



**HAL**  
open science

## Smart design of functional fermented dairy foods

Gwénaél Jan

► **To cite this version:**

Gwénaél Jan. Smart design of functional fermented dairy foods. STLOpendays, Institut National de Recherche Agronomique (INRA). UMR UMR INRA / AgroCampus Rennes: Science et Technologie du Lait et de l'œuf (1253)., Mar 2019, Rennes, France. hal-02097208

**HAL Id: hal-02097208**

**<https://hal.science/hal-02097208>**

Submitted on 5 Jun 2020

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

AGRO  
CAMPUS  
OUEST



# Smart design of functional fermented dairy foods



STL Open Days  
19-21 March 2019



Gwénaél JAN - Microbio



## Food quality & safety



Develop safe, healthy, sustainable and hedonic fermented foods



## Food spoilage



Reduce health risks and food losses and waste

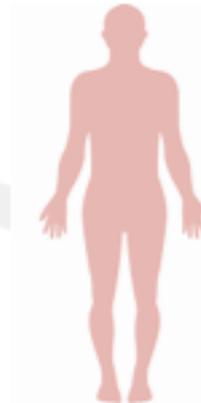


# The cheese matrix as a delivery vehicle for probiotics bacteria

## Animal health



Offer alternatives to antibiotic treatments (probiotics)



## Health & wellbeing



Develop functional and designer food against modern lifestyle diseases

# Driving functionality

→ through matrices



→ this talk

→ through processes



→ earlier

# The concept of « 2-in-1 » bacteria

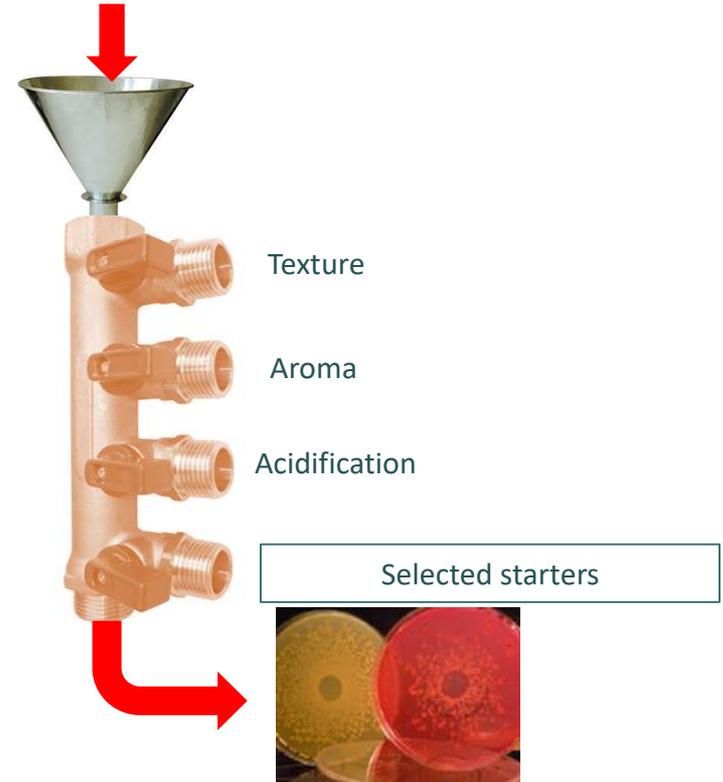


And now we select the bacteria

The technological pathway use to select the bacteria



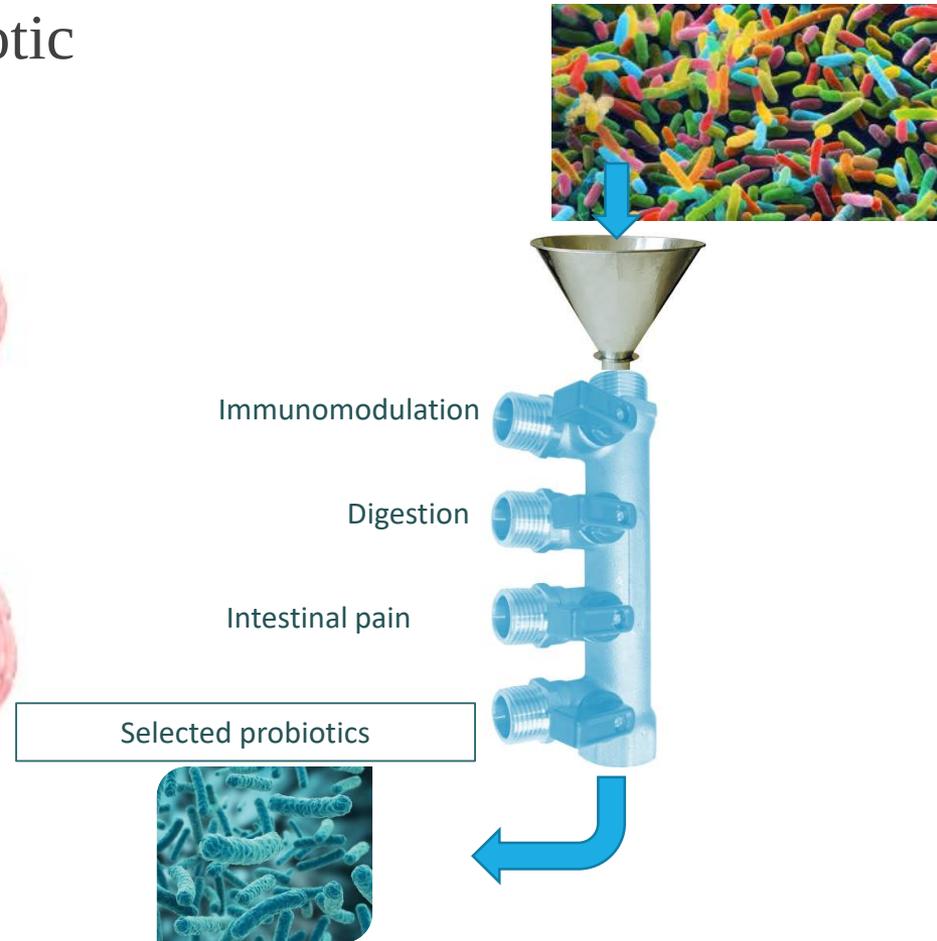
Historically without added starter!!!!



