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How to reduce the energy costs of food and dairy products to spray drying?

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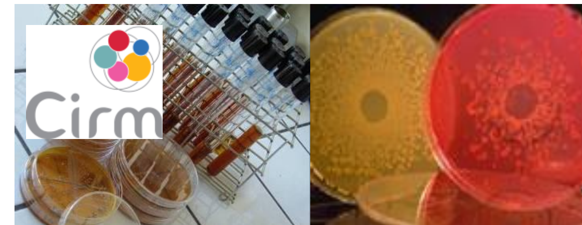
STLO

Science & Technology of Milk & Egg

A multidisciplinary and multiscale approach, reinforced by two high-calibre facilities:

Dairy Platform — **Biological Resource Centre**



80 standing fellow workers
25 PhD students

- **Structuration / destructuration mechanisms of food matrix:** *from structural characterisation to digestion*
- **Dairy processing and cheese making:** *toward sustainable dairy systems*
- **Microbial interaction:** *food matrix and host cell*

Please visit http://www6.rennes.inra.fr/stlo_eng

_01

Backgrounds & Objectives

Introduction (1)

❶ Spray drying is a useful technique for water evaporation using hot air, but **very black box in nature.**

❷ So the question is "how to anticipate the behaviour of dairy products to drying ?"

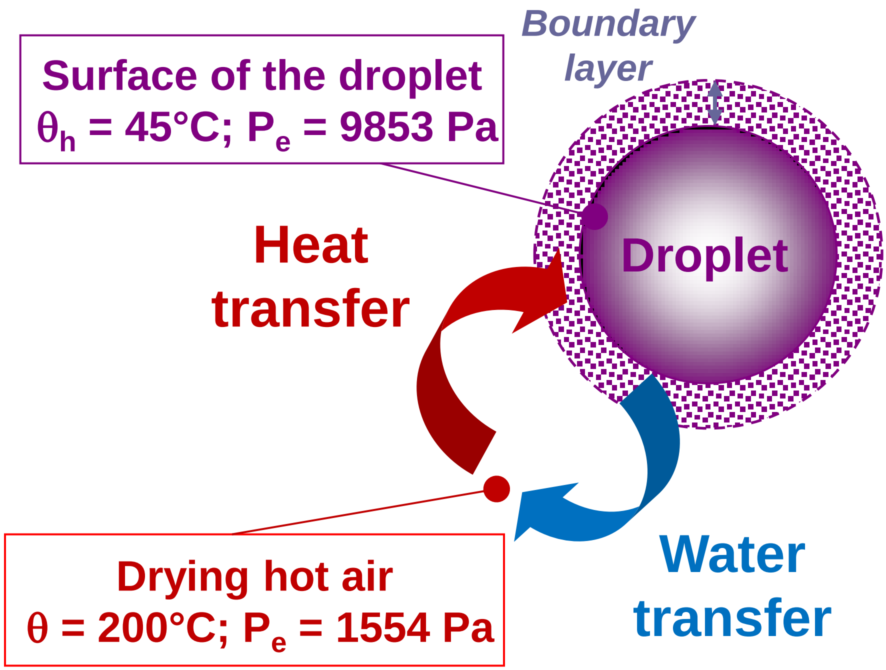
❸ To date, there are 4/5 methods available to determine precisely the parameters of spray drying for food products before drying.

❹ The first way to determine *a priori* & precisely the parameters of spray drying for food products is via pilot / plant experiments → **expensive, time consuming, empirical & sometimes unreliable.**

❺ **The other ways are** ⇨ spray drying modeling based on drying physics (transport phenomena, fluid mechanics, heat and mass transfer, reaction engineering, particle engineering as well as material science)

Introduction (2)

❻ **One difficulty remains** ⇨ **taking into account water availability = ƒ(product)**



❼ **Why ?**

- **Kinetics of mass / heat transfer phenomena and drying behaviour depend on the water availability**

