



➤ Du -80 au digesteur dynamique, le parcours STLO des bactéries d'intérêt alimentaire dans la conception de nouveaux produits laitiers fermentés

## UMR1253 STLO

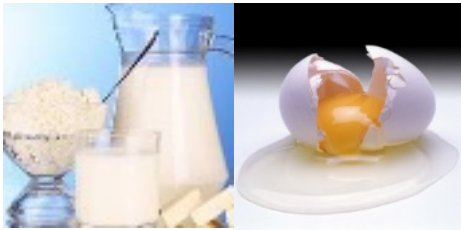
Science and Technology of Milk and Egg Products

[www6.rennes.inrae.fr/stlo](http://www6.rennes.inrae.fr/stlo)



# ➤ Our playgrounds

## Food and raw materials, milk and egg



- Composition
- Structure
- Quality

## But also plant-based matrices

- Protein components
- Quality

## Transformation Processes

### Mastering the functionalities

- Process management
- Eco-efficiency
- Ecoconception

*Fermentation, heat treatment, drying, membrane fractionation, Dairy technology*

## Human food

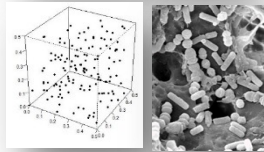
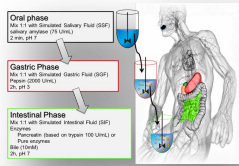






- Digestion  
*Food matrices*

Design of foods, safe, secure, adapted to human needs and sustainable

# Organization

INRAE – Institut Agro Rennes-Angers  
 ~140 staff members (incl. ~80 permanent positions)  
 8 R&D units (private sector)



Director:    

Vice-Directors Administrator


**Optimisation of infant formulas**

**MICROBIO** 

**PSF**  

**BN**  

**CIRM-BIA**   **PFL**

**Animal-plant mix**



 **SAPHIRE**  
 Administration, Informatics & Infrastructure, Doc & Com





# INRAE Biological Resource Center dedicated to the preservation and exploration of microbial diversity

## Bacteria for fermented products and bio-preservation

4000 strains, online catalog ([http://www6.inrae.fr/cirm\\_eng](http://www6.inrae.fr/cirm_eng))

30 genera

160 species

## High level of intra-species diversity

400 strains of *Bifidobacterium* species

600 strains *Propionibacterium* species

2,000 strains of lactic acid bacteria



# ➤ DAIRY PLATFORM ISO 9001 Management Certified

Process in Platform (1000 m<sup>2</sup>)  
> whole range of dairy technologies



- Heat treatment (pasteurization to UHT-sterilization)
- Homogenization, cream separation, melting...
- Membrane separation modules :
  - ✓ Microfiltration
  - ✓ Ultrafiltration
  - ✓ Reverse osmosis
- Two cheese production lines (soft- and hard-type cheeses)
- Spray drying facilities: pilot (1-7 kg of water per hour) and semi-industrial (BIONOV) units

The platform uses the analytical facilities as well as the expertise of the STLO research teams