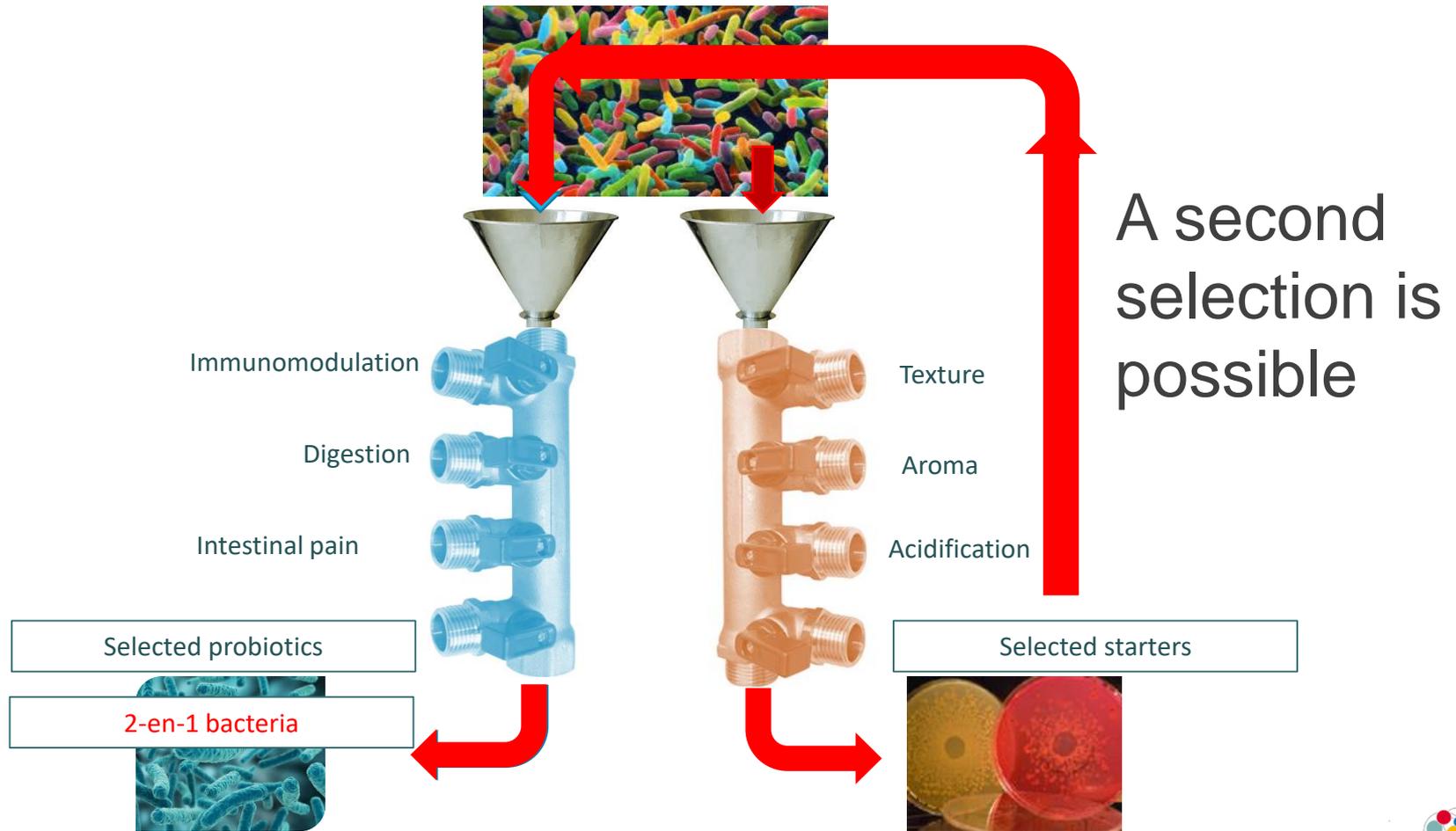
# The concept of « 2-in-1 » bacteria

Other bacteria are selected for probiotic properties

IBS, IBD, atopy, intolerance ...