⇨ **needs extra energy to overcome binding of water**

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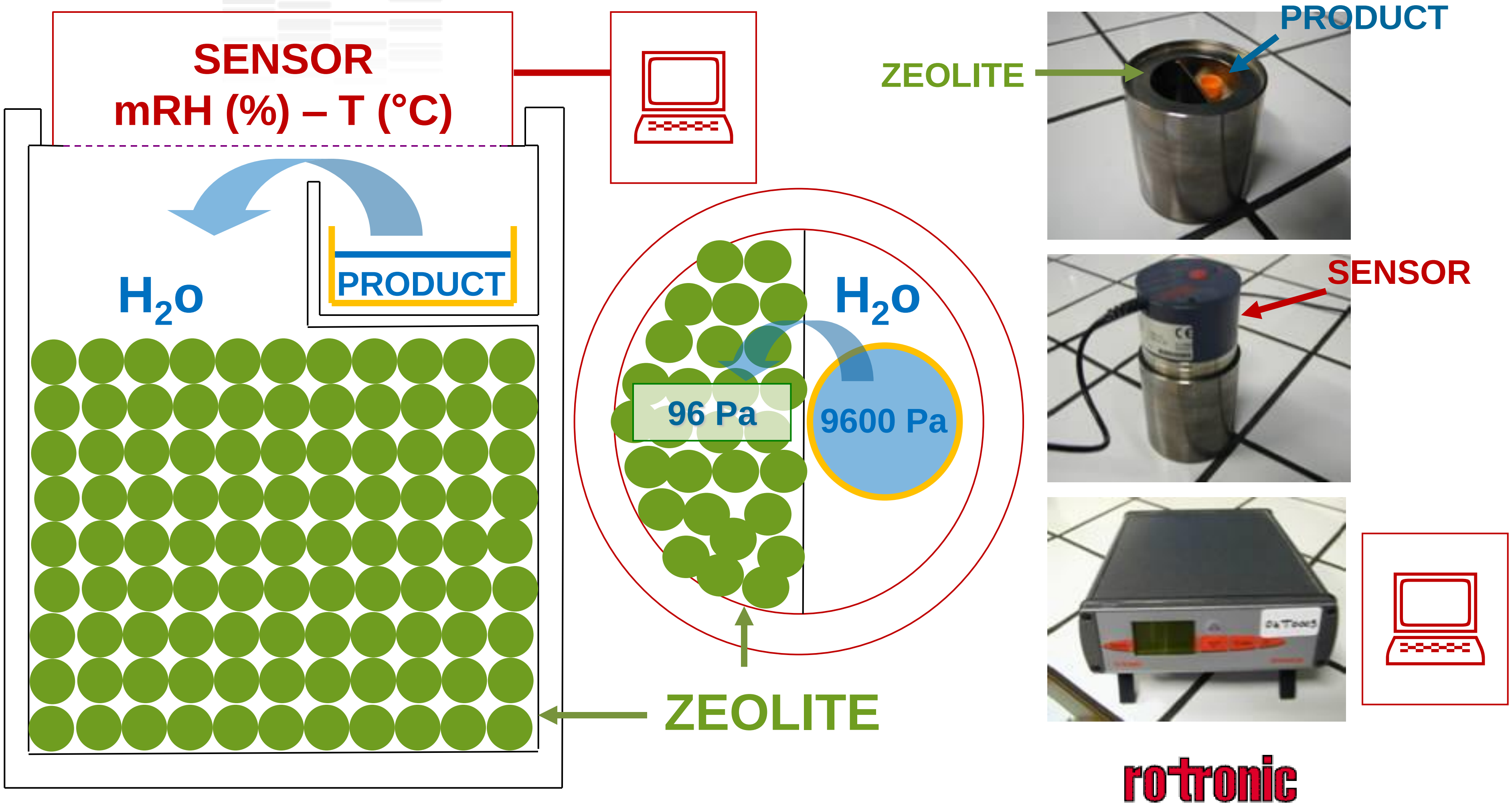
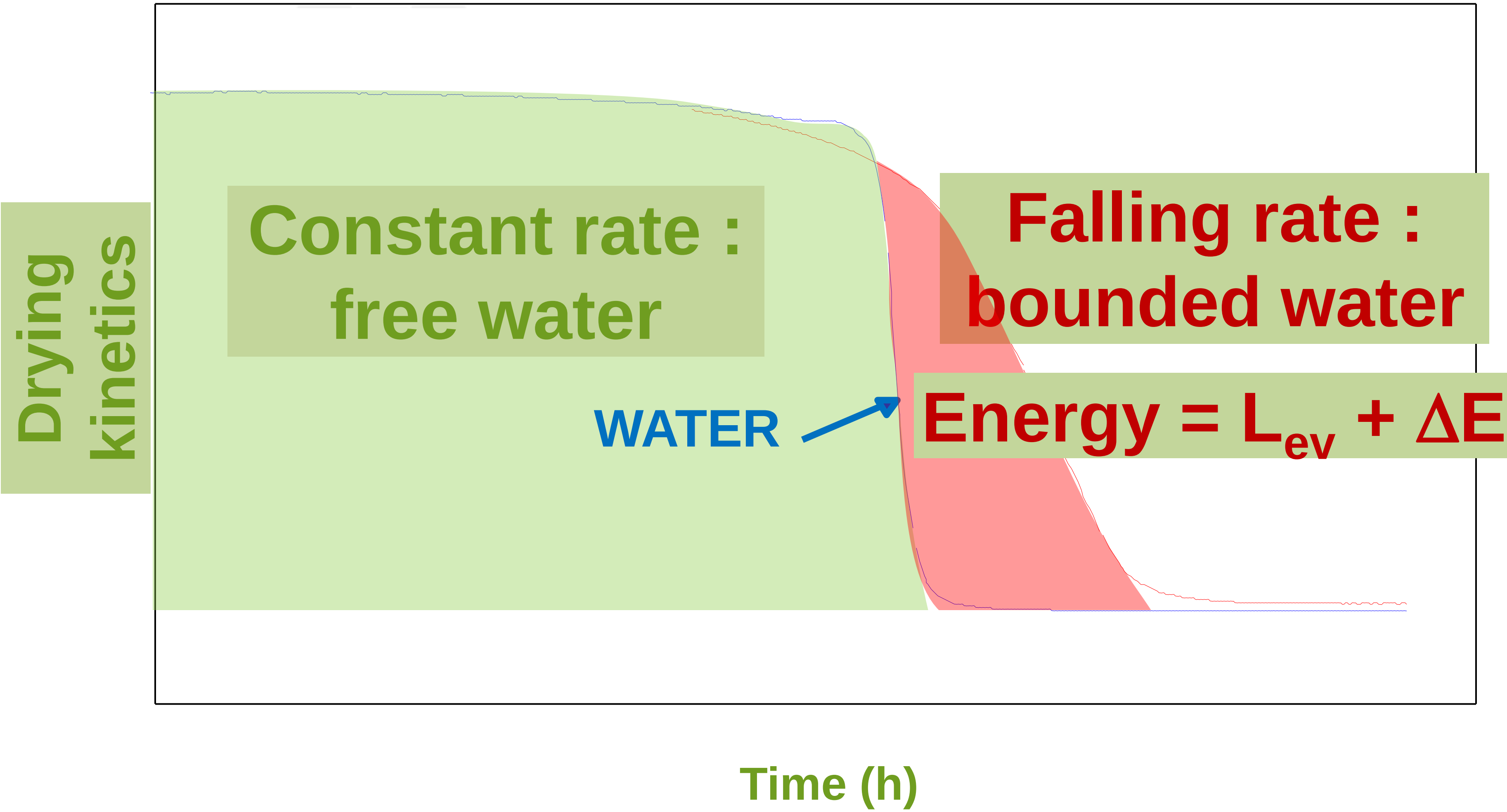
Drying by desorption

