



# Probiotics already in your fridge?



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# *Cheese, an old story ...*

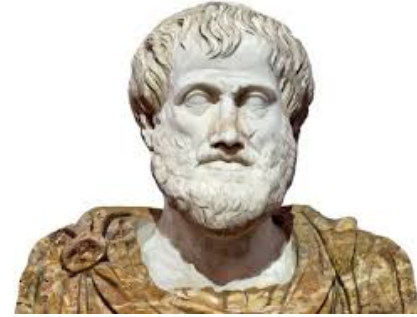


# *Sarting at the Neolithic ages*



→ Cheese is the most ancient fermented food product

# Aristotle (384 BC – 322 BC)



**Kykeon** (Gr. κυκεών, from κυκάω, "to stir, to mix"), an ancient greek recipe made with **wine** and grated **cheese**.

A **magic** medicinal beverage



*Pliny the Elder (born Gaius Plinius Secundus, AD  
23–79) « Natural History »  
«De diversitate caseorum»*



Describes a ewe milk cheese from Babales (Lozère, France)

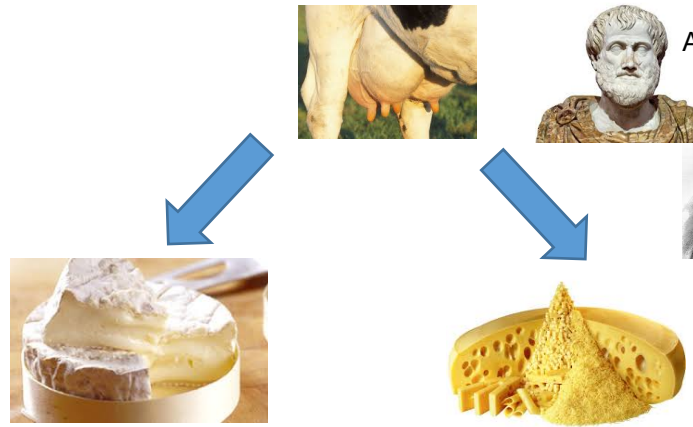


And a cow milk cheese from Arverni (Auvergne, France)

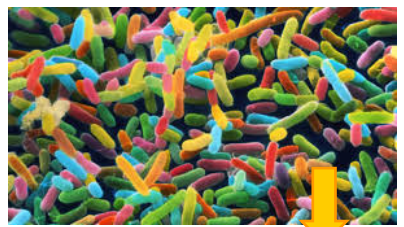


All these cheeses without added starter !!!!

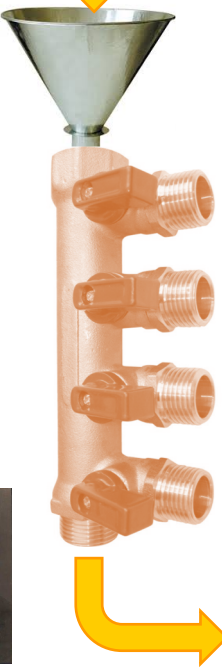
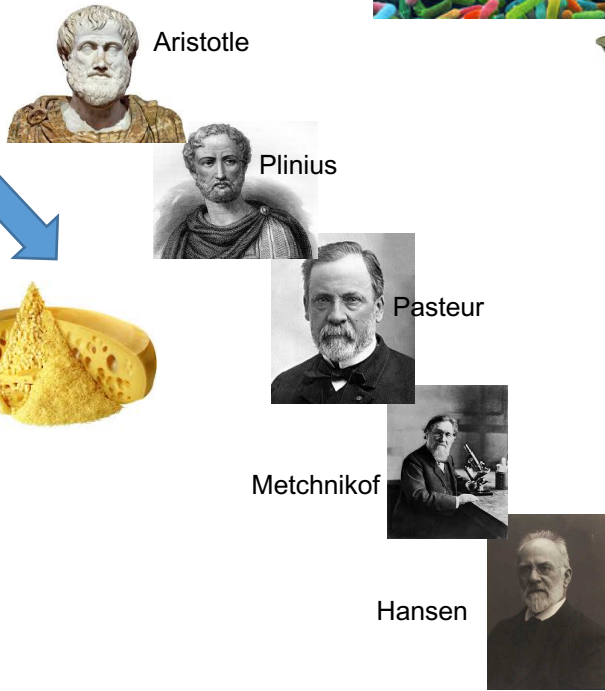
*The technological pathway use to select the bacteria*



*Without added starter!!!!*

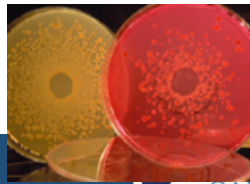


*And now we select the bacteria*



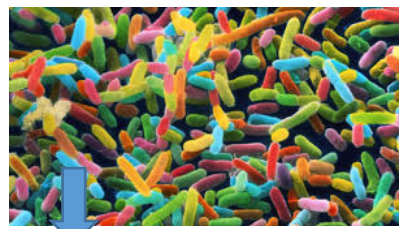
- Texture
- Aroma
- Acidification

Selected starters



*Other bacteria are selected for probiotic properties*

IBS, IBD, atopy,  
intolerance ...