# The concept of « 2-in-1 » bacteria



# « 2-in-1 » propionibacteria

## Anti-inflammatory properties



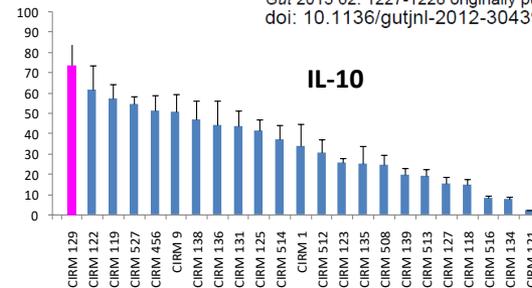
*Propionibacterium freudenreichii*



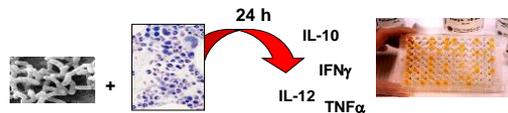
### Tracking the microbiome functionality: focus on Propionibacterium species

Benoit Foligné, Jérôme Breton, Denis Mater, et al.

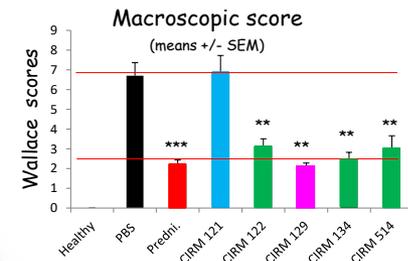
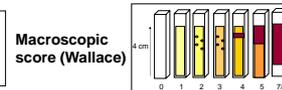
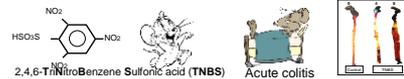
Gut 2013 62: 1227-1228 originally published online February 6, 2013  
doi: 10.1136/gutjnl-2012-304393



◆ *In vitro*



◆ *In vivo*



APPLIED AND ENVIRONMENTAL MICROBIOLOGY, Dec. 2010, p. 8259-8264  
0099-2240/10/\$12.00 doi:10.1128/AEM.01976-10  
Copyright © 2010, American Society for Microbiology. All Rights Reserved.

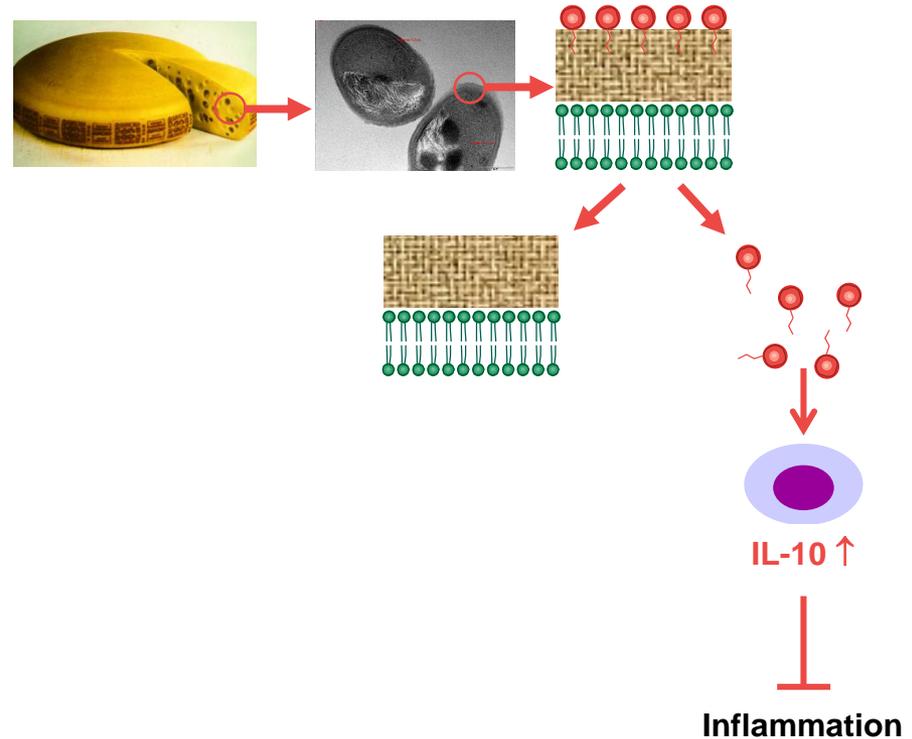
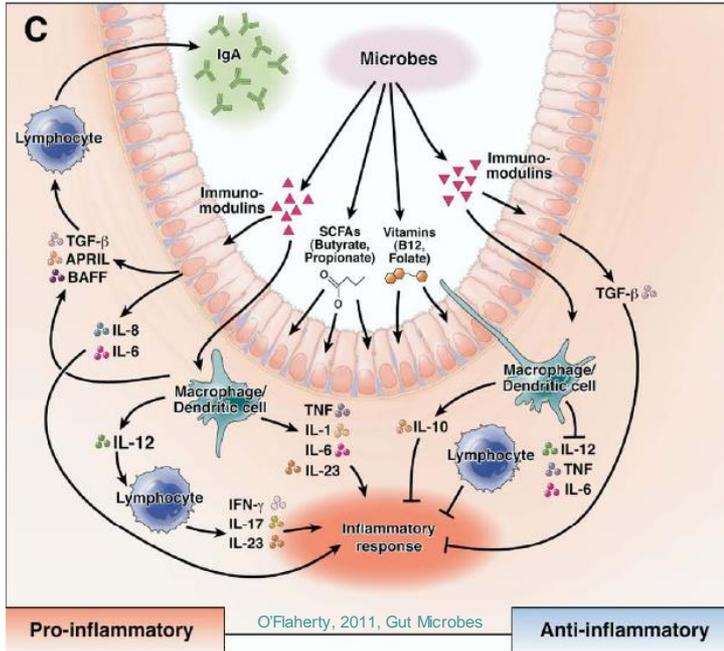
Vol. 76, No. 24