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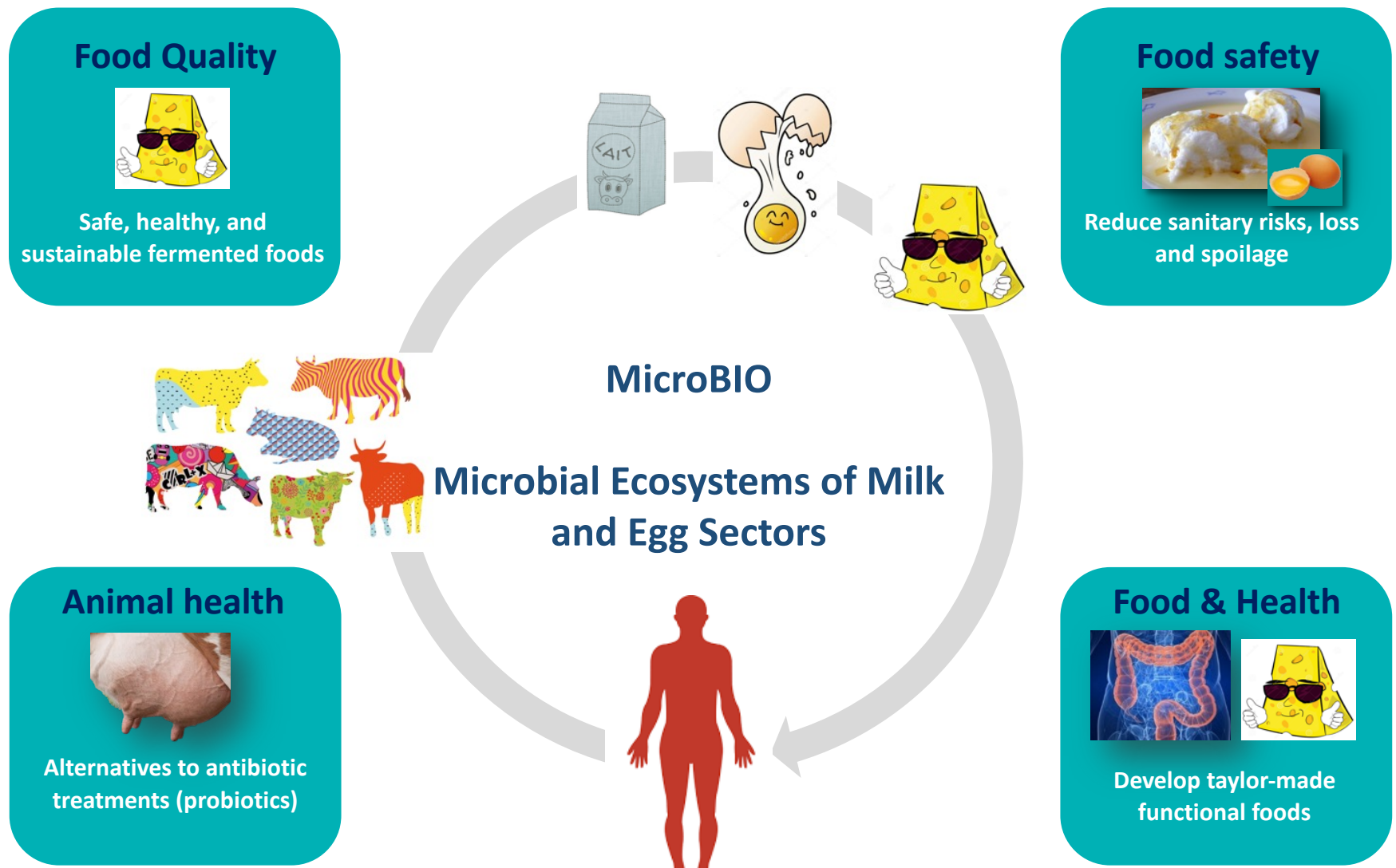
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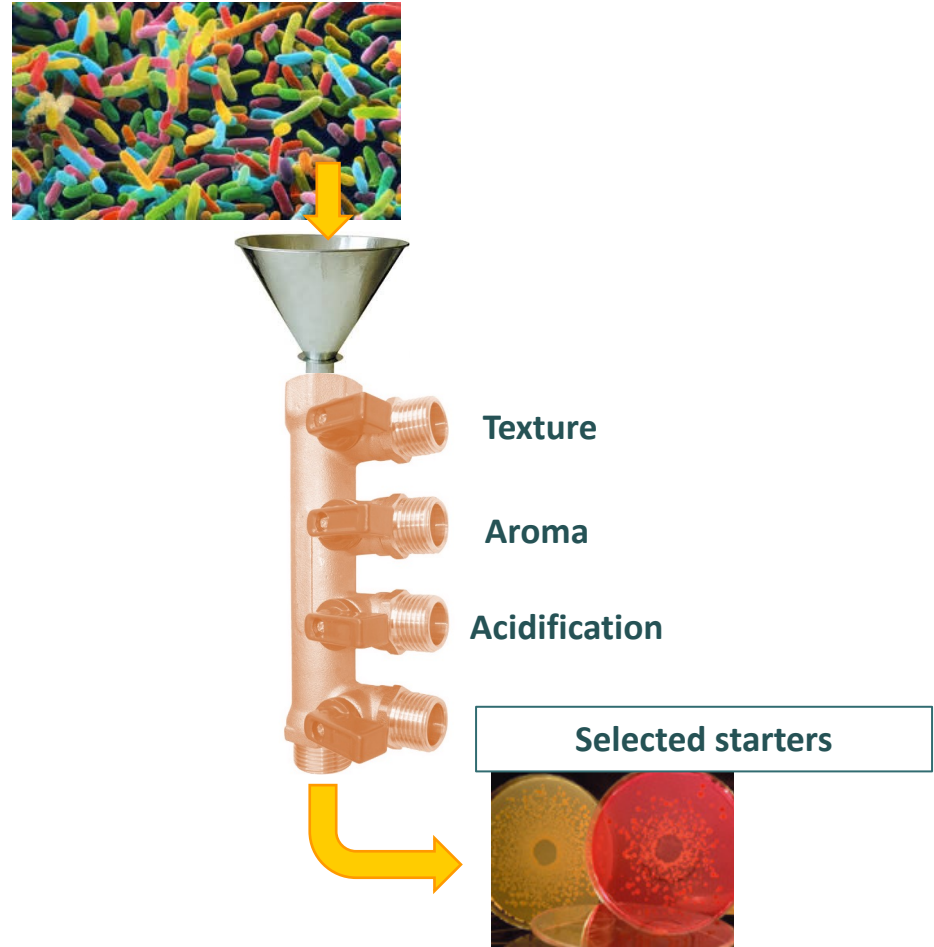
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LABELLISÉ CARIOT  
Réseau de recherche pour l'innovation alimentaire

