HIGH PURITY LACTOSE PRODUCTION WITH CHROMATOGRAPHY: INDUSTRIAL SCALE AND GREEN PROCESS

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Novasep Process – Industrial Biotechs

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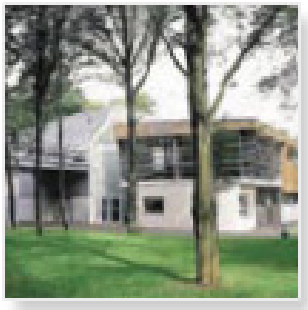
Summary

- Introduction to Novasep
- Needs for Processes in Dairy Industry
- Novasep position and partnerships for Lactose production
- Purifications processes for Lactose
- Chromatography to purify Lactose
- Lactose production from Mother Liquors
- Conclusion



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INTRODUCTION to NOVASEP

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your Partner in Performance

Structure of Groupe Novasep and Technologies

groupe novasep

novasep process

Competences:

- Chromatography
- Ion Exchange
- Membranes
- Crystallisation
- Evaporation
- Reactions

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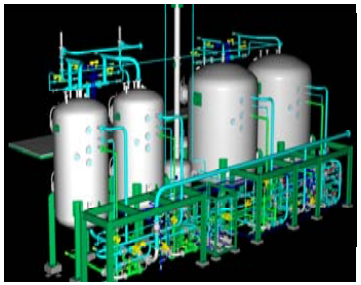
your Partner in Performance

« We are a Process Engineering Company »

- R&D (Lab and piloting)
- Process Engineers (process design and scale up)
- Design, basic and detailed Engineering
- Purchasing, quality control
- Installation or supervision of erection
- Plant Start up
- After sales (ASAP), Resin and membrane analysis, training…



« Our main work is to provide our Customers
With process solutions applied to their products »

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NEEDS FOR PROCESSES IN DAIRY INDUSTRY

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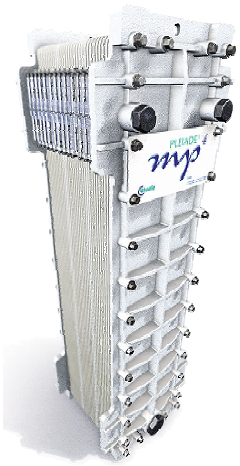
Trends in Dairy Industry

- Consolidation **of the Industry**
  - ➔ Larger Scale plants
- Growth in cheese **production**
  - ➔ Increasing amounts of Whey
- **Research for** new products
  - ➔ by fractionation or transformation
- **Growing** Environmental pressure
  - ➔ Need for clean or « sobre » Process

Applications to Dairy Industry

- **Fractionation**
  - Milk (« Ideal Whey »)
  - Whey
- **Demineralization**
  - Whey (DK-NF-RO-IX)
  - Permeates from whey ultrafiltration
  - Whey protein concentrates
  - Decolorization
- **Removal lipidics (« Fat ») from Milk & Whey**
- **Debacterisation**
- **Reactions**
  - Acidification
  - Catalytic resin process
  - Enzymatic process
- **Milk Standardisation**
- **Lactose**
- **Fractionation / Isolation of High Value products**



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NOVASEP POSITION AND PARTNERSHIPS FOR LACTOSE PRODUCTION

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Background: Ion Exclusion developments

- Since 1992: continuous work on chromatographic separation of dairy products, particularly lactose recovery by ion exclusion.
- Backed by 20 years of industrial experience in the field of industrial chromatography for sweeteners
- License agreement with Valio, which pioneered industrial chromatography of milk, wheys, permeate, and DLP.
- Improvements compared to the Valio process:
  - Continuous Chromatography has better efficiency compared to batch systems
  - Better calcium removal without frequent regeneration of chromato resins

Novasep Process – UWS / DA / FSA Licence agreement

- Both UWS/FSA/DA and Novasep Process scientists have pioneered environmentally-friendly, cutting-edge technologies that separate the nutrients contained in whey, and turns them into valuable food and pharmaceutical-grade supplements for use in medicines and health.