### Promising Immunomodulatory Effects of Selected Strains of Dairy Propionibacteria as Evidenced *In Vitro* and *In Vivo*<sup>†</sup>

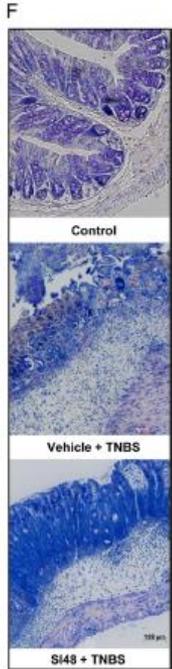
Benoit Foligné,<sup>1,2,3,4</sup> Stéphanie-Marie Deutsch,<sup>5,6</sup> Jérôme Breton,<sup>1,2,3,4</sup> Fabien J. Cousin,<sup>5,6,7</sup> Joëlle Dewulf,<sup>1,2,3,4</sup> Michel Samson,<sup>8</sup> Bruno Pot,<sup>1,2,3,4</sup> and Gwénaél Jan<sup>5,6\*</sup>



# A key role of propionibacteria surface proteins



# Other « 2-in-1 » bacteria



APPLIED AND ENVIRONMENTAL MICROBIOLOGY, Dec. 2010, p. 8259-8264  
 0099-2240/10/\$12.00 doi:10.1128/AEM.01976-10  
 Copyright © 2010, American Society for Microbiology. All Rights Reserved.

Vol. 76, No. 24

## Promising Immunomodulatory Effects of Selected Strains of Dairy Propionibacteria as Evidenced *In Vitro* and *In Vivo*<sup>†</sup>

Benoît Foligné,<sup>1,2,3,4</sup> Stéphanie-Marie Deutsch,<sup>5,6</sup> Jérôme Breton,<sup>1,2,3,4</sup> Fabien J. Cousin,<sup>5,6,7</sup>  
 Joëlle Dewulf,<sup>1,2,3,4</sup> Michel Samsø



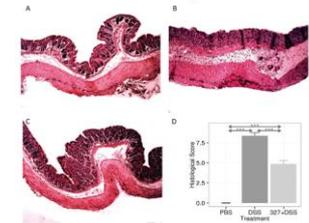
Let's make probiotic cheese!!!

OPEN ACCESS Freely available online



## Local and Systemic Immune Mechanisms Underlying the Anti-Colitis Effects of the Dairy Bacterium *Lactobacillus delbrueckii*

Clarissa Santos Rocha<sup>1,3,4</sup>, Ana Cristina Gomes-Santos<sup>2</sup>, Thais Garcias Moreira<sup>2</sup>, Marcela de Azevedo<sup>1</sup>,  
 Tessalia Diniz Luerce<sup>1</sup>, Mahendra Mariadassou<sup>5</sup>, Ana Paula Longaray Delamare<sup>6</sup>, Philippe Langella<sup>3,4</sup>,  
 Emmanuelle Maguin<sup>3,4</sup>, Vasco Azevedo<sup>1</sup>, Ana Maria Caetano de Faria<sup>2</sup>, Anderson Miyoshi<sup>1\*</sup>,  
 Maarten van de Guchte<sup>3,4,\*</sup>



# A reverse-engineered 2-strains cheese



Microfiltr. Milk

↓  
Powder 100 g/L

↓  
Cream 150 g/L

↓  
Sterilisation

↓  
Culture *P. freudenreichii*  
30°C, 72 h

↓  
Pre-cheese

UHT Milk

↓  
Culture *L. delbrueckii*  
42°C, 4 h

↓  
Fermented Milk



↓  
Clotting, stirring, cooking, moulding,  
pressing, wrapping, ripening

Mol. Nutr. Food Res. 2016, 60, 935–948

Molecular Nutrition  
Food Research

935

RESEARCH ARTICLE

**Combining selected immunomodulatory  
*Propionibacterium freudenreichii* and *Lactobacillus delbrueckii* strains: Reverse engineering development  
of an anti-inflammatory cheese**

