amsic 3 The 3rd African Membrane Society International Congress

Dakar, SENEGAL - November 2-5, 2021

3rd Congress of the African Membrane Society
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# MEMBRANE-BASED TECHNOLOGIES AS AN EMERGING TOOL FOR PURIFYING AND CONCENTRATING BETACYANINS

Abdoulaye Tamba , Adrien Servent , Christian Mertz , Mady Cissé , Manuel Dornier*





- ✓ Food color: sensory characteristics
- ✓ Important for consumers
- ✓ Industrials : High production of dyes

- ✓ Discovery of the toxicity of certain artificial colors: carcinogen, hyperactivity, attention deficits → Interdictions
- ✓ Current trends : return to natural food
- ✓ Industrials: more enthusiasm for dyes of natural origin

Delgado-Vargas 2000 Foodsafetynews, 2010

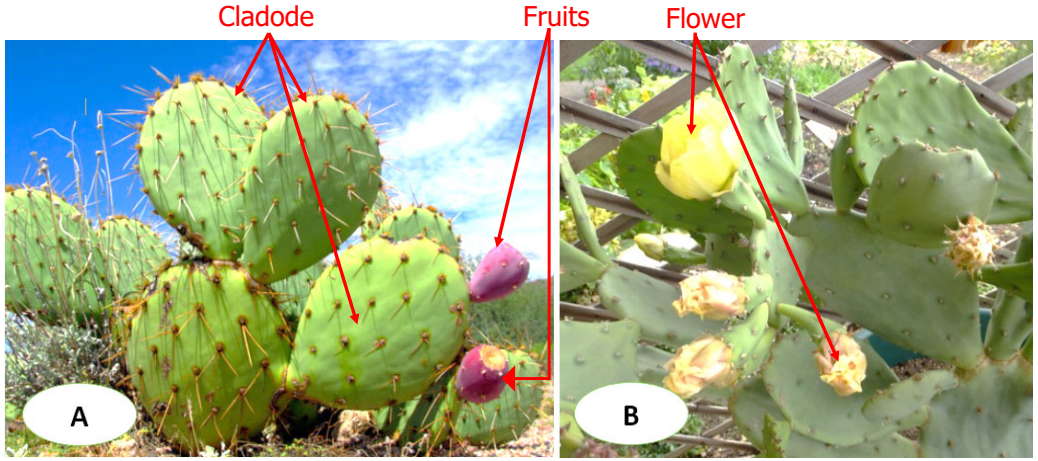




- ❖ Natural pigments: anthocyanins, caroténoids, chlorophylls et betalains
- ❖ betalains: water-soluble
  - ✓ anticancer
  - ✓ antiviral
  - ✓ antibacterial
  - ✓ antioxidant activities...

