Eco-conception des bio-procédés : exemple des bactéries lactiques stabilisées

Caroline Pénicaud, Fernanda Fonseca, Bruno Perret, Stephanie Passot, Ioan-Cristian Trelea

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Séminaire CEPIA 2017

C. Pénicaud, F. Fonseca, B. Perret, S. Passot, C. Trelea
UMR 782 GMPA, INRA/AgroParisTech, Grignon

INTRODUCTION

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®)

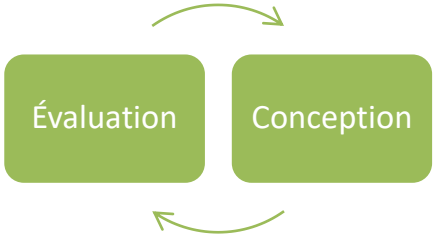
INTRODUCTION

CONCEVOIR DES PROCÉDÉS COUPLÉS/INTÉGRÉS, DANS UNE LOGIQUE D'ECO-CONCEPTION

- Procédé multi-étapes avec de **FORTES CONNEXIONS ENTRE LES OPÉRATIONS UNITAIRES** (ex: fermentation/stabilisation)

ISO 14062

- Une prise en compte globale de l'environnement
  - **APPROCHE MULTI-CRITÈRES SUR L'ENSEMBLE DU CYCLE DE VIE DU PRODUIT**
- Intégration de la dimension environnementale dans les méthodes de conception
  - **AU MÊME TITRE QUE LA QUALITÉ**
- Utilisation de méthodes et d'outils d'évaluation
  - **ANALYSE DE CYCLE DE VIE**
- Combinaison de stratégies de réduction des impacts potentiels
  - **IDENTIFICATION DES LEVIERS D'ACTION POSSIBLES**
- Le dialogue et le partenariat
  - **PLURIDISCIPLINARITÉ**