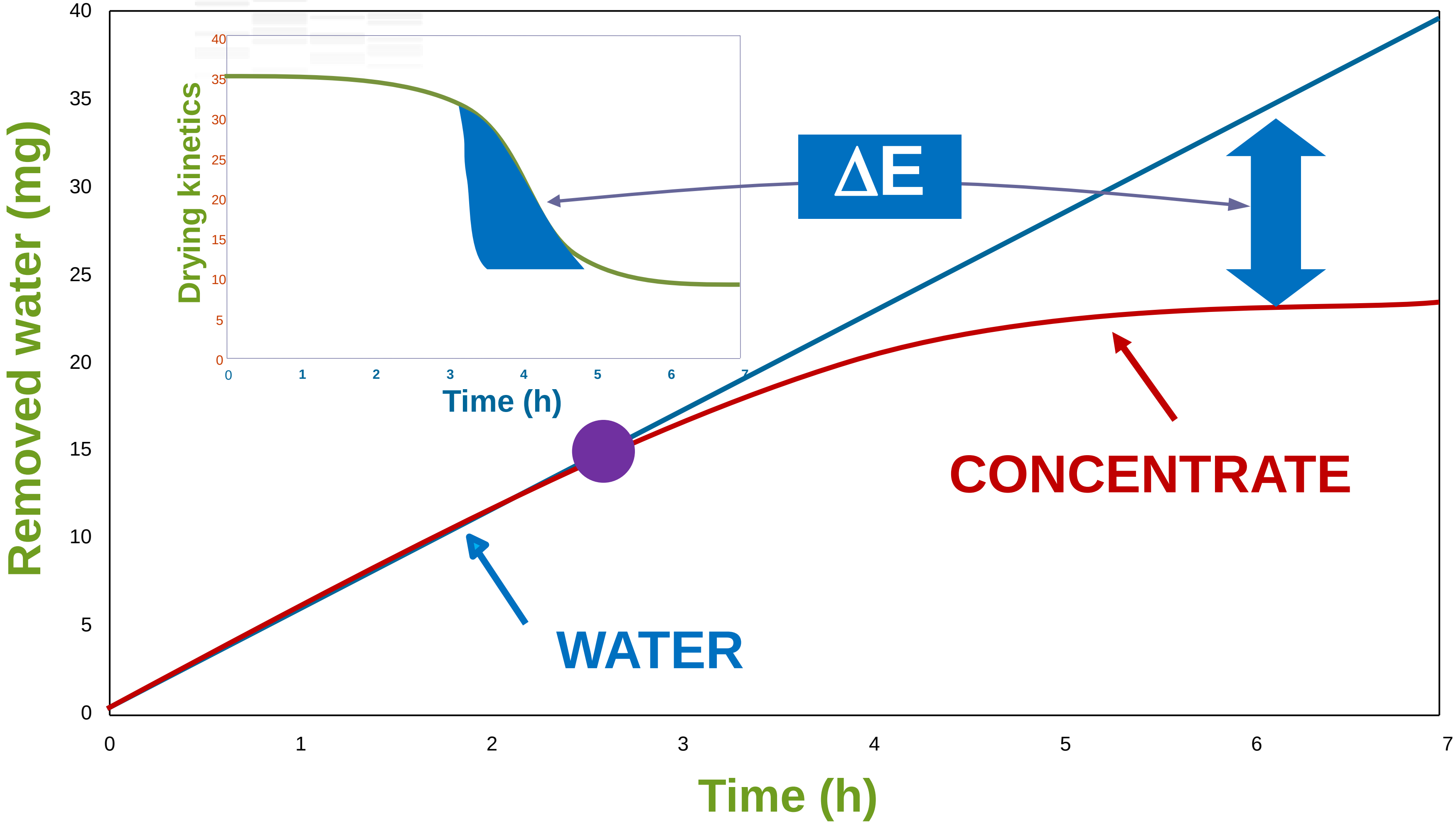
Step ➊:
Concentrate desorption by a_w-metry



