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# **CHROMATOGRAPHIC SEPARATION OF LACTOSE AND ITS APPLICATIONS IN THE DAIRY INDUSTRY**

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# SUGAR VS. DAIRY PROCESSES

- Crystallization
- Centrifugation
- Ion exchange
- Chromatographic separation
- Centrifugation
- Homogenisation
- Fermentation
- Membrane separations



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# PRINCIPLE OF CHROMATOGRAPHIC SEPARATION

- **Molecular sieve effect**
  - Large molecules are not able to flow into resin particles
- **Cation exchange resin**
  - Anions are not able to flow into resin particles
- **Donnan effect**
  - when the cationic composition of the resin is same as in the liquid, the resin rejects also cations
- **Lactose is a non-ionized small molecule**
  - It is able to flow into resin particles



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# SEPARATION EFFICIENCY

- Void volume (free volume outside the resin) is about 30 %
- Water content of the resin is 65-75 %, when DVB-content is 3.5 – 5.5 %
- Viscosity vs. temperature is an important parameter
- A lactose molecule may have over two times longer route through the column than a protein molecule



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# DISTRIBUTION COEFFICIENTS FOR THE COMPONENTS OF SKIM MILK AND WHEY (4,5 % DVB, 65 °C)

Component	Skim milk	Whey
Total protein (6.38xN)	0,1	0,2
Non protein nitrogen	1,1	3,4
Ash	0,07	0,06
Lactose	0,5	0,5



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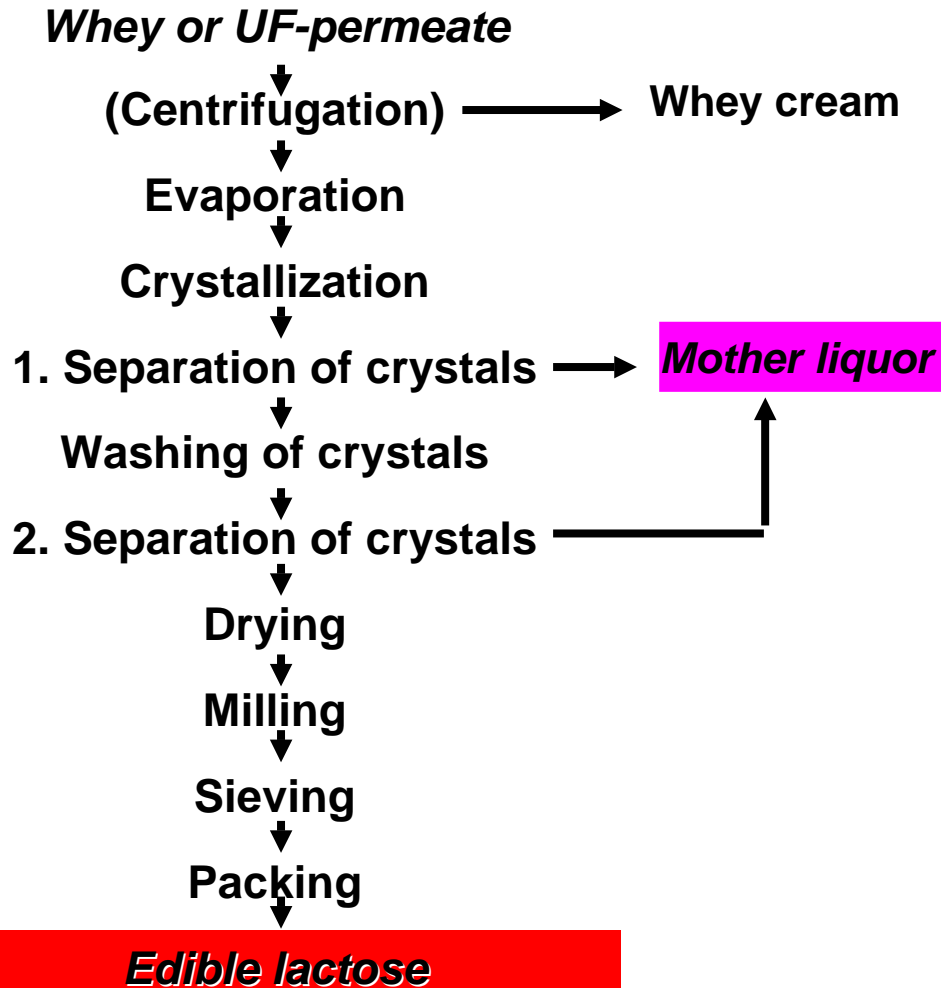
# DETAILS OF CHROMATOGRAPHIC SEPARATION