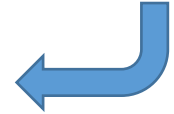


Immunomodulation

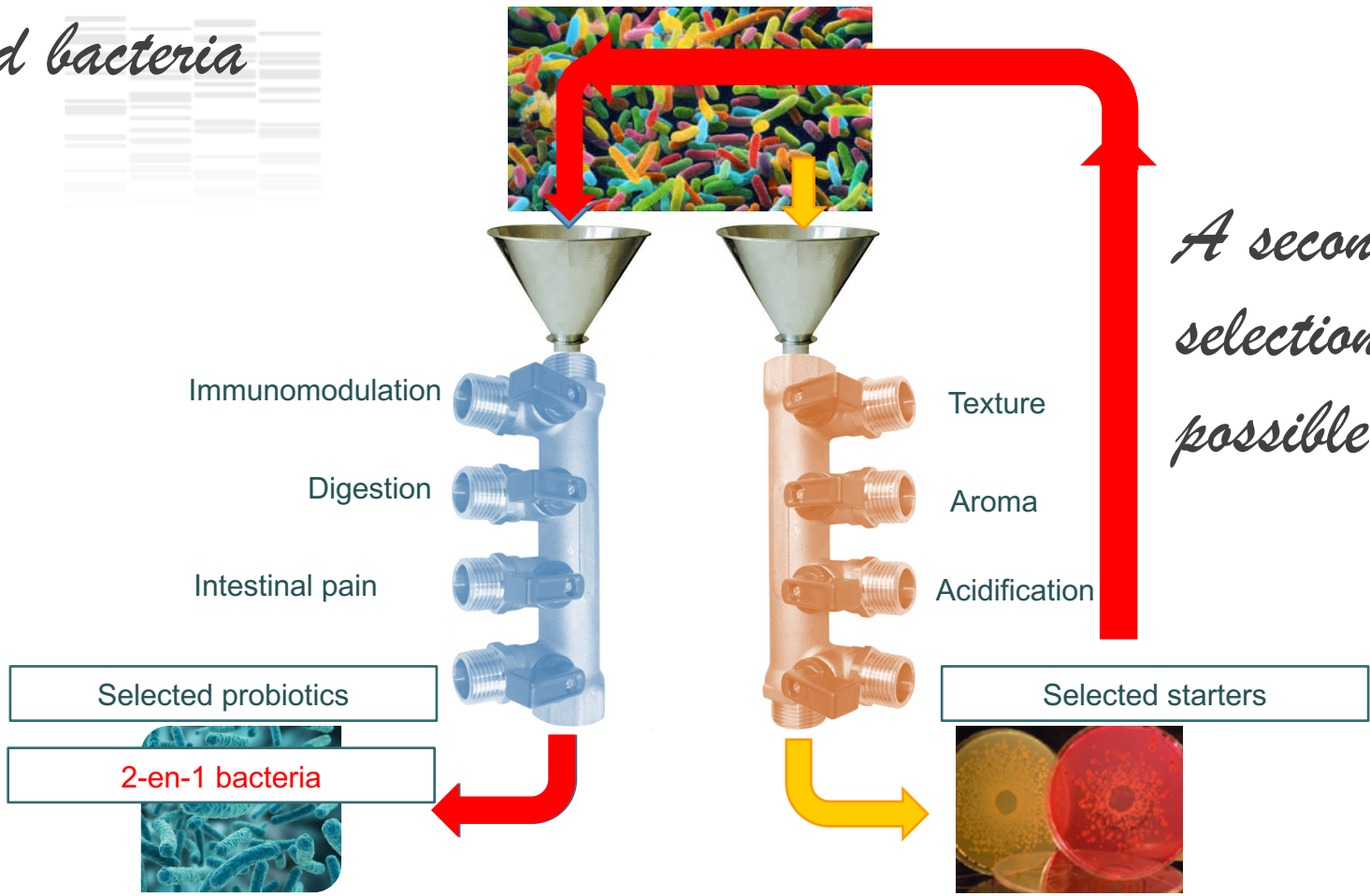
Digestion

Intestinal pain

Selected probiotics

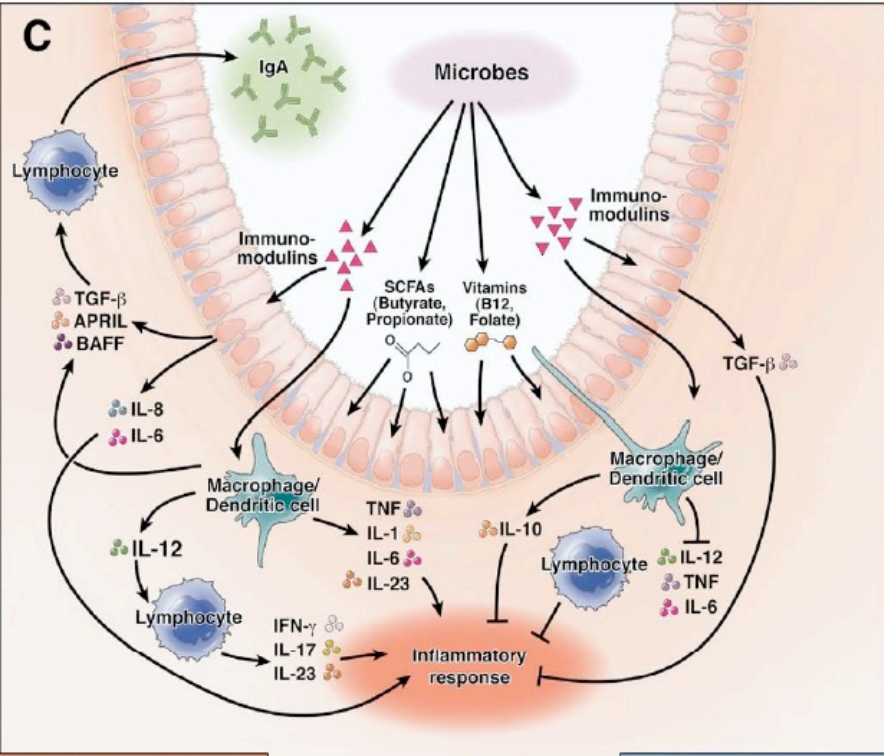


# Selected bacteria





# Examples of selected bacteria: propionibacteria



Pro-inflammatory

O'Flaherty, 2011, Gut Microbes

Anti-inflammatory

→ Vitamin producer  
B9, B12



→ Probiotics



→ Food bio-preservative



→ Ripening starter



Short Chain Fatty Acids (SCFA)  
Known effect on health

# Promising immunomodulators ?

APPLIED AND ENVIRONMENTAL MICROBIOLOGY, Dec. 2010, p. 8259–8264  
 0099-2240/10/\$12.00 doi:10.1128/AEM.01976-10  
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Vol. 76, No. 24

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

Benoit Foliigné,<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>1,2,3,4</sup>

*Institut Pasteur de Lille, Lactic Acid Bacteria & Mucosal Immunity, Center for Infection and Immunity of Lille, 1, Rue du Pr Calmette, BP 245, F-59019 Lille, France<sup>1</sup>; Université Lille Nord de France, F-59000 Lille, France<sup>2</sup>; CNRS, UMR 8204, F-59021 