and cleaning challenge
- Outlook and conclusions





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Membranes in the food industry

Why???

Key advantages of membranes:

- Gentle product treatment due to moderate temperature changes during processing
- High selectivity based on unique separation mechanism e.g. sieving, solution-diffusion or ion-exchange mechanism
- Compact and modular design for ease of installation and extension
- Low energy consumption compared to condensers and evaporators.

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Membranes in the food industry

A little history…..

Research on membrane applications for the food industry started at the beginning of the 1970ies.

The break-through of membrane technology was the demineralisation of whey for the dairy industry.

Since, then membranes have developed themselves to the key separation technology in the food industry.

One of the latest development: Membrane Bioreactors (MBRs) to treat food industry effluents.

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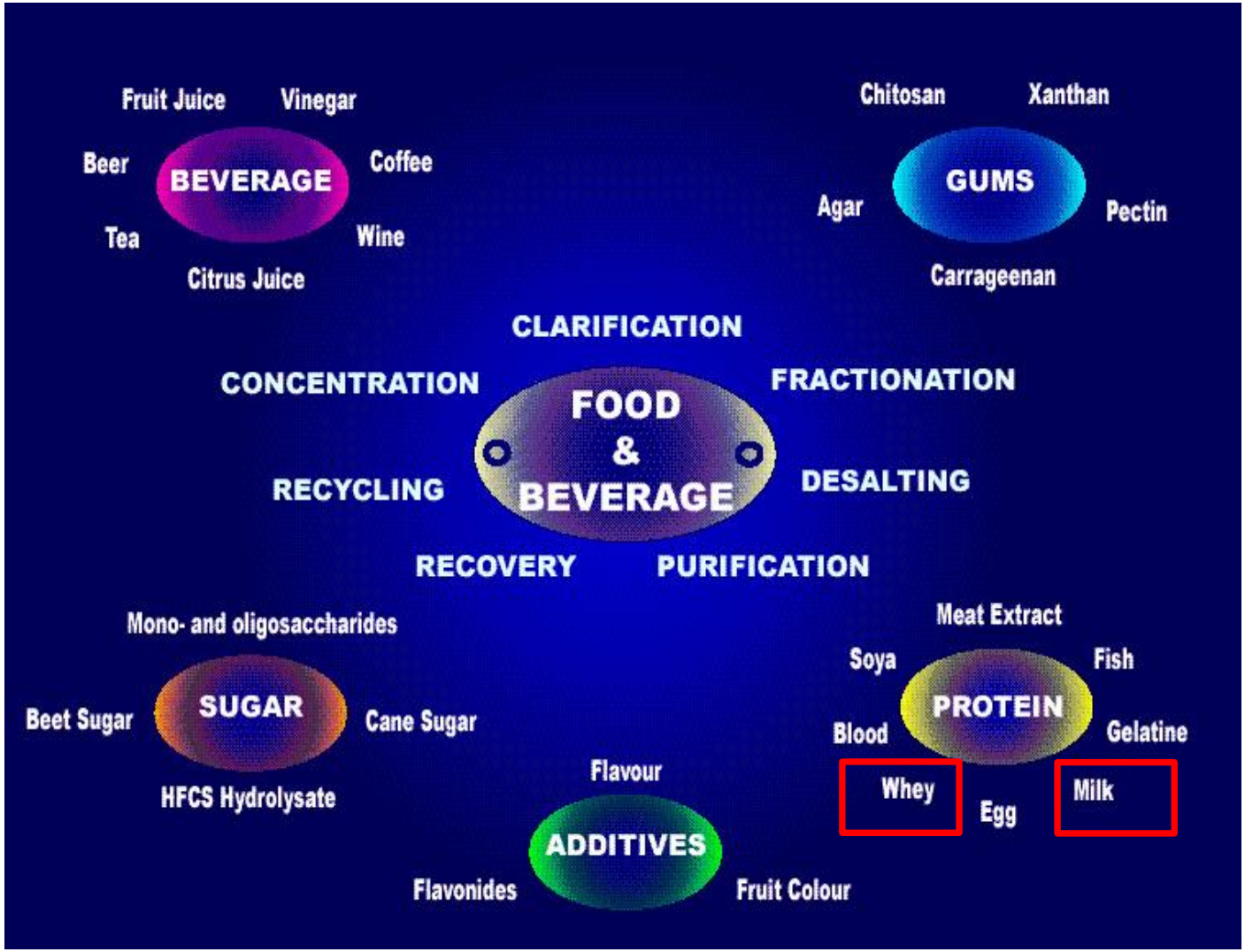
Membrane processes – Overview

Dairy



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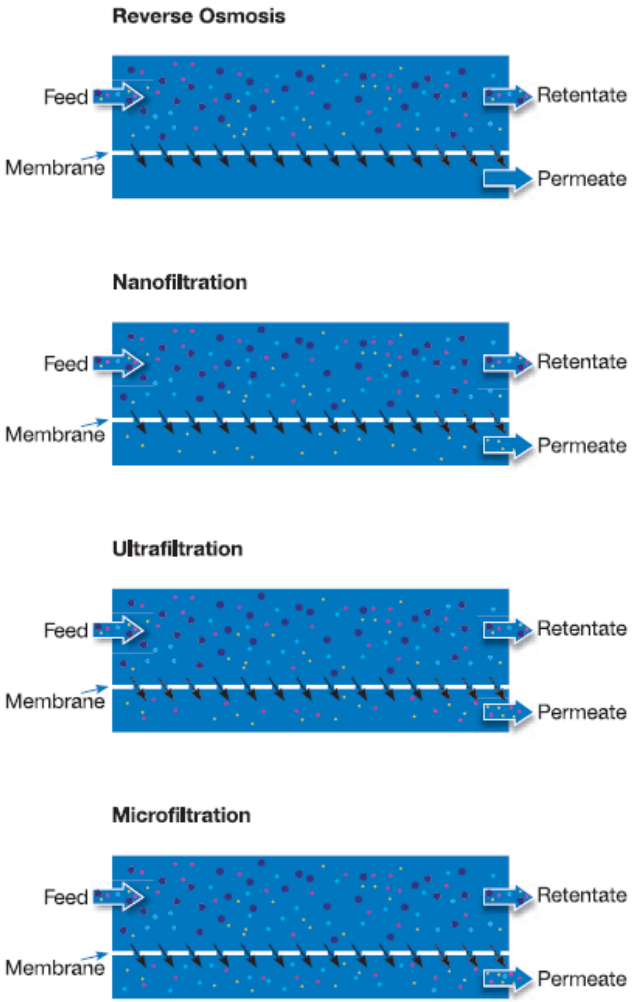
Dairy applications

