



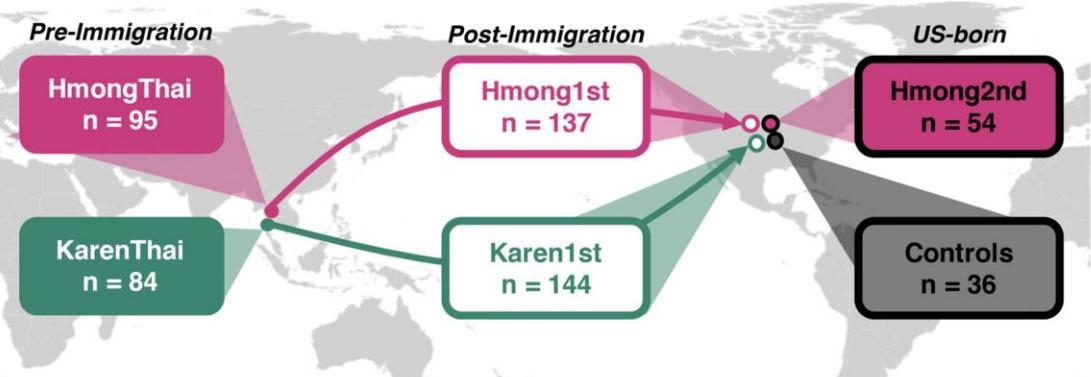
# Health promoting fermented foods: scientific developments and new opportunities



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# Renewed interest in fermented foods

- Produced by every society across the planet
- Had become less common in the Western diet
- Renewed interest...especially due to perception as health promoting



Vangay et al Cell 2018. Sonnenburg, Blaser, etc... 'Missing Microbes'

The screenshot shows the navigation bar of The London Free Press website. It includes a logo on the left and a series of menu items: NEWS, BUSINESS, OPINION, SPORTS, ARTS, LIFE, CAREERS, OBITS, CLASSIFIEDS, DRIVING, VIDEOS, SIGN IN, and SUBSCRIBE. Below these are featured categories: EXCLUSIVE READS, FEDERAL ELECTION, LONDON KNIGHTS, LONDON LIGHTNING, OBESITY, WE ARE THE, and MORE. A search icon and the POSTMEDIA logo are also present.

## Scientist wants fifth food group added to Canada's Food Guide

RDA Fermented foods  
Gregor Reid

# 'There is a mega-trend around fermentation': The rising star of fermented foods

By Katy Askew

08-May-2018 - Last updated on 23-Jul-2019 at 11:33 GMT



Fermented food is getting a boost from its reputation for being both natural and healthy  
©iStock/YelenaYemchuk

Fermentation is making a 'comeback' in western markets, with growing demand supported by consumer perceptions of it as a 'natural' and 'healthy' food preservation method.

## Fermented food and ingredient market is projected to reach \$689.34 billion by 2023

# Fermented foods - Fact vs Fiction!

FRIDAY, SEPTEMBER 25, 2009

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## The value of fermented foods

Source of live, active microbes

Improve food taste, texture, and food digestibility

Increase concentrations of vitamins and bioactive compounds in foods

Remove/reduce toxic or anti-nutrients in raw foods

Increase food safety and shelf-life

## Questions:

- What is meant by 'health-promoting' fermented foods?
- What is the evidence that they are health-promoting?
- What microbes are present in these foods and how might they be contributing to health benefits?

## Long-term Goal:

- Harnessing the microbes in these foods to generate fermented foods with genuine health-promoting features.

# Health benefits of fermented foods

## Fermented foods and gut health

The human digestive tract contains 100 trillion bacterial cells. These bacteria, termed our intestinal microbiota, are important to our health.

Modern practices, such as sanitation, antibiotic use, caesarean birth, formula feeding and eating foods devoid of live cultures, may be leading to a poorly functioning intestinal microbiota.

Fermented foods containing living cultures add beneficial bacteria to the digestive tract.

These fermented foods may benefit human health by reducing risk for some acute and chronic diseases and helping maintain a healthy intestinal microbiota.