Lille, France<sup>3</sup>; Institut National de la Santé et de la Recherche Médicale, U1019, F-59019 Lille, France<sup>4</sup>; INRA, UMR1253 Science et Technologie du Lait et de l'Oeuf, F-35042 Rennes, France<sup>5</sup>; AGROCAMPUS OUEST, UMR1253 Science et Technologie du Lait et de l'Oeuf, F-35042 Rennes, France<sup>6</sup>; CNIEL/Synlflrais, 42 Rue de Châteaudun, F-75314 Paris 09, France<sup>7</sup>; and EA 4427 SeRAIC, Faculty of Pharmacy, University of Rennes 1, IFR 140 GEAS, Rennes F-35043, France<sup>8</sup>*

Received 20 August 2010/Accepted 7 October 2010

Immunomodulatory properties of 10 dairy propionibacteria, analyzed on human peripheral blood mononuclear cells (PBMCs), revealed a highly strain-dependent induction of anti-inflammatory cytokine interleukin 10 (IL-10). Two selected strains of *Propionibacterium freudenreichii* showed a protective effect against two models of colitis in mice, suggesting a probiotic potential predicted by immune-based selection criteria for these cheese starter bacteria.

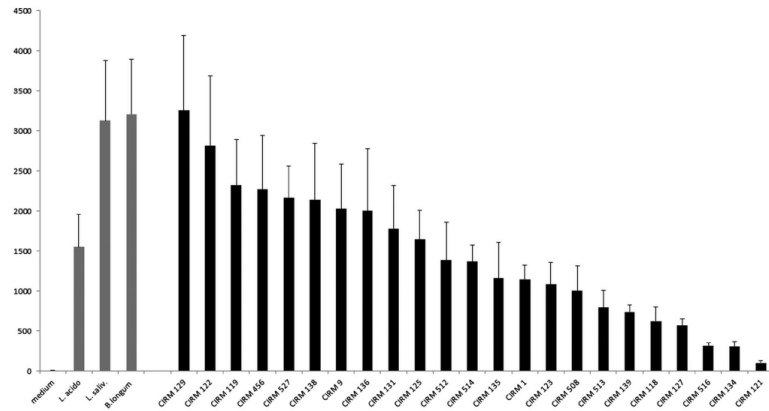
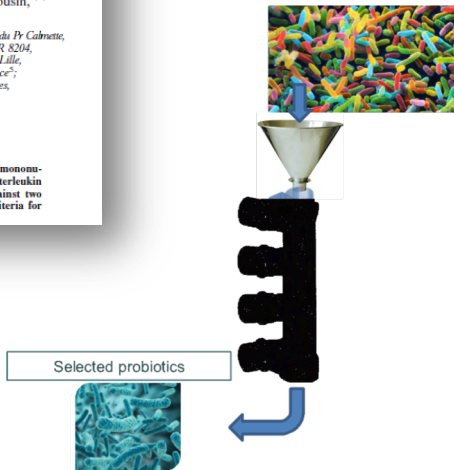