Membrane processes

- Bacteria and spore removal
  - Microfiltration (MF)
- Concentration/Fractioning
  - Reverse osmosis (RO)
  - Nanofiltration (NF)
  - Ultrafiltration (UF)
- Purification
  - Diafiltration (DF)



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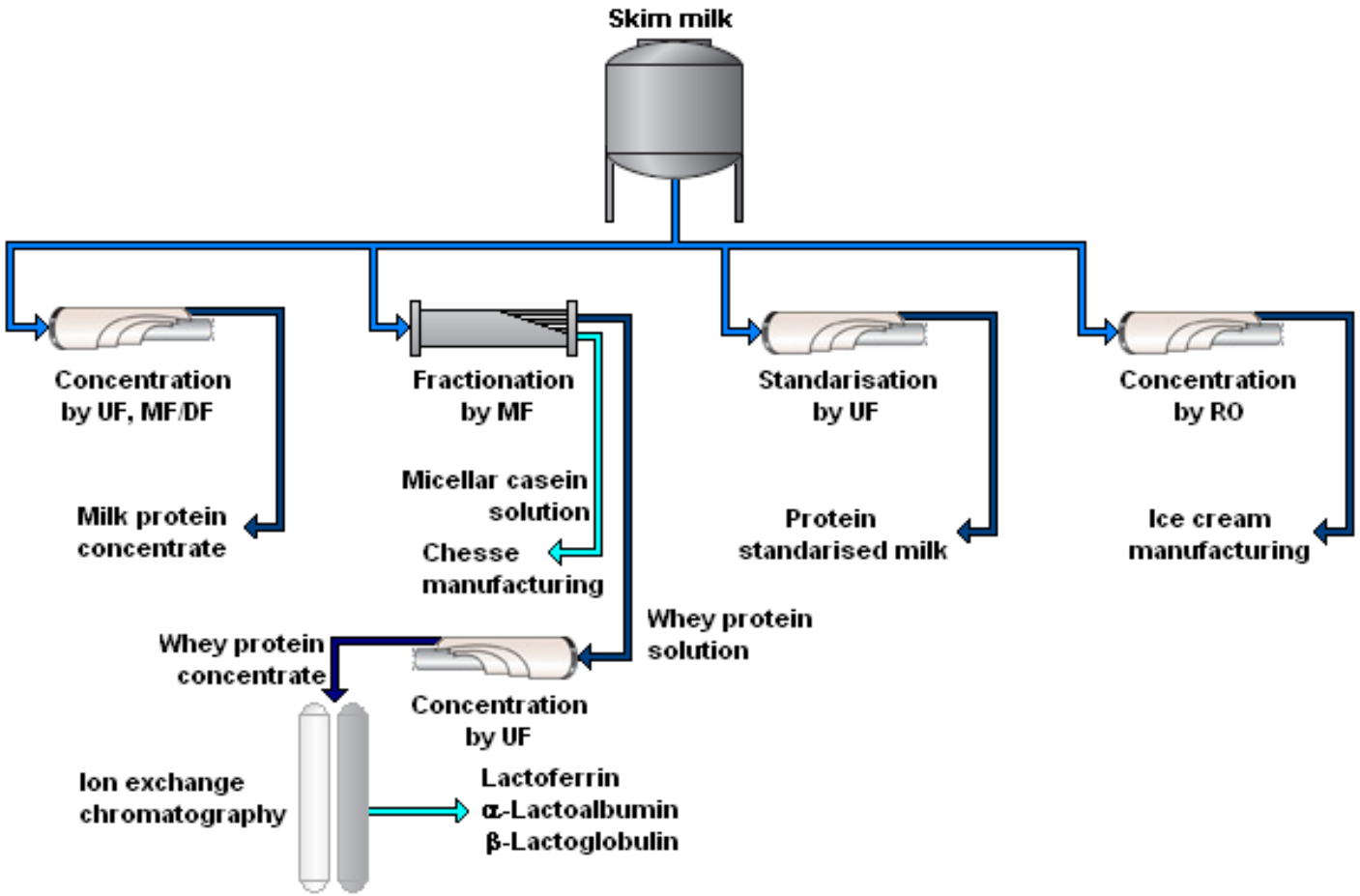
Dairy applications