- Strong acid cation exchange resin (polystyrene divinylbenzene polymer)
- Molecular sieve effect controlled by cross linking degree (3,5 to 5,5 % divinylbenzene)
- Particle size variation has to be very small
- Particle size 0.3 mm => very low pressure drop
- Resin is very heat stable (Column can be heat sterilized)
- Resin is very cheap
- Resin is very durable (resin can be used for 10 years)



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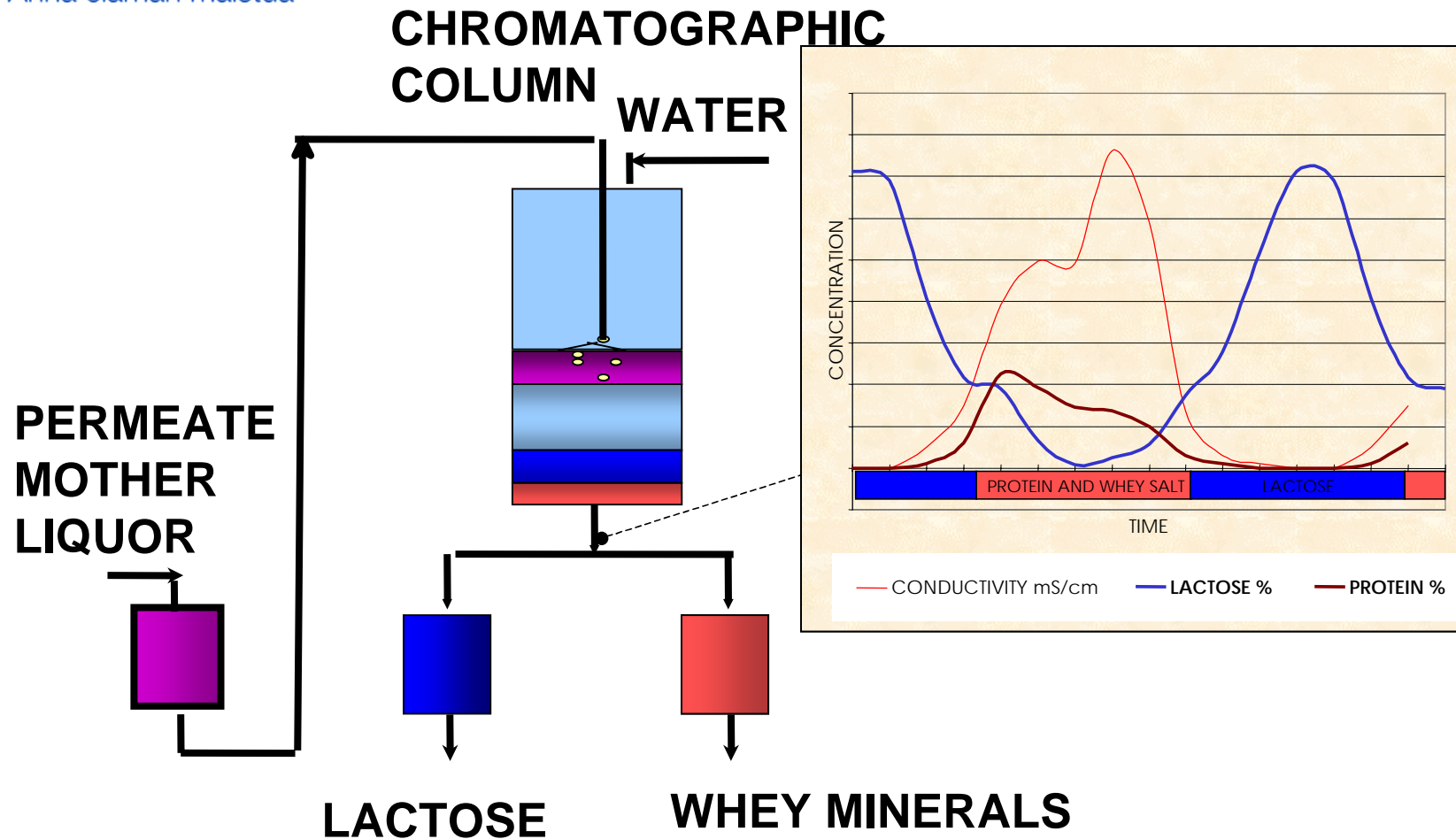
# LACTOSE PRODUCTION FROM WHEY AND UF-PERMEATE