Figure 1 Anti-inflammatory profile of dairy *Propionibacterium freudenreichii* strains assessed on human peripheral blood mononuclear cells (PBMCs). Comparative IL-10 release (in pg/ml) of human PBMCs for 3 reference benchmark probiotic strains (*Lactobacillus acidophilus* NCFM, *L. salivarius* LS33 and *Bifidobacterium longum* BB536) and for 23 propionibacteria strains (CIRM-BIA, INRA, Rennes, France). Immunocompetent cells were stimulated at multiplicity of infection of 10 for 24 h and supernatants analysed by ELISA. Detailed methodology was previously published.<sup>†</sup>

## ➤ Highly strain-dependent

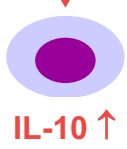
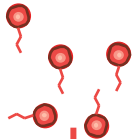
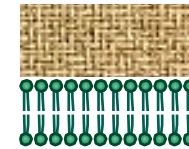
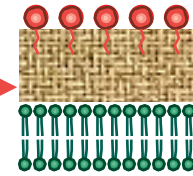
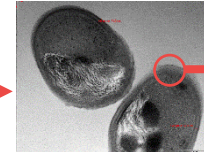
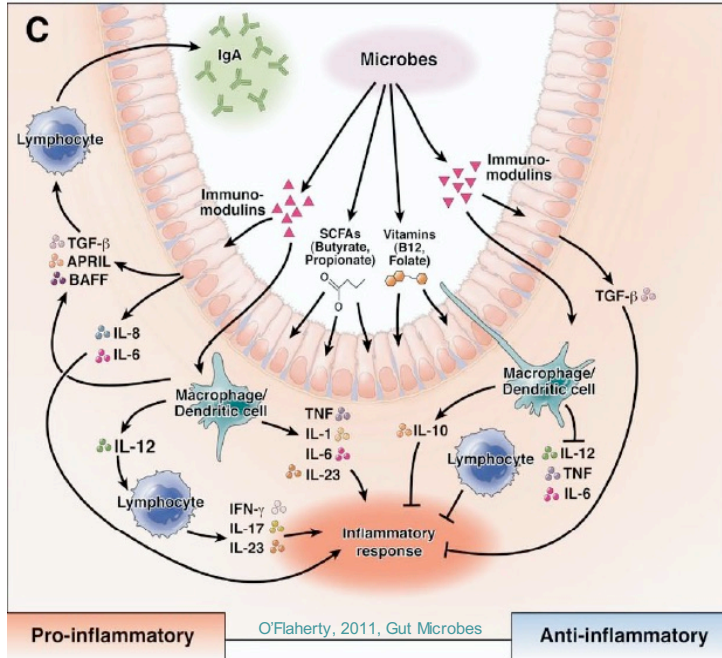


## Tracking the microbiome functionality: focus on *Propionibacterium* species

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

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

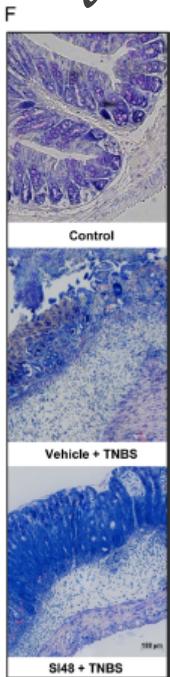
# A key role of a surface protein



IL-10  $\uparrow$

Inflammation

# Examples of selected bacteria



APPLIED AND ENVIRONMENTAL MICROBIOLOGY, Dec. 2010, p. 8259–8264  
 0099-2240/10/\$12.00 doi:10.1128/AEM.01976-10  
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## 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 Samson,<sup>8</sup>



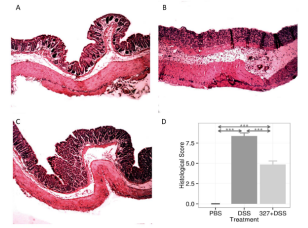
Let's make probiotic cheese!!!