Coline Plé<sup>1</sup>, Jérôme Breton<sup>1</sup>, Romain Richoux<sup>2</sup>, Marine Nurdin<sup>2</sup>, Stéphanie-Marie Deutsch<sup>3,4</sup>,  
Hélène Falentin<sup>3,4</sup>, Christophe Hervé<sup>5</sup>, Victoria Chuat<sup>3,4,6</sup>, Riwanon Lemée<sup>5</sup>,  
m<sup>3,4</sup>, Maarten Van de Guchte<sup>7,8</sup> and Benoit Foligné<sup>1</sup>



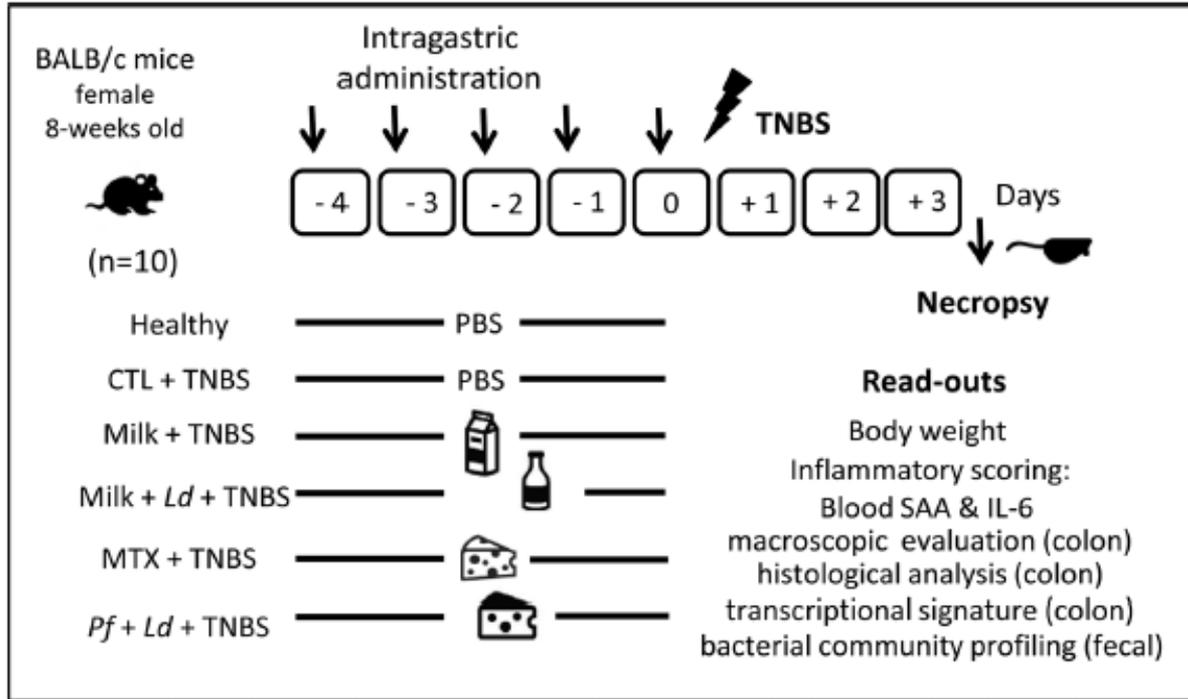
Dairy Platform



Starter Surface  
against Inflammation of the Gut

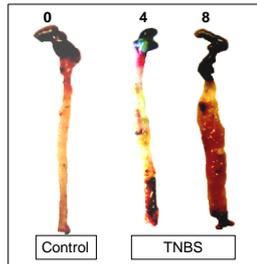


# A reverse-engineered 2-strains cheese challenged *in vivo*

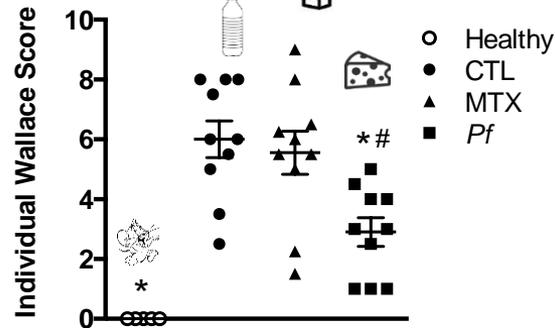
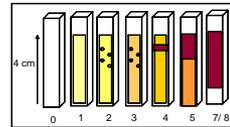