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# CHROMATOGRAPHIC SEPARATION IN LACTOSE MANUFACTURE







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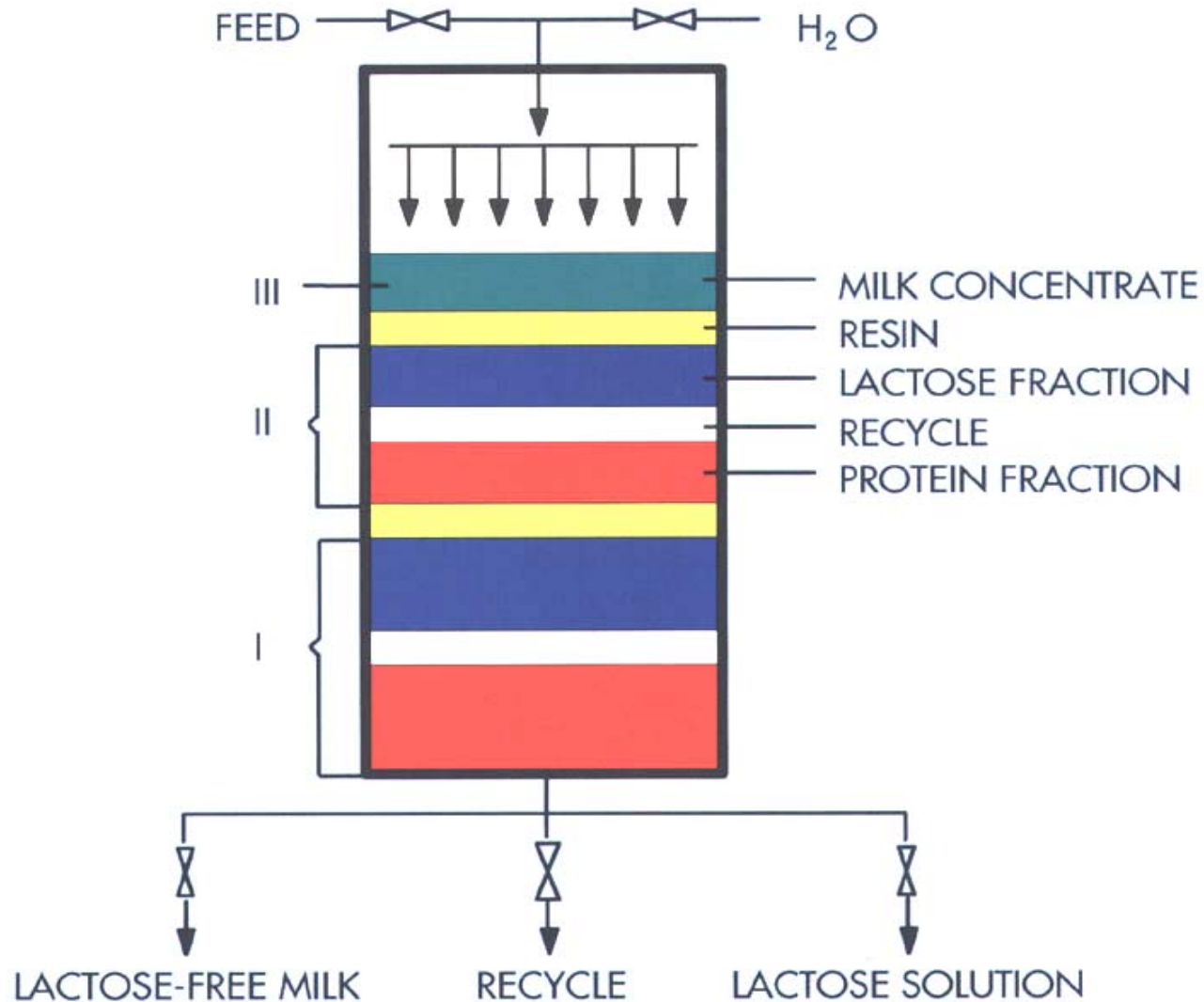
# WHEY MINERALS

- Can be easily dried with an ordinary spray dryer
- Natural mineral salt
- No bitter taste
- Physiological composition
- Natural low sodium alternative in cheese and butter
- It is industrially produced and protected by Valio



