CONCENTRATION OF AROMA AND VITAMIN RICH FRUIT JUICES BY COMPLEX MEMBRANE TECHNOLOGY

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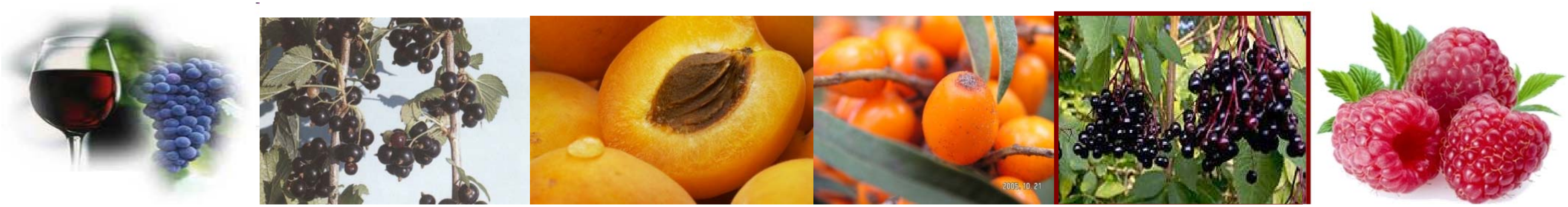
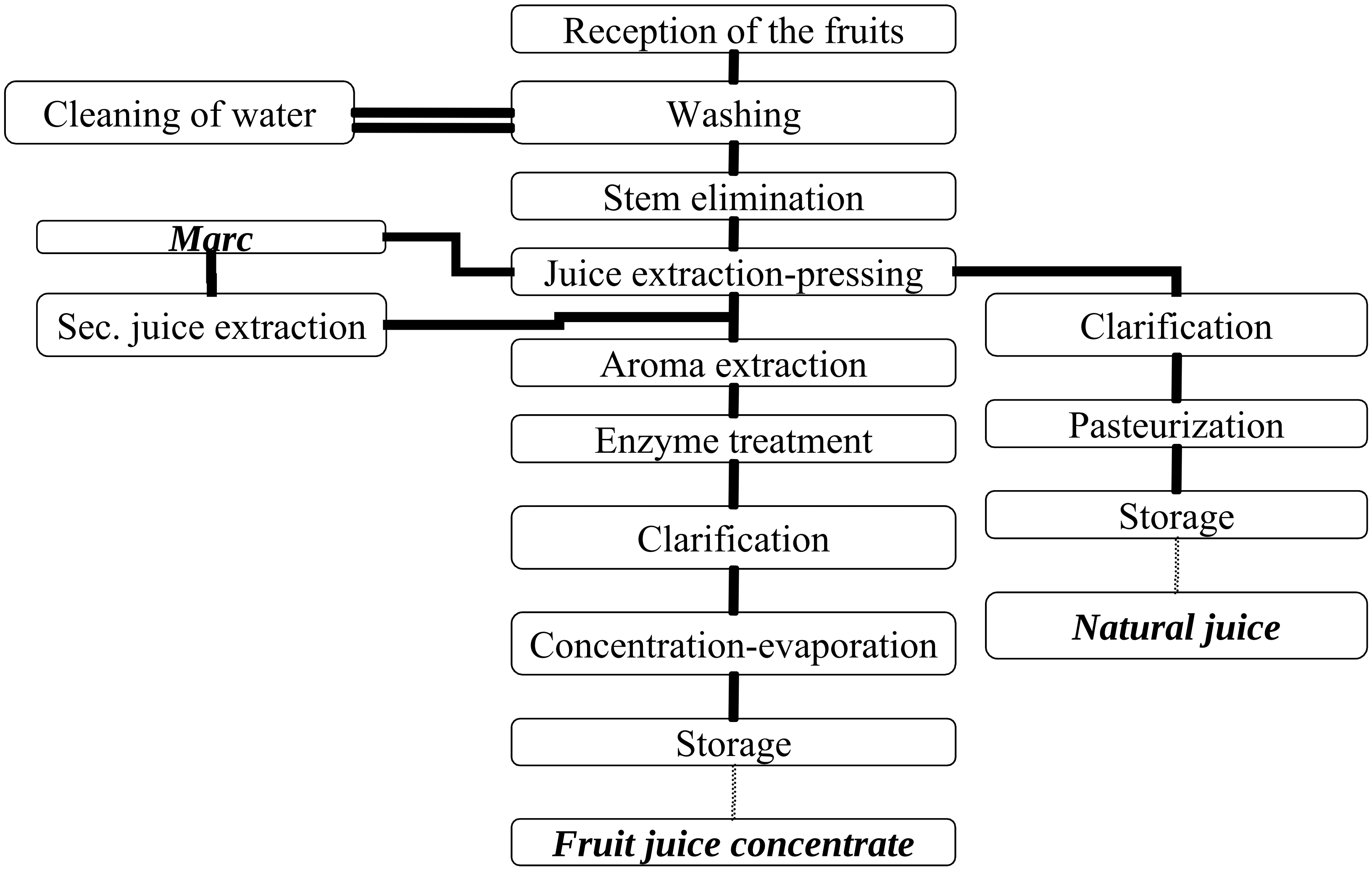
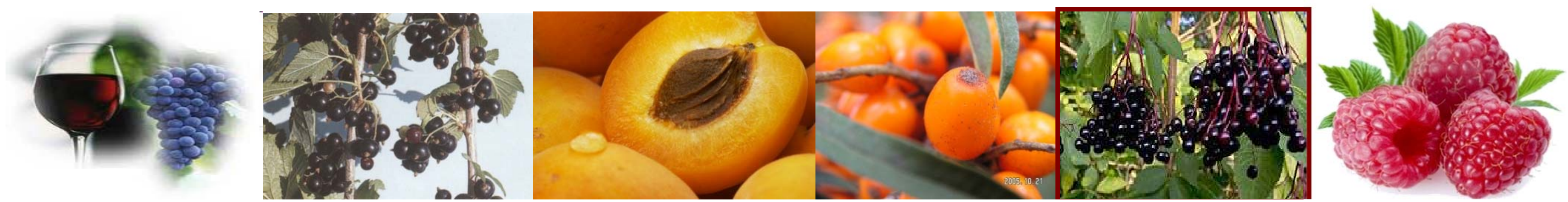
BUDAPESTI CORVINUS EGYETEM
Faculty of Food Science




Reception of the fruits
Cleaning of water
Washing
Stem elimination
Marc
Juice extraction-pressing
Sec. juice extraction
Aroma extraction
Enzyme treatment
Clarification
Concentration-evaporation
Storage
Fruit juice concentrate
Clarification
Pasteurization
Storage
Natural juice



Application of membrane separation processes in fruit juice concentration

Key factors of conventional evaporation and membrane concentration techniques (Jiao, Cassano, Drioli, 2004)

Process	Maximum achievable concentration (Brix)	Product quality	Evaporation rate or flux	Operating cost	Capital investment	Energy consumption	Maturity of technology
Evaporation	80	Very poor	200–300 l/h	Moderate	Moderate	Very high	Developed
Reverse osmosis	25–30	Very good	5–10 l/m2 h	High	High	High	Developed
Direct osmosis	50	Good	1–5 l/m2 h	High	High	Low	Developing
Membrane distillation	60–70	Good	1–10 l/m2 h	High	Moderate	Low	Developing
Osmotic distillation	60–70	Very good	1–3 l/m2 h	High	Moderate	Low	Developing



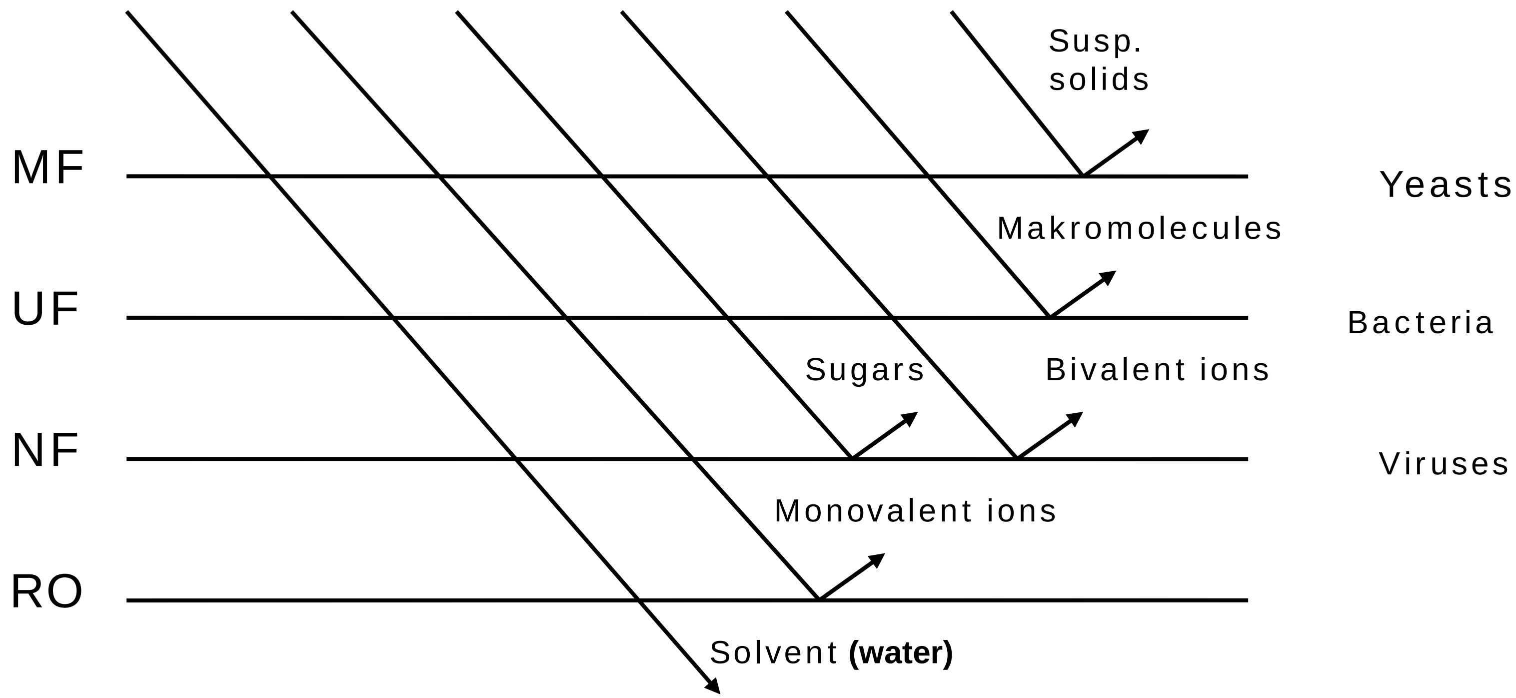



Membrane filtration processes

Process (Abbreviation)	Driving force bar	Mechanism	Membrane type	Dimension of rejected solute
Microfiltration (MF)	**Δp 1 - 3**	**sieving**	**porous**	**100-10000 nm[1)] 0,1 – 10 µm**
Ultrafiltration (UF)	**Δp 3 -10**	**sieving**	**porous**	**10-100 nm[2)]**
Nanofiltration (NF)	**Δp 10-40**	**sieving, ion transport**	**porous, charged**	**1-10 nm[3)]**
Reverse osmosis (RO)	**Δp 20 -80**	**solution-diffusion**	**dense**	**<1 nm[4)]**

Substances to be treated: [1)] dispersed solids; [2)] macromolecules; [3)] ions; [4)] ions, uncharged organic low molecular solutes. Molecular sizes in kDa: MF > 1000, UF = 10-1000, NF = 0,3-1,0, RO = 0,1-0,3.