OPEN ACCESS Freely available online

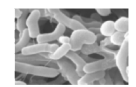
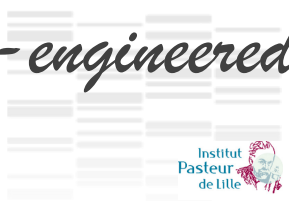


## Local and Systemic Immune Mechanisms Underlying the Anti-Colitis Effects of the Dairy Bacterium *Lactobacillus delbrueckii*

Clarissa Santos Rocha<sup>1,3,4</sup>, Ana Cristina Gomes-Santos<sup>2</sup>, Thais Garcia 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>3,4,9</sup>



# A reverse-engineered cheese



Microfiltr. Milk

Powder 100 g/L

Cream 150 g/L

Sterilisation

Culture *P. freudenreichii*

30°C, 72 h

Pre-cheese

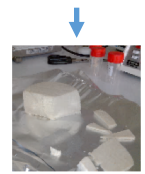
UHT Milk

Culture *L. delbrueckii*

42°C, 4 h

Fermented Milk

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



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

DOI 10.1002/mnfr.201500580

935

RESEARCH ARTICLE

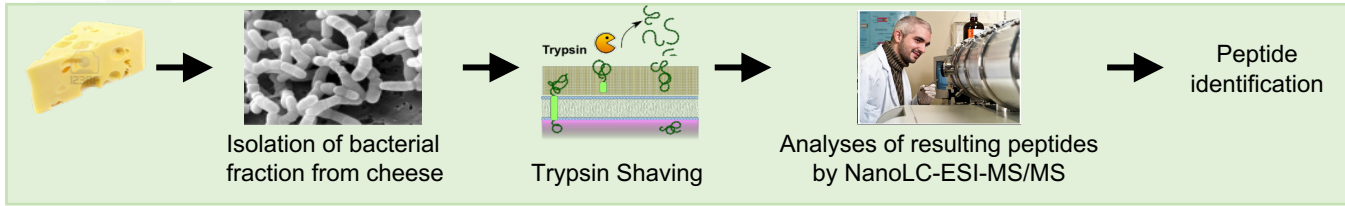


## Combining selected immunomodulatory *Propionibacterium freudenreichii* and *Lactobacillus delbrueckii* strains: Reverse engineering development of an anti-inflammatory cheese

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>,  
Emmanuelle Maguin<sup>7,8</sup>, Gwénaél Jan<sup>3,4</sup>, Maarten Van de Guchte<sup>7,8</sup> and Benoit Foligné<sup>1</sup>



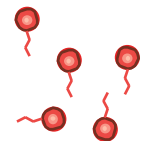
# Key proteins are expressed in the cheese