# > MicroBio



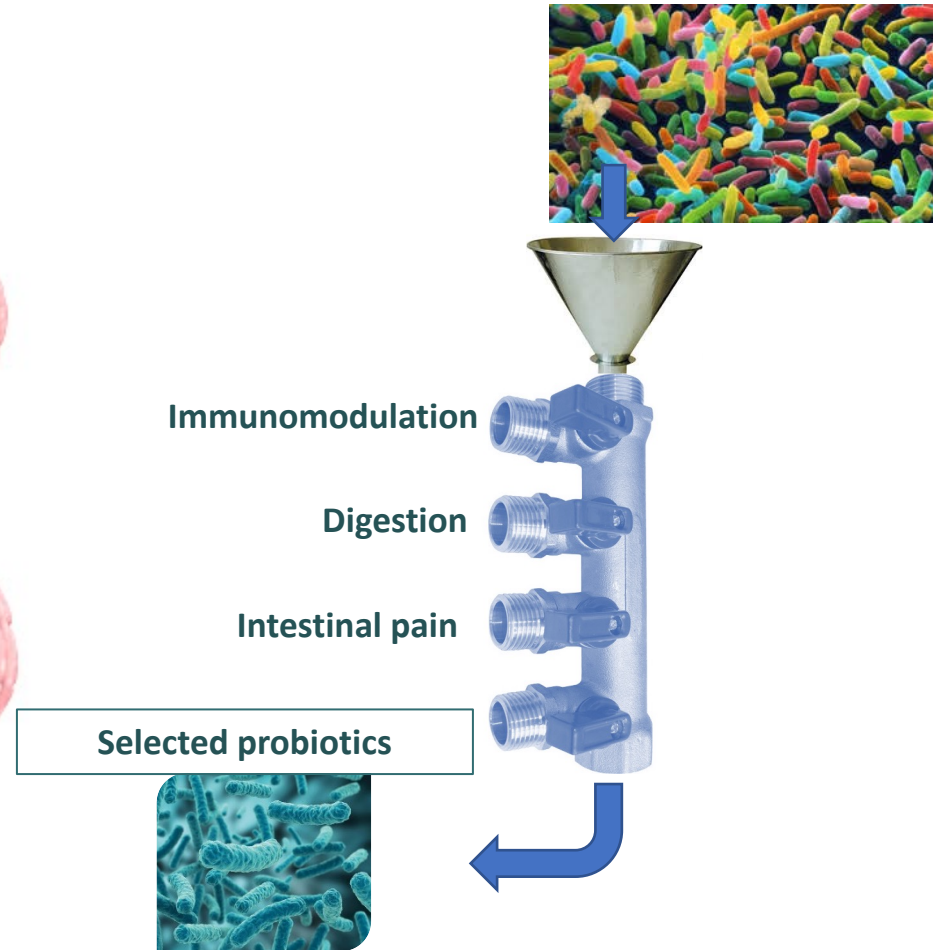
# ➤ Double trigger specifications

The technological pathways used to select the bacteria...