# A reverse-engineered 2-strains cheese protects from colitis

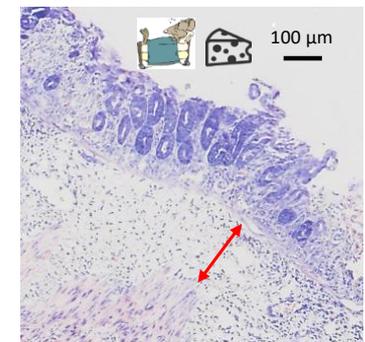
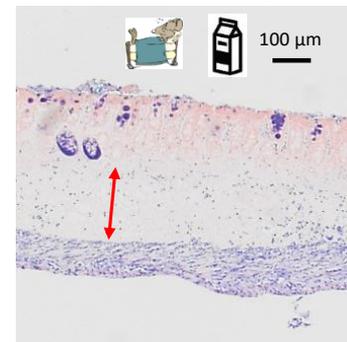
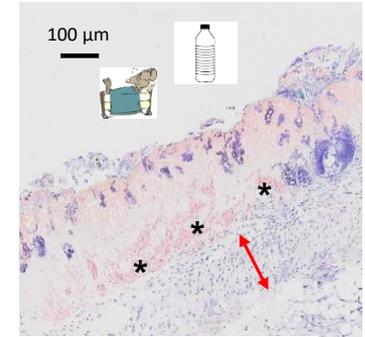
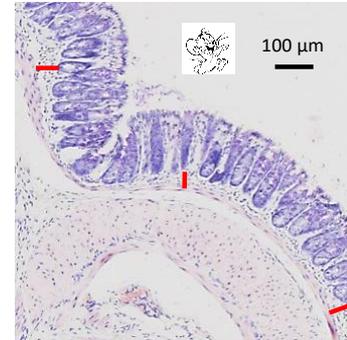
## Macroscopic level



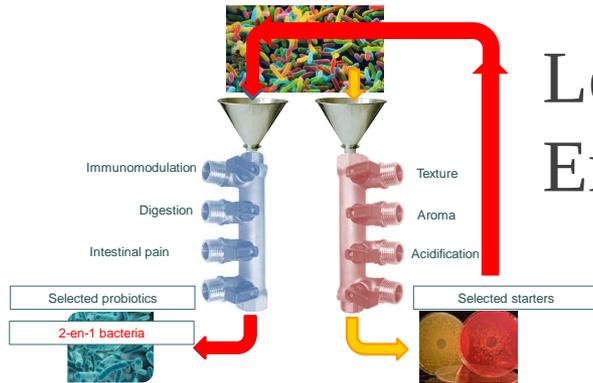
Macroscopic score (Wallace)



## Microscopic level



# But it is still a lab cheese!



Let's make a real  
Emmental cheese!

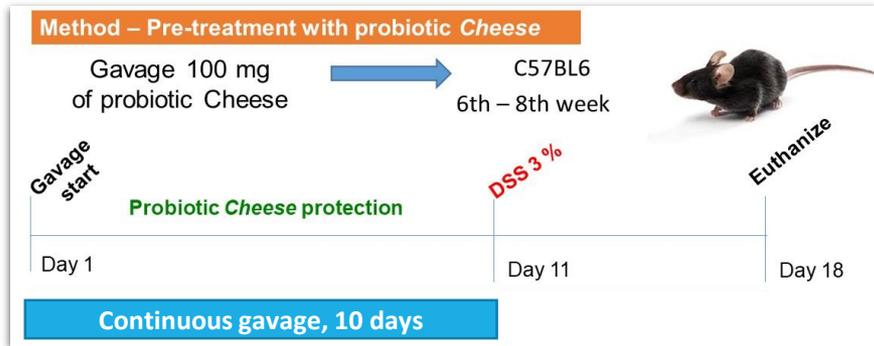
*Propionibacterium freudenreichii*

*Streptococcus thermophilus*

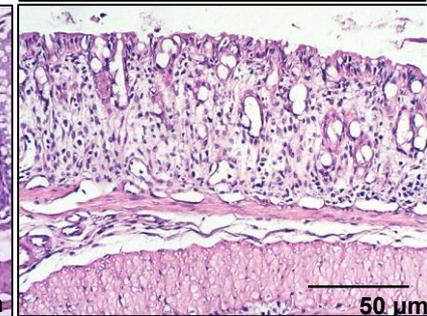
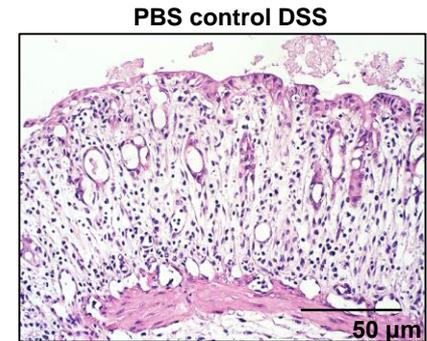
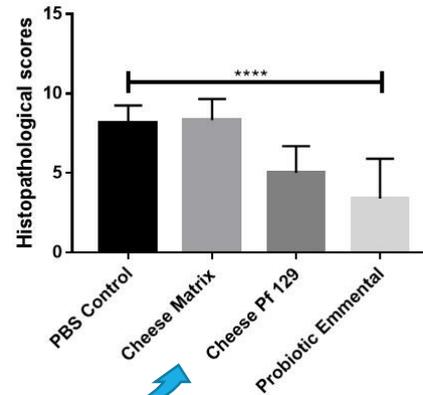
*Lactobacillus delbrueckii*



# This Emmental cheese protects from colitis



Probiotic Emmental x Colitis



Noninflamed control

Probiotic Emmental

# Another example of application: fighting mucositis

## GI inflammatory diseases

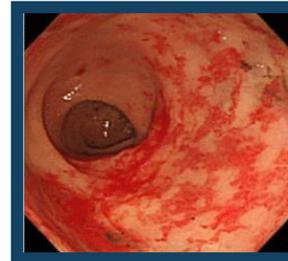
IBD

- GIT Chronic inflammation

Ulcerative  
Colitis



Mucositis



GI Mucositis



Oral mucositis

5-Fluoracil (5-FU)

- Head, neck and colon cancer.

