Methodological approach towards environmentally friendly processes for preserving lactic acid bacteria

Club des Bactéries Lactiques – 13th June 2019

Caroline Pénicaud, Bruno Perret, Stéphanie Passot, Camille Quentier, Fernanda Fonseca
UMR 782 GMPA, INRA, AgroParisTech, Grignon, France

Stabilized Lactic Acid Bacteria

Fermentation

↓

Cooling

↓

Concentration

↓

Formulation

↓

Stabilization
Freeze-drying
Freezing

↓

Storage

***Lactobacillus delbrueckii ssp. bulgaricus* strain CFL1**

- Freeze-drying
  - Soft for the bacteria
  - Energy intensive: freezing + drying of the frozen product

Functionality: acidification activity (CinAc®)

Life Cycle Assessment (LCA)

INPUTS

Buildings

Refrigerants

Raw materials

Fuel

Gas

Electricity

Packaging

OUTPUTS

Products

GHG

Refrigerant leakages

Wastes

quantitative

multi-criteria

ENVIRONMENTAL IMPACT

Climate Change | Acidification | Eutrophisation | Human Toxicity

Ozone Depletion | Water depletion | Non Renewable Resource Depletion

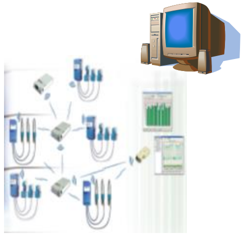
LCA of Freeze-Dried Bacteria

Data Acquisition

	Growth medium preparation	Fermentation	Centrifu-gation	Protection	Freeze-drying	Storage (T = - 20°C)	Transport
Input	Water , Electricity, growth medium	Electricity, Steam, Water, chemicals products	Electricity	Composition of protective medium	Electricity	Electricity*, Packaging	Km traveled,
Output	-	Liquid wastes	Liquid wastes	-	Leakage of refrigerant gas	Leakage of refrigerant gas	Leakage of refrigerant gas

Sensors used for data collection

- Wi-LEM® energy sensors (DISTRAME, France) for electricity
- Receiver Coronis ® for water, steam and liquid wastes



Pénicaud et al. 2018

Other sources

- Data collected during handling (chemical products, water and liquid wastes)
- Database (Simapro, Ademe)
- Developed tool to estimate the electric consumption of cold storage supported by Intelligent Energy Europe. The electric consumption of storage is reported to the stored volume.

LCA of Freeze-Dried Bacteria

Methodology

➢ **<u>Functional Unit</u>**: stabilization of 3 kg of protected bacteria

Weighting with Physiologic state of the bacteria

SimaPro

ILCD 2011 method

- **<u>Specific activity</u>**

$$t_{spe} = \frac{\text{Acidifying activity}}{\log(\text{viability})}$$

- **<u>Weighting</u>**

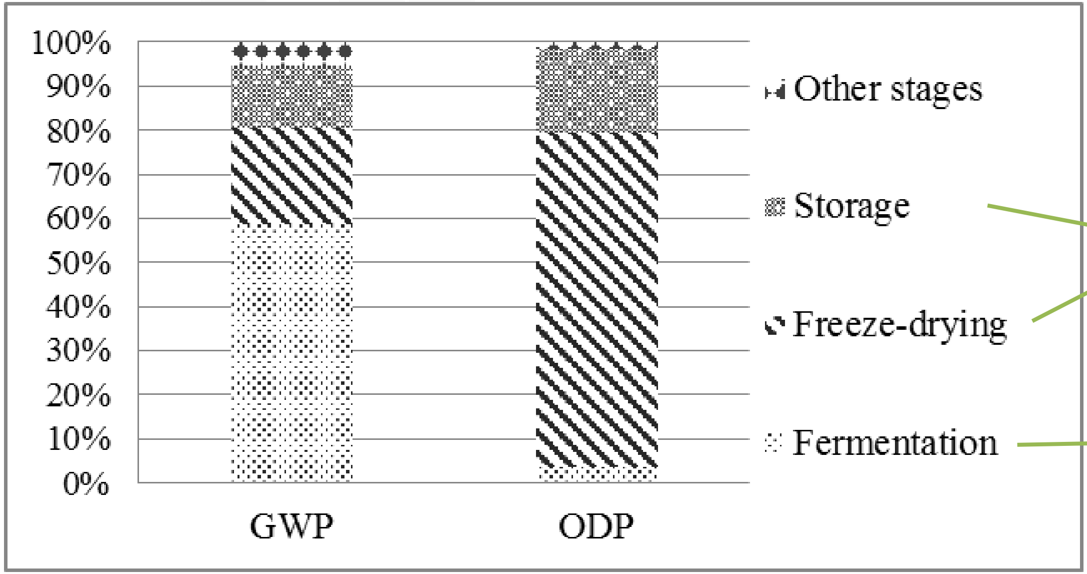
Weighted Impact = characterized impact value x Specific activity