Membrane processes for milk processing



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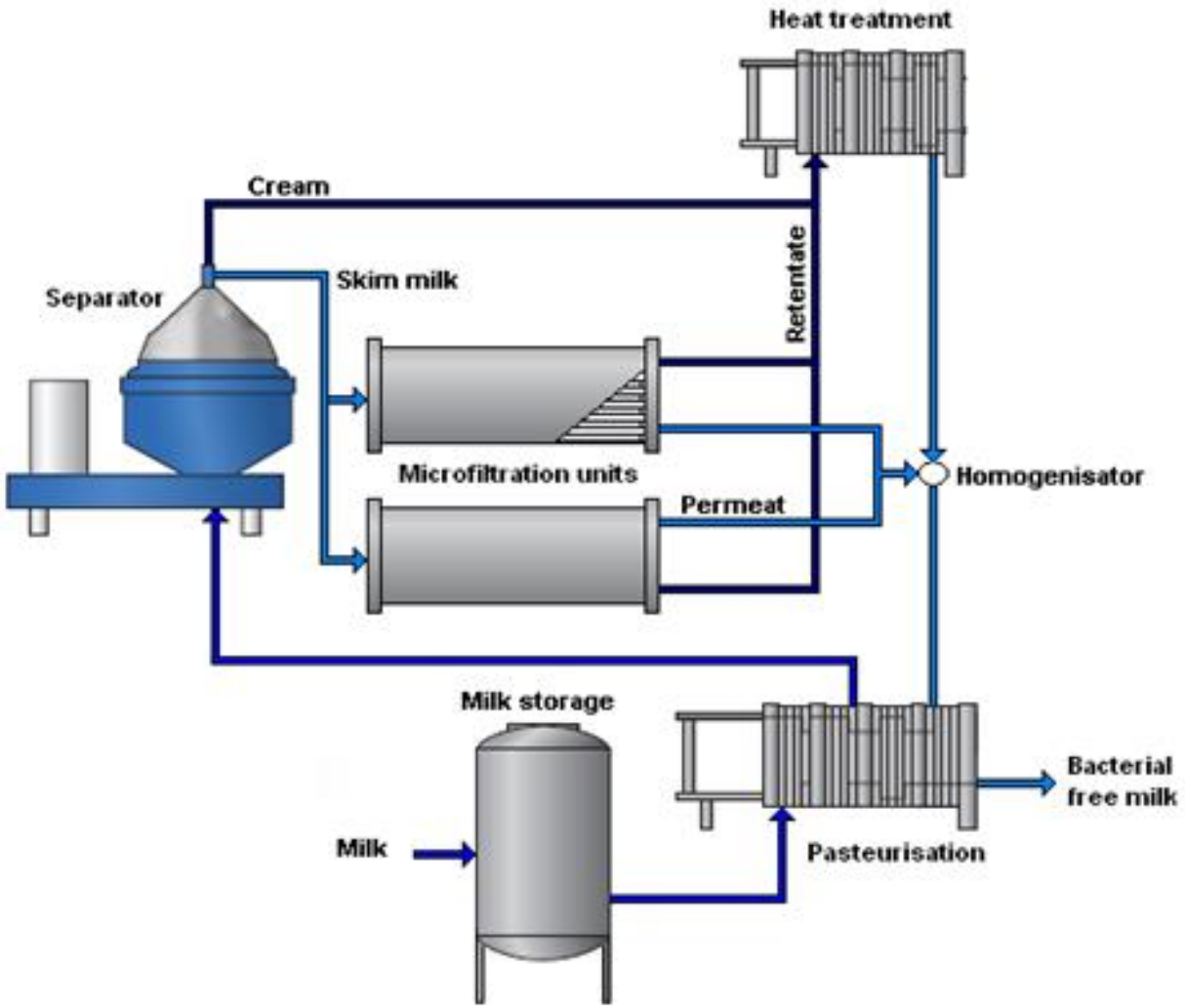
Dairy applications

Bacteria and spore removal from milk – Process overview



Dairy applications

Bacteria and spore removal from milk – Process details

- Extended shelf life (ESL) and improved product quality.
- Minimised product losses.
- High temperature treatment for cream and retentate, only.
- For premium products the retentate not blended with the cream and handled as secondary product.

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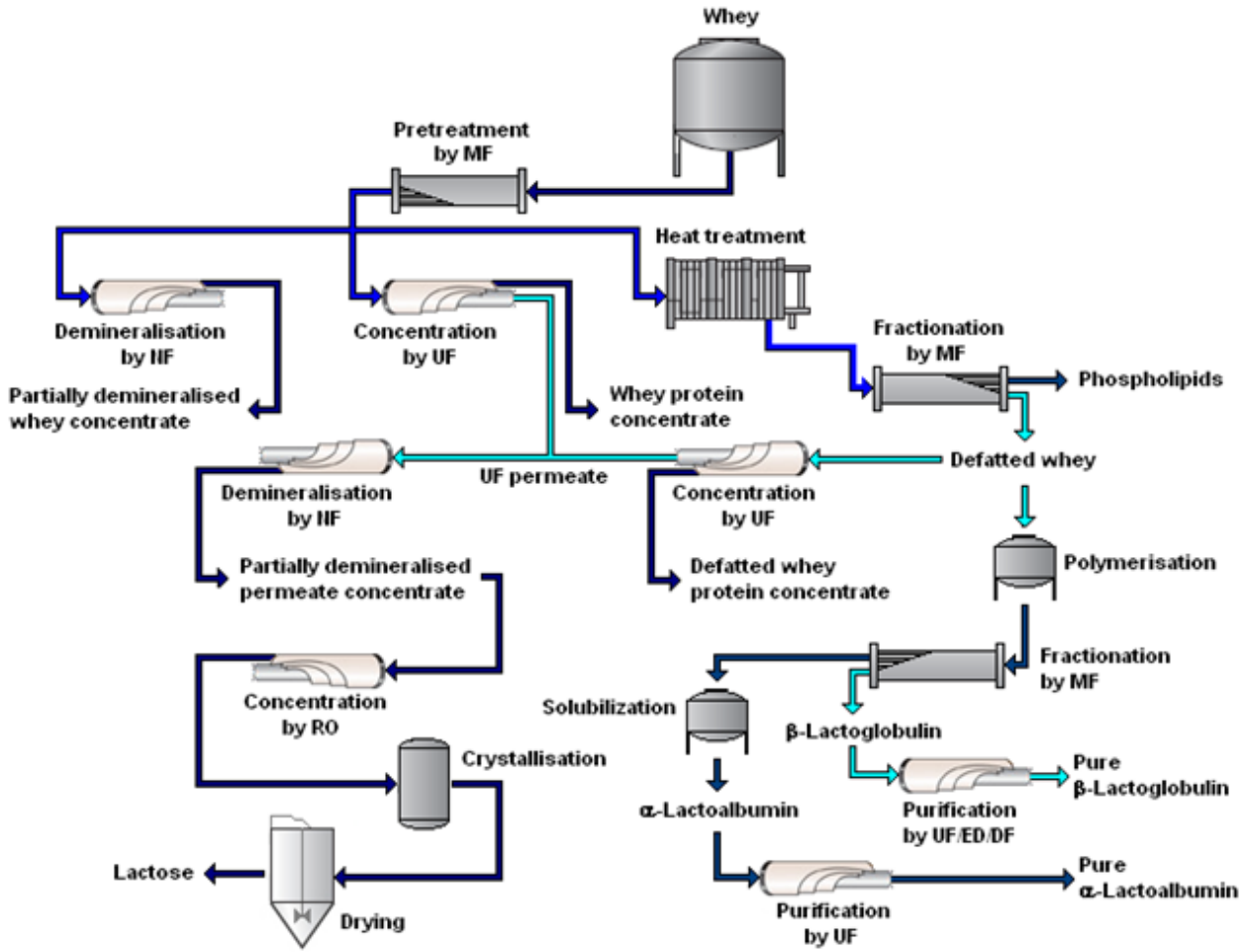
Dairy applictions