*Acosta et al. 2014 . Cejudo-Bastante et al. 2014 Strack et al. 2003*

❖ Cactus pear description

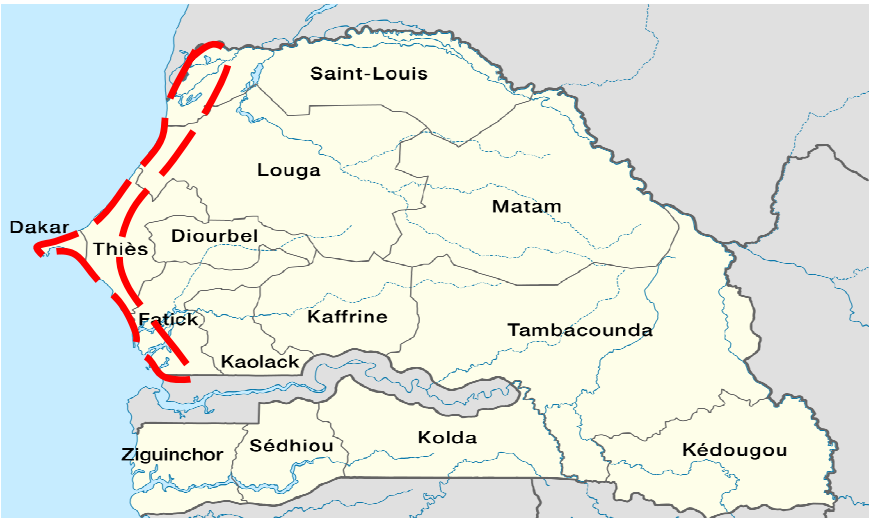



T.T. Mauseth et al. 1997





❖ Cactus pear in Senegal








## MAIN OBJECTIVE

Contribute to national efforts to fight food insecurity and malnutrition by promoting the cactus pear





## 3- clarification by microfiltration

✓ Main characteristics of the different membranes used

| Manufacturer | material | Pores size diameter (µm) | Water permeability * ($kg.h^{-1}.bar^{-1}.m^{-2}$) | effective filtration area ($cm^2$) |
|---|---|---|---|---|
| ORELIS | $Al_2O_3$ | 0,1 | 144 | 55 |
| ORELIS | $Al_2O_3$ | 0,2 | 158 | |
| TAMI | $TiO_2$ | 0,2 | 170 | |
| PALL-EXEKIA | $Al_2O_3$ | 0,2 | 112 | |

## 3- clarification by microfiltration

✓ 2 types of tests

- Recycling entire permeate (Mass reduction ratio FRM = 1) .
- Continuous extraction (FRM > 1)

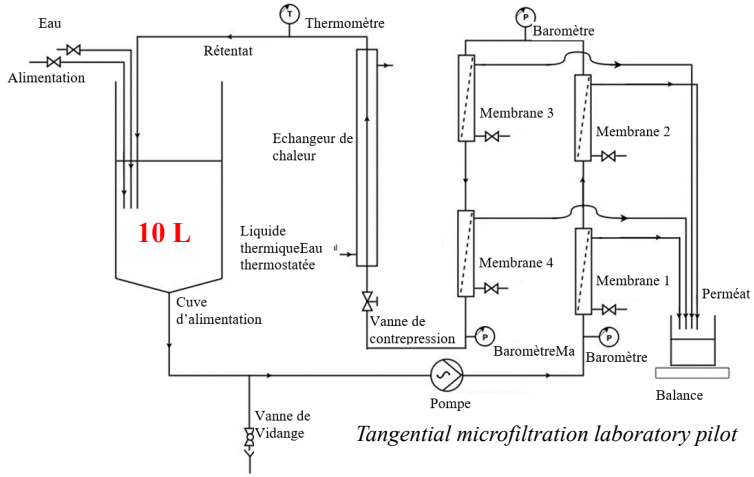
$$FRM = \frac{M_a}{M_r} = \frac{M_a}{M_a - M_p}$$

$M_a$: total mass of the feed
$M_r$: mass of the retentate
$M_p$: mass of the permeate