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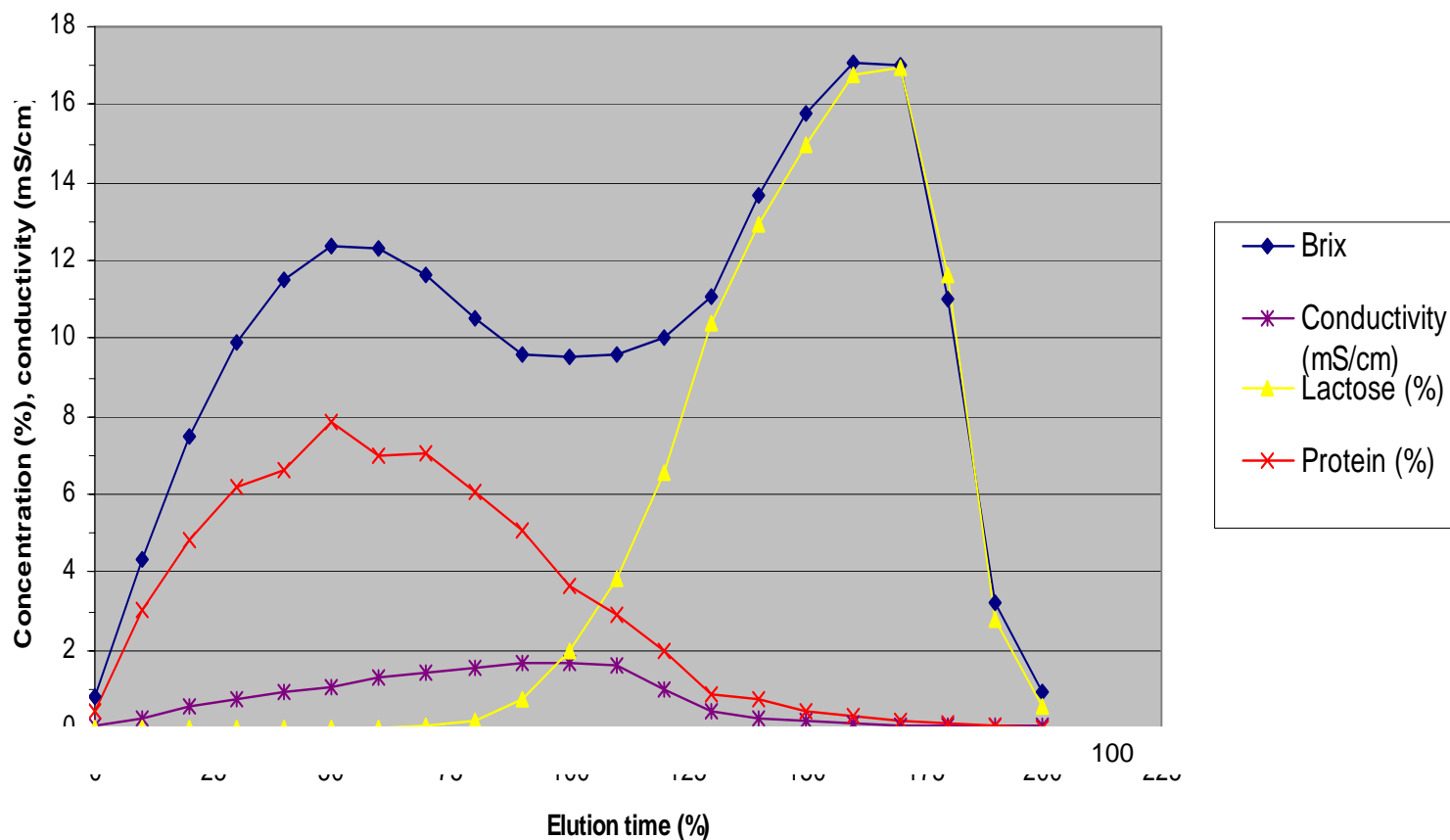
# THE OPERATION OF CHROMATOGRAPHIC SEPARATION





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# ELUTION CURVE OF LACTOSE SEPARATION FROM SKIM MILK





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**Skim milk  
concentrate  
fed on the  
surface of  
the resin  
under the  
water**