Available online at [www.sciencedirect.com](http://www.sciencedirect.com)

ScienceDirect



International Scientific Association for Probiotics and Prebiotics

## Health benefits of fermented foods: microbiota and beyond

Maria L Marco<sup>1</sup>, Dustin Heeney<sup>1</sup>, Sylvie Binda<sup>2</sup>, Christopher J Cifelli<sup>3</sup>, Paul D Cotter<sup>4</sup>, Benoit Foligné<sup>5</sup>, Michael Gänzle<sup>6</sup>, Remco Kort<sup>7</sup>, Gonca Pasin<sup>8</sup>, Anne Pihlanto<sup>9</sup>, Eddy J Smid<sup>10</sup> and Robert Hutkins<sup>11</sup>



### Traditional or novel food fermentations with probiotic organisms

Species with recognized probiotic activity <sup>a</sup>	Fermented foods that reproducibly contain high cell counts of strains of the species
<i>Lactobacillus acidophilus</i>	NSLAB long ripened cheese
<i>Lactobacillus johnsonii</i>	Kefir
<i>Lactobacillus fermentum</i>	Bushera, ting and other African cereal porridges and beverages
<i>Lactobacillus plantarum</i>	Salami <sup>b</sup> , sauerkraut/kimchi, olives, others
<i>Lactobacillus paracasei</i>	Salami, kvass, NSLAB in long-ripened cheese
<i>Lactobacillus rhamnosus</i>	'Villi', fermented oatmeal
<i>Lactobacillus casei</i>	NSLAB long-ripened cheese

NSLAB, non-starter lactic acid bacteria.

<sup>a</sup> According to Health Canada.

<sup>b</sup> Fermented foods are printed in bold if presence of the probiotic organism depends on its addition as competitive starter culture.

# Fermented beverages

Amasi, Aryan, Garris, Kefir, Kivuguto, Koumiss/Arag, Kumis, Nyarmie, Rob, Suusac, Shubat, Amazake, Boza, Bushera, Koko, Sour water, Kvass, Mahewu, Pozol, Togwa, Hardaliye, Kombucha, Water Kefir



**Boza**



**Fermented  
beverages with  
health-promoting  
potential: Past and  
future perspectives**

Alan J. Marsh<sup>a,b,c</sup>, Colin Hill<sup>b,c</sup>,  
R. Paul Ross<sup>a,b</sup> and  
Paul D. Cotter<sup>a,b,\*</sup>



**Kvass**

# Omics – Revolutionising microbiology

**Traditional, culture-based, approaches to microbiology only reveal the ‘tip of the iceberg’**

The success of culture based approaches is dependent on having types of agar/culture media/growth conditions that allow all microbes to grow



**Such an agar does not exist!!**

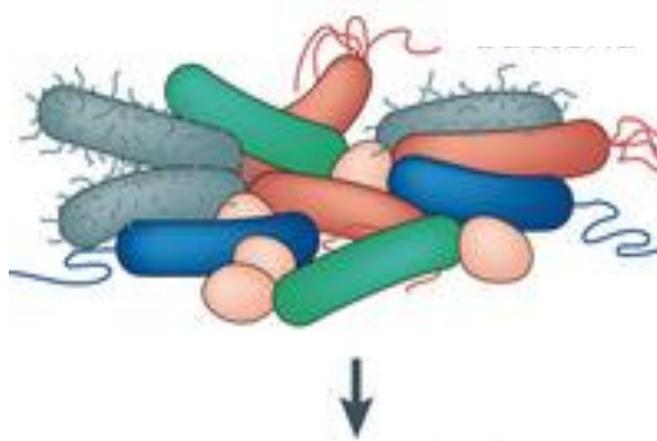
**Indeed only a small % of microbes are easily cultured in the laboratory (see next slide)**



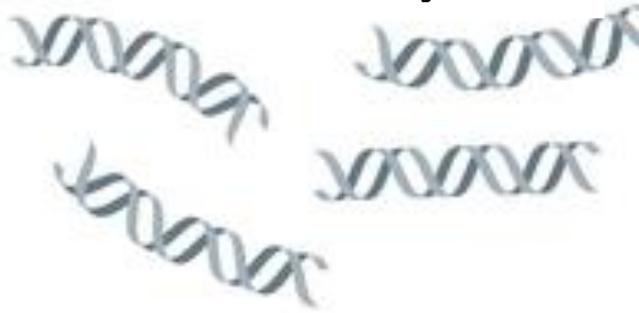
**DNA sequencing-based approaches can allow an analysis to the entire population regardless of whether it can be grown or not**