- Both companies hold inter-dependant patents concerning these technologies

- To develop this technology as widely as possible in the dairy industry, an agreement was signed that gives Novasep Process the exclusivity to design, build and sell the industrial-scale technology worldwide.

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PURIFICATION PROCESSES FOR LACTOSE

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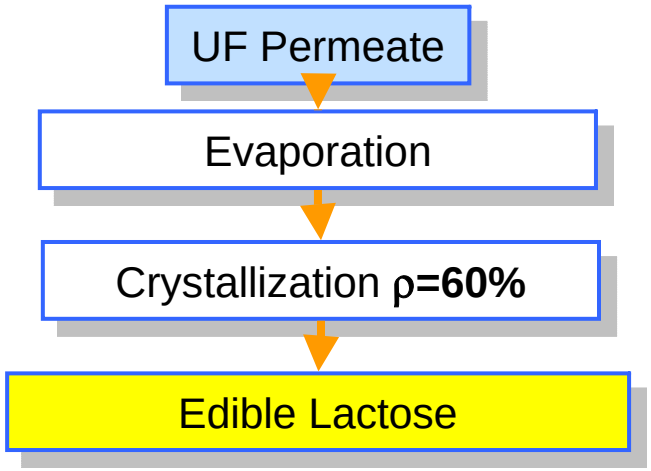
Conventional Process



	Edible Lactose	
Tons liquid		30
Volume liquid		
Liquid density		
%DS		30
Lactose %DS	**99,8%**	**30**
Monosaccharides		
Total Proteins	0,03%	0,01
Total minerals	0,09%	0,03
Other DS	0,06%	0,02
Ca in ppm/DS	36	0,001
Mg in ppm/DS	12	0,000
K in ppm/DS	202	0,006
Na in ppm/DS	68	0,002
Total cations	318	0,010
PO4 in ppm/DS	232	0,007
Cl in ppm/DS	207	0,006
Total anions	439	0,013

	UF Permeate	
Tons liquid		1055
Volume liquid		1029
Liquid density		1,025
%DS	5,8%	52
Lactose %DS	77,5%	40
Monosaccharides	1,7%	1
Total Proteins	13,4%	1,9
Total minerals	9,2%	5,2
Other DS	5,6%	3,4
Ca in ppm/DS	8350	0,432
Mg in ppm/DS	1400	0,072
K in ppm/DS	23500	1,215
Na in ppm/DS	7850	0,406
Total cations	41100	2,125
PO4 in ppm/DS	36000	1,861
Cl in ppm/DS	24000	1,241
Total anions	60000	3,102

The Challenge for Lactose Production

- The actual processes deliver a good Lactose quality
  - Single crystallisation for edible Lactose
  - Double crystallisation for Refined edible and Pharma grades
- Yields can be optimised (Lactose lost in mother liquors)

- How can we recover The Lactose lost in the current processes?
- How can we minimize waste streams production (and the use of chemicals?
- How can we make the cost of processing more attractive?

Development strategy

- Demineralize (partially) the UF permeate to :
  - Protect the evaporators
  - Protect the membrane filtration
  - Maximize the performance of the resins in the chromatographic steps
- Use continuous chromatography to purify the Lactose
  - Continuous injection of the Permeate
  - Continuous withdrawal of the Lactose fraction
  - No more regeneration steps
  - Optimal Lactose purity
  - Increased yield

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CHROMATOGRAPHY TO PURIFY LACTOSE