Pénicaud et al. 2018

LCA OF FREEZE-DRIED BACTERIA

RESULTS

-20 °C storage during 1 year



electricity consumption, leakage of refrigerant gas

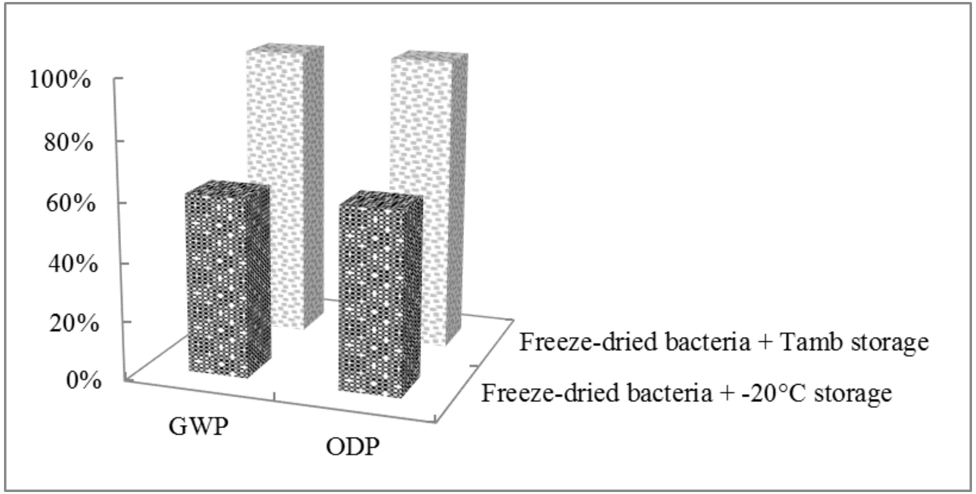
natural gas, tap water

Pénicaud et al. 2018

Reduce Energy Consumption: Increase of Storage Temperature

LCA Results

storage during 3 months



Weighted Impact = characterized impact value x Specific activity

If bacteria quality remained constant, raising the storage temperature would reduce environmental impacts of about 10 %

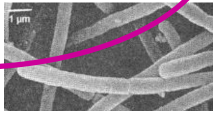
Effect of Product Quality

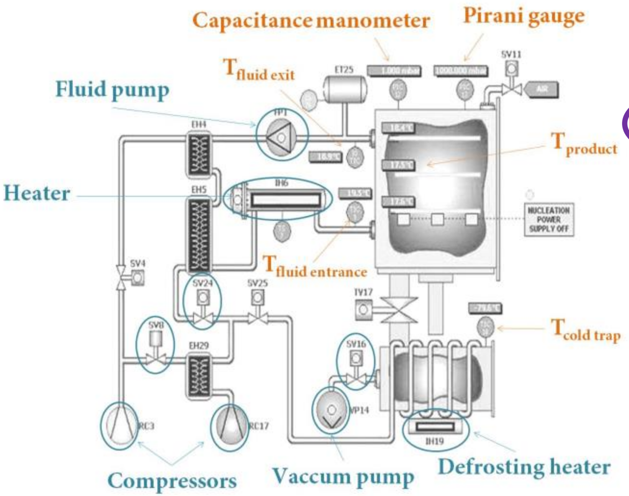
Pénicaud et al. 2018

REDUCE ENERGY CONSUMPTION: OPTIMIZATION OF FREEZE-DRYING

LyoBeta special
(Telstar, Terrassa, Spain)