**All of the DNA from the microbes present in a particular environment = Metagenomic DNA**

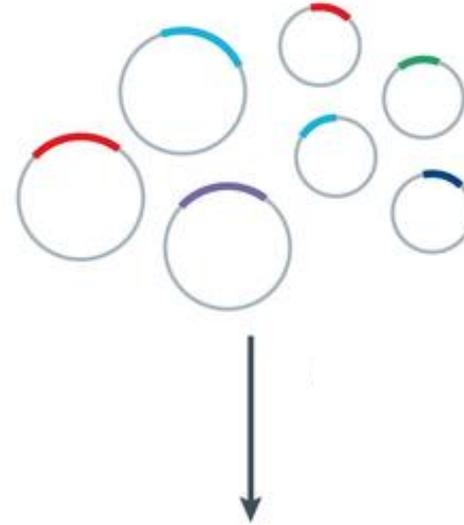
# DNA-based community analysis



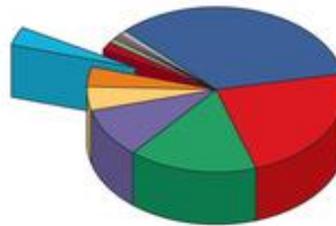
**Community DNA**



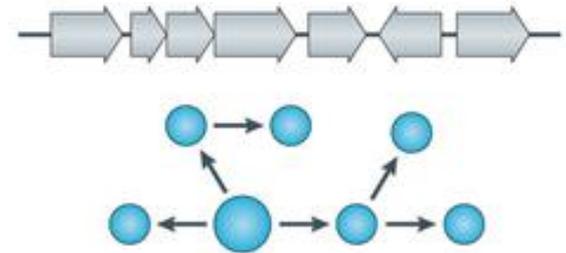
**Whole metagenome  
Shotgun sequencing**



**Community Composition**



**Genes or Pathways**



# Fermented beverage microbiome



Water kefir

Marsh et al  
FEMS 2013



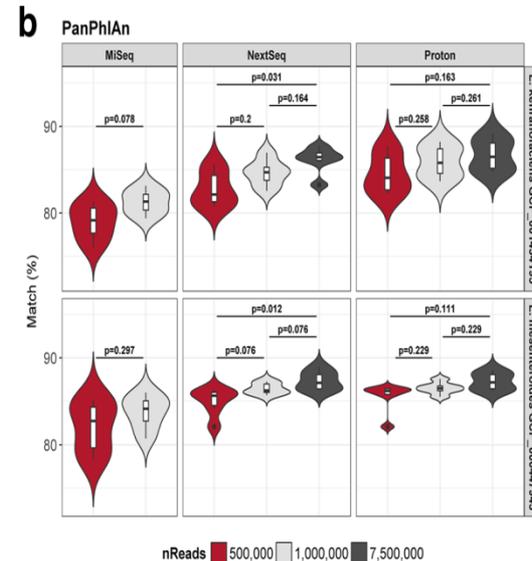
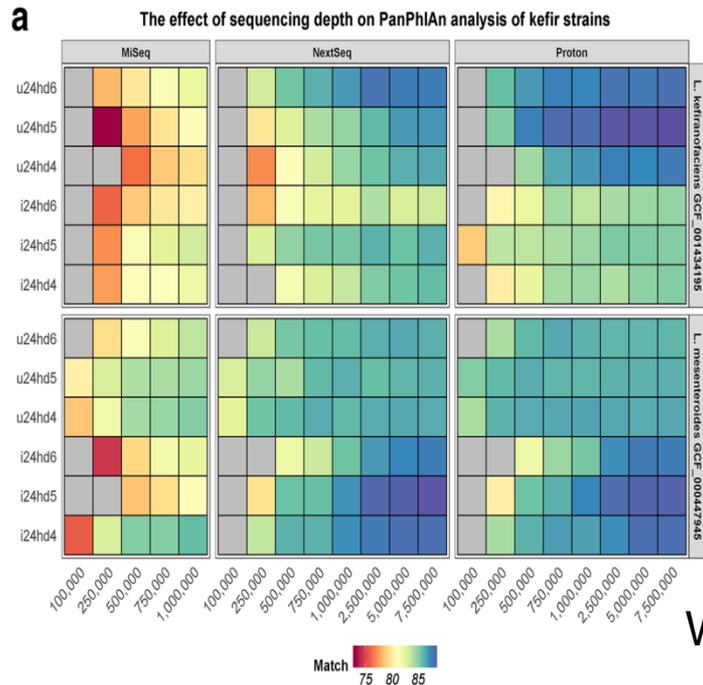
Kombucha