Membrane filtration

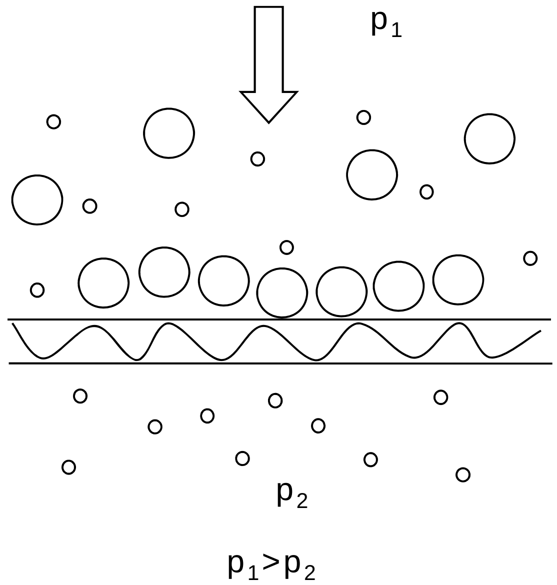


The **(R) rejection/retention** is defined by the concentrations in the permeate (c_P) and in the retentate (c_R):

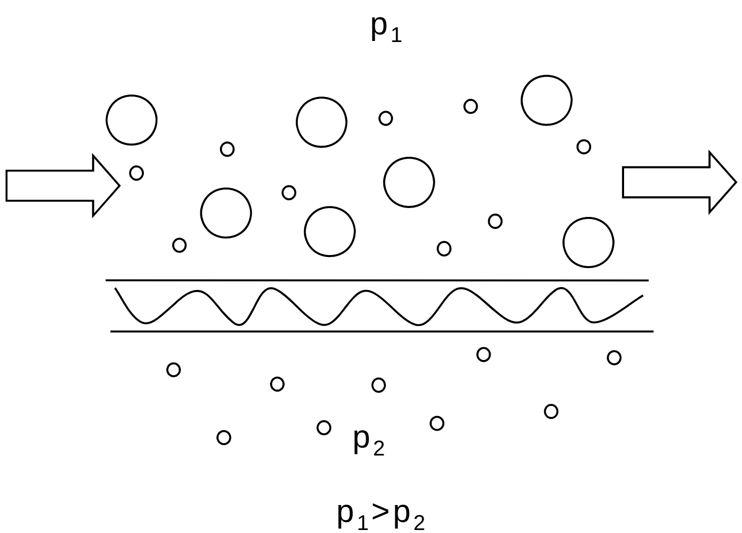
$$R = \frac{c_R - c_P}{c_R} = 1 - \frac{c_P}{c_R}$$

Membrane filtration – operation mode

1, Dead end



2, Cross flow



Principles of Membrane Distillation

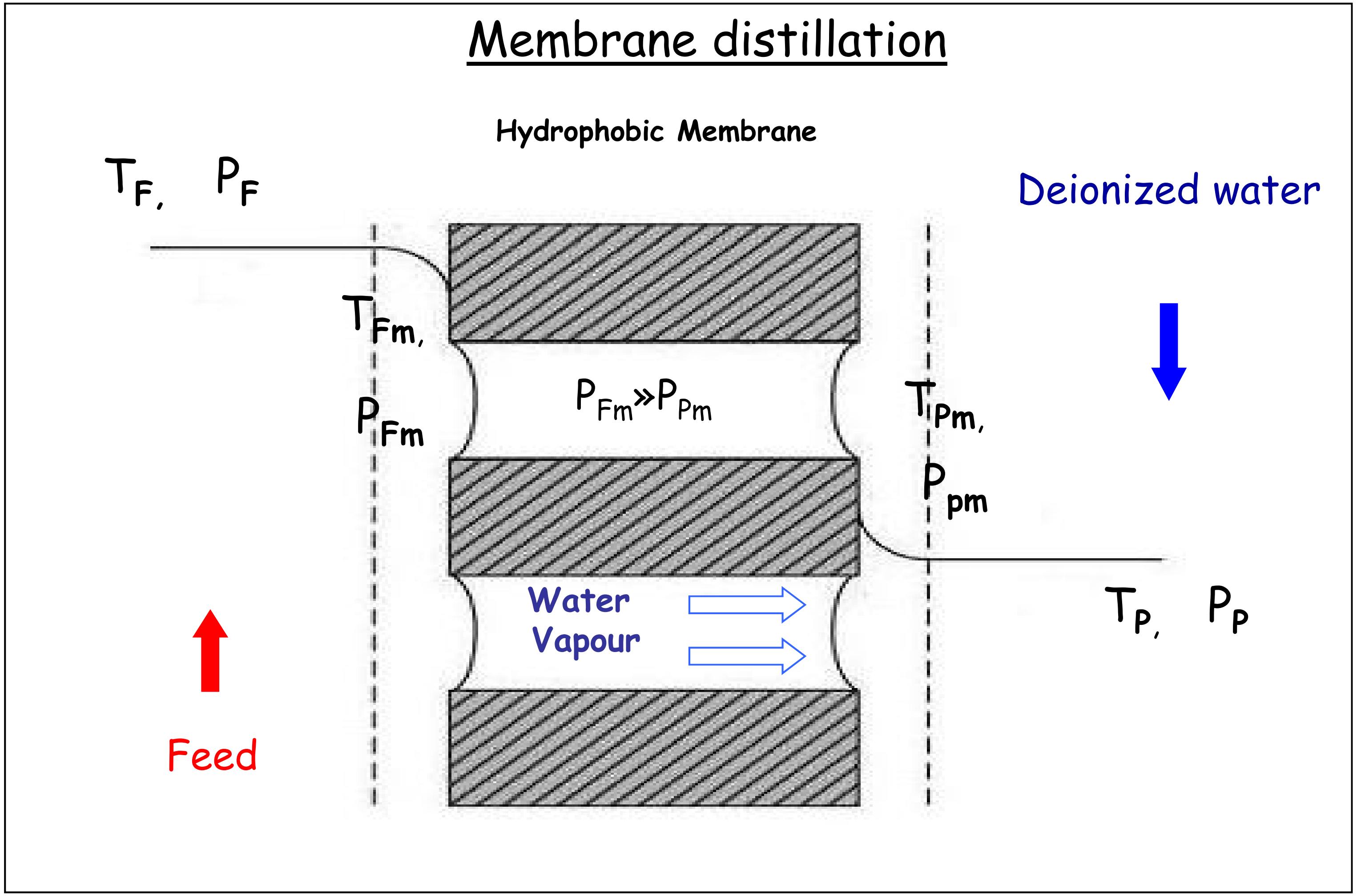


Figure 1. Membrane Distillation

Principles of Osmotic Distillation

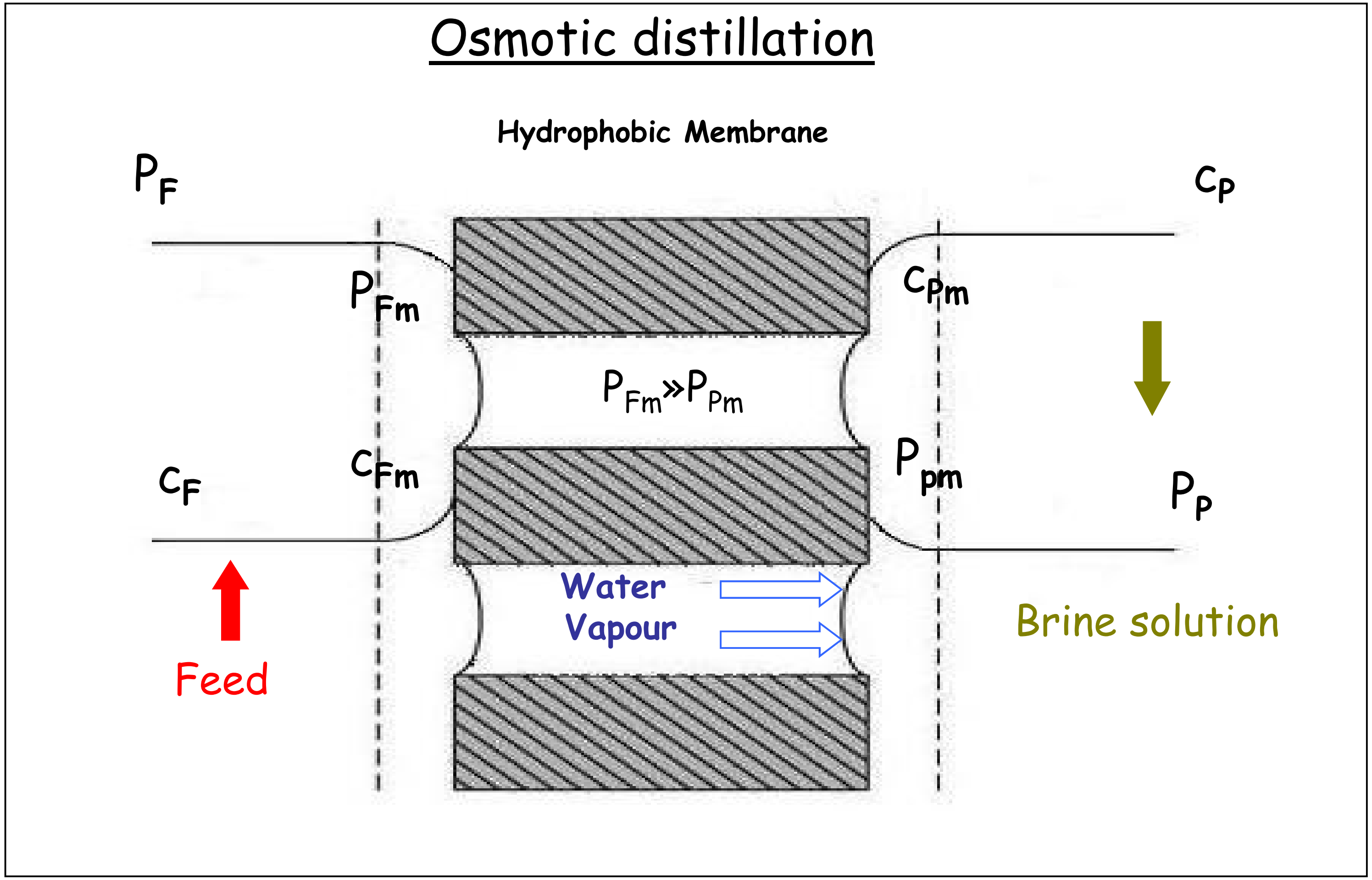
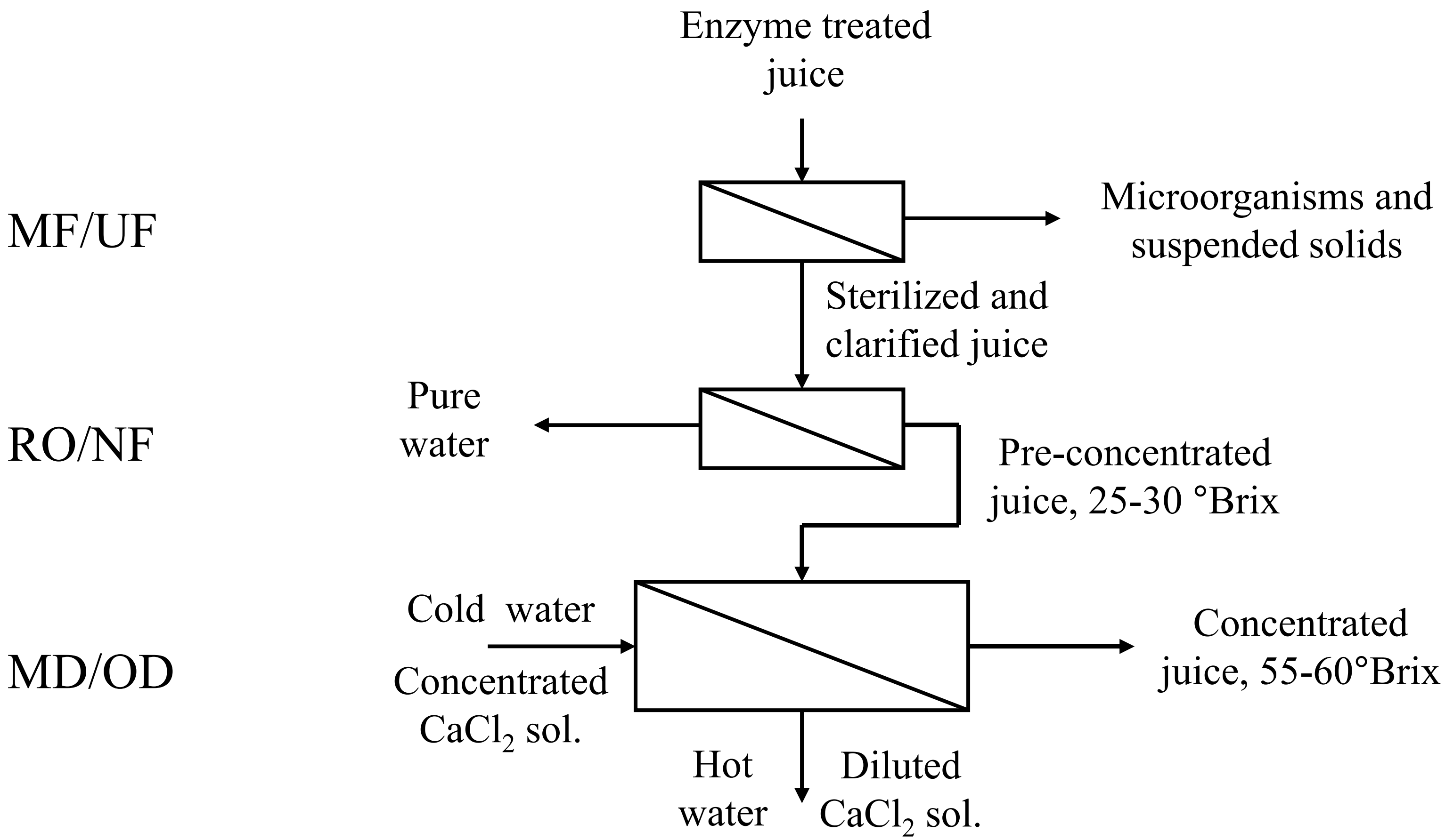
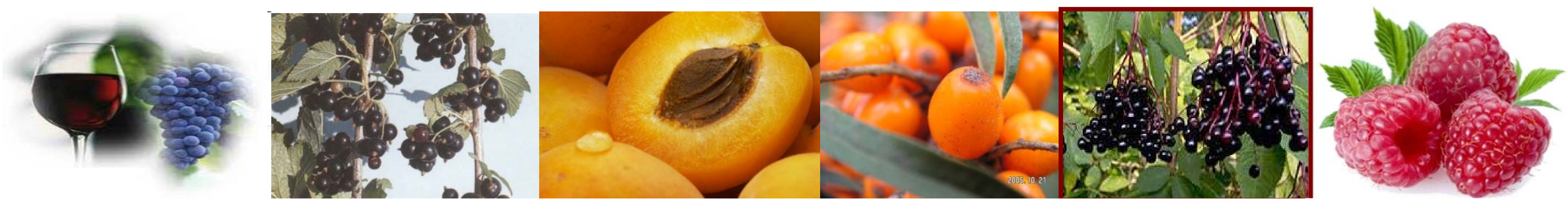