Applications for whey processing



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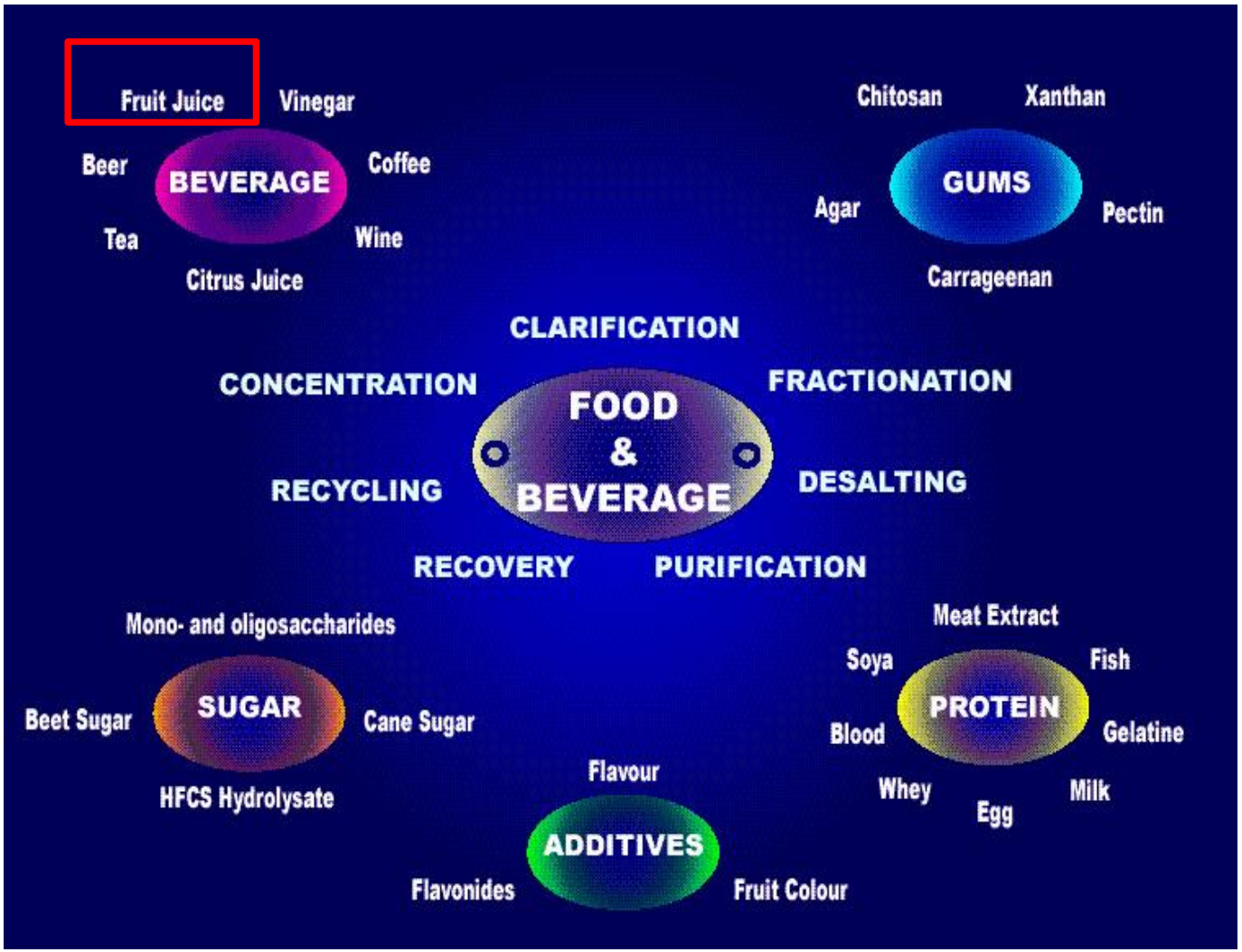
Membrane processes – Overview