(Chang *et al.*, 2012; Falvey *et al.*, 2015)



# Another example of application: fighting mucositis

→ NO CURE AVAILABLE

**IBD available treatment**

**Mucositis available treatment**

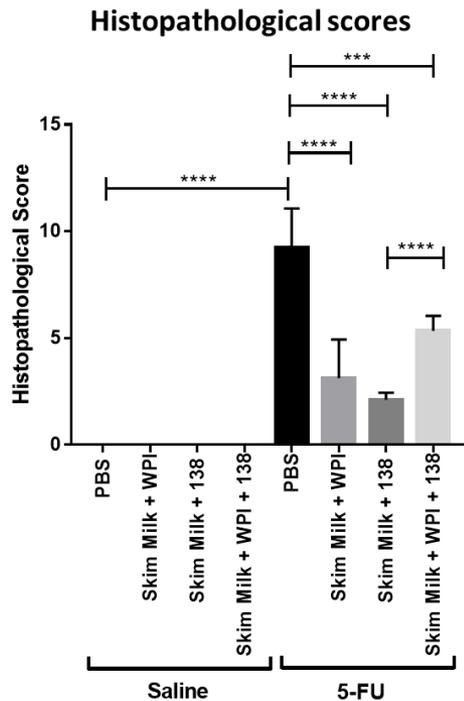
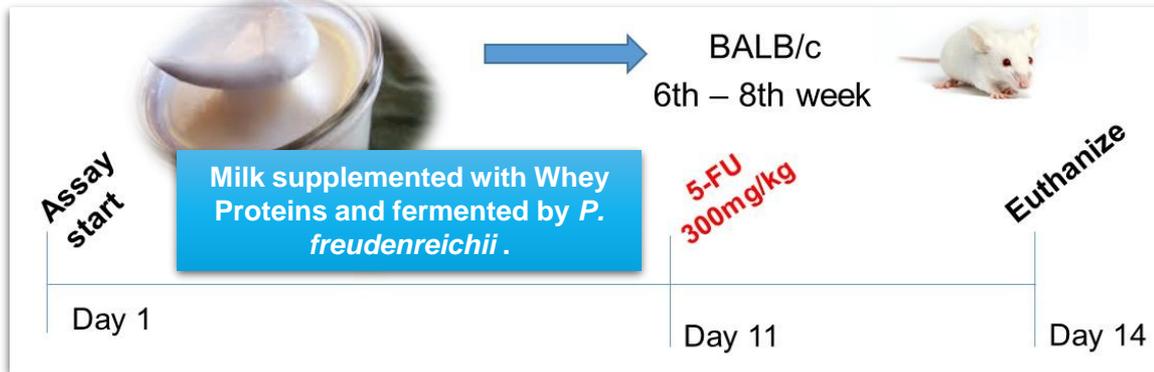
- Treatment for **mucositis** and **IBD** are limited;
- Development of **new therapies** is **necessary**.

**Strong side effects!!!**

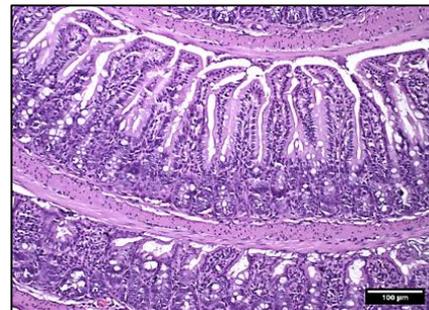
**Temporary benefit!!!**



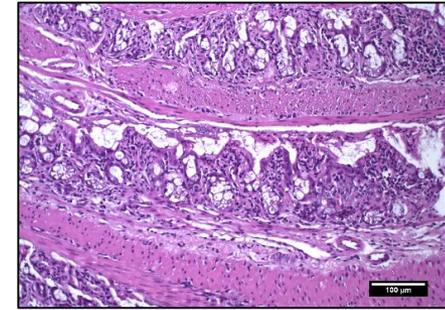
# Fermented milk protects from mucositis



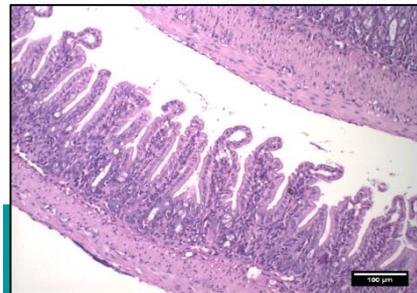
Representative images from mucosal histopathology (H&E)