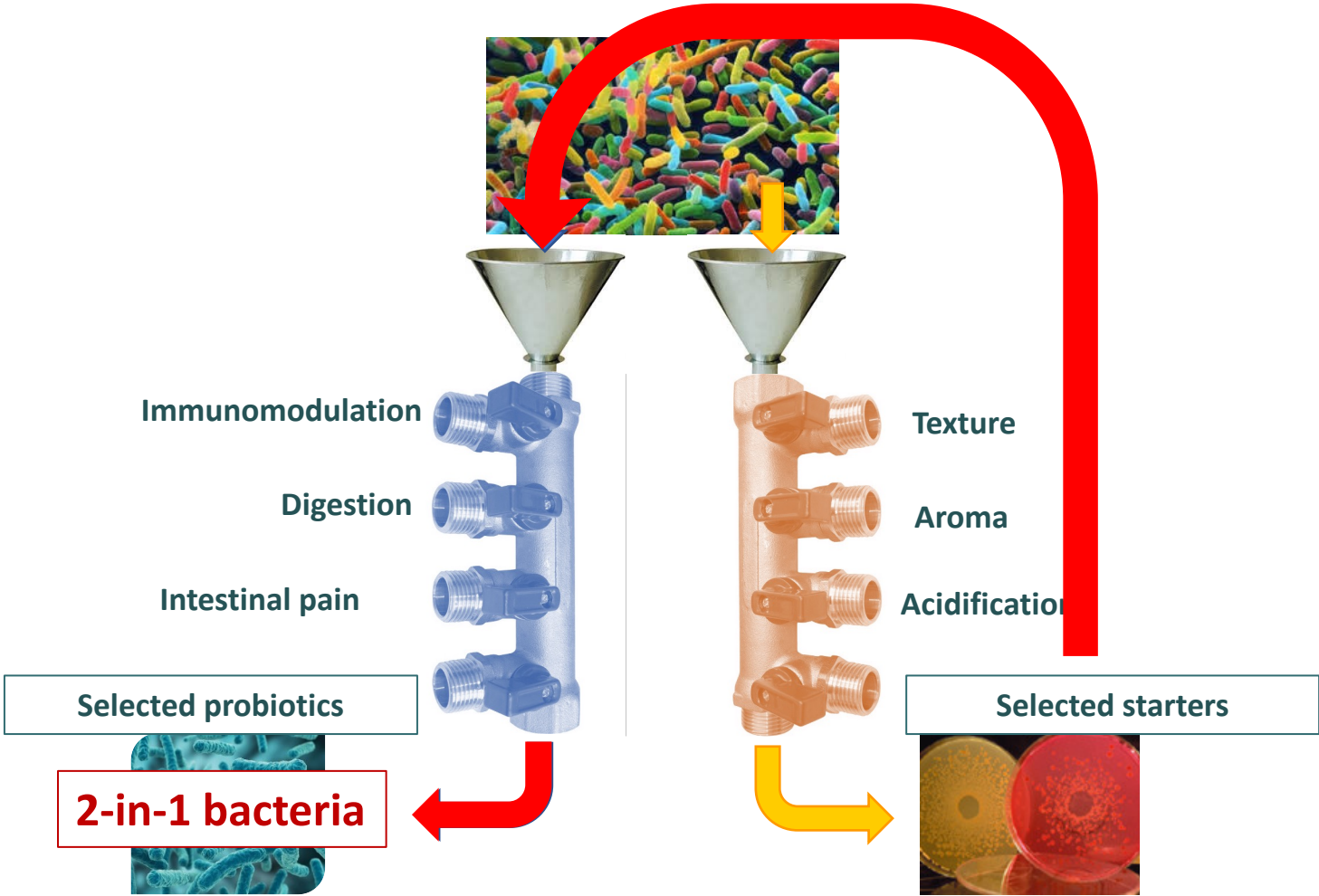
# Other bacteria are selected for their probiotic properties...

IBS, IBD, atopy, intolerance ...





# A double-step selection is possible.



➤ From -80°C to the digestive tract...

● Identification / culturomic approach

● In silico characterization

● In vitro (and in vivo) characterization

● Food processing / matrix characterization

● Digestive processing

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➤ From -80°C to the digestive tract...

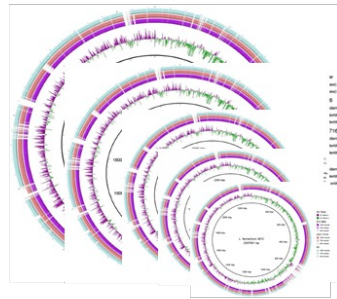
## Identification / culturomic approach



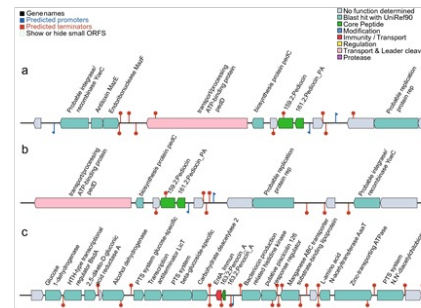
# ➤ From -80°C to the digestive tract...