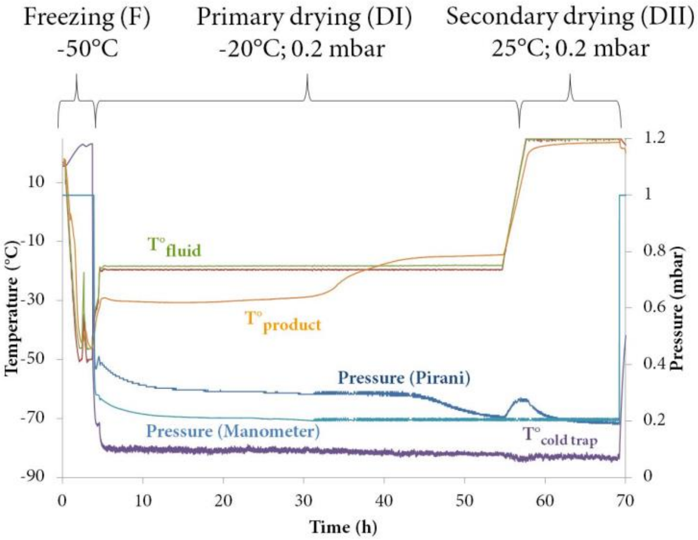
Product parameters
Viability
Acidifying activity
Structure





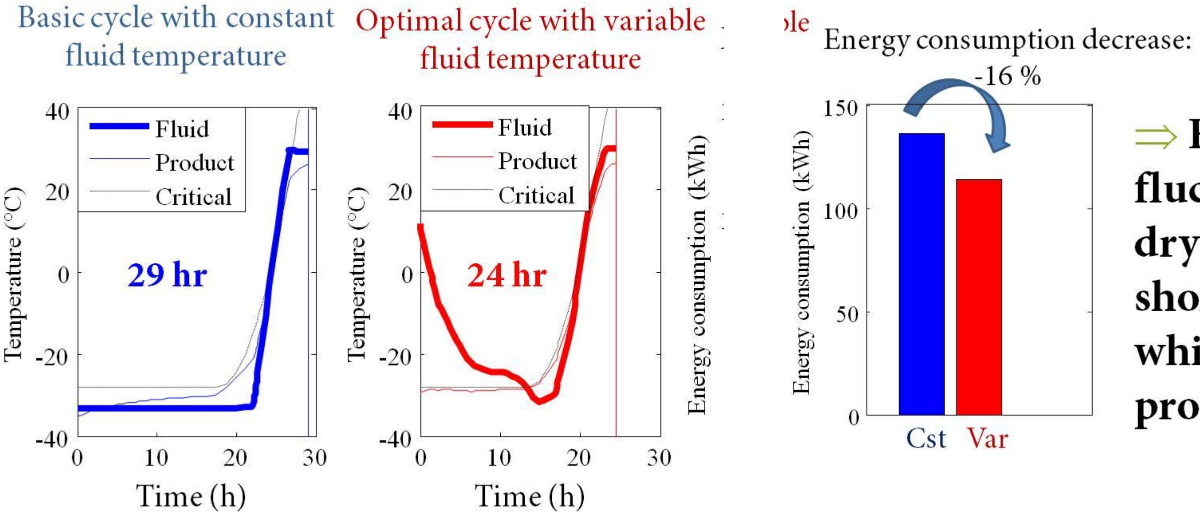
Process operating conditions
T_{fluid}, $T_{product}$ and $T_{cold\ trap}$
Pressure
Time

Mathematical model
Linear relationship



Process apparent energy consumptions
- Main components + Fans dedicated to compressors
- General supply

Reduce Energy Consumption: Optimization of Freeze-Drying



⇒ **Fluid temperature fluctuation in primary drying saves energy by shortening cycle duration, while maintaining the product quality**

Pénicaud et al. 2014, 2016

STABILIZATION ALTERNATIVE

Fermentation
↓
Cooling
↓
Concentration
↓
Formulation
↓
Stabilization
Freeze-drying
Freezing
↓
Storage