## 3- clarification by microfiltration

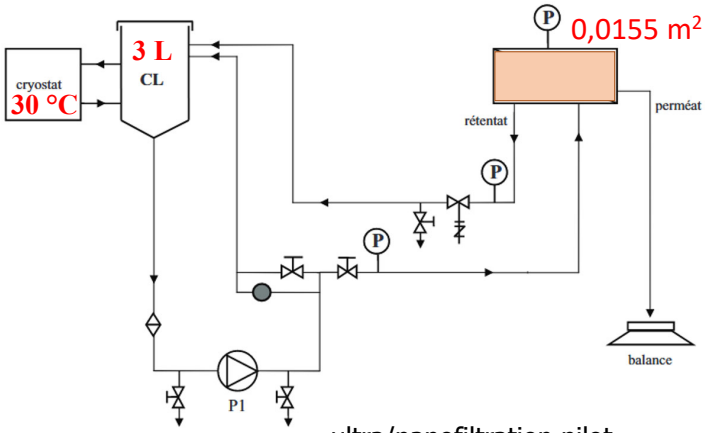



*Tangential microfiltration laboratory pilot*

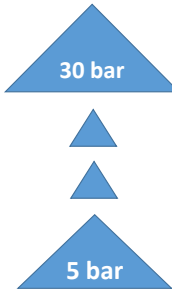




## 4- Separation by nano/ultrafiltration




ultra/nanofiltration pilot








## 4- Separation by nano/ultrafiltration

| Membrane | Manufacturer | Material | molecular weight cut-of (kDa) | Water permeability * (kg $h^{-1}$ $bar^{-1}$ $m^{-2}$) |
|---|---|---|---|---|
| Ultrafiltration | Microdyn Nadir | UH004, polyethersulphone | 4 | 20 |
| Nanofiltration | Microdyn Nadir | NP030, polyethersulphone | 0,2 | 4 |
| | Microdyn Nadir | NP010, polyethersulphone | 1 | 11 |
| | Koch | MPS 36, composite | 1 | 7 |

## 4- Separation by nano/ultrafiltration

### 3-3- Exploitation of results

- Equation of retention

$$R_i = 1 - \frac{C_{pi}}{C_{fi}}$$

Ri : retention of the compound i

$C_{pi}$ : concentrations in $g \cdot kg^{-1}$ of the compound i in the permeate

$C_{fi}$ : concentrations in $g \cdot kg^{-1}$ of the compound i in the feed





## * Modélisation concentration bétalaïnes par UF/NF

$$CF_i = \frac{C_i^{final}}{C_i^{initial}} = \boldsymbol{FRM}^{R_i} e^{DV(R_i - 1)}$$

$CF_i$ : *Concentration factor of compound i*

$C_i^{initial}$ = *initial concentration of compound i*

$C_i^{final}$ = *final concentration of compound i*

$FRM$ = *Mass reduction ratio*

$DV$ = *diavolume* : $\frac{\text{Volume of water added}}{\text{volume of retenate}}$

$R_i$ = *retention of compound i*





## * Modélisation concentration bétalaïnes par UF/NF

$$SF_{i/j} = \frac{CF_i}{CF_j} = exp\left[\left(R_i - R_j\right)\left(ln\,\mathrm{FRM} + DV\right)\right]$$

$SF_i$ : *Separation factor of compound i*

$C_i^{initial}$ = *initial concentration of compound i*

$C_i^{final}$ = *final concentration of compound i*

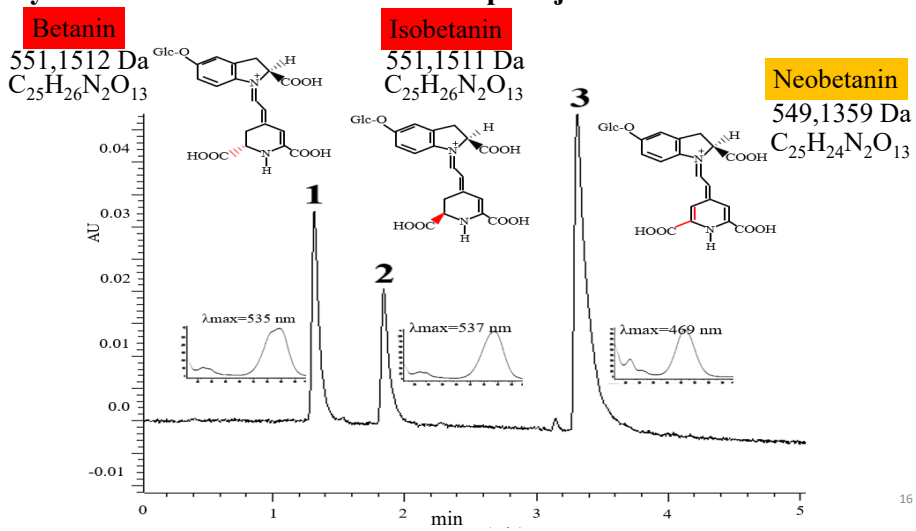
$DV$ = *diavolume* : $\frac{\text{Volume of water added}}{\text{volume of retenate}}$