Identification / culturomic approach

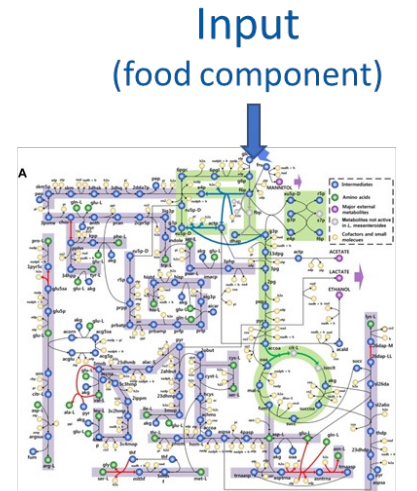
## In silico characterization



Available LAB and PAB genomes



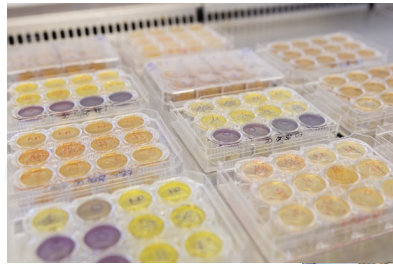
Genes encoding metabolic pathways



Metabolic network

Product prediction  
(for a strain or a consortium)

# ➤ From -80°C to the digestive tract...



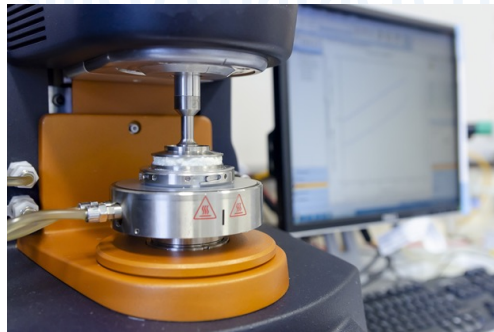
## In vitro (and in vivo) characterization



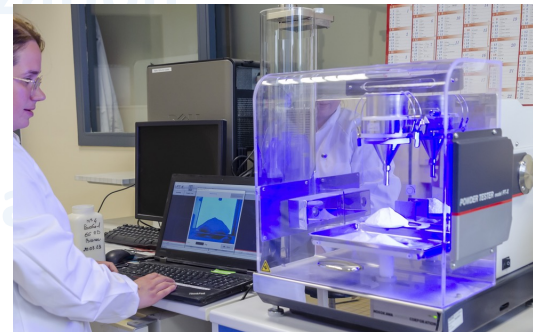
# ➤ From -80°C to the digestive tract...



In silico characterization



In



## Food processing / matrix characterization

Digestive processing

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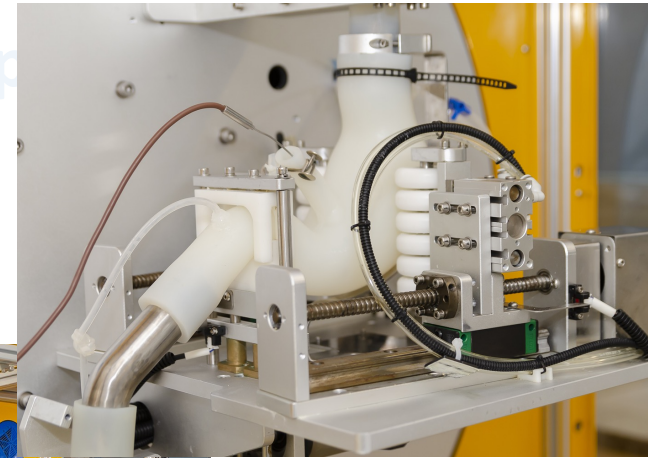
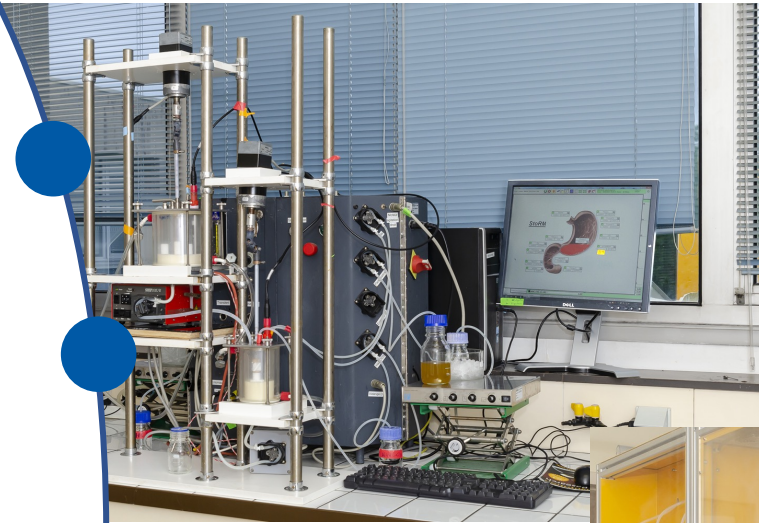
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# ➤ From -80°C to the digestive tract...