Marsh et al  
Food Microbiol 2014



Nunu

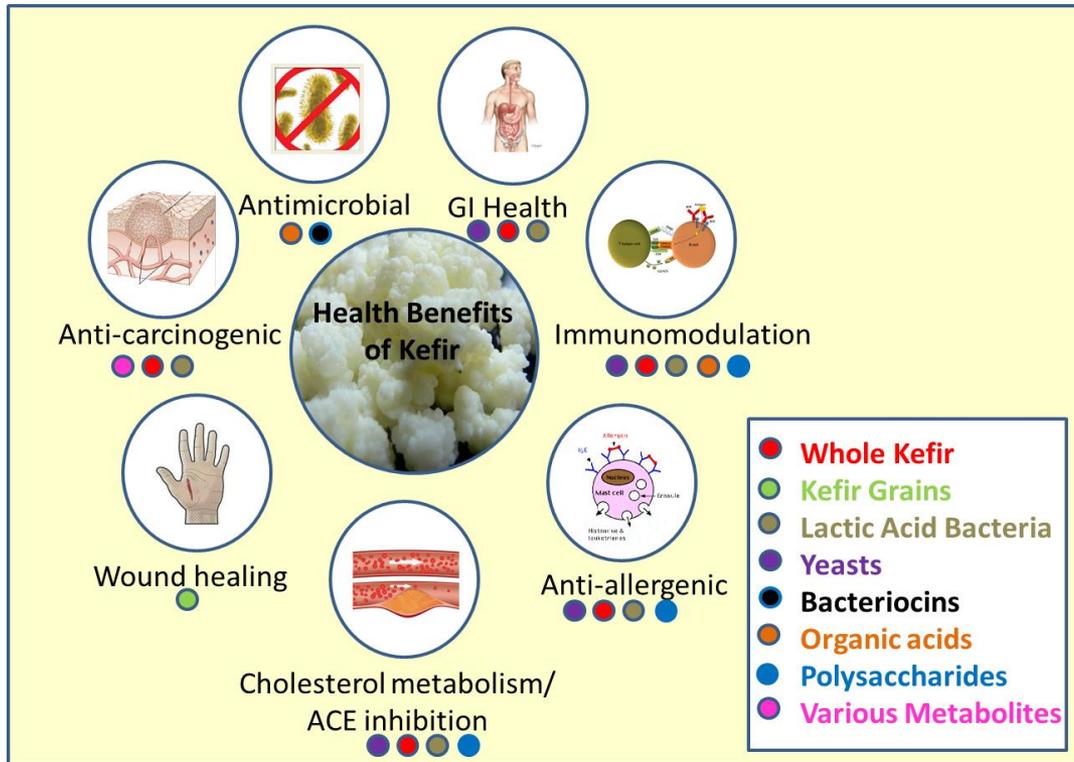
Walsh et al  
Appl Env Microbiol 2017



Walsh et al. Microbiome 2018

# Health Benefits of Kefir

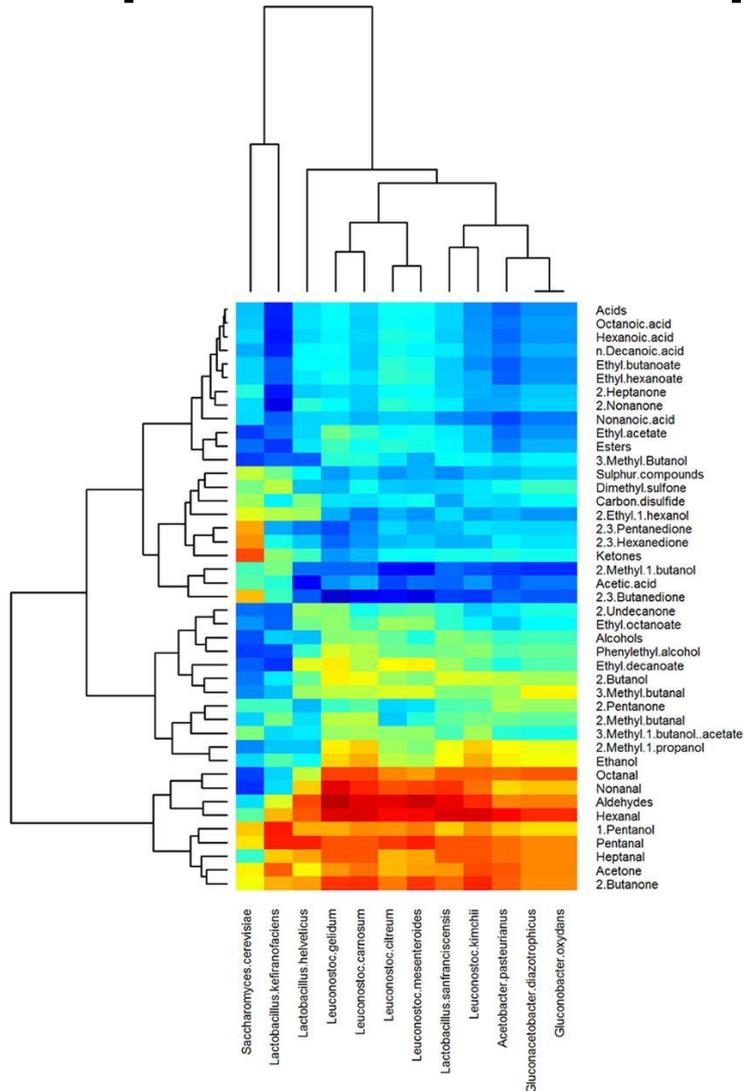
**Kefir = milk fermented with kefir grain (containing a consortium of bacteria and yeasts)**



**Some of the products on the market that are called 'kefir' are not really kefir**

**Many putative health benefits but quality of many of the associated publications leaves a lot to be desired**

# Correlations between the relative abundances of microbial species and the levels of volatile compounds in kefir samples.



Identified strong correlations between:

- *Acetobacter pasteurianus* and vinegary flavours
- *Lactobacillus kefirifaciens* and cheesy flavours
- *Leuconostoc mesenteroides* and buttery flavours
- *Saccharomyces cerevisiae* and fruity flavours

Adding *L. kefirifaciens* NCFB 2797 to increase fruitiness  
 Adding *L. mesenteroides* 213M0 to increase buttery flavour



<https://www.youtube.com/watch?v=uyibFCgXexA>



One can also harnessing the health-promoting potential of the entire kefir community