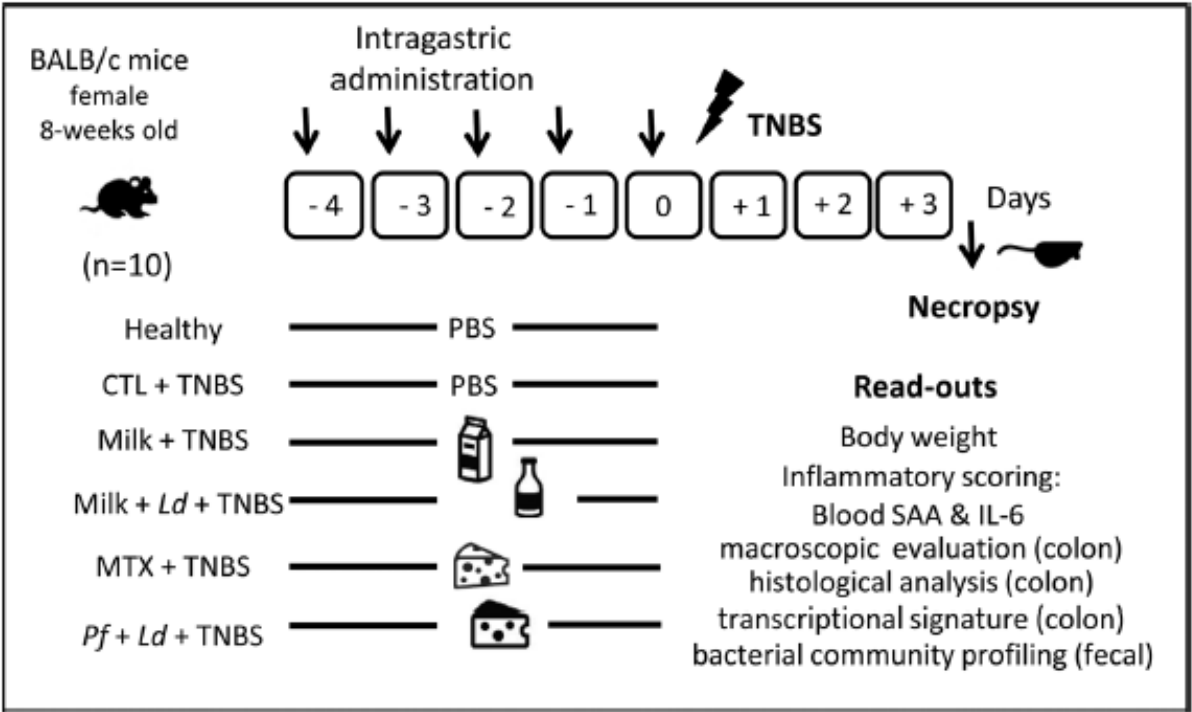
Description	Function	Gene	log(E value)	Peptides	PAI	Group	Sub-group
Surface layer protein B	Cell wall	slpB	-569,10	81	77,3	1	1.1
Surface protein with SLH domain	Cell wall	slpE	-271,21	40	21,5	1	1.2
Surface layer protein A	Cell wall	slpA	-7,48	3	0,6	1	1.3
Internaline A	Miscellaneous	inIA	-838,69	103	26,9	2	2.1
Heat shock protein 202	Protein folding	hsp202	-69,41	10	19,9	3	3.1
60 kDa chaperonin 2	Protein folding	groL2	-275,04	36	17,0	4	4.1
60 kDa chaperonin 1	Protein folding	groL1	-371,42	49	14,8	4	4.2
Cold shock-like protein CspA	Adaptation to atypical conditions	cspA	-28,17	3	15,5	5	5.1
methyltransferase	Miscellaneous		-66,29	7	15,0	6	6.1
Methylmalonyl-CoA mutase large s	Specific carbohydrate metabolic pathway	mutB	-331,83	43	14,1	7	7.1
Elongation factor Tu	Translation elongation	tuf	-177,14	23	13,6	8	8.1
50S ribosomal protein L7/L12	Ribosomal proteins	rplL	-79,13	10	13,2	9	9.1
Lsr2-like protein	Miscellaneous		-24,65	3	13,0	10	10.1
30S ribosomal protein S9	Ribosomal proteins	rspI	-74,75	12	12,4	11	11.1
30S ribosomal protein S7	Ribosomal proteins	rpsG	-77,54	14	11,5	12	12.1
Hypothetical protein	Protein of unknown function		-183,92	23	10,8	13	13.1
30S ribosomal protein S1	Ribosomal proteins	rpsA	-214,68	27	10,7	14	14.1
ErfK/YbiS/YcfS/YnhG precursor	Cell wall		-120,71	20	10,4	15	15.1
NAD(P)(+) transhydrogenase	Metabolism of coenzymes and prosthetic groups	pntA	-146,56	19	10,4	16	16.1
50S ribosomal protein L35	Ribosomal proteins	rpmI	-17,33	4	10,0	17	17.1

Surface proteins are involved in probiotics properties of *P. freudenreichii* in vitro.

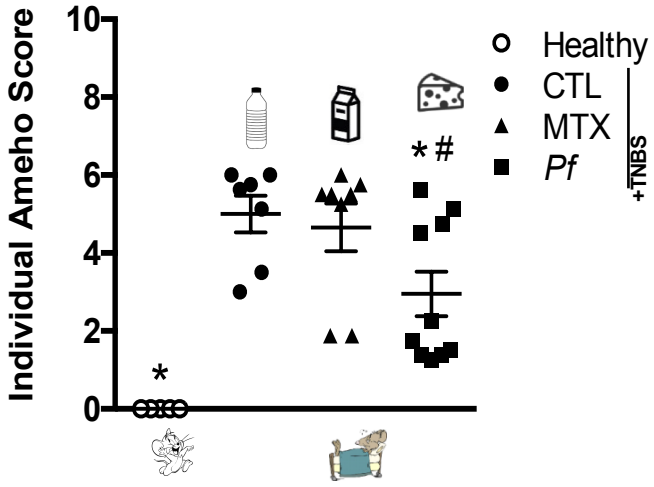
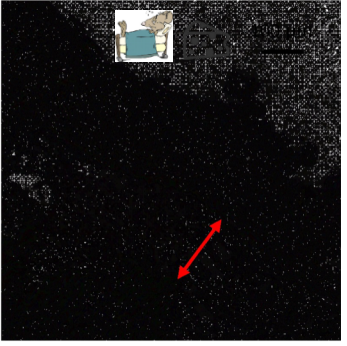
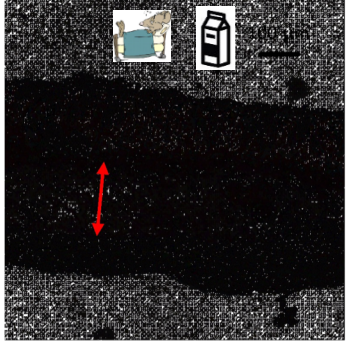
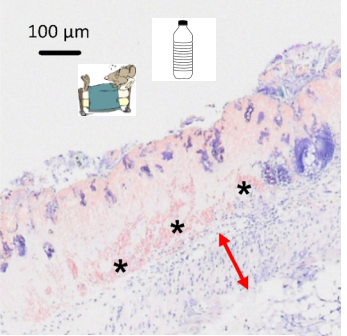
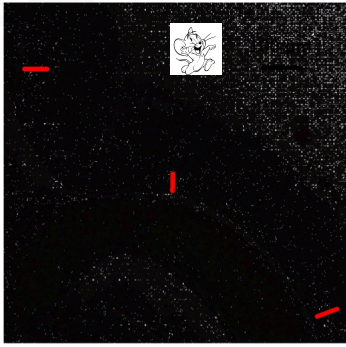
(Review Carmo et al, 2018)