Figure 2. Osmotic Distillation

Multi step concentration of the fruit juices by integrated membrane process





CONCENTRATION OF AROMA AND VITAMIN RICH FRUIT JUICES BY COMPLEX MEMBRANE TECHNOLOGY

- ***Multistep membrane processes for concentration of valuable fruit juices,***

- *Membrane processes depend on fruit*
  - *Parameters*
    - *Temperature*
    - *Pressure*
    - *Flow-rate*

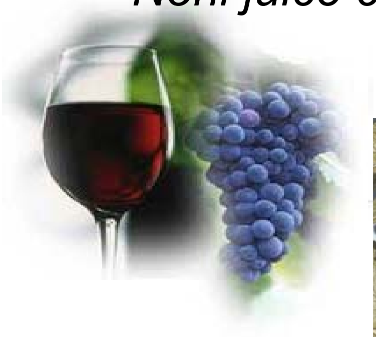
need new experiments with every fruit






CONCENTRATION OF AROMA AND VITAMIN RICH FRUIT JUICES BY COMPLEX MEMBRANE TECHNOLOGY

- *Blood orange juice concentration (Galverna et al, 2008; Cassano et al, 2007)*
- *Kiwifruit juice concentration (Cassano&Drioli, 2007; Cassano et al, 2004; 2006; 2007)*
- *Citrus and carrot juice concentration (Cassano et al, 2003)*
- *Apple and pear juice concentration (Warczok et al, 2004)*
- *Trophical fruit juice concentration (Pereira et al, 2002)*
- *Mosambi juice concentration (Citrus sinensis (L.) Osbeck – Rai et al, 2007)*
- *Passion fruit juice concentration (Vaillant et al, 2001)*
- *Clementine mandarin juice clarification by UF (Cassano et al, 2009)*
- *Cactus pear concentrate production (Mosshammer et al, 2006)*
- *Noni juice concentration by OD (Valdes et al, 2009)*



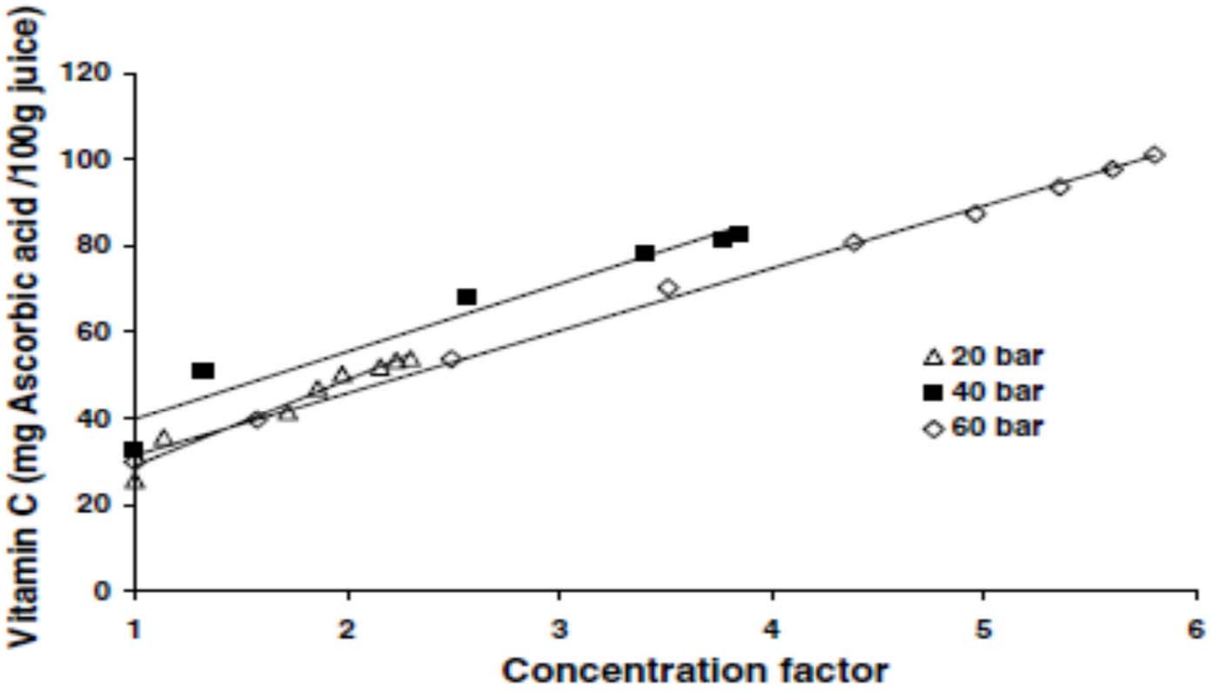


Fig. 5. Vitamin C of orange juice as a function of concentration factor at three transmembrane pressures (batch concentration mode).

D. F. Jesus, M. F. Leite, L. F. M. Silva, R. D. Modesta, V. M. Matta, L. M. C. Cabral: Orange (*Citrus sinensis*) juice concentration by reverse osmosis. J. Food Eng. Vol. 81, 287-291 (2007)

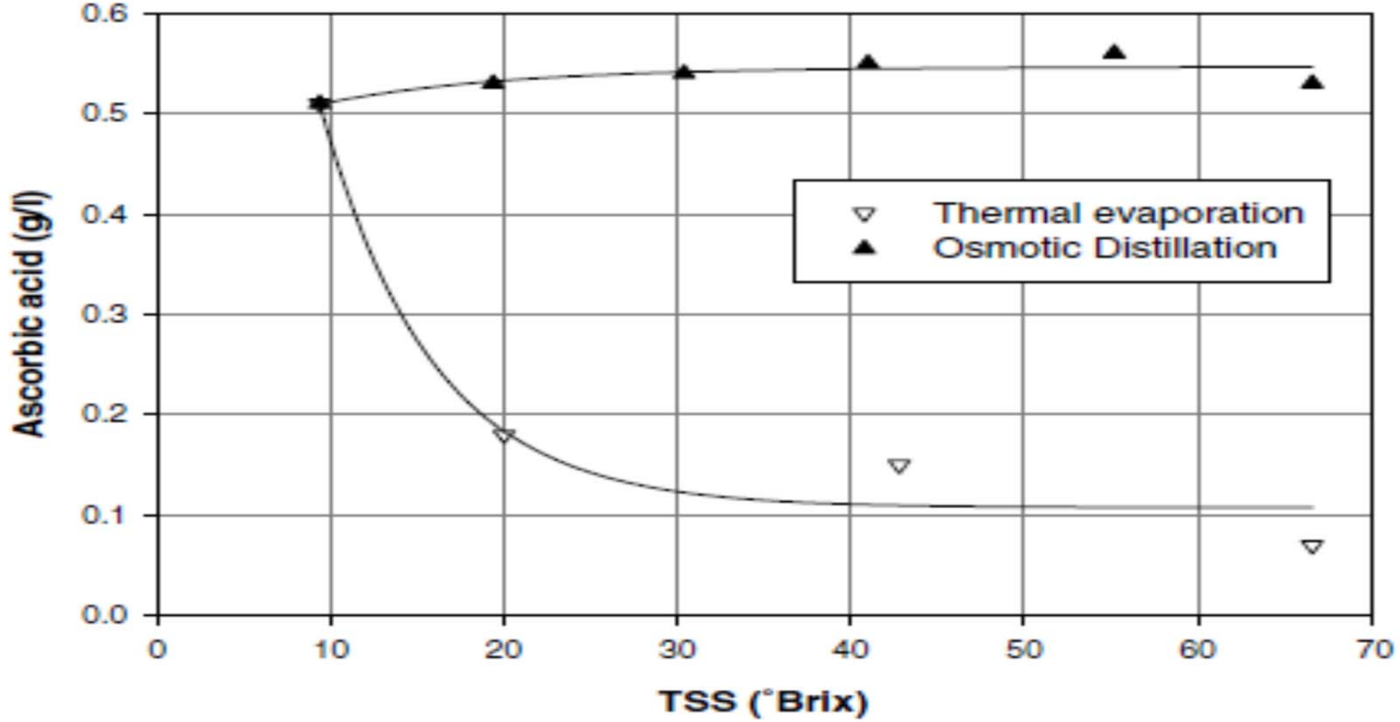


Fig. 4. Relation between ascorbic acid content and TSS in thermal and osmotic evaporation of clarified kiwifruit juice.