***Lactobacillus delbrueckii* ssp. *bulgaricus* strain CFL1**

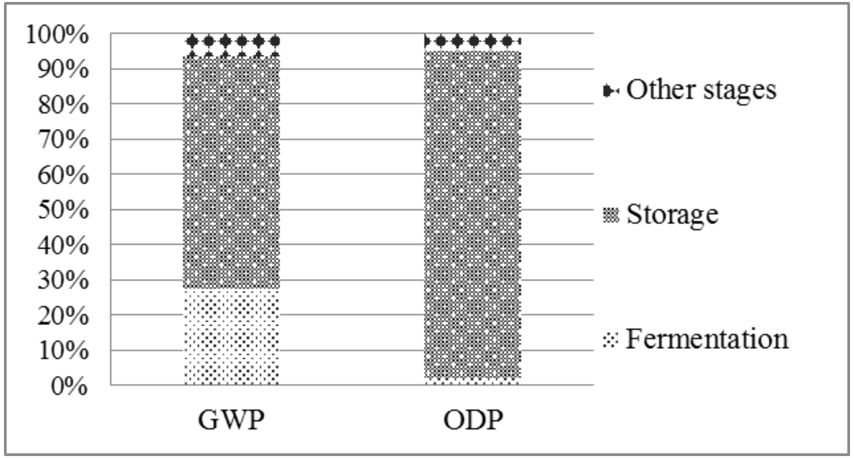
- Freeze-drying
  - Soft for the bacteria
  - Energy intensive: freezing + drying of the frozen product
- Alternative: Freezing
  - Need of frozen storage
  - **Is it really more eco-friendly than freeze-drying if we consider the whole life cycle?**

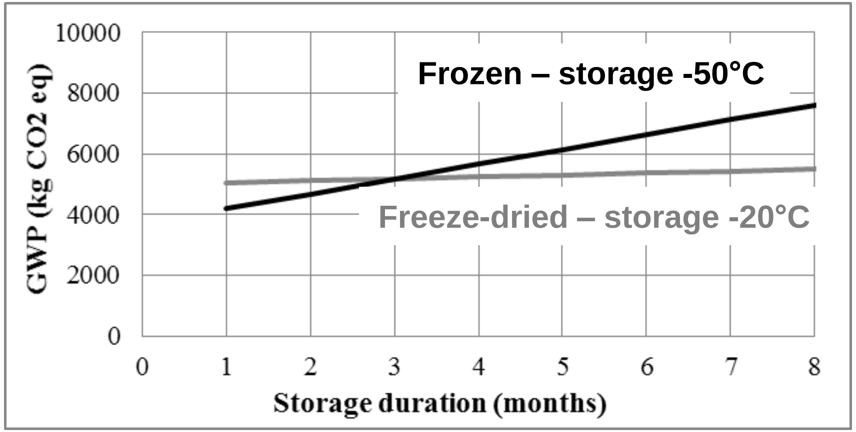
Functionality: acidification activity (CinAc®)

LCA of Frozen vs Freeze-dried Bacteria

Results

Frozen, -50 °C storage during 1 year





Trend remains the same for all indicators
BUT
Depending on the indicator, the duration for which $\text{Impact}_{\text{frozen}} = \text{Impact}_{\text{freeze-dried}}$ is different (from 2 to 8 months).

Pénicaud et al. 2018

Conclusion

Eco-design options

- Improve / re-design processes
  - Freeze-dryer
  - Fermentor
- Process alternative
  - Freezing instead of freeze-drying for short-term storage
- Preserve cell quality to allow new options
  - Increase $T_{storage}$

- **Necessary to take simultaneously into account product quality / process conditions / environmental impact**
  - Knowledge integration

BAGATEL DATABASE

Stabilized Lactic Acid Bacteria – PREMIUM

Preserving bacteria with oligosaccharides and eco-friendly processes

(2018-2021)

A large variety of functionalities offered by microorganisms remains under-exploited due to their sensitivity to the manufacturing processes

The **objective of PREMIUM project is to develop new strategies to preserve lactic acid bacteria from laboratory to industrial scale**

High functionalities
Exploit new microorganisms

Innovative processes
High productivity

Low environmental impacts

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 777657

Stabilized Lactic Acid Bacteria –

PREMIUM
Preserving bacteria with oligosaccharides and eco-friendly processes

- Bacteria
- Fermentation
- Cooling
- Concentration
- **Protection**
- **Freezing** / **Freeze-Drying** / **Spray-Drying**
- Storage
- Thawing / Rehydration

Lb bulgaricus
Lb plantarum
Carnobacterium maltaromaticum

Encapsulation

Oligosaccharides
FOS / GOS

STABILIZED LACTIC ACID BACTERIA – PREMIUM

Preserving bacteria with oligosaccharides and eco-friendly processes

- Different strains
- Encapsulated or not with FOS/GOS
- Different stabilisation processes

Environmental impact

Bacteria functionalities

Many case studies

Generalization of some results

BAGATEL DATABASE

Industrial and Pilot data

BIOSEARCH LIFE

Answers to scaling issues

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