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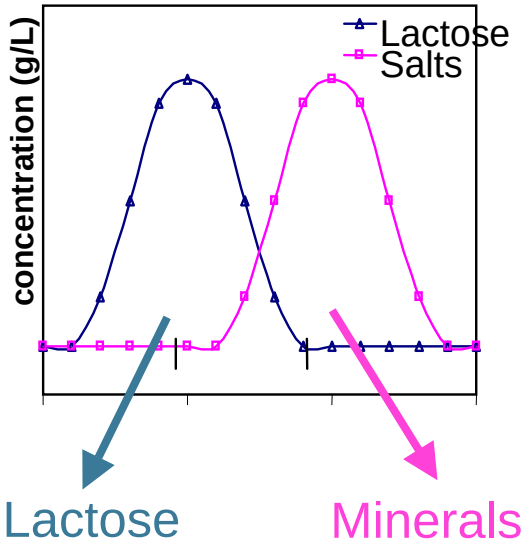
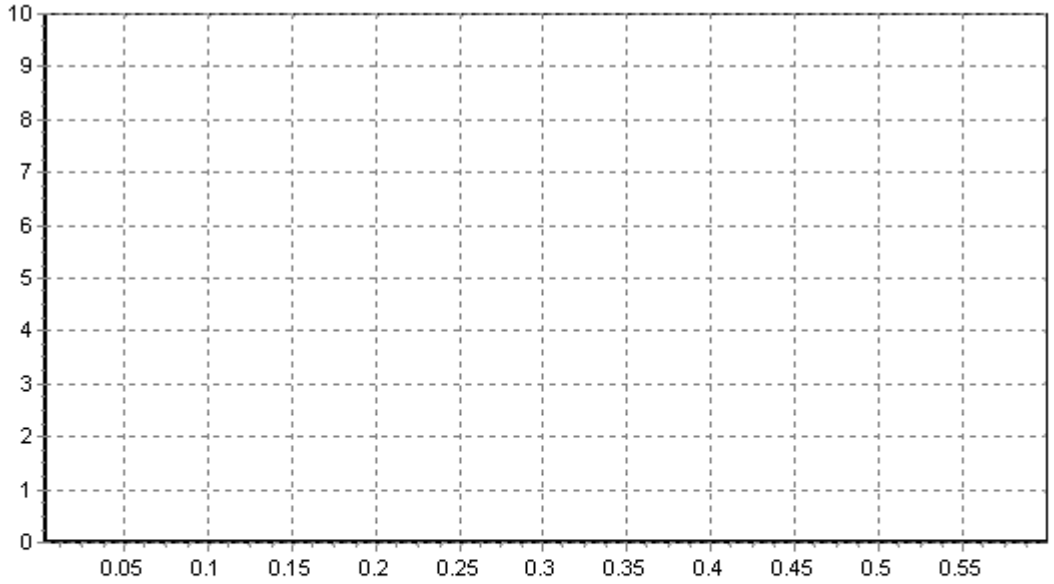
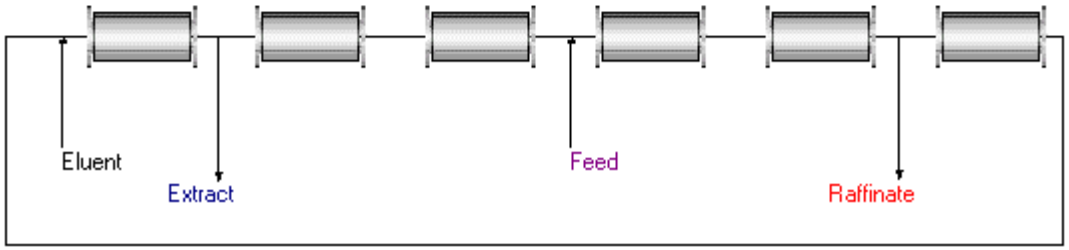
How Does the Chromatography Work?







- Lactose Fraction = Most Retained
- Mineral Fraction = Less Retained

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LACTOSE PRODUCTION FROM MOTHER LIQUORS