Step ❷:
Desorption curve vs. time



Step ❸:
Desorption curve vs. time



Step ❹: Calculation by INRA Software SD²P® integrating the ratio of bound and unbound water.

Skim Milk Concentrate @ 50% TS

Reduce | Settings

	Mass flow rate (kg DA/h)	Enthalpy (kJ/kg DA)	Temperature (°C)	AH (g/kg DA)	RH (%)
Inlet air before heating		38	20	7	47,8
Inlet air after heating 'I'	75000	248	225.2	7	0,04
Cooling air 'C'	2000	38	20	7	47,8
Recirculation air 'R'	2000	38	20	7	47,8
Complementary air 'C'	0	17,5	0	7	183,3
Air mix (I+C+R+C)	79000	237.4	214,2	7	0,05
Outlet air 1 stage (I+C+R+C)	79000	213,2	89,8	45,8	10
IFB inlet air before heating		37,8	20	7	47,8
IFB inlet air after heating 'B'	15000	118,2	98.4	7	1,2
IFB outlet air 'B'	15000	86	56.8	11	10,2
Overall outlet air (I+C+R+C+B)	94000	192,9	84.8	40,2	10,7

Evaporation capacity (kg/h)	3125,2
Water flow rate in concentrate (kg/h)	3250,2
Concentrate flow rate (kg/h)	6500.4
Concentrate flow rate (l/h)	5417
Concentrate density (-)	1,2
Concentrate dry matter (%)	50
Powder moisture (%)	4
Powder flow rate (kg/h)	3385.6
Concentrate temperature (°C)	45
Concentrate Cp (kJ/(kg.°C))	3,5

Wet bulb temperature of overall outlet air (°C)	47,6
Dew temperature of overall outlet air (°C)	36,8
Energy balance (kJ/kg water)	5426
Energy consumption ratio (60°C) (kg vapour/kg water)	2,3
Yield (60°C) (%)	43,5
Cost ($/ton water)	90.4
Cost ($/ton powder)	83.5
kWh cost ($)	0,06
Corresponding standard breakpoint (%)	100