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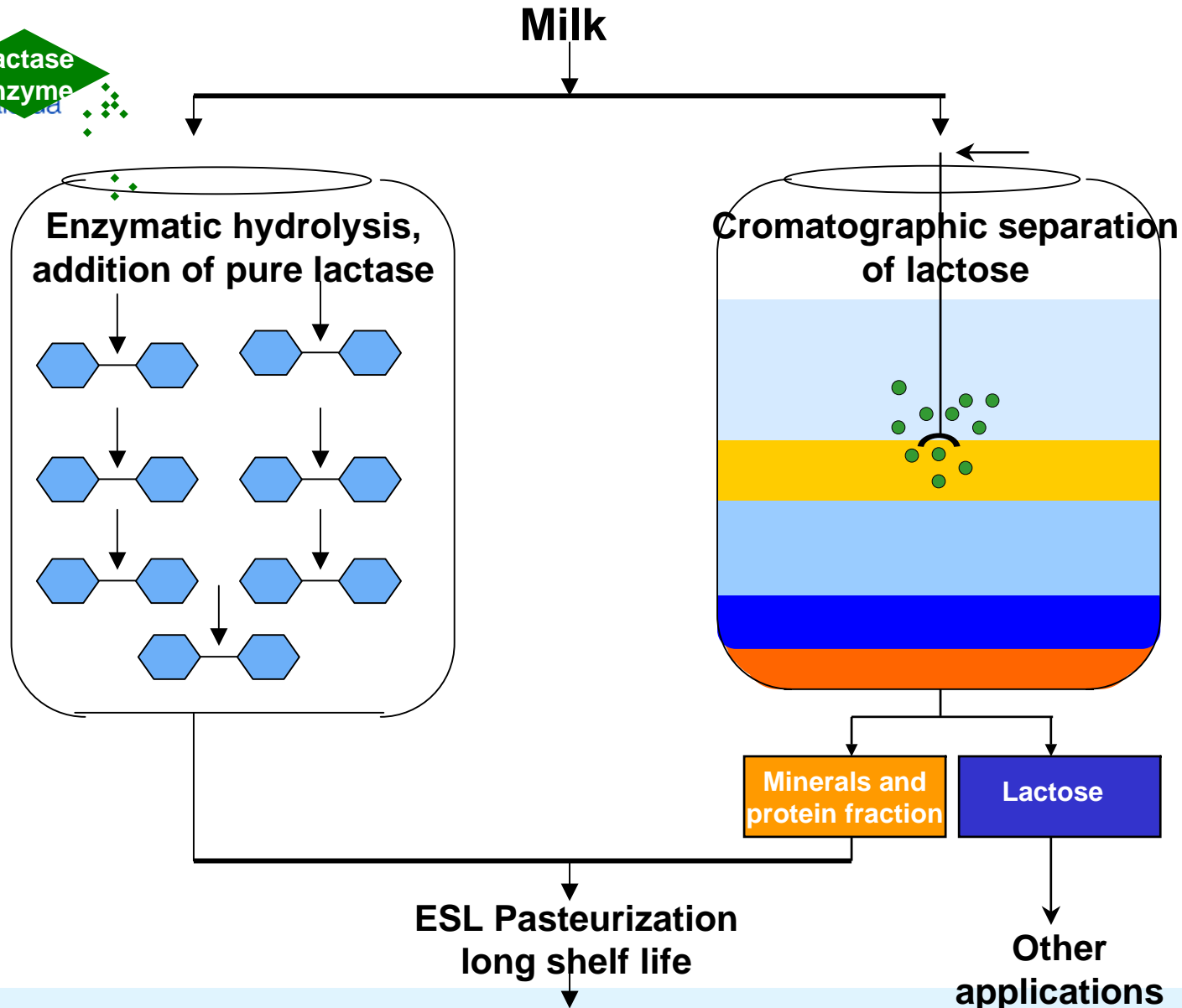