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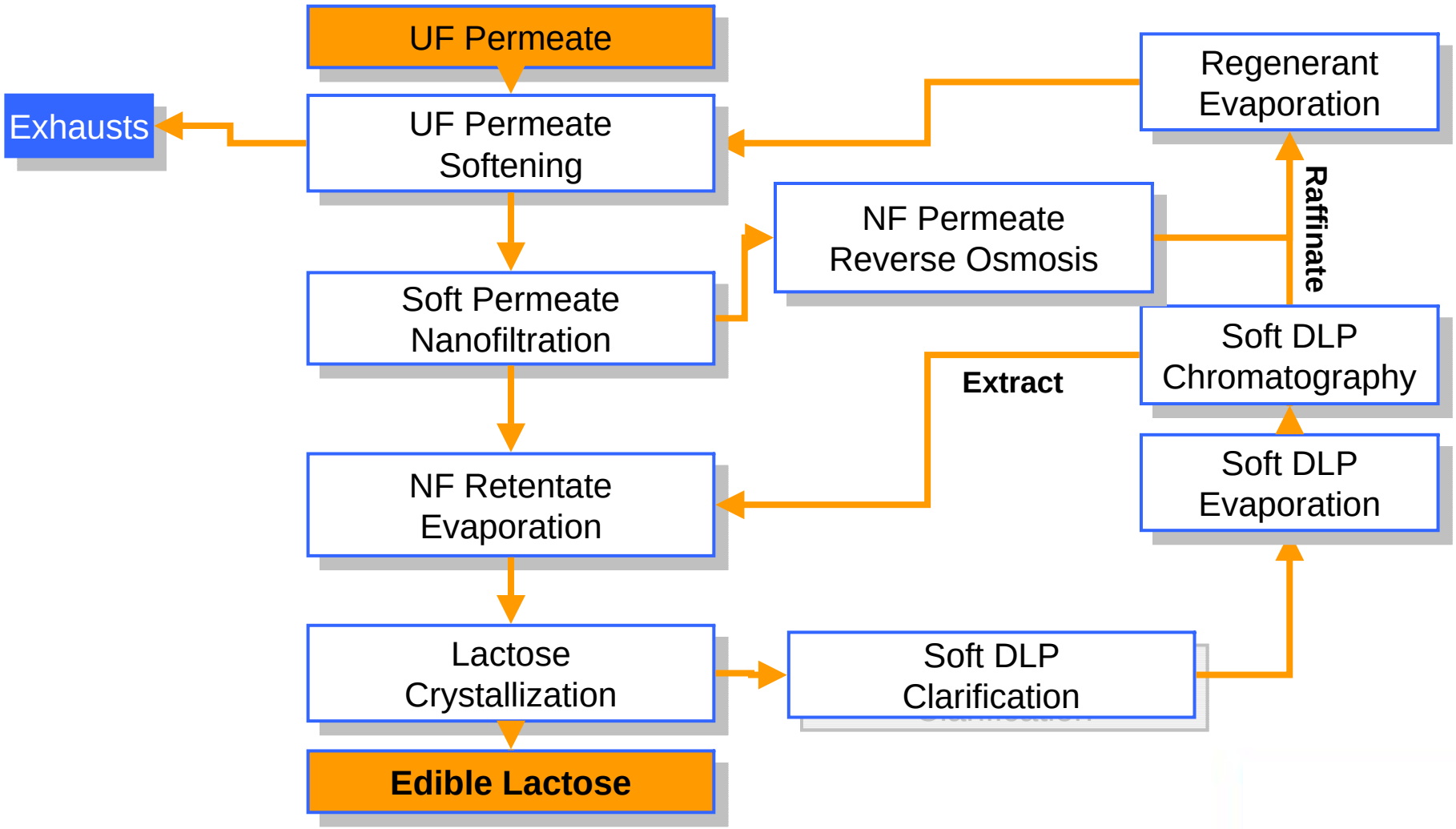