Default | Print | Export | Quit

Materials

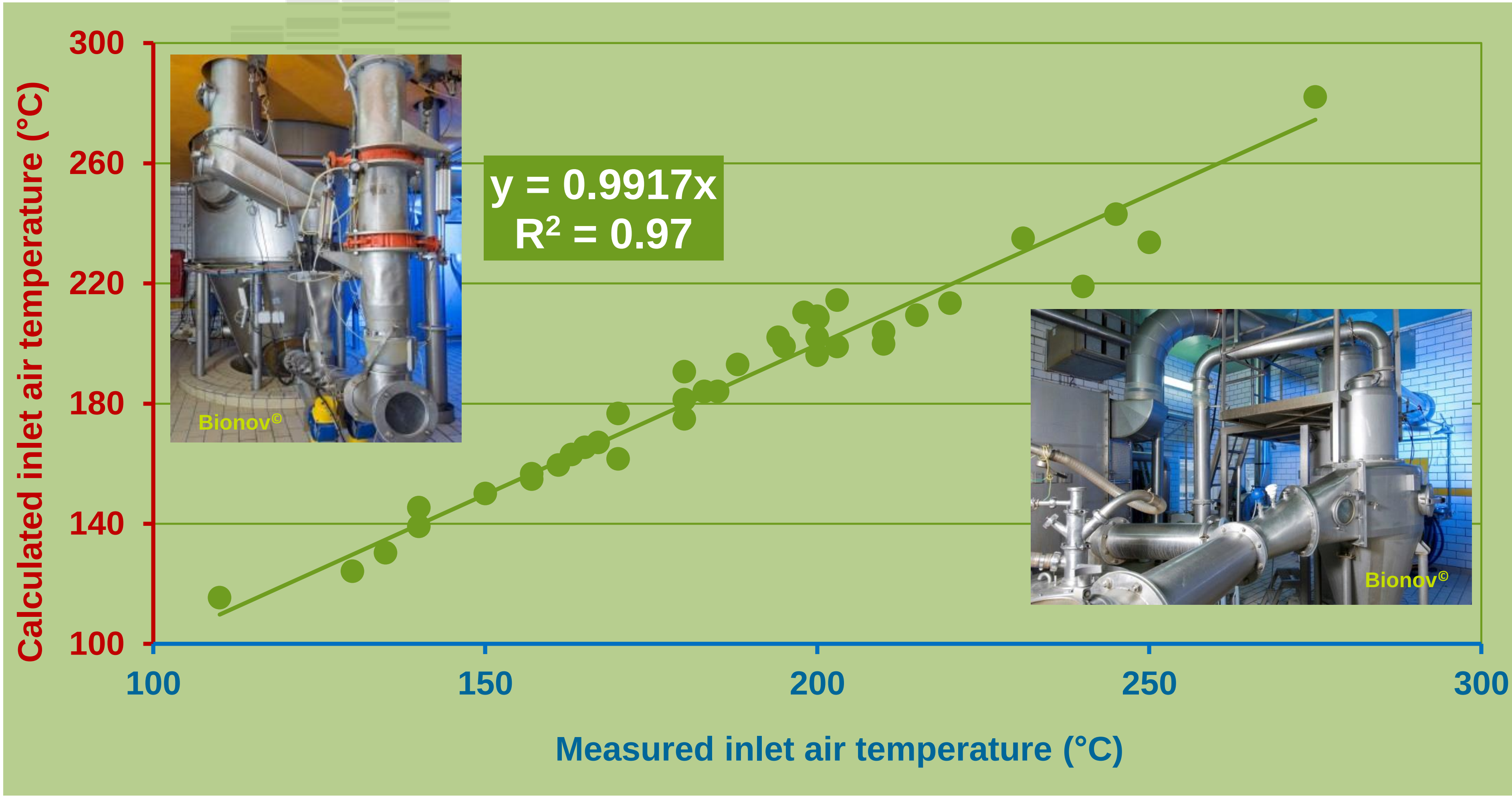
B
I
O
N
O
V

Pilot workshop : Research and development for evaporation / drying

"MSD type" drying tower

80 kg of water evaporated per hour

Results



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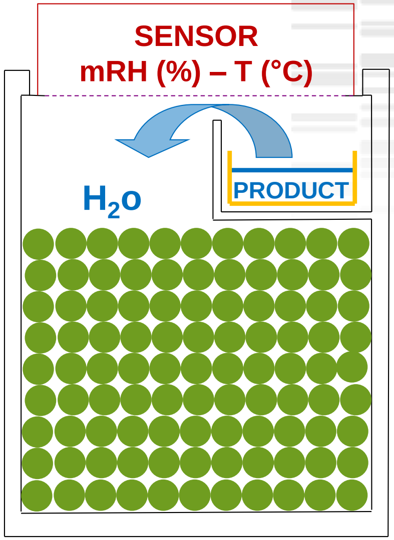