## Column in the backwashing stage

# LACTOSE-FREE MILK PROCESS



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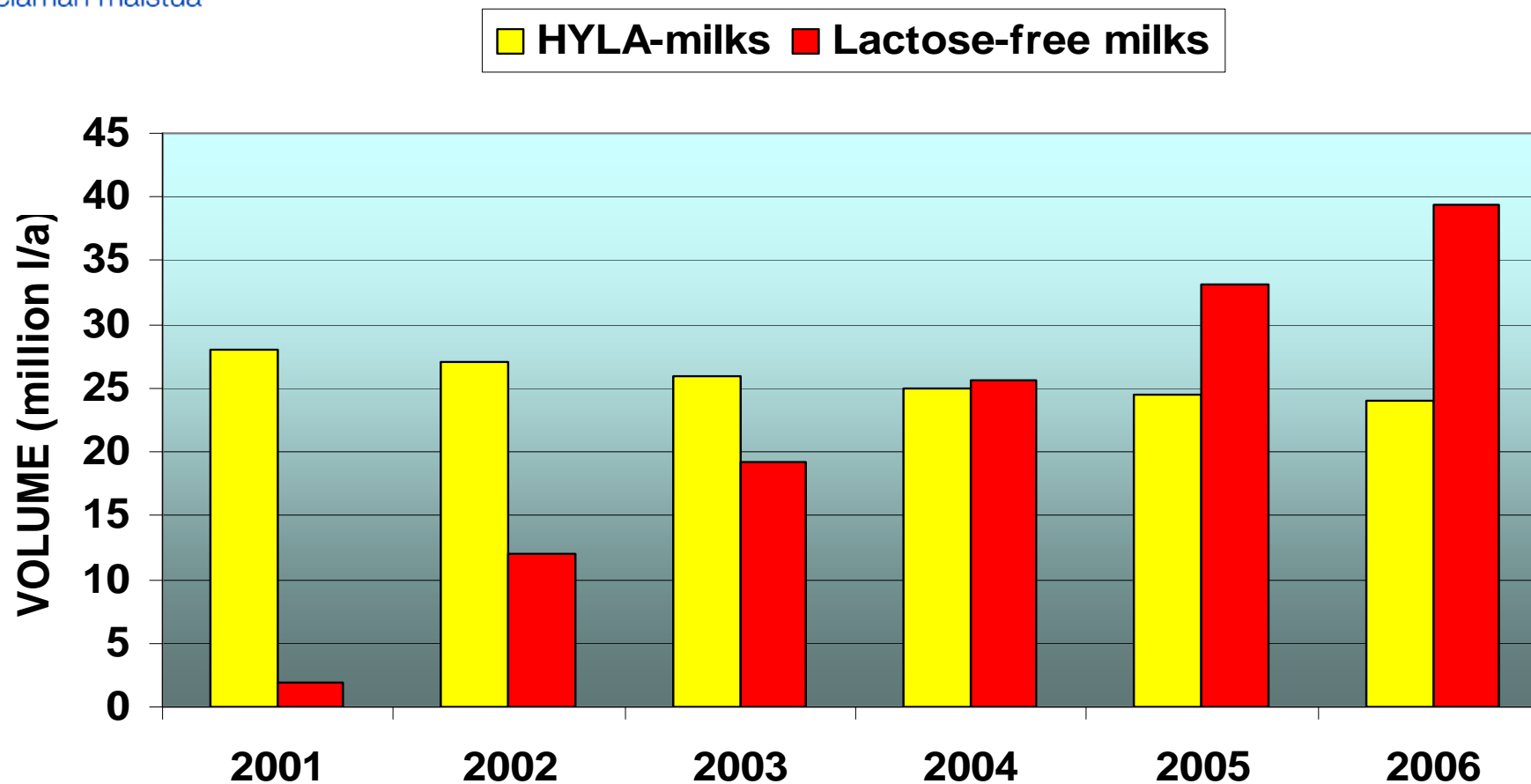
# COMPOSITION OF LACTOSE-FREE MILK

	<b>Low fat milk</b>	<b>Low lactose milk</b>	<b>Lactose-free milk</b>
<b>Protein (%)</b>	<b>3.2</b>	<b>3.2</b>	<b>3.2</b>
<b>Carbohydrates (%)</b>	<b>4.8</b>	<b>4.8</b>	<b>2.8</b>
<b>Lactose (%)</b>	<b>4.8</b>	<b>&lt;1</b>	<b>&lt;0.01</b>
<b>Ash (%)</b>	<b>0.7</b>	<b>0.7</b>	<b>0.7</b>
<b>Fat (%)</b>	<b>1.5</b>	<b>1.5</b>	<b>1.5</b>
<b>Calcium (mg/100 g)</b>	<b>120</b>	<b>120</b>	<b>120</b>
<b>Energy (kJ/100 g)</b>	<b>193</b>	<b>193</b>	<b>160</b>



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## SALES VOLUMES OF HYL- AND LACTOSE-FREE MILKS IN FINLAND







# LACTOSE-FREE MILKS MADE BY VALIO TECHNOLOGY

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# OTHER APPLICATIONS

- Separation of glucose and galactose
- Purification of galacto-oligosaccharides
- Separation of lactose and lactulose