# Cheese is tested in an experimental model of colitis



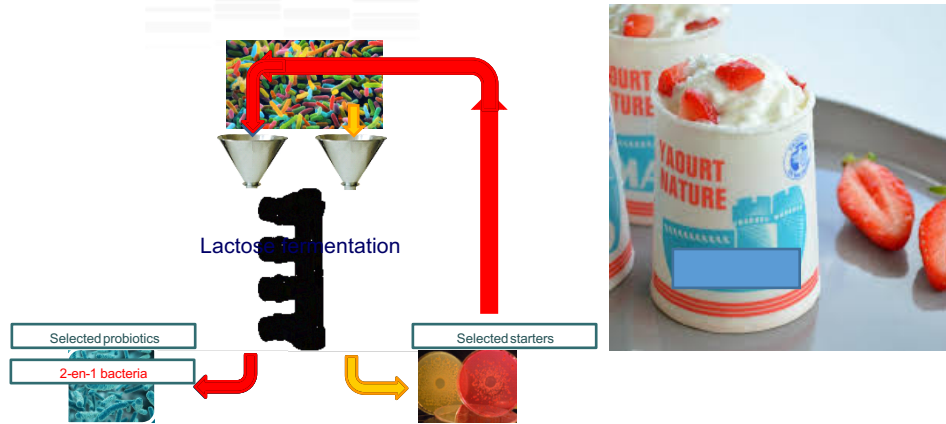
# Cheese protects from colitis



5



# The selection may also be 2-in-1



## SCIENTIFIC OPINION

**Scientific Opinion on the substantiation of health claims related to live yoghurt cultures and improved lactose digestion (ID 1143, 2976) pursuant to Article 13(1) of Regulation (EC) No 1924/2006<sup>1</sup>**

**EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA)<sup>2, 3</sup>**

European Food Safety Authority (EFSA), Parma, Italy

This scientific output, published on 12 January 2011, replaces the earlier version published on 19 October 2010<sup>4</sup>.

The Panel concludes that a cause and effect relationship has been established between the consumption of live yoghurt cultures in yoghurt and improved digestion of lactose in yoghurt in individuals with lactose maldigestion

# Other probiotics in your fridge?

Appl Microbiol Biotechnol (2017) 101:1605-1614  
DOI 10.1007/s00253-016-7953-2



APPLIED MICROBIAL AND CELL PHYSIOLOGY

## *Lactobacillus plantarum* HAC01 regulates gut microbiota and adipose tissue accumulation in a diet-induced obesity murine model

Soyoung Park<sup>1,2</sup>, Yosep Ji<sup>1</sup>, Hoe-Yune Jung<sup>2,3</sup>, Hyunjoon Park<sup>1</sup>, Jihee Kang<sup>4</sup>, Sang-Haeng Choi<sup>4</sup>, Heuynkil Shin<sup>5</sup>, Chang-Kee Hyun<sup>5</sup>, Kyong-Tai Kim<sup>3</sup>, Wilhelm H. Holzapfel<sup>1</sup>



Nutrition 26 (2010) 321-330

Basic nutritional investigation

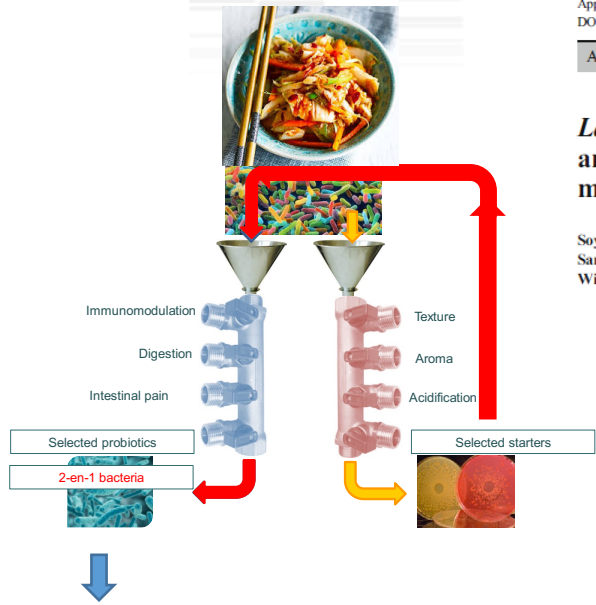
### Hypocholesterolemic effects of *Lactobacillus plantarum* KCTC3928 by increased bile acid excretion in C57BL/6 mice