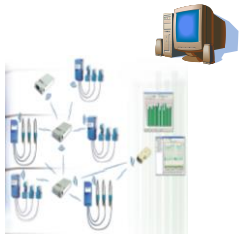
LCA OF FREEZE-DRIED BACTERIA

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



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

➢ **Functional Unit**: stabilization of 3 kg of protected bacteria

Weighting with Physiologic state of the bacteria

SimaPro

ILCD 2011 method

• **Specific activity**

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

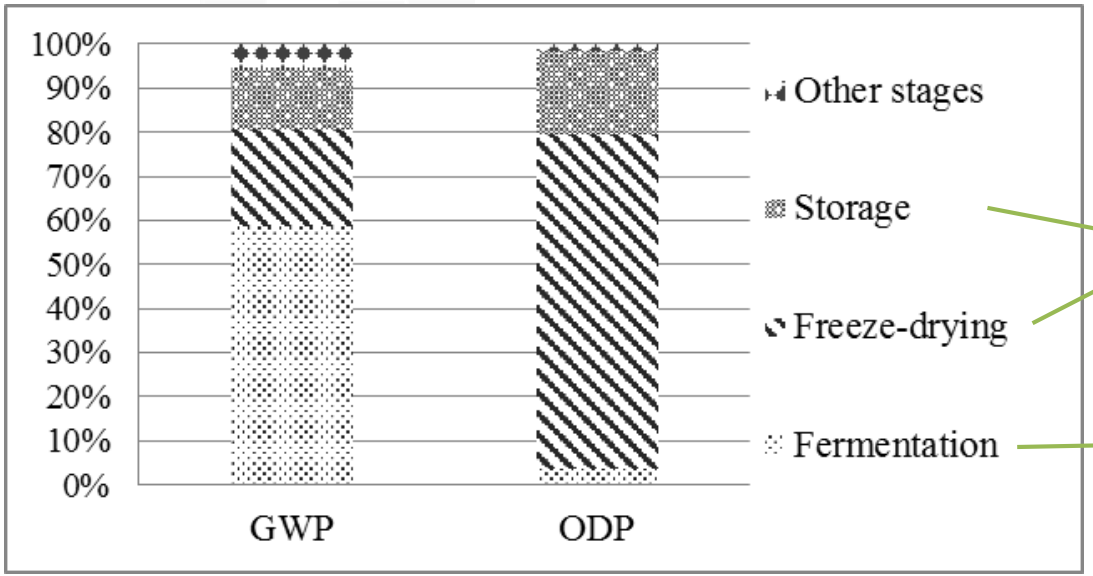
• **Weighting**

Weighted Impact = characterized impact value x Specific activity

LCA OF FREEZE-DRIED BACTERIA

RESULTS

-20 °C storage during 1 year



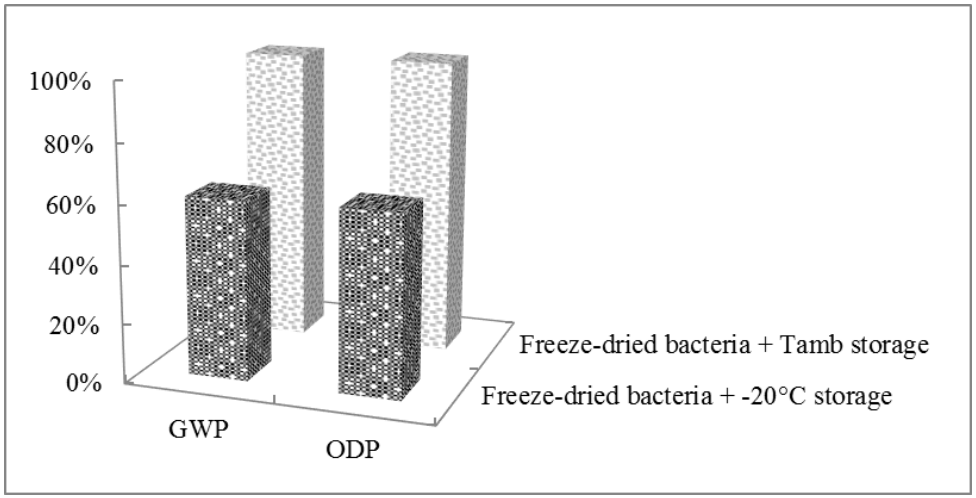
electricity consumption, leakage of refrigerant gas

natural gas, tap water

Reduce Energy Consumption: Increase of Storage Temperature

LCA Results

storage during 3 months



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

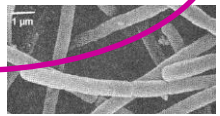
Effect of Product Quality

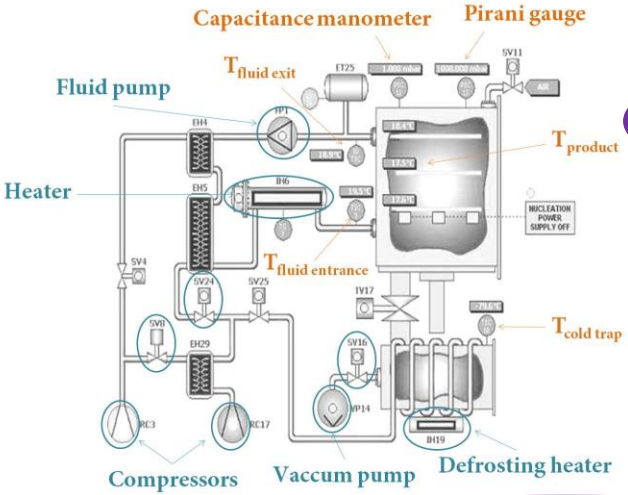
Weighted Impact = characterized impact value x Specific activity

Reduce Energy Consumption: Optimization of Freeze-Drying

LyoBeta special
(Telstar, Terrassa, Spain)