Fruit juice



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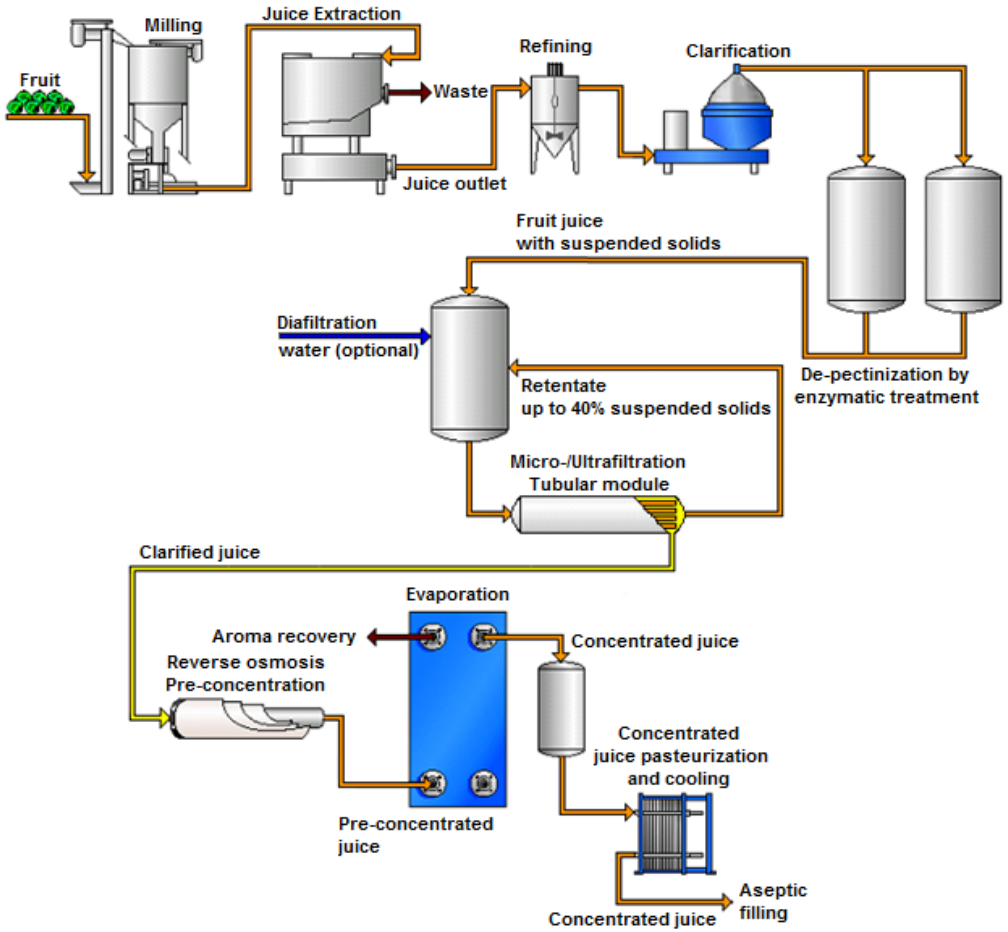
Fruit juice processing

Membrane processes for fruit juice



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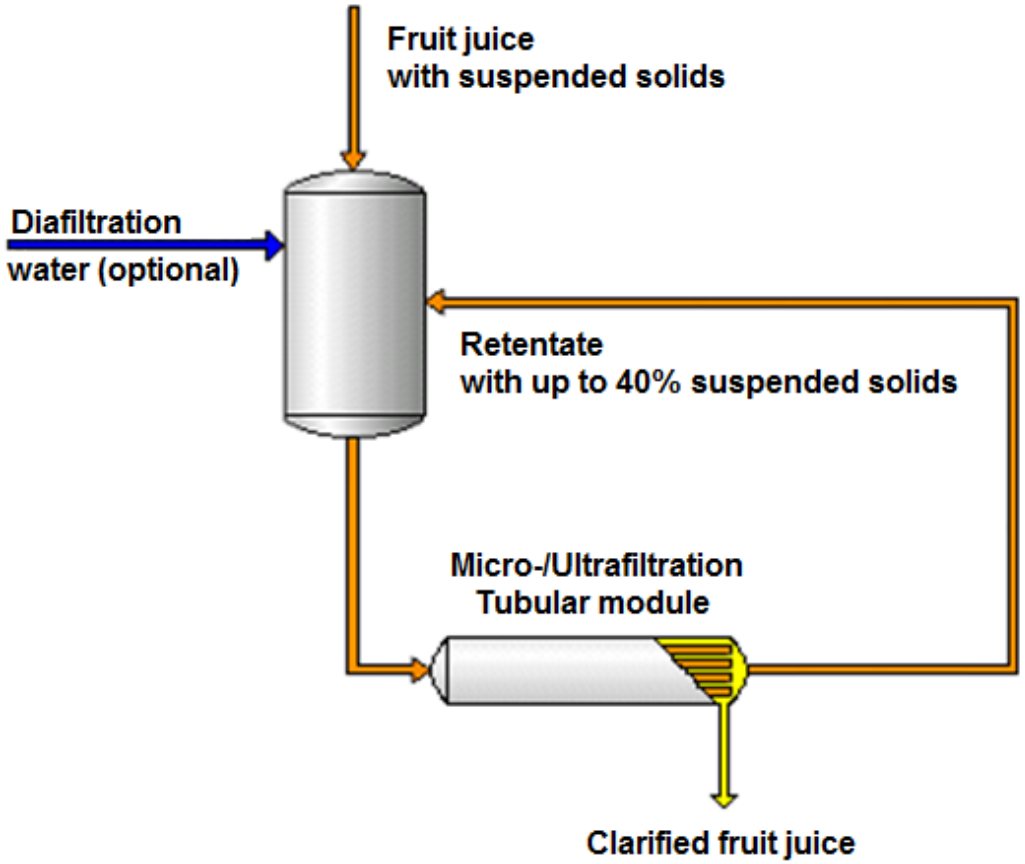
Fruit juice processing

Fruit juice clarification – Process overview



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Fruit juice processing

Fruit juice clarification – Process details

- High quality juice with respect to colour, taste and clarity.
- Elimination of bentonite, gelatine, and kieselguhr.
- Higher efficiency compared to dead-end filtration regarding product quality.
- Reduced number of production steps.