**Cultures from 16 kefir grains (and milk) from 6 countries**

**Phenotype - screening**

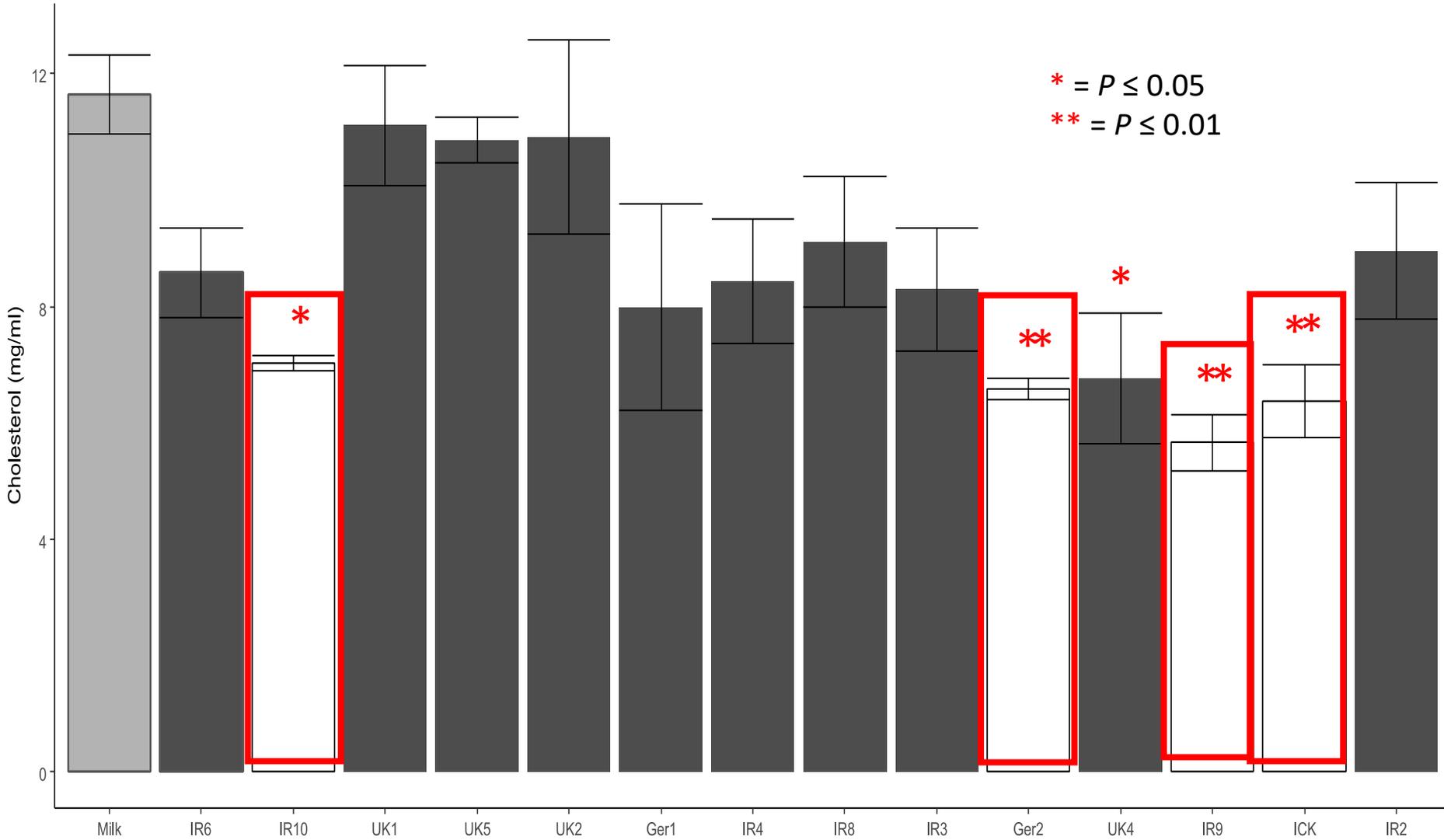
- 2000 Bacterial and 2000 Fungal isolates
- pH tolerance (pH2)
- Bile tolerance (3% Ovgall)
- Antimicrobial production
- Cholesterol assimilation assays
- Adherence and anti-cytotoxicity