A. Cassano, E. Drioli: Concentration of clarified kiwifruit juice by osmotic distillation. J. Food Eng. Vol. 79, 1397-1404 (2007)

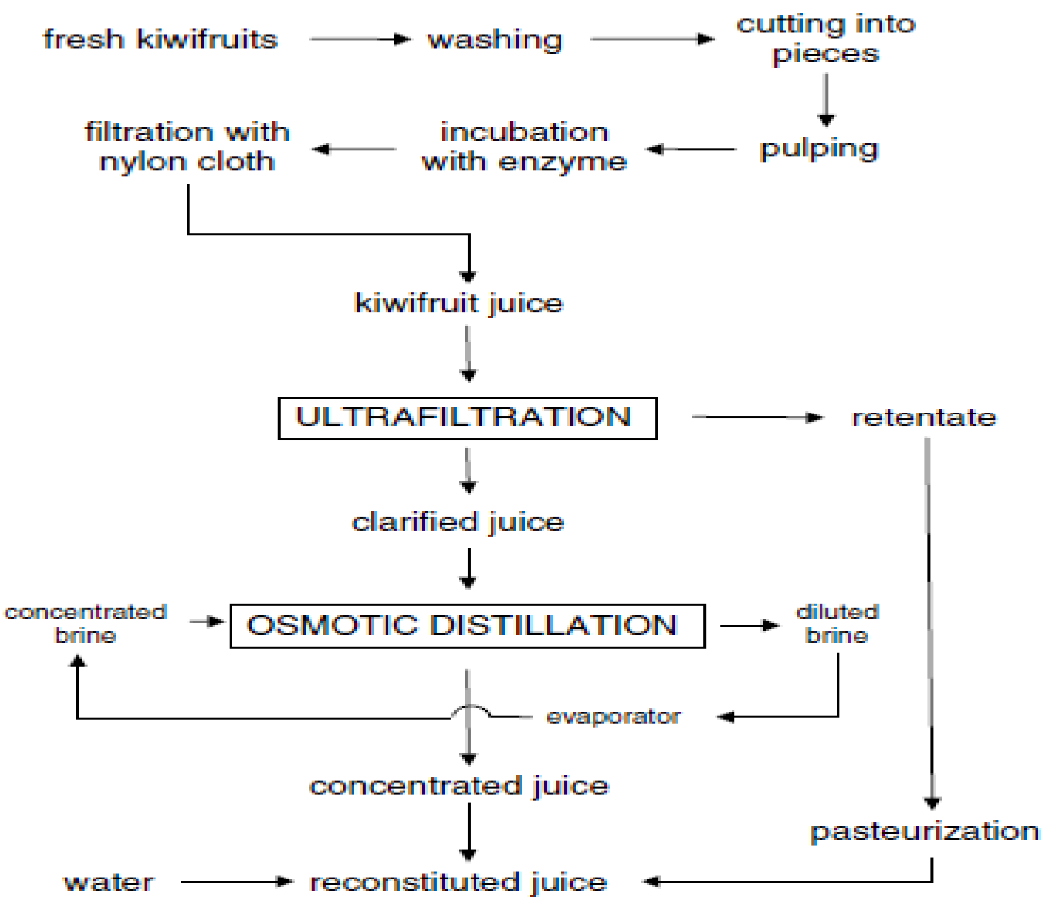


Fig. 7. Integrated membrane process for the production of highly nutritional.

A. Cassano, E. Drioli: Concentration of clarified kiwifruit juice by osmotic distillation. J. Food Eng. Vol. 79, 1397-1404 (2007)

Apricot

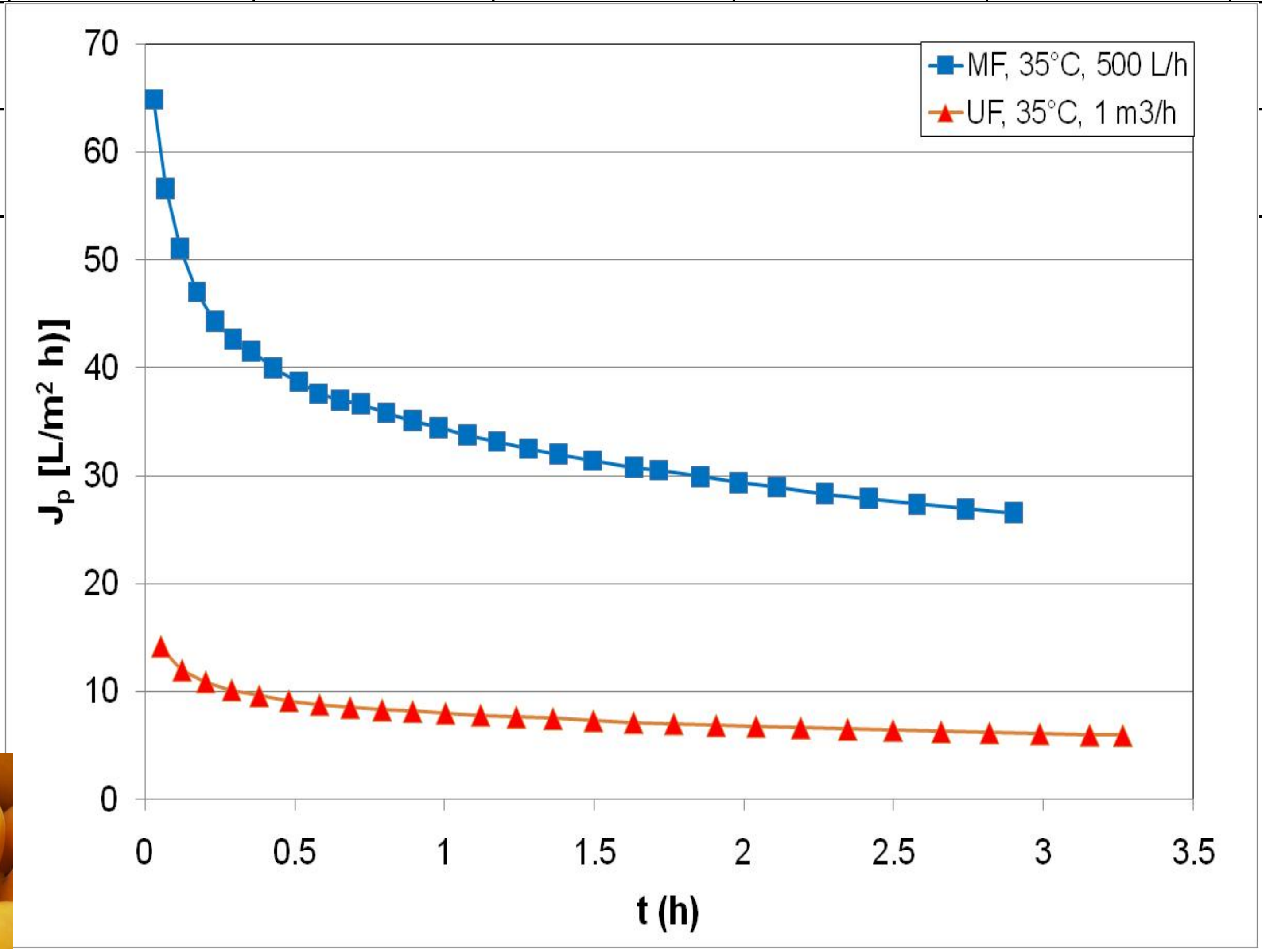
- ***Important components:***
  - *vitamin B1, -B2, -C, β-carotene*
  - *Glucose, Fructose, Sacharose, Citric Acid*
  - *Copper, Manganese, Selen*
- ***Concentration of the fruit juice:***
  - *Evaporation*
  - *Crioconcentration*
  - ***Membrane technology***