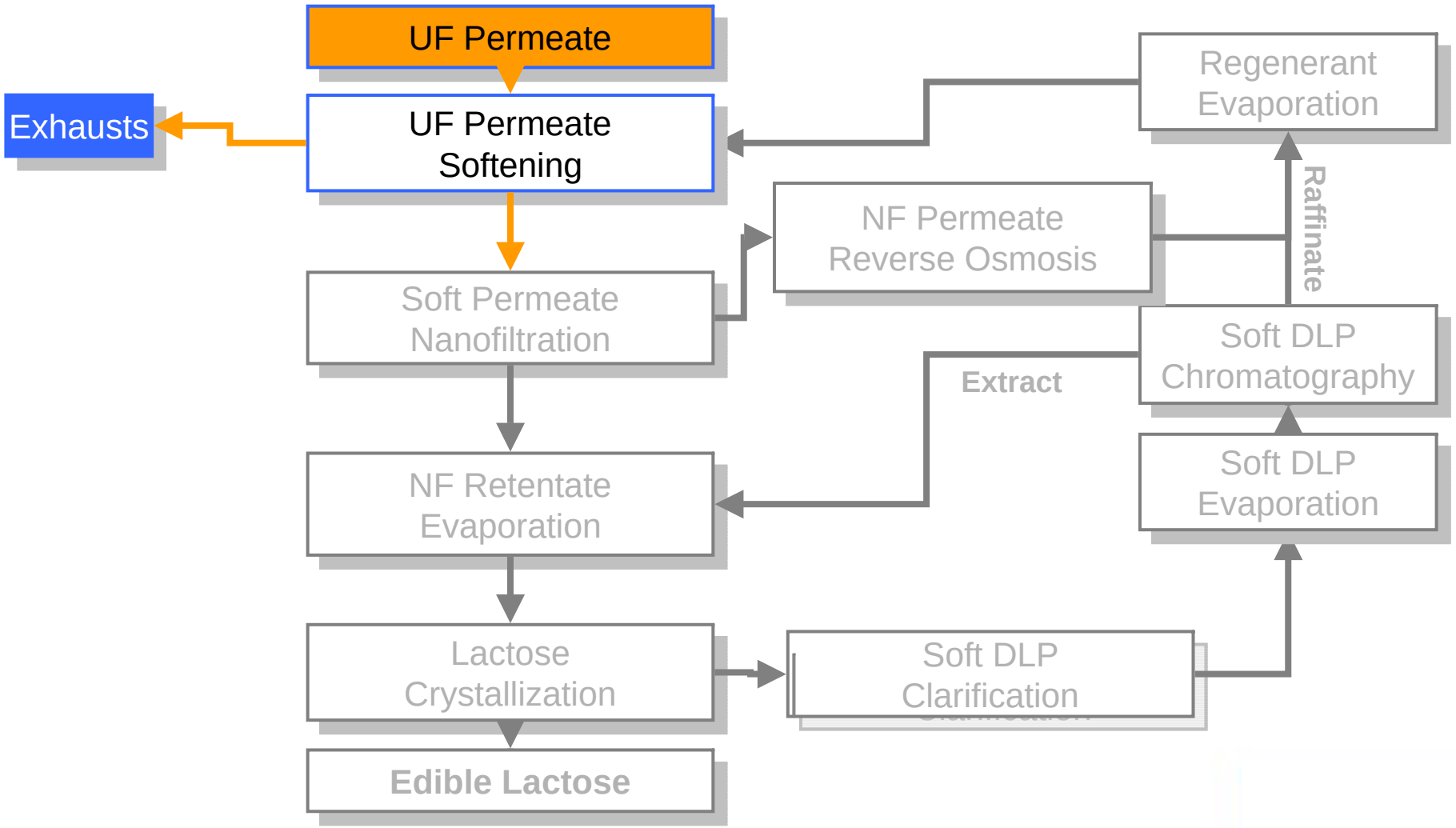
Chromatography on Mother Liquors