$R_i$ = *retention of compound i*



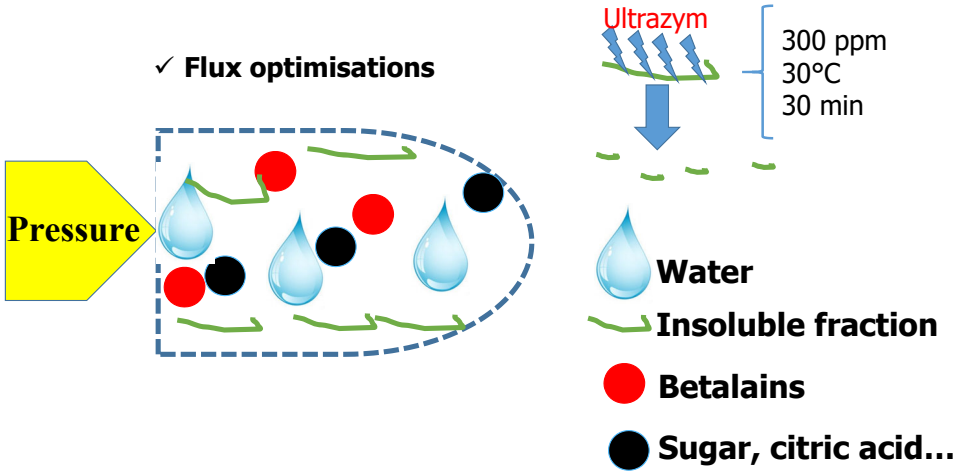


## 1- Betacyanins extracted from raw cactus pear juice



## 2- Clarification

✓ **Flux optimisations**





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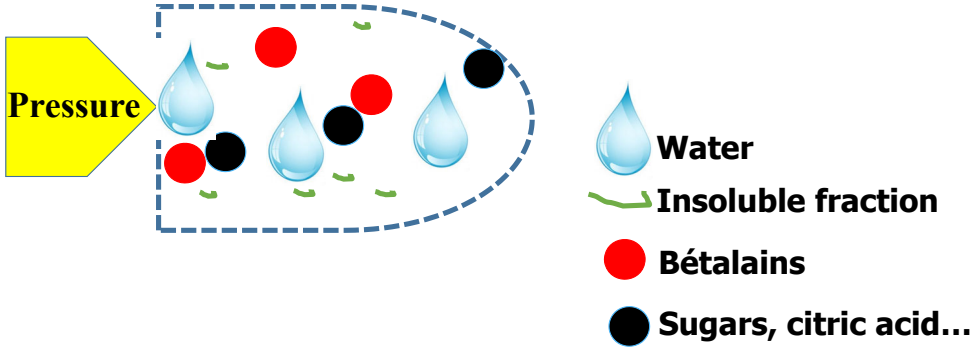