    UF-RO-OD, UF-RO-MD

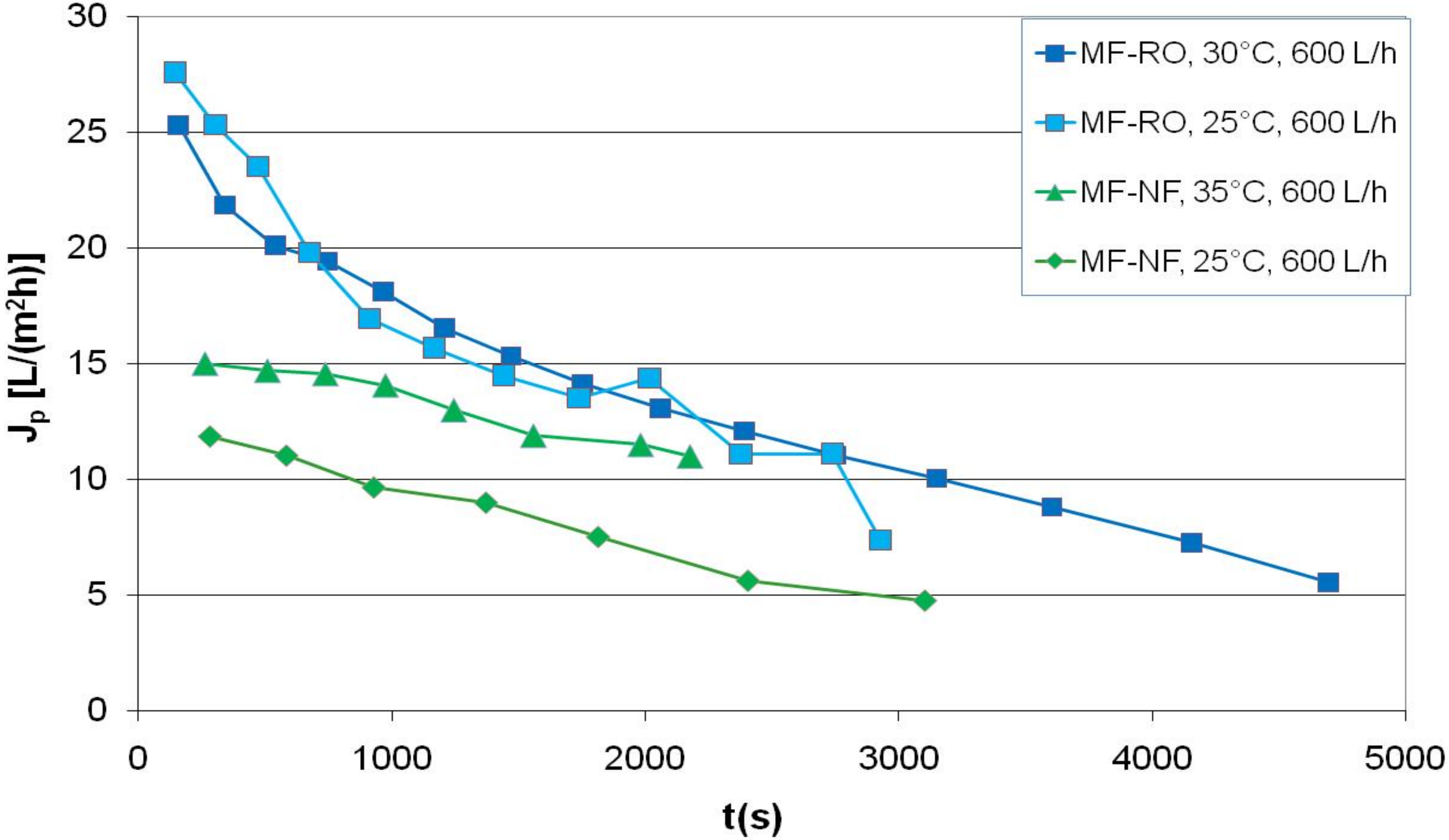
Juice production

CLARIFICATION - Comparison of MF and UF

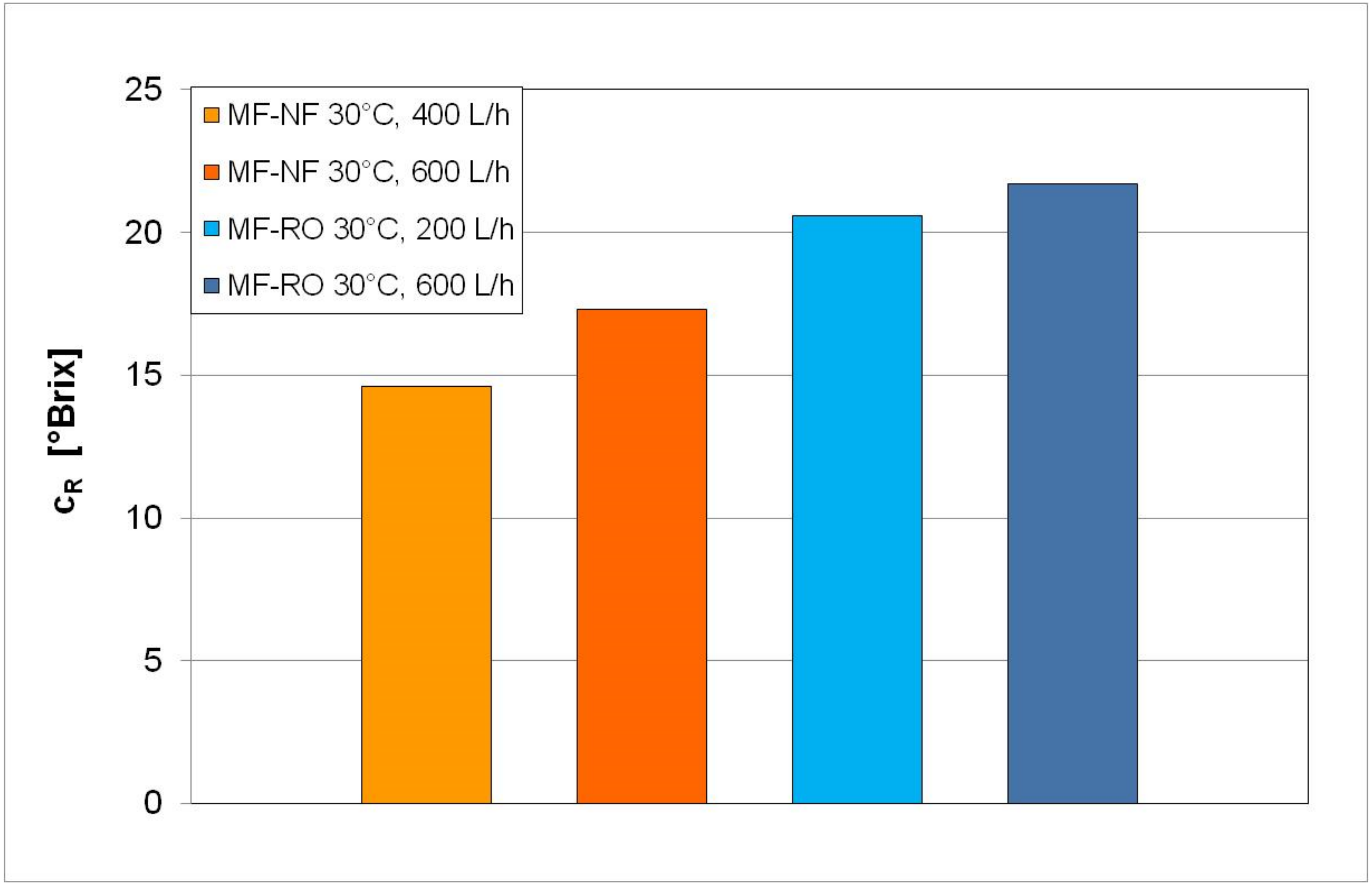
	d_b (mm)	n_m (db)	Q_R	A_{ker} (m^2)	v (m/s)	Re
MF						3700
UF						3400



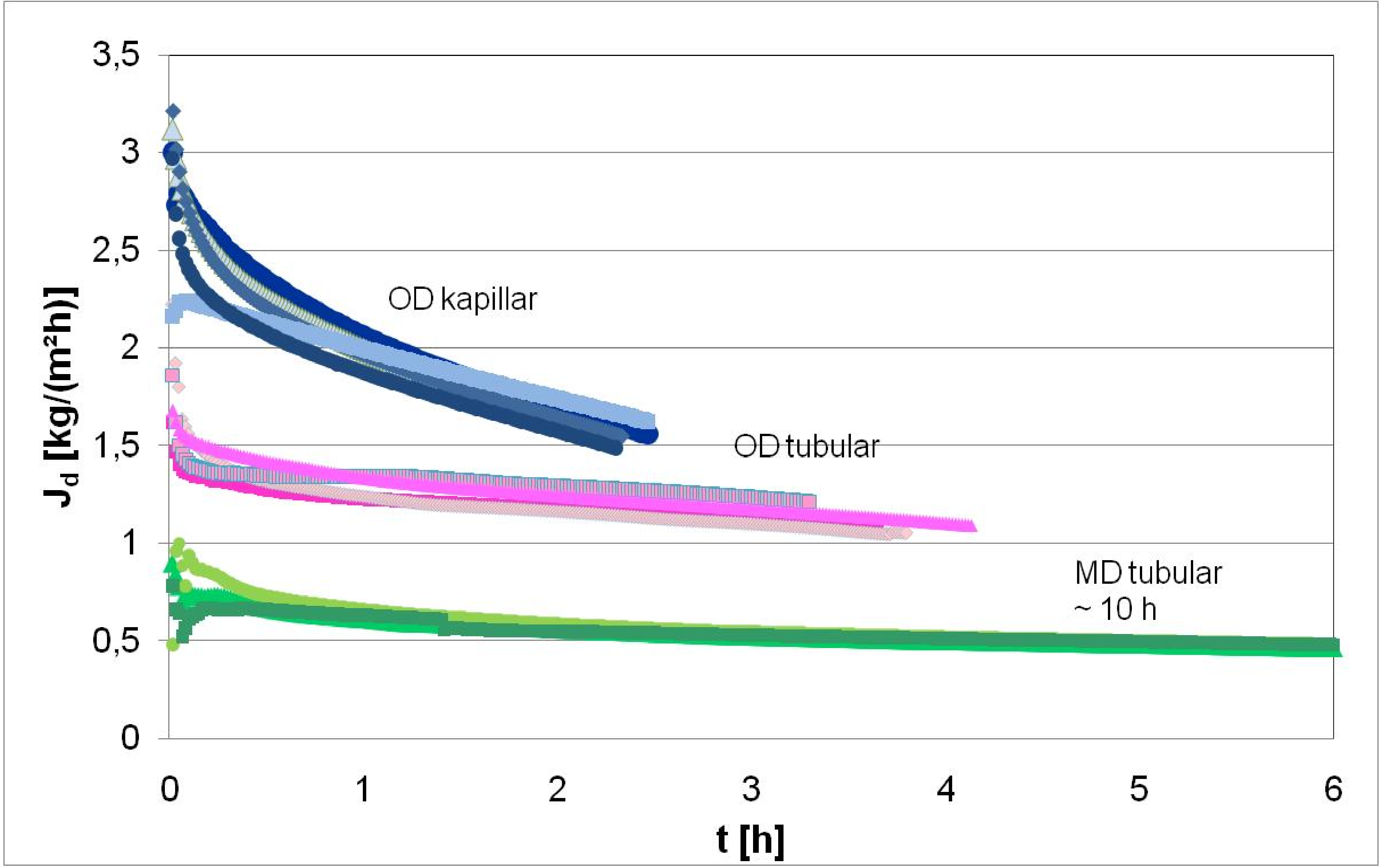
Comparison of MF-RO and MF-NF fluxes



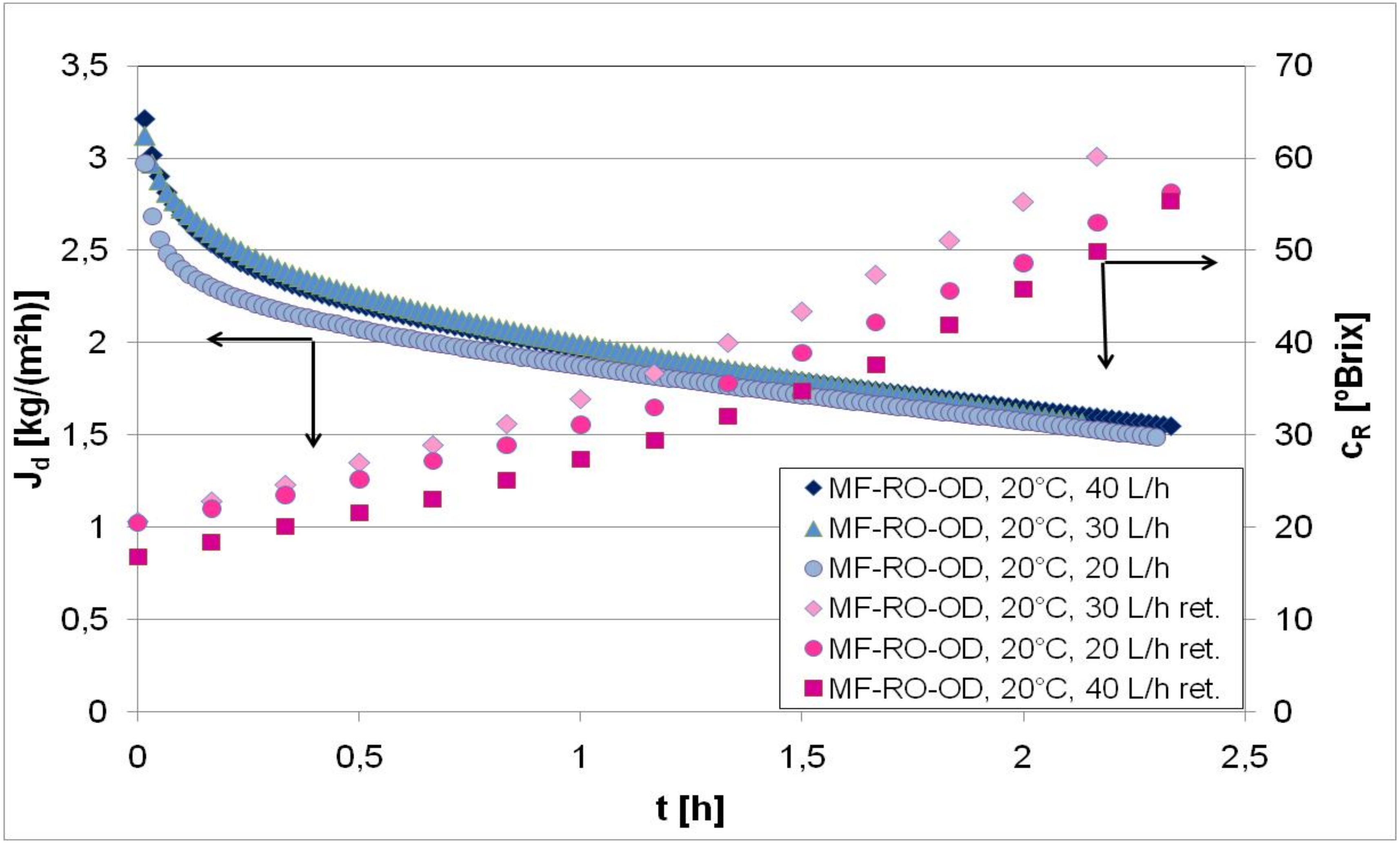
Comparison of MF-RO and MF-NF: final retentate concentrations