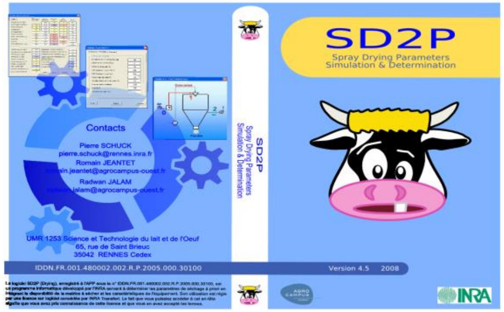

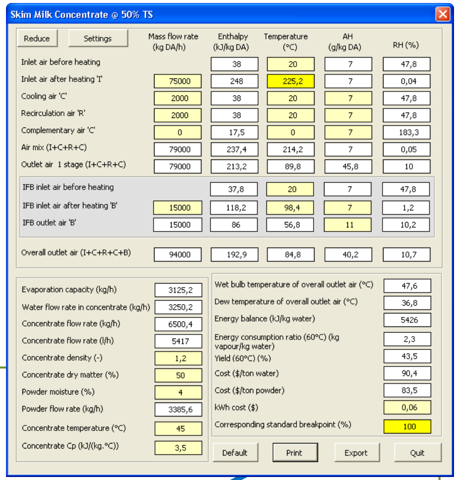

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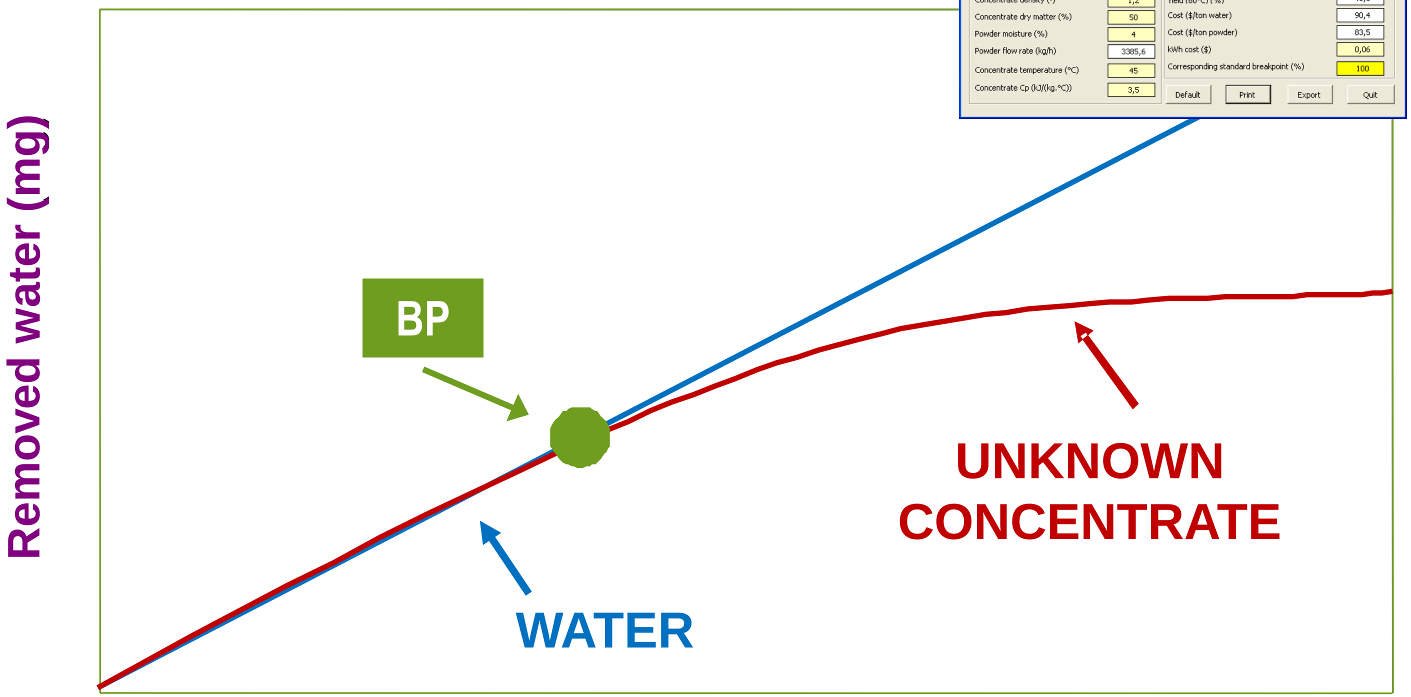
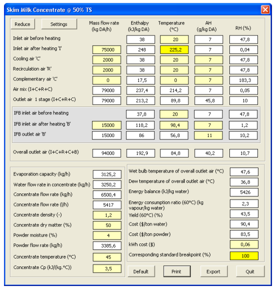
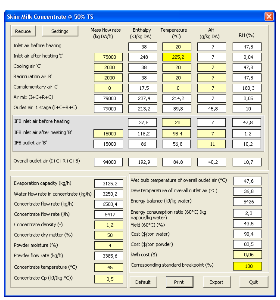