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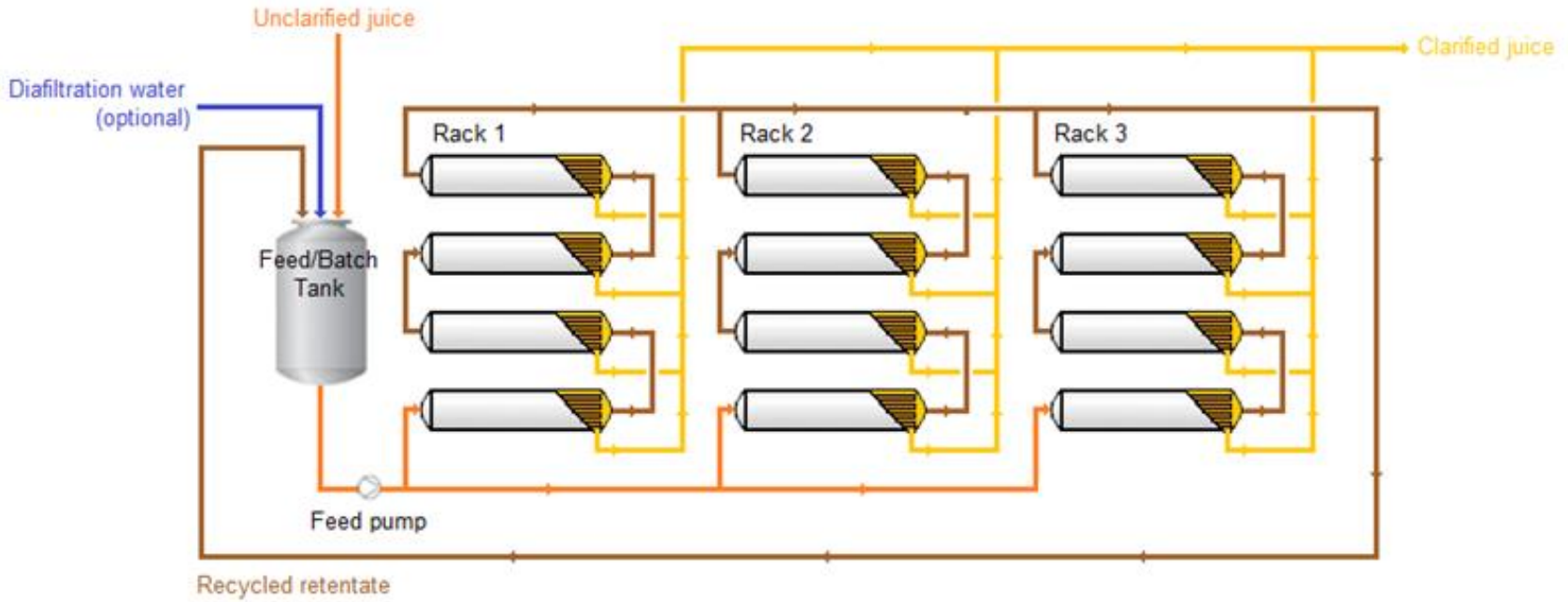
Fruit juice processing

Fruit juice clarification – Process layout



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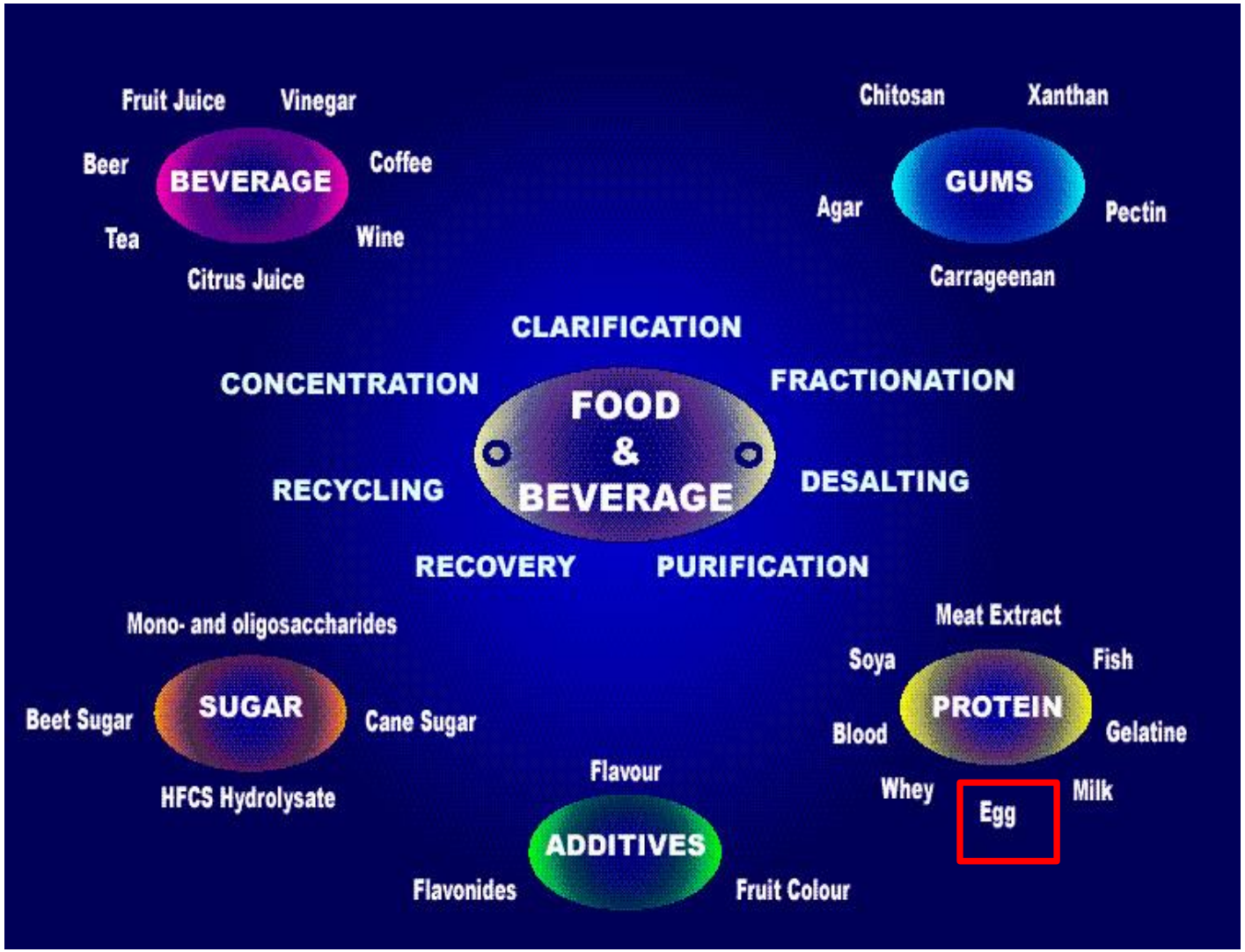
Membrane processes – Overview