Jungae Jeun, Ph.D.<sup>a</sup>, Sukyung Kim, M.Sc.<sup>a</sup>, Sung-Yun Cho, B.Sc.<sup>a</sup>, Hee-jin Jun, M.Sc.<sup>a</sup>, Hyun-Jin Park, Ph.D.<sup>a</sup>, Jae-Gu Seo, Ph.D.<sup>b</sup>, Myung-Jun Chung, Ph.D.<sup>b</sup>, and Sung-Joon Lee, Ph.D.<sup>a,\*</sup>

<sup>a</sup>Division of Food Bioscience and Technology, College of Life Sciences and Biotechnology, Institute of Biomedical Sciences and Food Safety, Korea University, Seoul, South Korea

<sup>b</sup>R&D Center of Cellbiotech Co. Ltd., Gyeonggi-Do, South Korea

NUTRITION  
www.nutritionjnl.com

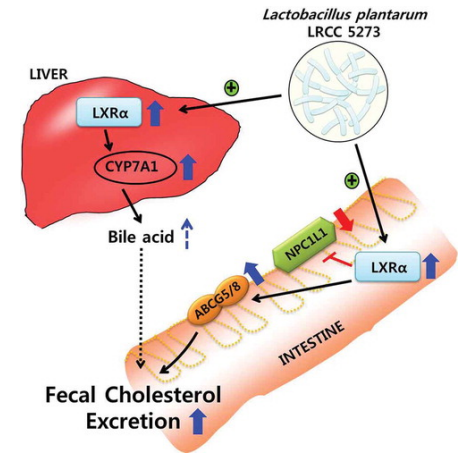


*Lactobacillus sakei*

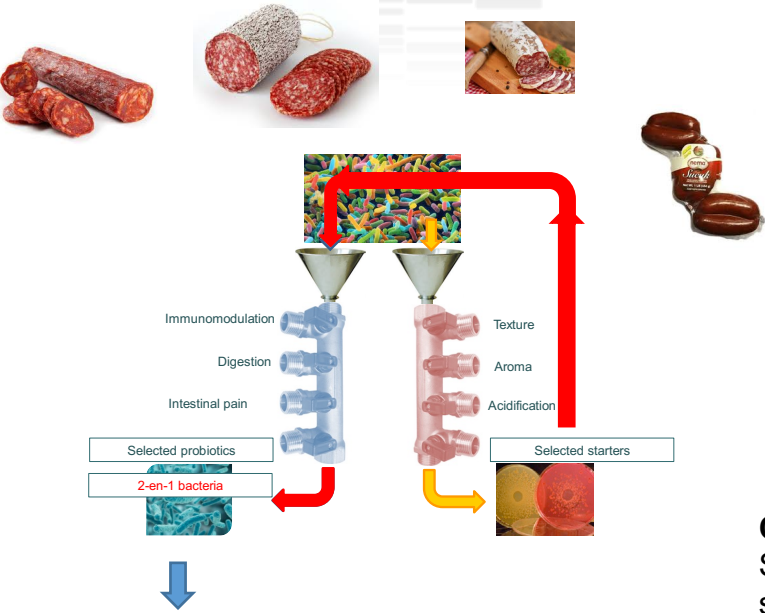
*Lactobacillus plantarum*



*Streptococcus, Pediococcus, Leuconostoc* .....



# Other probiotics in your fridge?



*Lactobacillus sakei, brevis, plantarum*  
*Staphylococcus xylosus,*  
*Pediococcus pentosaceus* (see M. Zommiti)



Annals of Allergy, Asthma & Immunology

Volume 104, Issue 4, April 2010, Pages 343-348



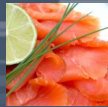
Original article  
 Intervention

## Effect of *Lactobacillus sakei* supplementation in children with atopic eczema–dermatitis syndrome

Sung-Il Woo MD \*, Ji-Yoon Kim MD \*, Yong-Ju Lee MD \*, Nam-Shik Kim PhD†, Youn-Soo Hahn MD, PhD \* ✉

### CONCLUSIONS:

Supplementation of *L. sakei* in children with AEDS was associated with a substantial clinical improvement and a significant decrease in chemokine levels, reflecting the severity of AEDS.



Fermented foods : 30% of our diet

A major source of bacteria : 10<sup>10</sup> per day!

A huge variety of bacteria



IMPACT



Thank you for your attention

Don't ask tough questions



Houem Rabah

P 071

Fillipe do Carmo

Song Huang

Floriane Gaucher

O 027