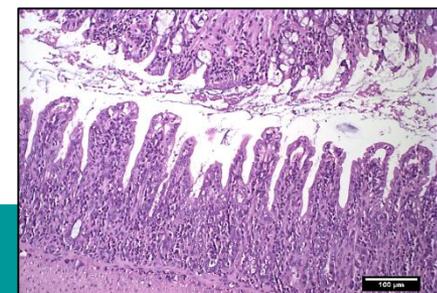
Healthy Ileum



PBS + 5-FU

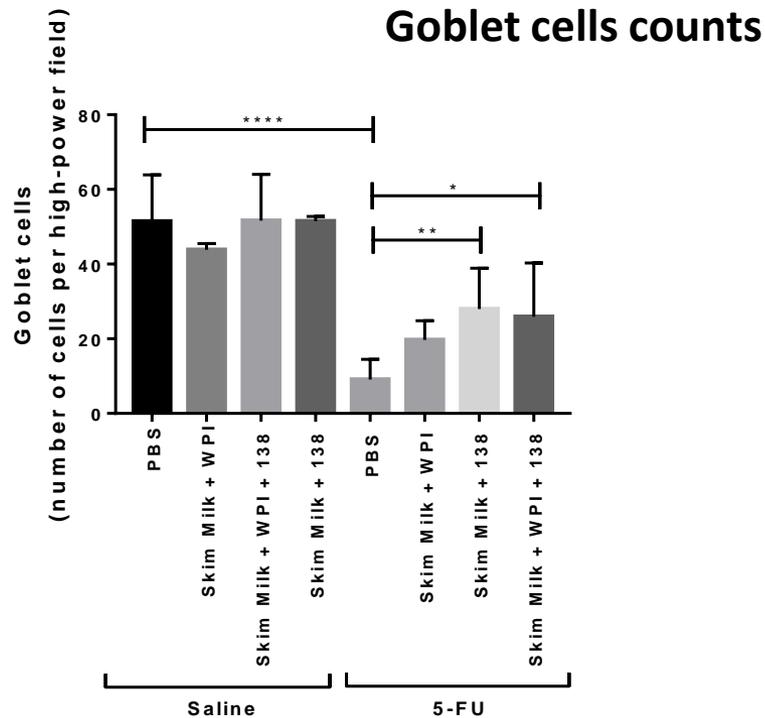


LDF + 138 + 5-FU

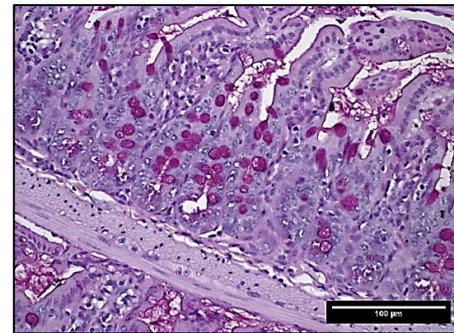


LDFWPI + 138 + 5-FU

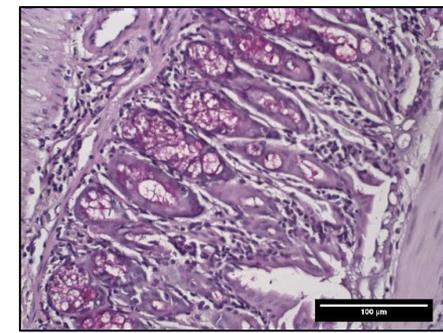
# Fermented milk preserves mucus



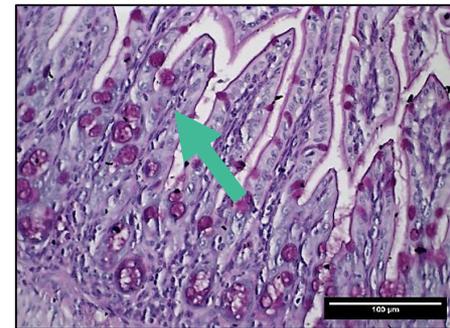
Representative images of stained goblet cells (PAS)



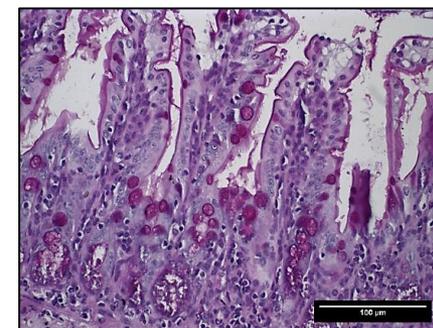
Healthy Ileum



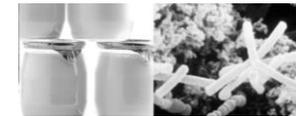
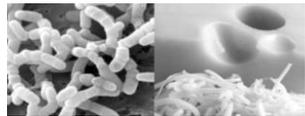
PBS + 5FU



LDF + 138 + 5FU



LDFWPI + 138 + 5FU



## Conclusion:

- ✓ Fermented foods: a source of immunomodulatory bacteria
- ✓ Molecules and strains involved are being identified

## Perspectives :

- ✓ Preclinical and clinical studies with fermented products
- ✓ Fermented food for specific populations



Benoit Foligné



Vasco Azevedo



Houem Rabah

Song Huang

Fillipe Rosa do Carmo



Thank you  
for your  
attention

Don't ask  
tough questions

**THANK YOU FOR  
YOUR ATTENTION**



Please visit [http://www.rennes.inra.fr/stlo\\_eng](http://www.rennes.inra.fr/stlo_eng)