Egg



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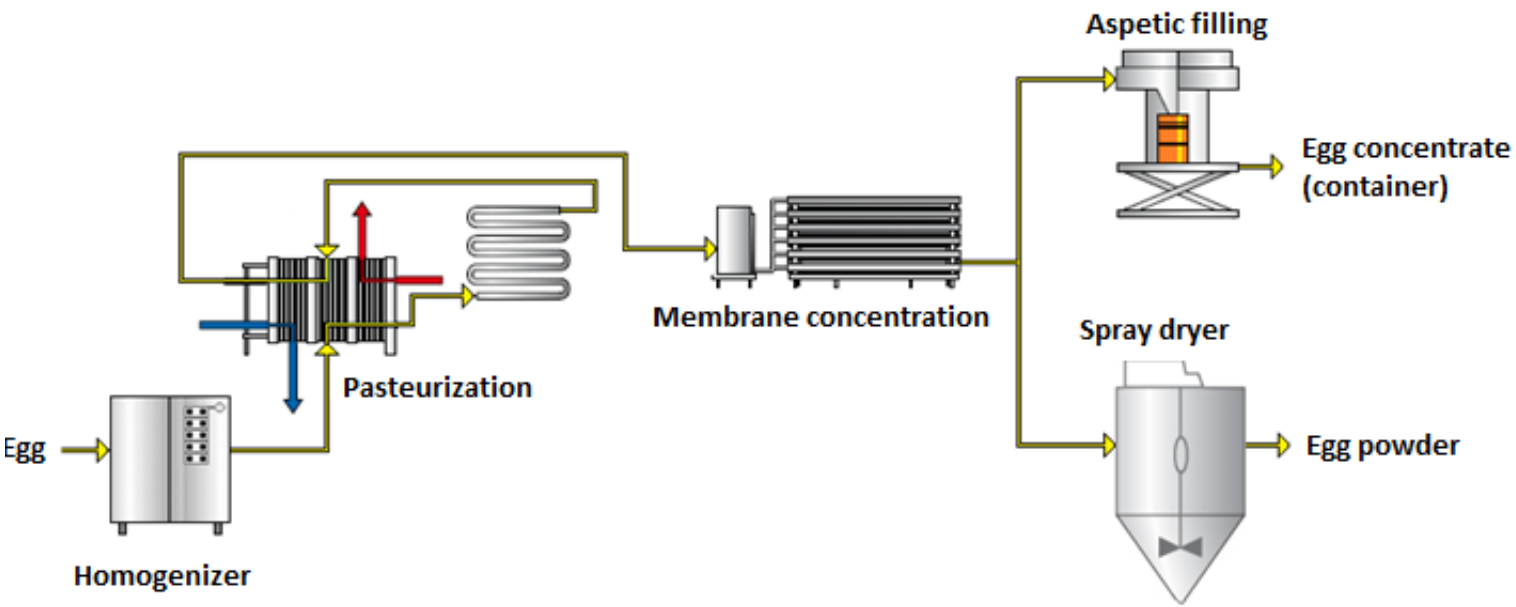
Egg processing

Membrane processes for egg processing



- Whole egg concentration (UF)
- Egg white concentration (UF/RO)

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Egg processing

Egg white concentration – Process details

- High product quality due to gentle operating temperature
- Low investment compared to spray drying
- Lower energy consumption than spray drying
- Easy expansion of capacity
- Concentration and purification in one unit operation
- Sanitary design
- Continuous, batch or semibatch operation