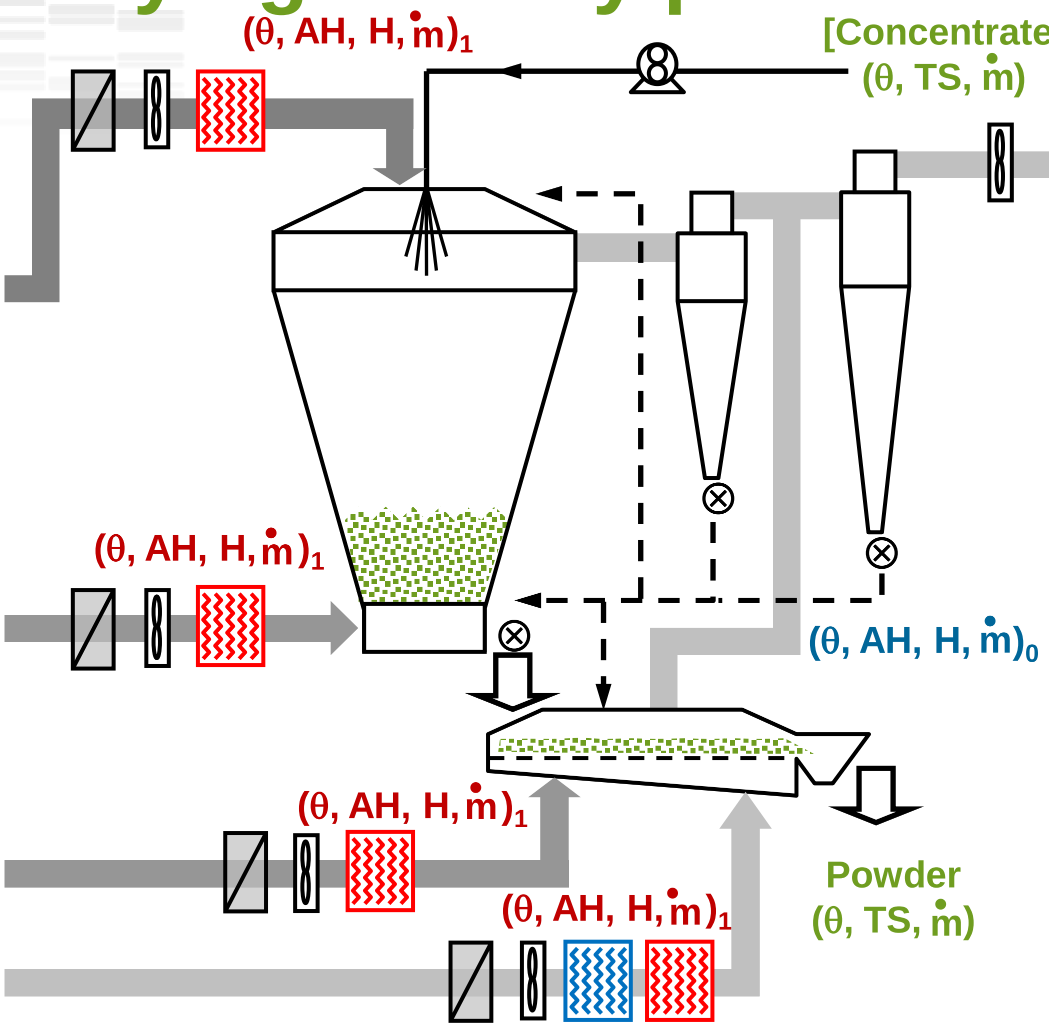
Time (h)

How to optimize the energy cost of spray drying of dairy products ?



Inlet air
(θ, AH, H, ṁ)$_0$





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How to optimize the energy cost of spray drying of dairy products ?

By variation of drying parameters and concentrate parameters with the helpful on the INRA software (SD^{2}P®) for prediction.

→ High interest to increase, the TS of the [C] and the T°C of the inlet air before heating,

→ High interest of the IFB for easy (drying) or difficult (cooling) product to spray dry,

→ Interest of the dehumidification the air ✓ To increase the production ✓ To have regular spray drying parameters (Major air) and ✓ To decrease the powder temperature (IFB).

But to optimize, don't forget to take into account the cost of the investment that you have to realize and the quality of the dairy powder too.

_03

CONCLUSIONS

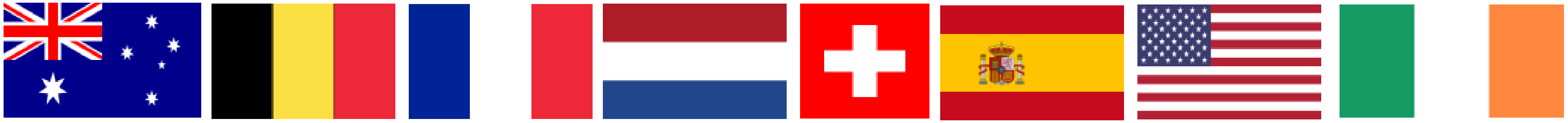
SD²P®

- With this method, it is possible to predict and optimize the **spray drying parameters** (± 1-5%) for food products in relation to their desorption behavior

- **Validation tests** (>100 products) indicate that this method could be applied to a large range of food products & spray dryer types.

- For reasons of calculation speed and reliability, the method has been computerized. **Spray Drying Parameters Simulation & Determination *Software* (SD²P®)**
  N° IDDN.FR.001.480002.003.R.P.2005.000.30100

- Up-to-date, 31 licenses have been sold at 24 factories [80% Dairy (4 of the Top 5 and 9 of the Top 25) – 20% Non Dairy], from 8 different countries:



- Top 1 for Inra licenses and Top 15 for Inra licenses and patents, since 1946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