## Digestive processing

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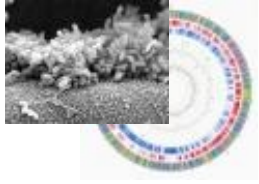
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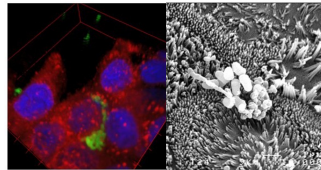


# Characterize interactions between bacteria/environment with regard to product quality, food safety and probiotic activity

## Cheese with propionibacteria, a new way to fight gut inflammation

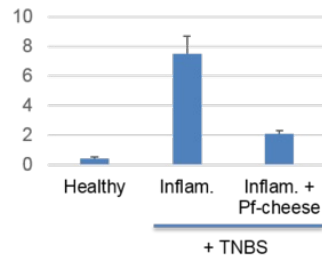
*P. freudeunreichii* surface layer proteins are involved in adhesion and anti-inflammatory properties.

*Pf* adhesion to cultured human colon epithelial cells



The use of these strains leads to the expression of immunomodulatory proteins within the cheese.

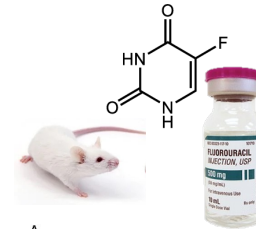
Level of inflammation marker in mice's colon (AU)



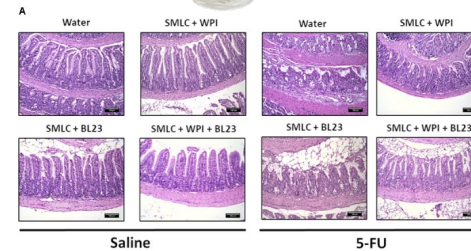
Mice, healthy or with TNBS-induced colitis, consumed a control diet without (Inflam.) or with (Inflam. + *Pf*-cheese) supplementation of semi-hard cheese containing *Pf*.

Le Marechal, C. et al (2015). J. Proteomics. 113C, 447-461  
 Plé, C. et al (2015). J. Funct. Foods 18, 575-585.  
 Do Carmo FRD et al. (2017) Front Microbiol. 8:1033.  
 Deutsch et al. (2017). Sci Rep. 7:46409.

## Dairy based beverage, fermented by *Lactobacillus casei* BL23 or *Propionibacterium freudenreichii* 138 prevents from mucositis in mice.



5-FU, an antineoplastic drug, has cytotoxic effects and induces mucositis in mice

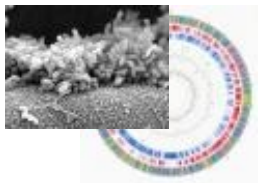


Administration of skim milk supplemented with WPI fermented by *L. casei* BL23 prevents mucosal damage in mice.

Cordeiro et al., 2018 Front Microbiol.  
 doi: 10.3389/fmicb.2018.02035.

Patent: NEW TREATMENT AGAINST MUCOSITIS. International patent PCT / EP2019 / 073626.

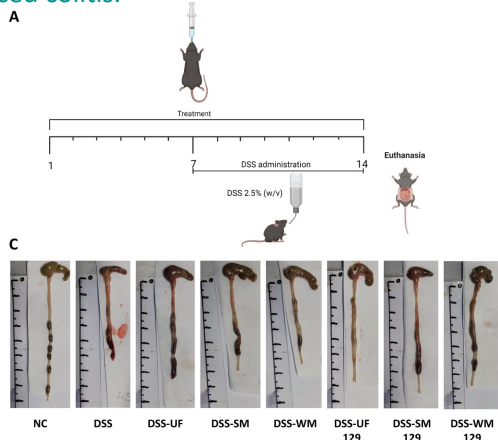




# Characterize interactions between bacteria/environment with regard to product quality, food safety and probiotic activity

## Fat matters: Fermented whole milk potentiates the anti-colitis effect of *Propionibacterium freudenreichii*

Whole milk fermented by the probiotic *Propionibacterium freudenreichii*, yet not fermented skim milk, reduced the histopathological score of DSS-induced colitis.



Milk constituents, including dairy fat, modulate the probiotic effect of the probiotic strain *Pf129*.