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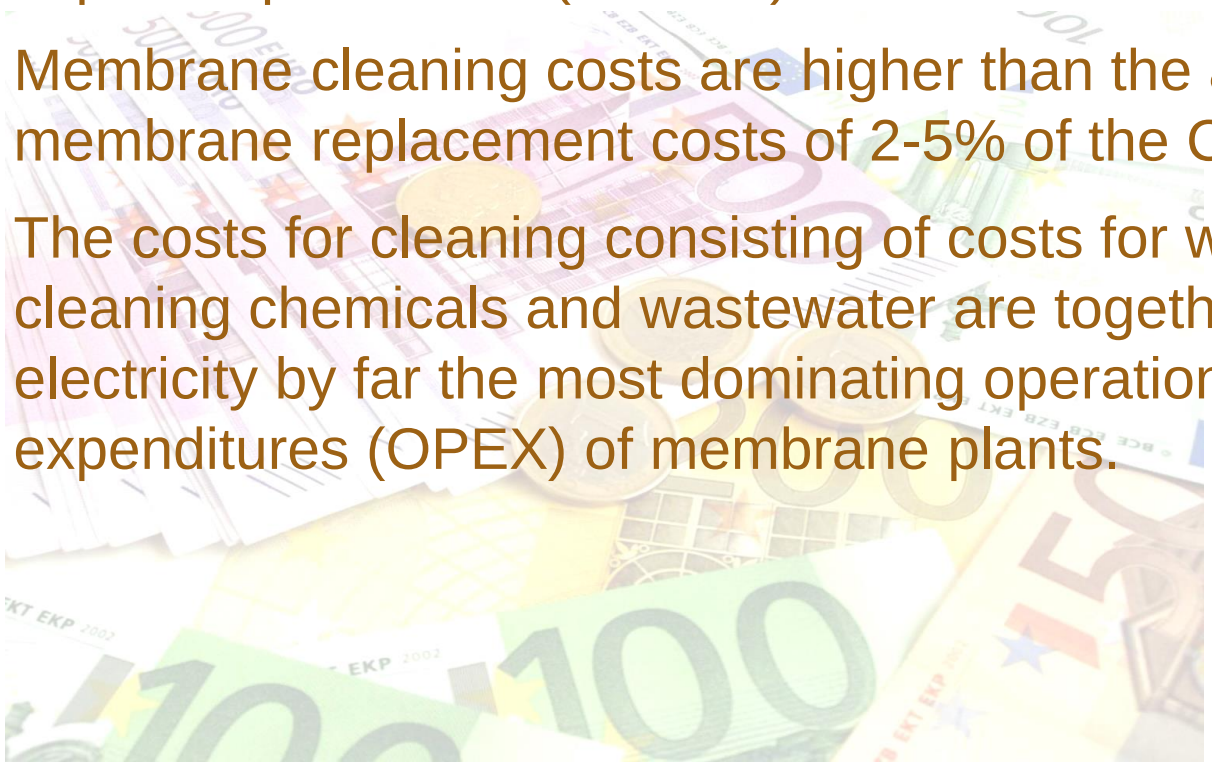
Fouling and cleaning challenges

Some financial highlights

- In the food industry with one cleaning cycle per day, the annual costs of membrane cleaning is typically 5-20% of capital expenditures (CAPEX).
- Membrane cleaning costs are higher than the annual membrane replacement costs of 2-5% of the CAPEX.
- The costs for cleaning consisting of costs for water, cleaning chemicals and wastewater are together with electricity by far the most dominating operation expenditures (OPEX) of membrane plants.



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Fouling and cleaning challenges

Split-up of cleaning costs

Cleaning costs = Cleaning frequency x

(Cleaning costs + Rinsing costs + Wastewater costs)

- Cleaning agent concentration
- Costs of cleaning agents
- Volume of cleaning solution
- Water quality
- Price of water
- Volume of rinsing water

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Fouling and cleaning challenges

Cleaning frequency and costs

The cleaning frequnecy is a trade-off between CAPEX and OPEX

Higher cleaning frequency:

+ higher design flux → smaller plant
  → lower CAPEX
- higher cost of cleaning and shorter membrane liftetime → higher OPEX

Rule of thumb: Each additional cleaning reduces membrane life cycle by 20 – 30%.

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Fouling and cleaning challenges

Cleaning frequency and impact on plant operation

- **Higher cleaning frequency:**

  → greater loss of productivity due to the downtime during cleaning

- **Too high drop of flux before cleaning:**

  → irreversible fouling may occur and frequent membrane replacement will be needed

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Fouling and cleaning challenges

Ways to optimise cleaning

Optimizing cleaning can reduce OPEX and CAPEX

Consideration:

- ❑ Select suitable cleaning agents
- ❑ Optimize concentration and temperature
- ❑ Modify duration of cleaning*
- ❑ Adjust cleaning frequency

*** Typical times:**
Cleaning: 30-60 min
Rinsing: 10-20 min

Example:

For animal blood plasma 2 x 2 h cleaning per day instead of 1 x 4 h increased daily plant capacity by approx. 20%.

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Outlook and conclusions

- Membrane processes are well-established in the food industry.
- Key membrane processes for the food industry are: Microfiltration, ultrafiltration, nanofiltration and reverse osmosis.
- New membrane process will establish themselves e.g.
  - Pervaporation (alcohol removal and aroma recovery)
  - Electrodialysis (tartaric stabilisation and whey demineralisation)
  - Membrane contactors (bubble-free carbonation of soft-drinks, juice concentration, alcohol removal)

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Outlook and conclusions

- Key membrane applications in the food industry range from dairy to beverages and food proteins.
- New key application areas under development e.g.:
  - Plant protein recovery (rape seed and quinoa)
  - Wastewater treatment and water recycling
- Fouling and cleaning are key challenges for membranes in the food industry.
- Other key challenges e.g.:
  - Process integration
  - Energy-efficient scale-up

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The future looks bright !!!!

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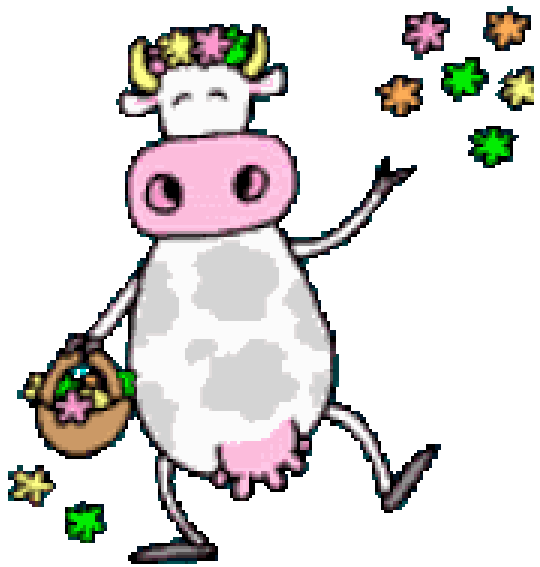
Thank you for your attention



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