Focus #1 : Softening

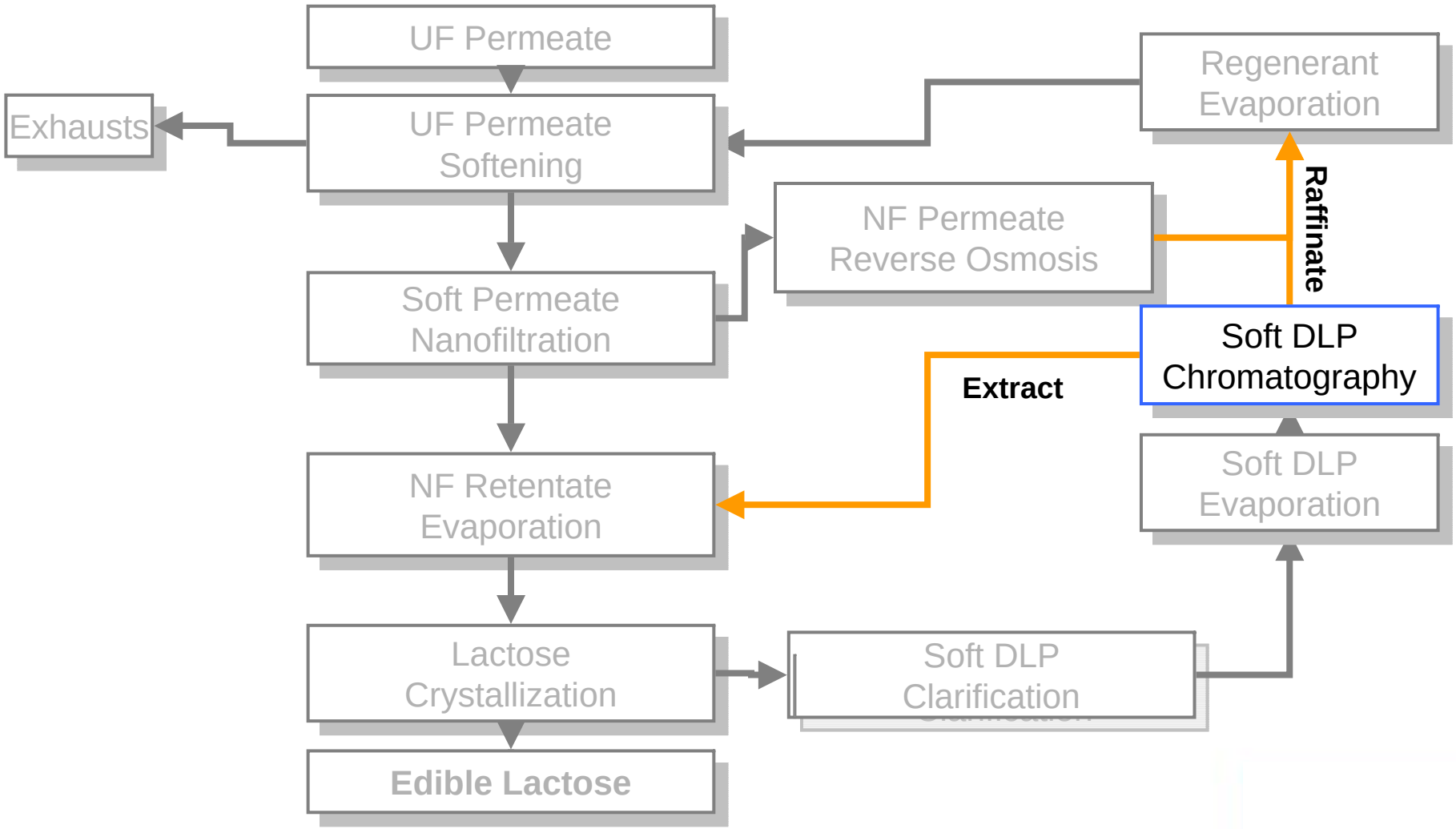


Focus #1 : Softening

	UF Permeate	
Tons liquid		1056
Volume liquid		1030
Liquid density		1,025
%DS	5,8%	52
Lactose %DS	77,5%	40
Monosaccharides	1,7%	1
Total Proteins	13,4%	2
Total minerals	9,2%	5
Other DS	5,6%	3
Ca in ppm/DS	8350	0,43
Mg in ppm/DS	1400	0,07
K in ppm/DS	23500	1,22
Na in ppm/DS	7850	0,41
Total cations	41100	2,13
PO4 in ppm/DS	36000	1,86
Cl in ppm/DS	24000	1,24
Total anions	60000	3,10

	Soft UF Permeate	
Tons liquid		1174
Volume liquid		1146
Liquid density		1,025
%DS	4,4%	51
Lactose %DS	77,4%	40
Monosaccharides	2,1%	1,08
Total Proteins	3,8%	1,95
Total minerals	10,1%	5,17
Other DS	6,7%	3,41
Ca in ppm/DS	421	0,02
Mg in ppm/DS	71	0,004
K in ppm/DS	31497	1,62
Na in ppm/DS	9201	0,47
Total cations	41190	2,11
PO4 in ppm/DS	18151	0,93
Cl in ppm/DS	30914	1,59
Total anions	49065	2,52