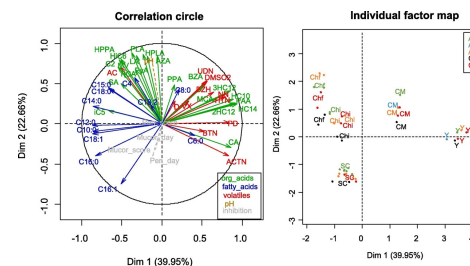
Mantel et al., 2023. Journal of Functional Foods  
<https://doi.org/10.1016/j.jff.2023.105614>

## Development of starter cultures with natural antifungal activities

To avoid chemical additives and get a clean label



Selection of antifungal bacterial strains on a dairy medium



Identification of antifungal compounds (organic acids, fatty acids, volatiles) in 4 dairy products (cheese model; yogurt; sour cream; semi-hard cheeses)

Leyva Salas et al., 2019. Food Chem.  
 doi: 10.1016/j.foodchem.2019.125260.  
 Garnier et al., 2019. Food Microbiol.  
 doi: 10.1016/j.fm.2018.11.003.  
 Leyva Salas et al., 2018. Front Microbiol.  
 doi: 10.3389/fmicb.2018.01787.



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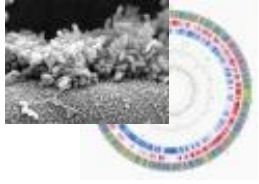
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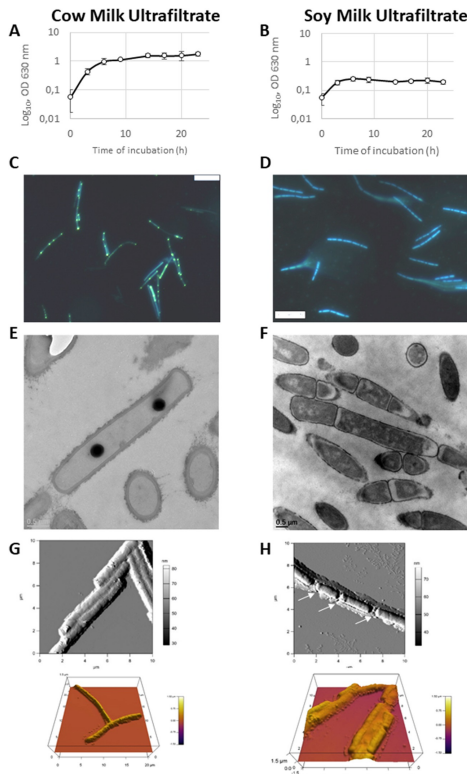
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# Characterize interactions between bacteria/environment with regard to product quality, food safety and probiotic activity

## The stressing life of *Lactobacillus delbrueckii subsp. bulgaricus* in soy milk



Low populations of lactobacilli are found in commercial fermented soy milks.

*Lactobacillus delbrueckii subsp. bulgaricus* grows poorly in soy milk.

Soy milk induces major morphological changes in *Lactobacillus delbrueckii subsp. bulgaricus*.

*Lactobacillus delbrueckii subsp. bulgaricus* accumulates a series of stress proteins in soy environment.

Jan G. et al, 2022. Food Mic. <https://doi.org/10.1016/j.fm.2022.104042>  
 Tarnaud F. et al., 2020. Food Mic. doi: 10.3389/fmicb.2020.549027  
 Harlé O. et al., 2020. Food Mic. doi: 10.1016/j.ijfoodmicro.2020.108574.

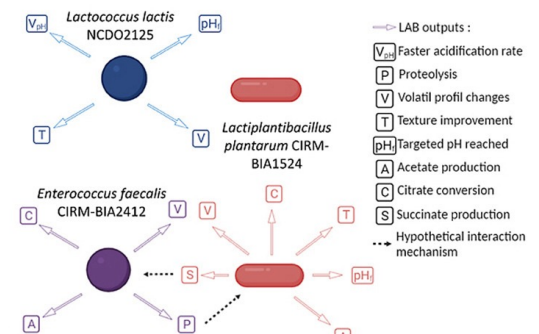
## Mixed dairy and plant-based yogurt alternatives (YA): Improving their physical and sensorial properties through formulation and lactic acid bacteria cocultures



	AMF Milk Lupin	AMF Milk Lupin	COCO Milk Lupin	COCO Milk Lupin
Firmness	-	++	--	+
Viscosity	-	++	--	+
Volatile compounds	-	+	-	+
Water holding capacity	--	+	-	++
Sensorial	-	+	-	+

Milk:lupin protein ratio and fat type impact textural and sensorial properties of YAs