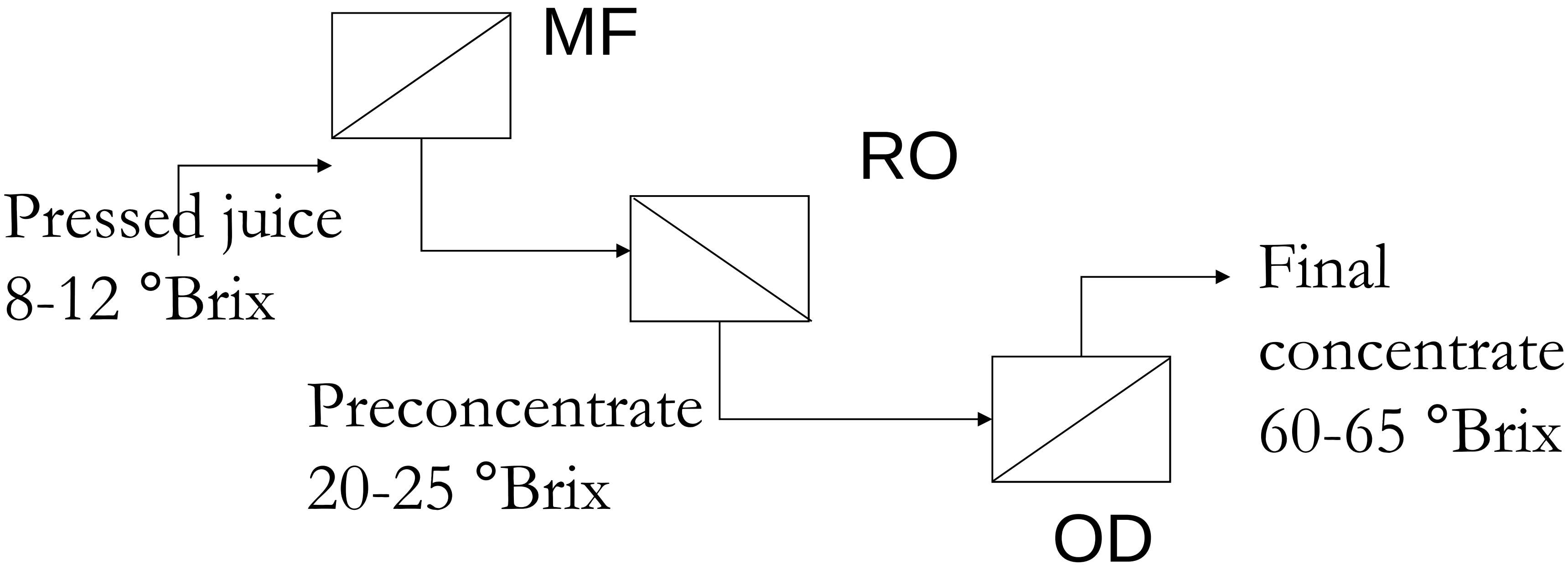
Comparison of MF-RO-OD, MF-RO-MD



MF-RO-OD: Influence of operational parameters

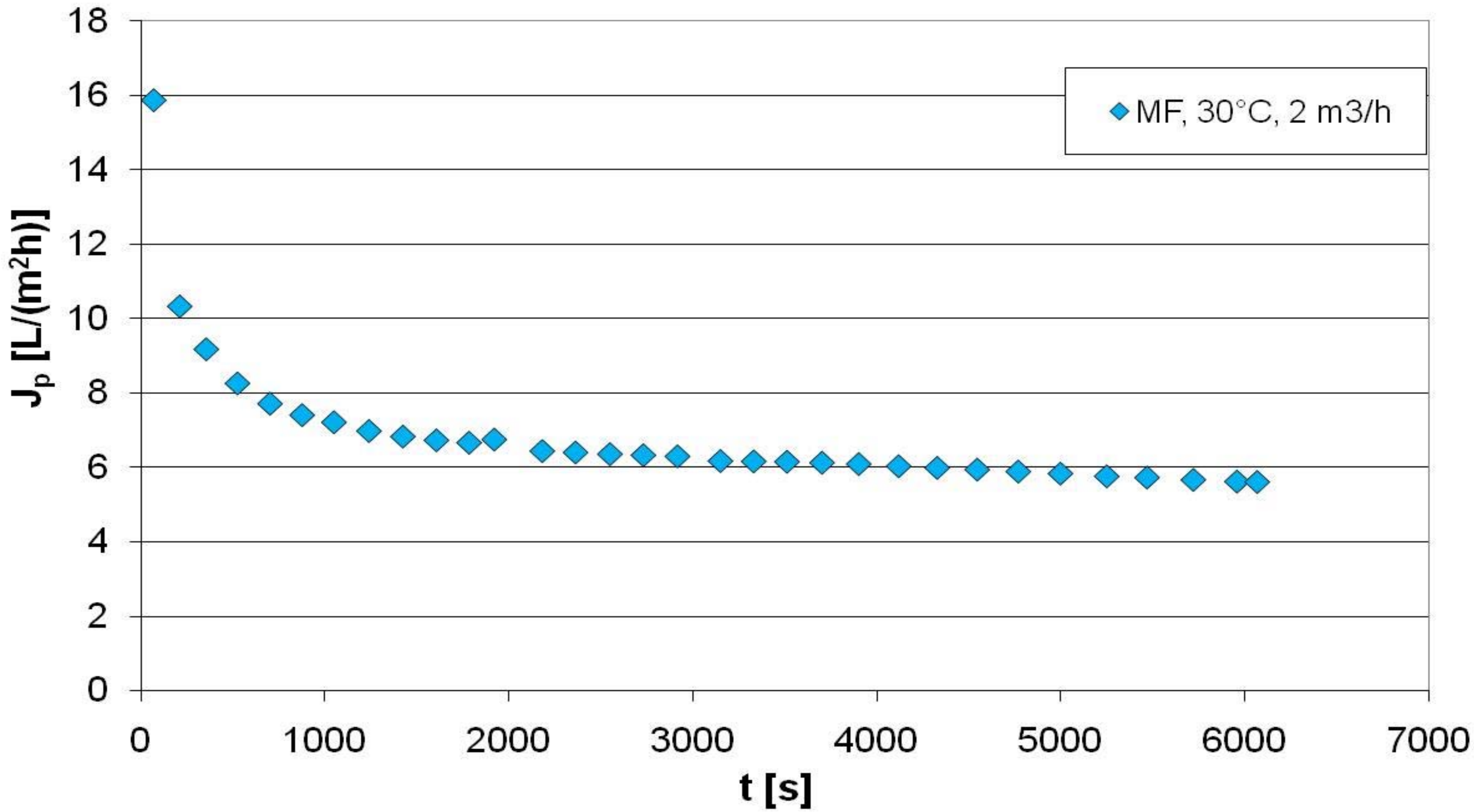


Laboratory Experiments - Optimal combination and operation parameters

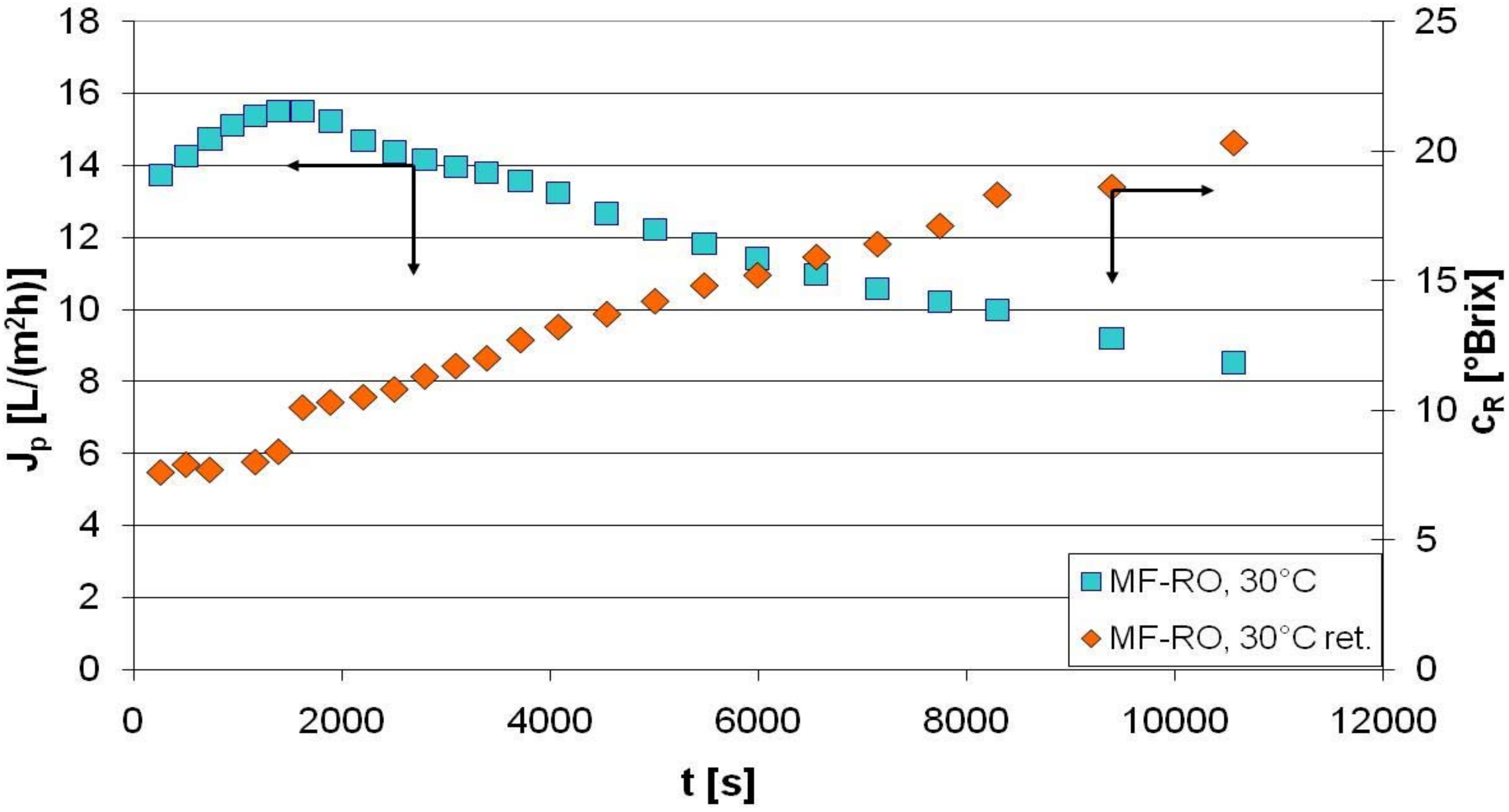


	Δp_{TM} (bar)	Q_R (L/h)	T (°C)
MF	4	500	35
RO	50	600	35
OD	-	30	20