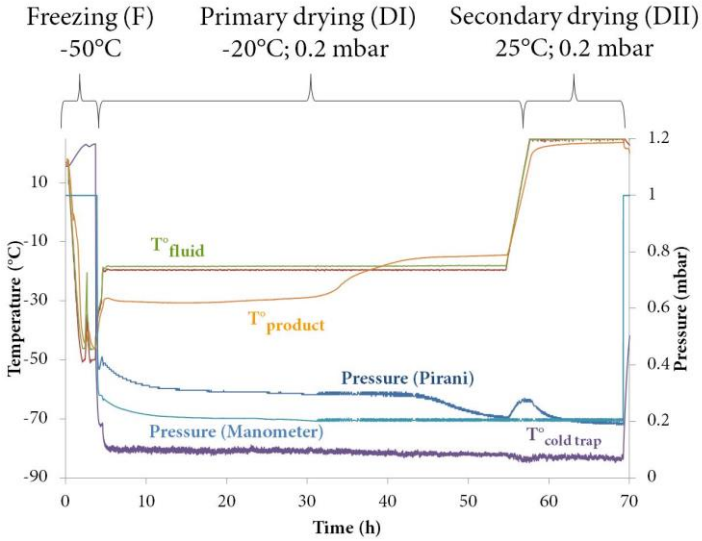
Product parameters
Viability
Acidifying activity
Structure





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

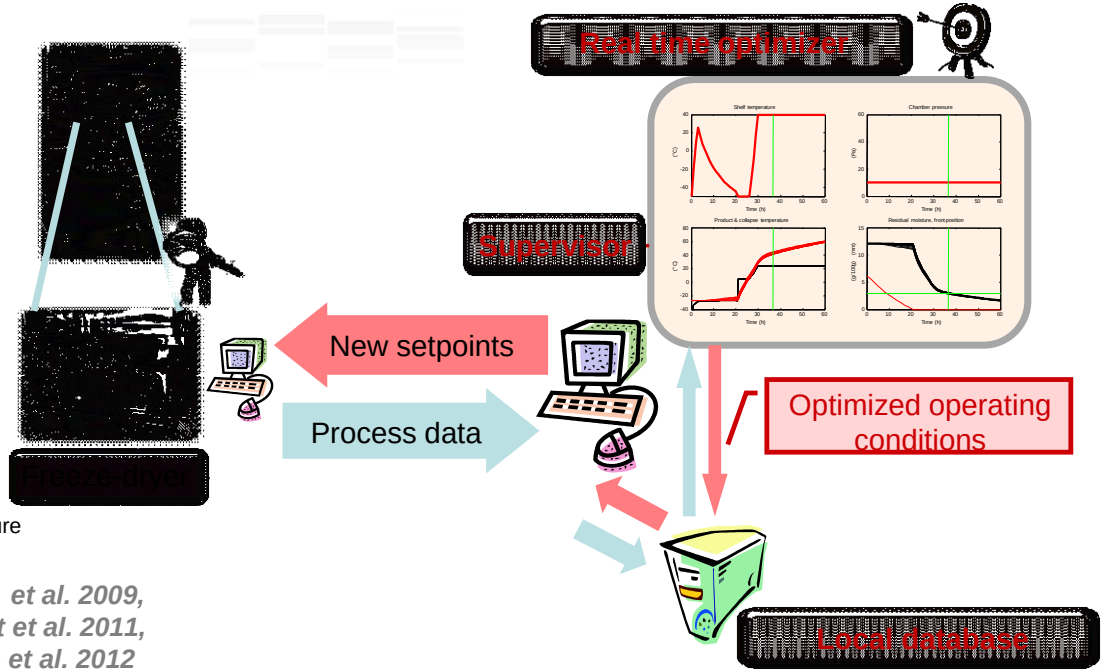
Mathematical model
Linear relationship



Process apparent energy consumptions

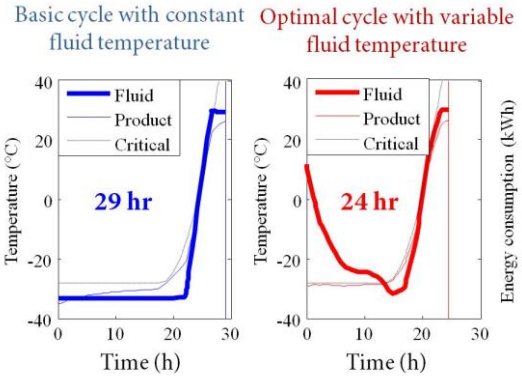
- Main components + Fans dedicated to compressors
- General supply

Reduce Energy Consumption: Optimization of Freeze-Drying

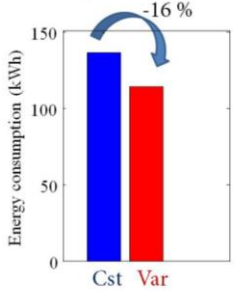


T_{fluid}
$P_{pressure}$

Trelea et al. 2009, Passot et al. 2011, Antelo et al. 2012



Energy consumption decrease:



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

Pénicaud et al. 2014, 2016

STABILIZATION ALTERNATIVE

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Stabilization
Freeze-drying
Freezing
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***Lactobacillus delbrueckii ssp. bulgaricus* strain CFL1**

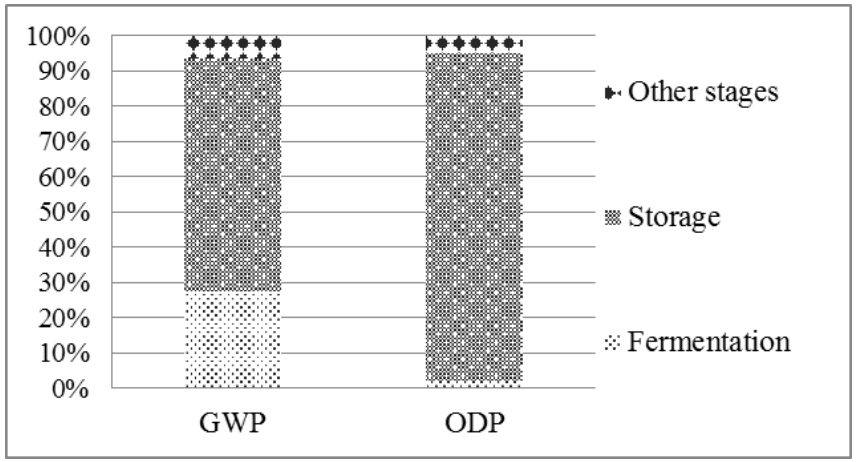
- Freeze-drying
  - Soft for the bacteria
  - Energy intensive: freezing + drying of the frozen product
- Alternative: Freezing
  - Need of frozen storage
  - **Is it really more eco-friendly than freeze-drying if we consider the whole life cycle?**

Functionality: acidification activity (CinAc®)

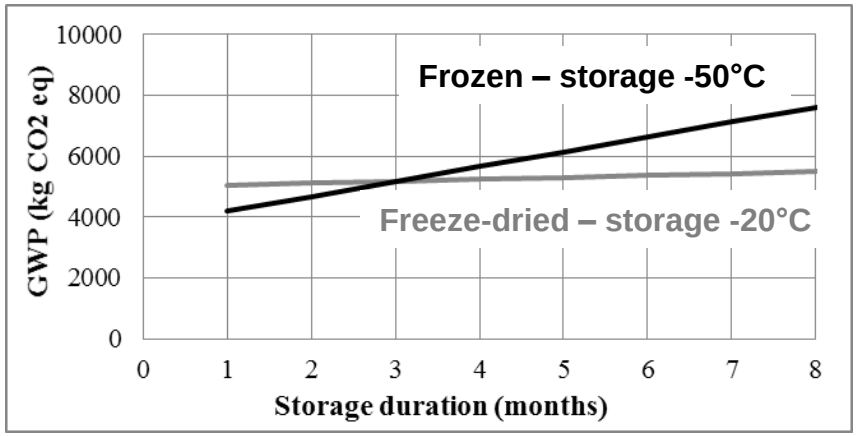
LCA OF FROZEN VS FREEZE-DRIED BACTERIA

RESULTS

Frozen, -50 °C storage during 1 year



Monclus et al. 2015
Pénicaud et al. 2016



Trend remains the same for all indicators
BUT
Depending on the indicator, the duration for which $Impact_{frozen}$ = $Impact_{freeze\text{-}dried}$ is different (from 2 to 56 months).

CONCLUSIONS

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 (ontology): cf pres. E. Guichard 16/03/2017

OUTLOOKS / REMAINING QUESTIONS

- **How to take into account concomitantly product quality and environmental impact?**
  - LCA: functional unit
  - Knowledge integration
  - ???

- **How to upscale lab -> pilot -> industry?**
  - at data level? at environmental impact level?
  - does it make sense?

- **How to shift from process consideration to value chains consideration?**
  - Many co-products / ingredients towards very different products / added values
  - Complex networks