Positive interactions in the YAs resulted in more functional outputs

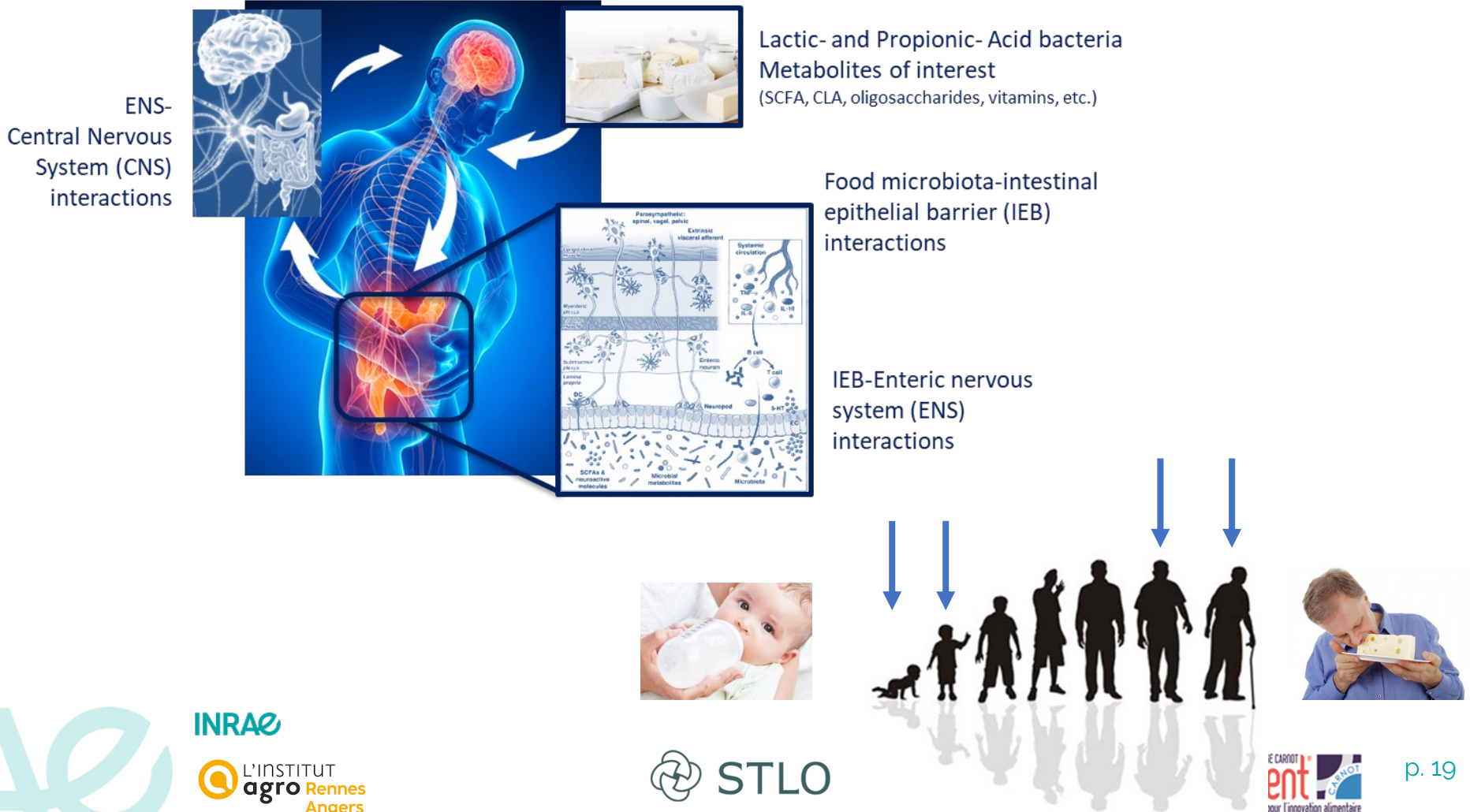


Canon F. et al., 2022. Curr Res Food Sci doi: 10.1016/j.crfs.2022.03.011.



# ➤ Example of specifications

PROLIFIC: Development of fermented dairy products with health benefits for targeted populations  
 «*Our product is your first medicine*»



## ➤ What do we do with these data?

Biochemical quantifications, bacterial growth, acidification... in **datagouv**

Deposition of omics data (genomes, metagenomes, transcriptomes and metatranscriptomes) in **EMBL-EBI** or **NCBI**

## ➤ Take home messages

Massive and heterogenous data

Importance of the **food matrix** characterization

Behaviour of the microbial consortia during the **processes** (food and digestive processing)



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