Focus #2 : Chromatography



Focus #2 : Chromatography

Soft DLP		
Tons liquid		47
Volume liquid		38
Liquid density		1,250
%DS	35%	24
Lactose %DS	59,2%	15
Monosaccharides	6,8%	1,0
Total Proteins	6,3%	1,3
Total minerals	16,7%	3,5
Other DS	11,0%	2,3
Ca in ppm/DS	913	0,02
Mg in ppm/DS	149	0,00
K in ppm/DS	49372	1,17
Na in ppm/DS	14425	0,34
Total cations	64858	1,54
PO4 in ppm/DS	36580	0,87
Cl in ppm/DS	48460	1,15
Total anions	85040	2,01

Lactose Fraction		
Tons liquid		62
Volume liquid		55
Liquid density		0,240
%DS	25%	16
Lactose %DS	90,4%	14
Monosaccharides	2,6%	0,41
Total Proteins	1,3%	0,20
Total minerals	3,4%	0,53
Other DS	2,2%	0,35
Ca in ppm/DS	208	0,00
Mg in ppm/DS	34	0,00
K in ppm/DS	11268	0,18
Na in ppm/DS	3292	0,05
Total cations	14802	0,23
PO4 in ppm/DS	8348	0,13
Cl in ppm/DS	11060	0,17
Total anions	19408	0,30

Raffinate SSMB		
Tons liquid		81
Volume liquid		77
Liquid density		1,050
%DS	10%	8
Lactose %DS	17,2%	1
Monosaccharides	7,6%	0,61
Total Proteins	13,8%	1,12
Total minerals	37,0%	3,01
Other DS	24,4%	1,99
Ca in ppm/DS	2264	0,02
Mg in ppm/DS	369	0,00
K in ppm/DS	122438	0,99
Na in ppm/DS	35771	0,29
Total cations	160842	1,31
PO4 in ppm/DS	90713	0,74
Cl in ppm/DS	120176	0,98
Total anions	210890	1,71

Edible Lactose		
Tons liquid		36
Volume liquid		
Liquid density		
%DS		36
Lactose %DS	99,9%	36
Monosaccharides		0,00
Total Proteins	0,02%	0,01
Total minerals	0,05%	0,02
Other DS		0,00
Ca in ppm/DS	3	0,00
Mg in ppm/DS	1	0,00
K in ppm/DS	179	0,01
Na in ppm/DS	52	0,00
Total cations	236	0,01
PO4 in ppm/DS	133	0,00
Cl in ppm/DS	176	0,01
Total anions	309	0,01

Comparison Crystallisation vs. Chromatography

	Lactose Fraction Crystallisation		Lactose Fraction DLP Process		Lactose Fraction Chromatography	
Lactose %DS	99,8%	**30**	99,9%	**36**	90,4%	**14**
Monosaccharides					2,6%	
Total Proteins	0,03%		0,02%		1,3%	
Total minerals	0,09%		0,05%		3,4%	
Other DS	0,06%				2,2%	
Ca in ppm/DS	36		3		208	
Mg in ppm/DS	12		1		34	
K in ppm/DS	202		179		11268	
Na in ppm/DS	68		52		3292	
Total cations	318		236		14802	
PO4 in ppm/DS	232		133		8348	
Cl in ppm/DS	207		176		11060	
Total anions					19408	
Global Yield	**75%**		**90%**		**(93%)**	

Economical impact

- For a plant producing 1 Mio Litres UF permeate per day
- Over a year (350 days), the chromatographic process on the Mother Liquors (12,600 tpy) yields **2,000 tonnes more** than the crystallisation process (10,500 tpy)
- At a value of 1600 USD/t, the chromatographic process allows for an increase of revenues of **3.4 Mio USD** par annum
- Considering the savings on OPEX balanced by the CAPEX relating to the chromatography, we anticipate a **ROI of about 2 years.**

Benefits of the Technology

- Innovation
  - Optimal Lactose Purity
  - Improved Yield

- Green Process
  - Lower Water Consumption
  - Lower Chemicals consumption
  - Lower effluent rejection

Thank you for your attention!

Jérôme THEOBALD

Natural Biomolecules/Global market leader

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