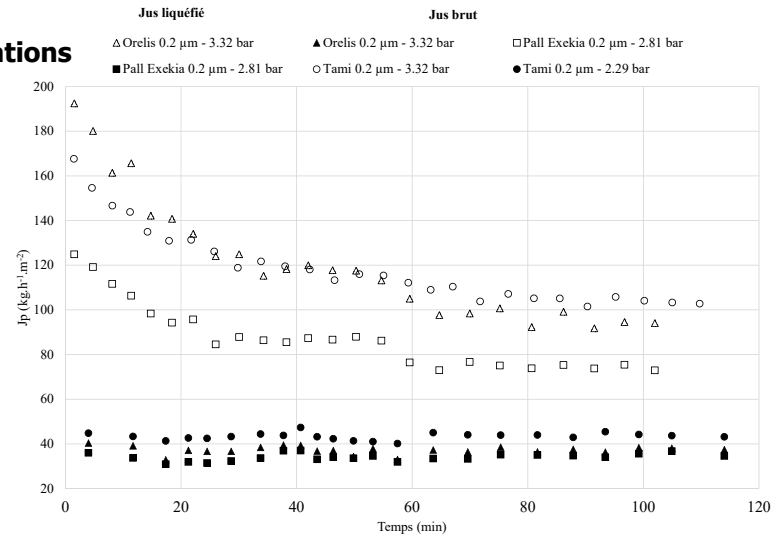





## 2- Clarification

✓ **Flux optimisations**

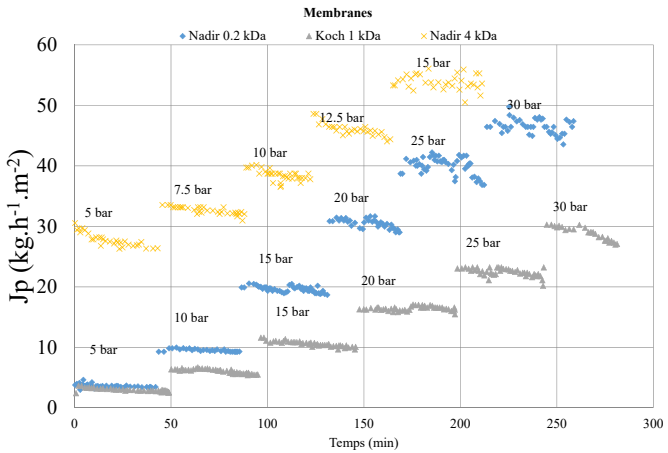
Permeate flux (Jp) increased by 2 or 3





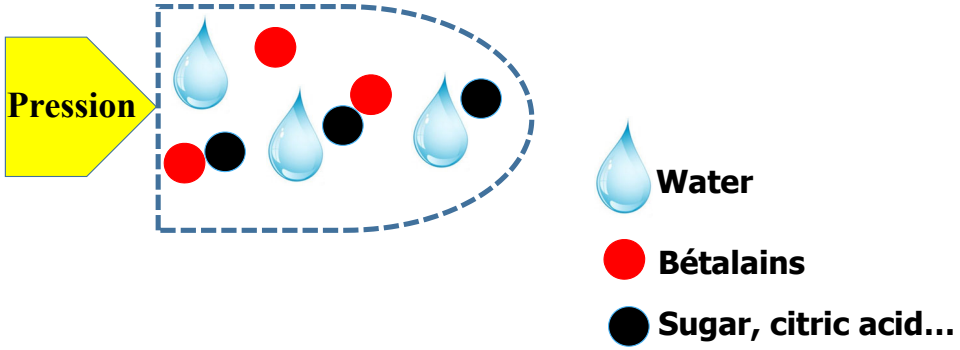

## 3- Ultra/nanofiltration

✓ **Permeate flux**



## 3- Ultra/nanofiltration

✓ **Concentration**

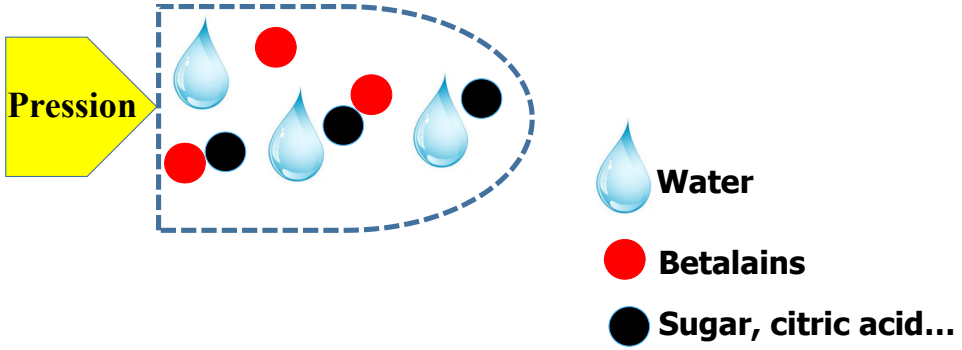







## 3- Ultra/nanofiltration

✓ **Purification of betalains**

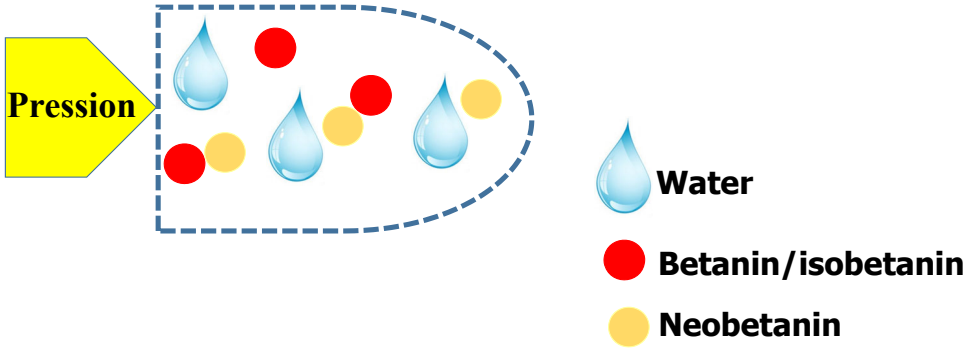







## 3- Ultra/nanofiltration

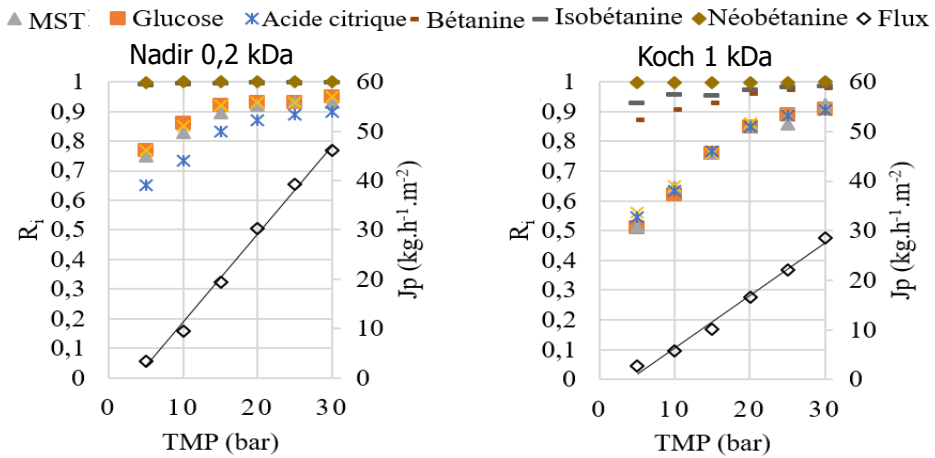