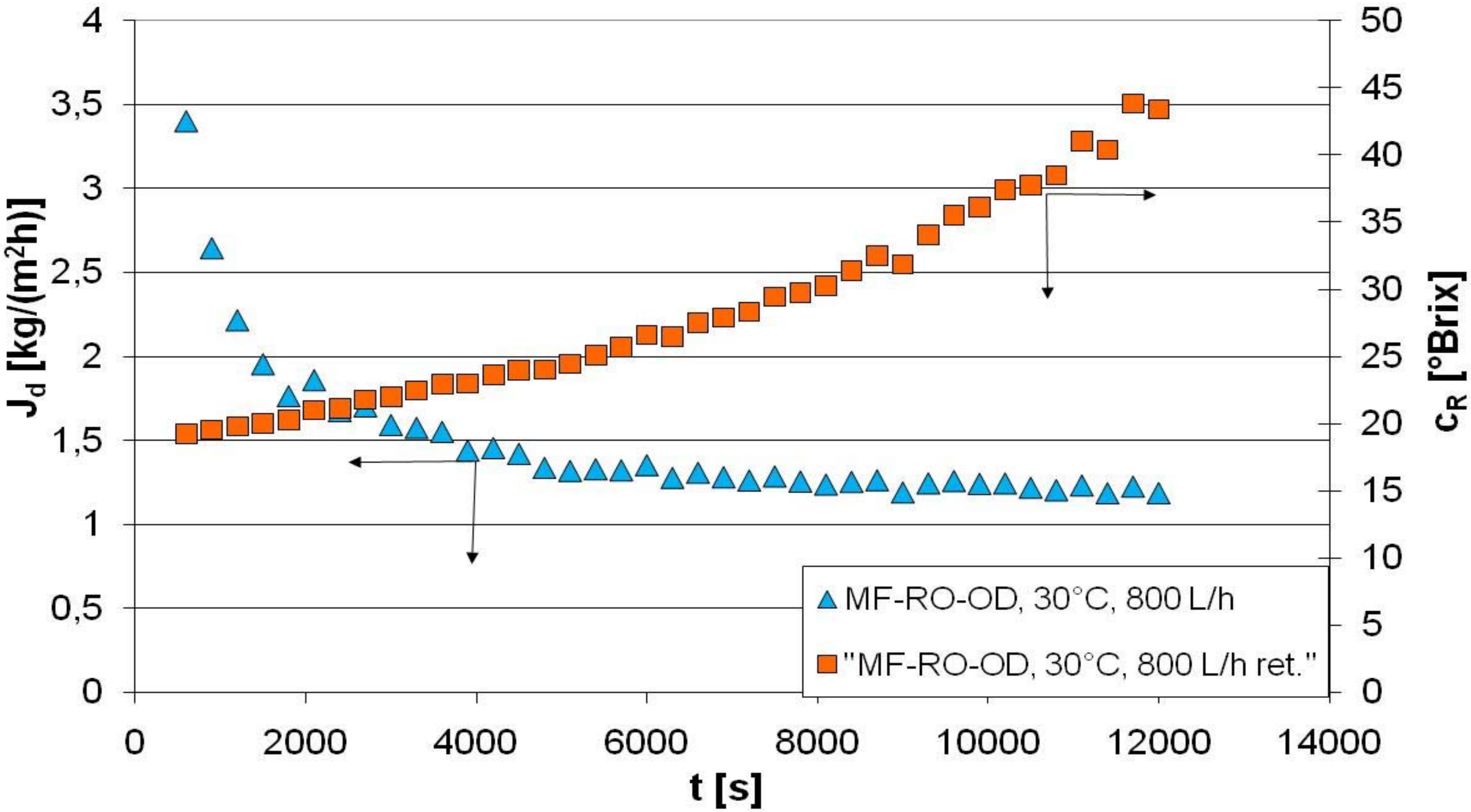
Pilot experiments MF



Pilot experiments MF-RO

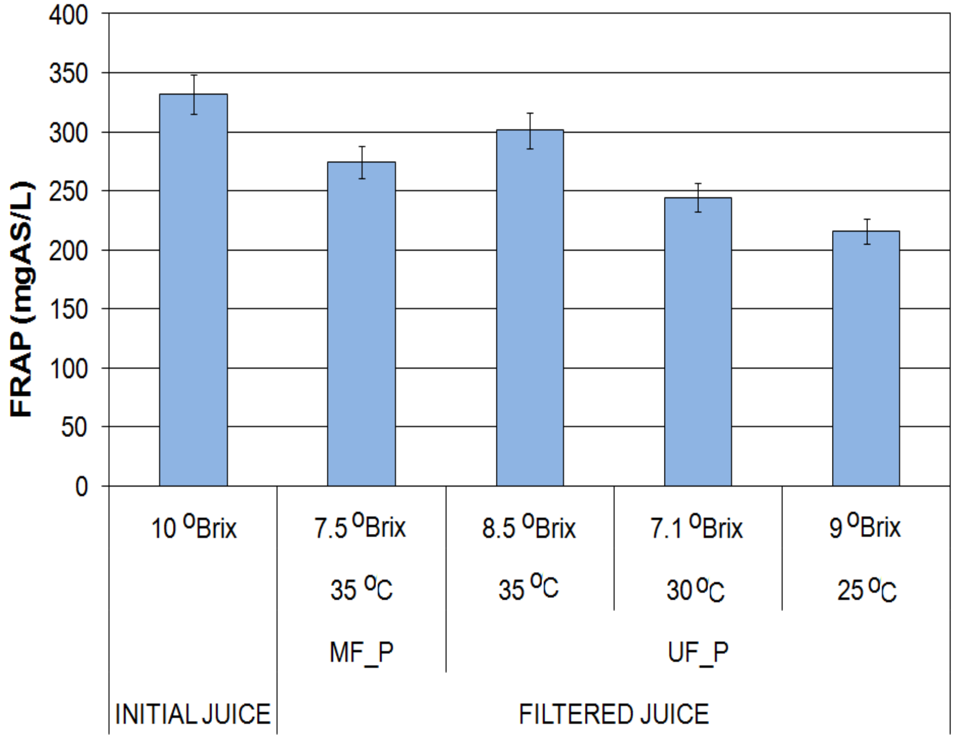


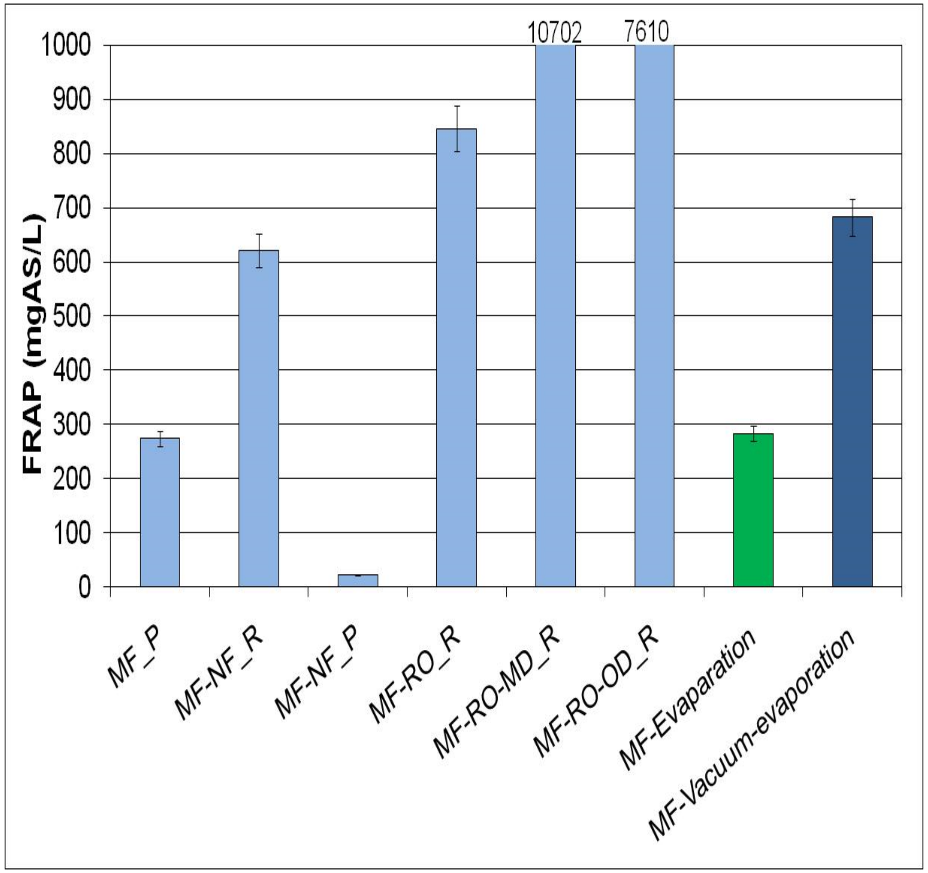
Pilot experiments MF-RO-OD



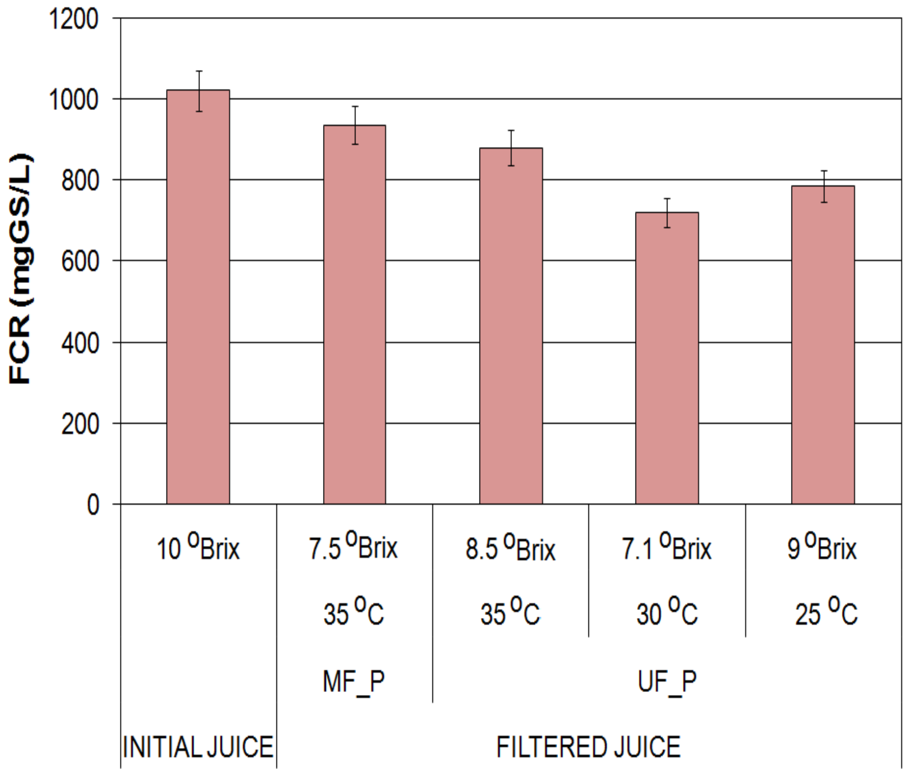
Results of Analysis

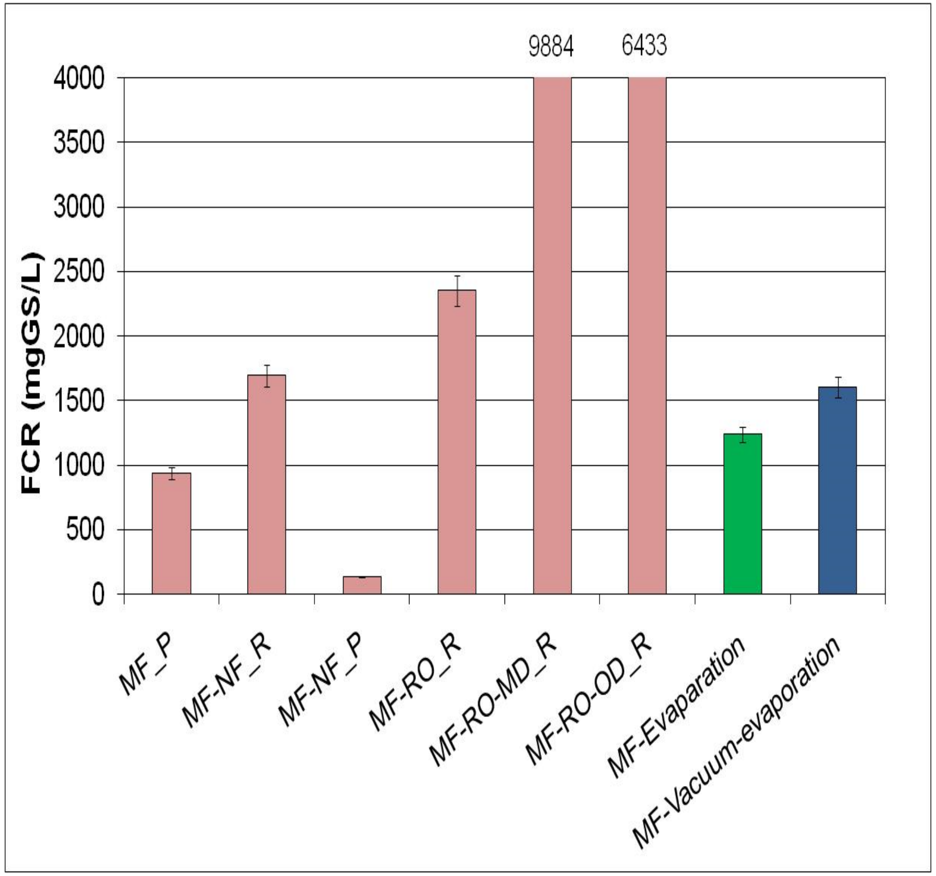
Total Antioxidant Capacity (FRAP)



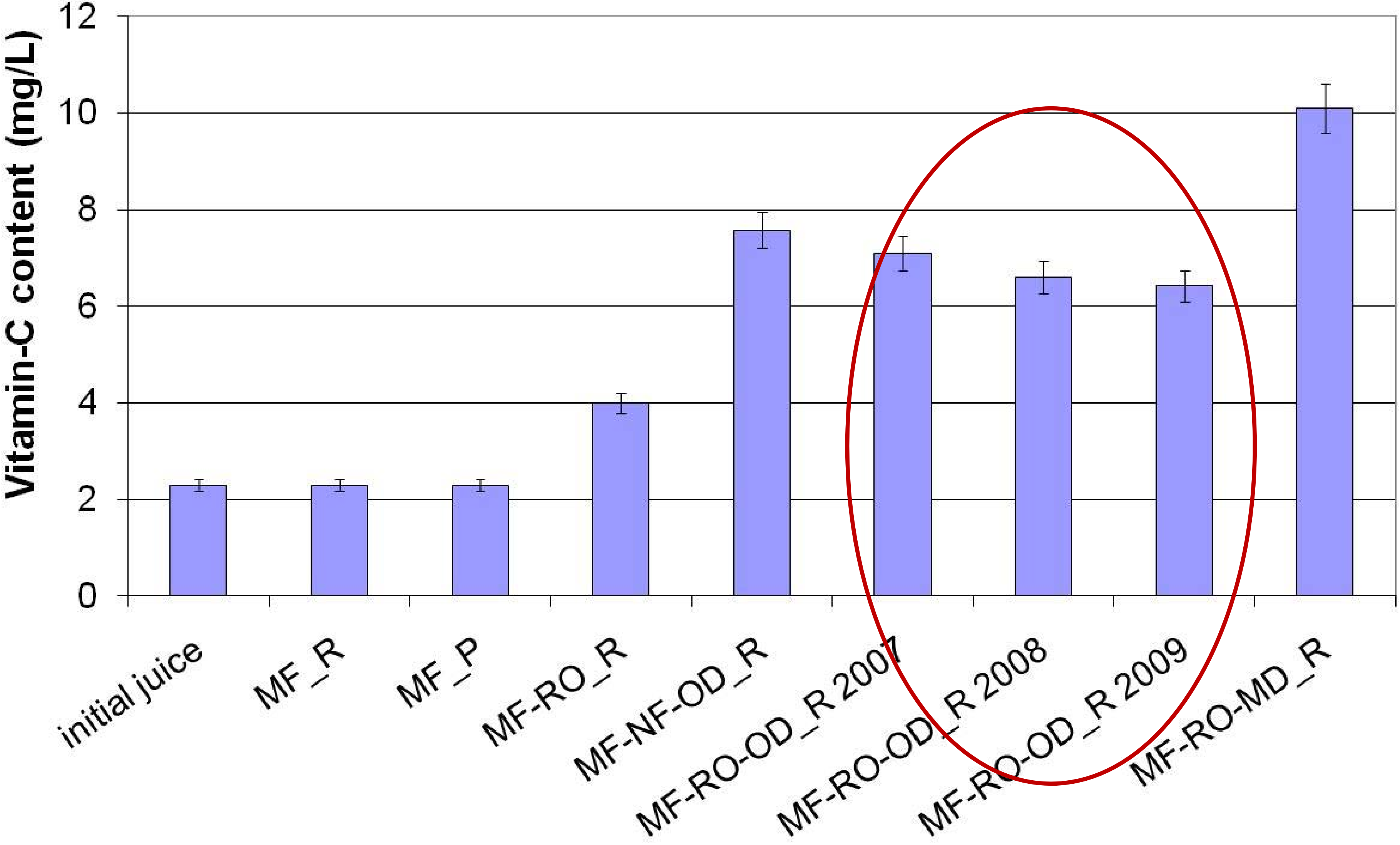


Total Polifenol (FCR)





Vitamin-C Content



Economical Analysis

1000 ton (10 hours/day) → 7% stem

↓

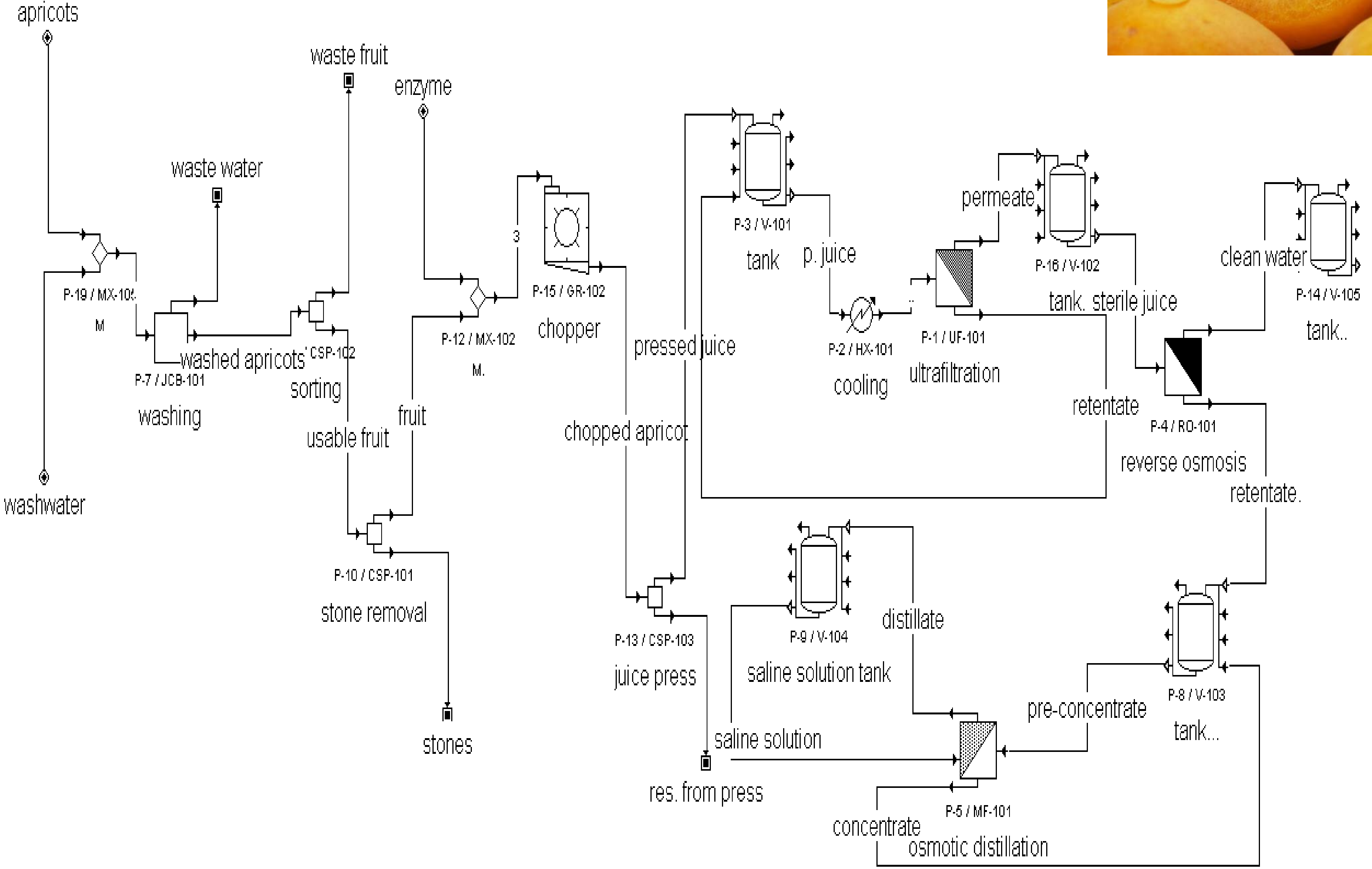
651 ton raw juice ← 930 ton Apricot (Juice yield 70%)

↓

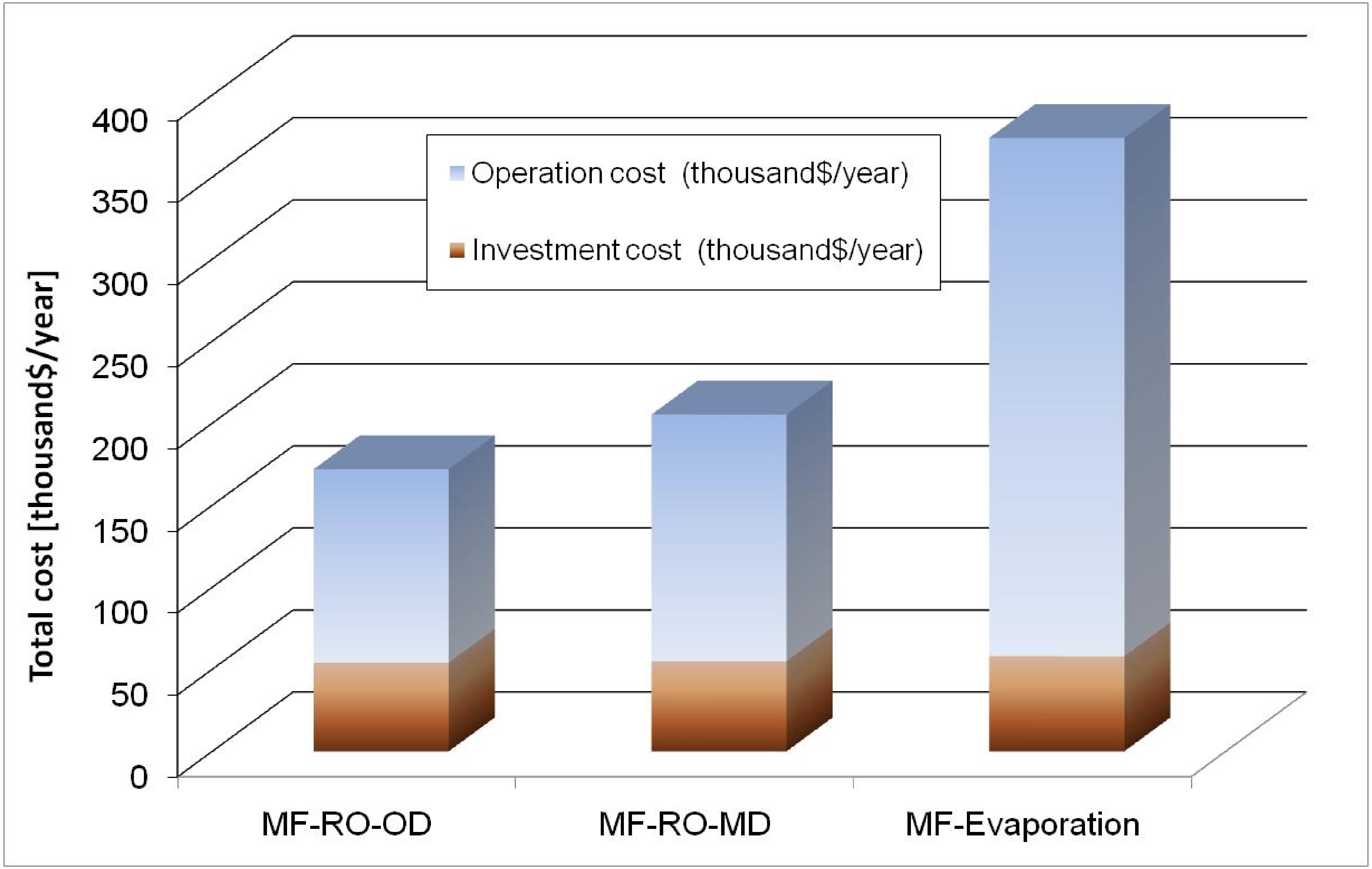
~ 90 ton 60°Brix Apricot Juice Concentrate

Membrane	W (L/h)	J (L/(m^{2}h))	A (m^2)
MF	1750	10	175
RO	1250	15	83
MD	300	0,4	750
OD	300	1,5	200

Apricot - UF-RO-OD

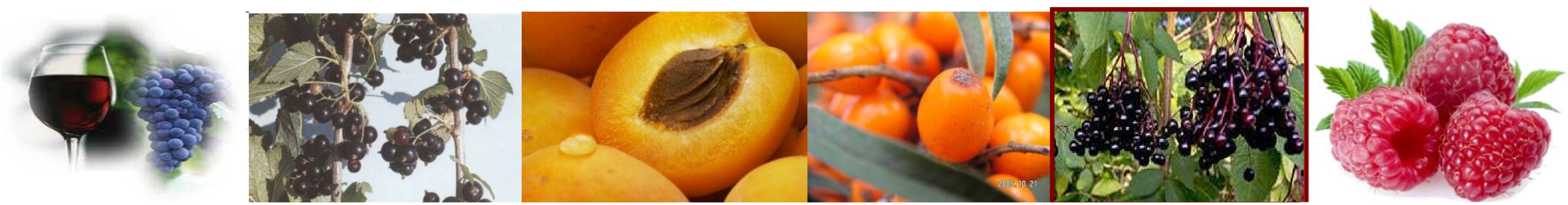


Cost Analysis



Overall conclusions

- New membranes – ceramic, metallic, ceramic hollow fibers
- New flux enhancement techniques – rotating, vibrating modules, electric field, turbulence promoters,
- Process modelling and optimization,
- Energy consumption reduction,
- Direct Osmosis, High pressure reverse osmosis



Thank you for Your attention!