✓ **Fractionation of betalains**



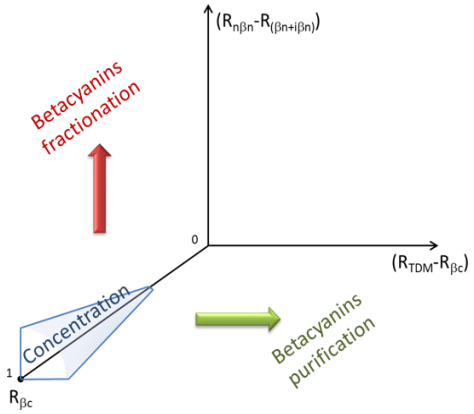


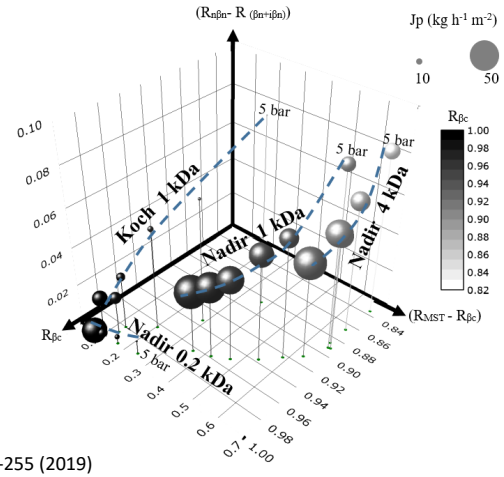



## 3- Ultra/nanofiltration



## 3- Ultra/nanofiltration



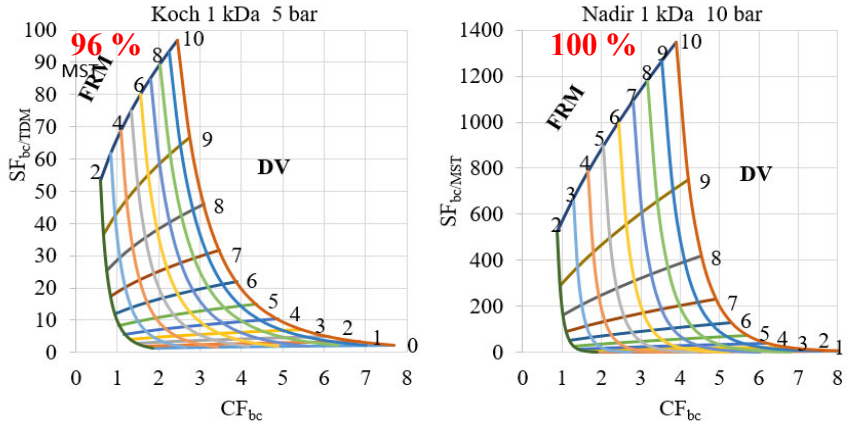




A. Tamba and al., IFSET, 245-255 (2019)



## 3- Ultra/nanofiltration

✓ Purification modelisation

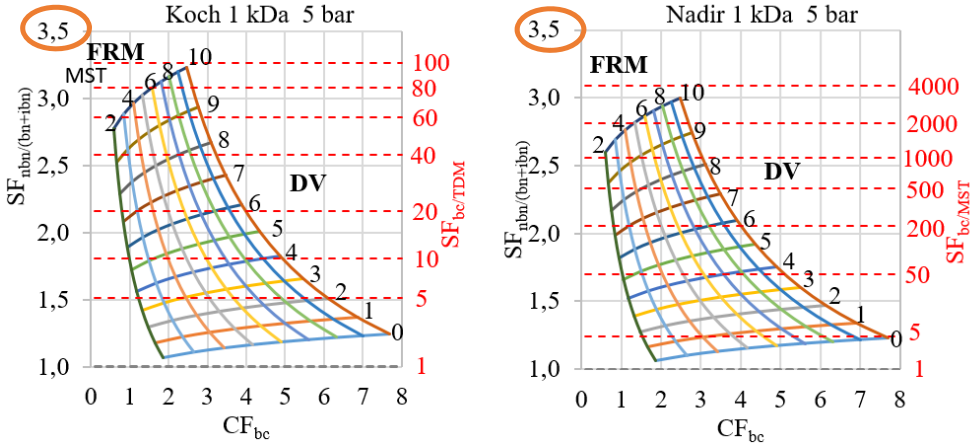







## 3- Ultra/nanofiltration

✓ Fractionation modelisation






✓ Pigment extraction by membrane process

- Concentration:
  enzymatic treatment 300 ppm, 30 min
  Orelis-0,2µm/3,32 bar
  Nadir 0,2 kDa/15 bar)

- Purification:
  enzymatic treatment 300 ppm, 30 min
  Nadir 1 kDa/ 10 bar
  DV= 5 , FMR=7

✓ Optimisation of extraction by fermentation (100 rpm, 30°C, 8%)

✓ Testing on a larger production scale

✓ Economic evaluation of the process



## Acknowledgments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  - Manuel Dornier,
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  Mady Cissé




# Thank you for your attention