**75% of isolates resistant**

**75% of isolates resistant**

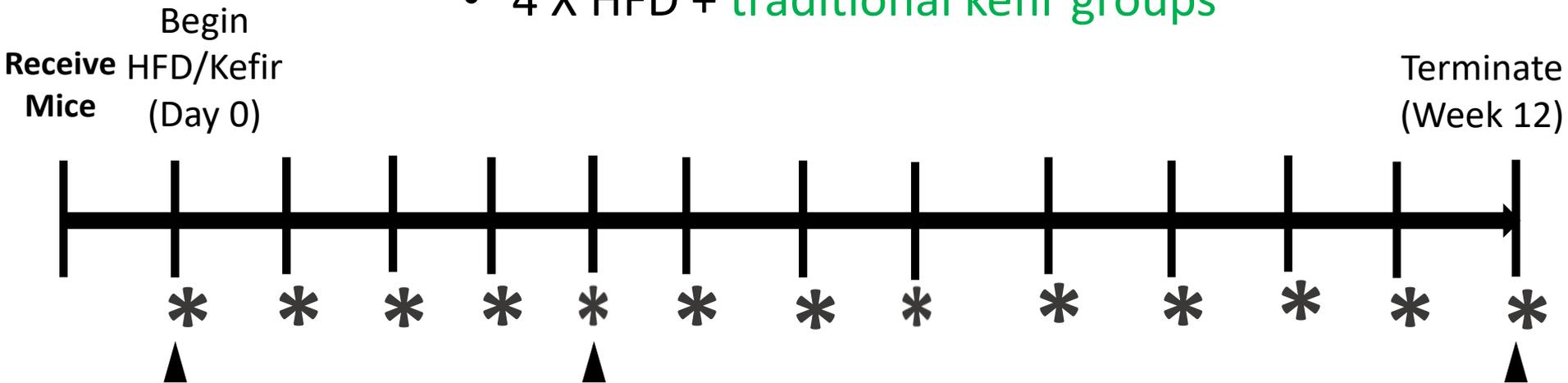
# Cholesterol assimilation in milk



# High fat fed mice

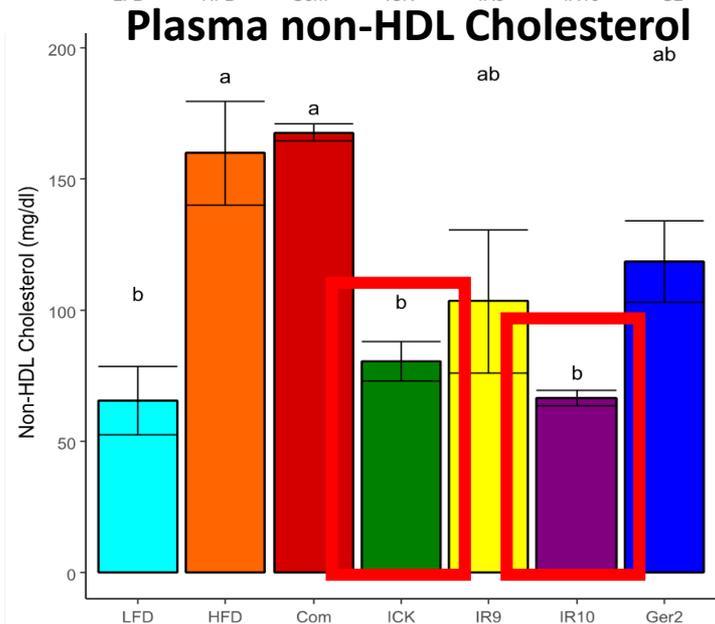
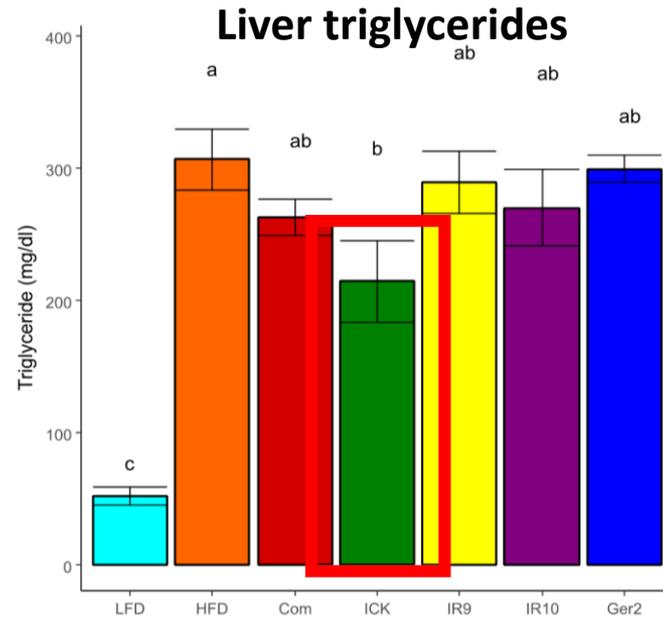
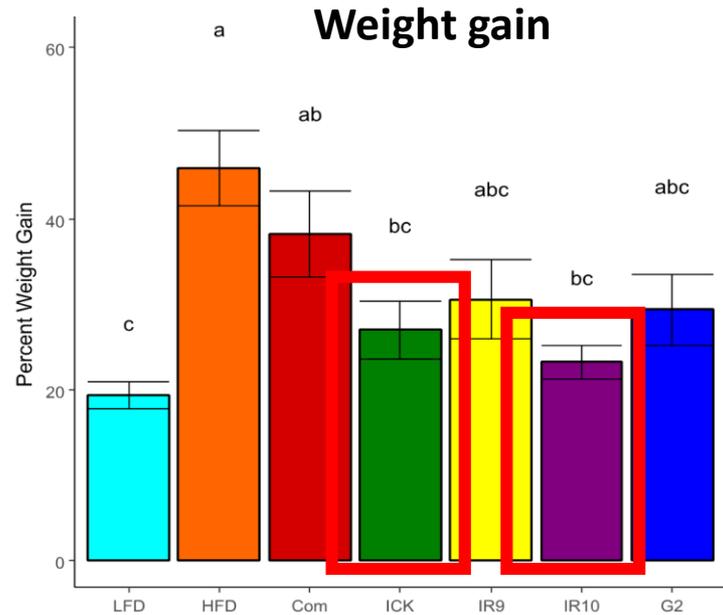
Groups:

- LFD control
- HFD control
- HFD + Commercial
- 4 X HFD + traditional kefir groups



- HFD (40% calories + 1.25% cholesterol) or LFD
- Daily gavage of 100  $\mu$ l milk (controls) or kefir

# Feeding studies



Some traditional, but not commercial kefir, reduced weight gain, levels of plasma LDL Cholesterol and liver TGs

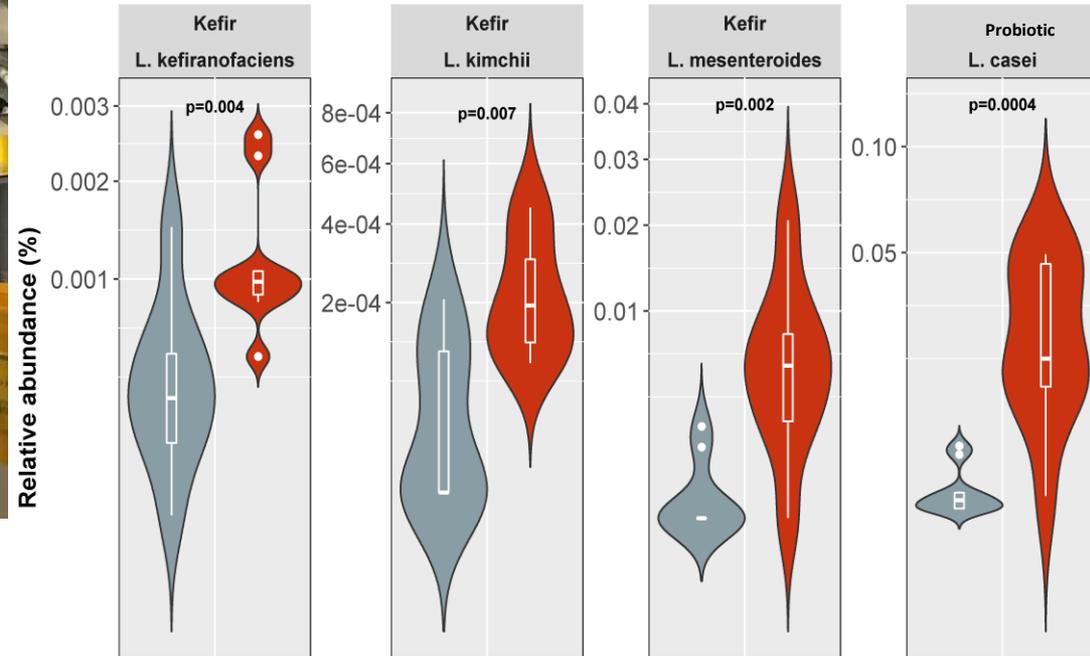
# Human feeding study



28 day intervention

- Off the shelf probiotic drink - once daily
- Kefir - once daily
- Attempting to achieve 7g of inulin / day

## Significantly altered taxa



## Stage

- Before-treatment
- Post-treatment

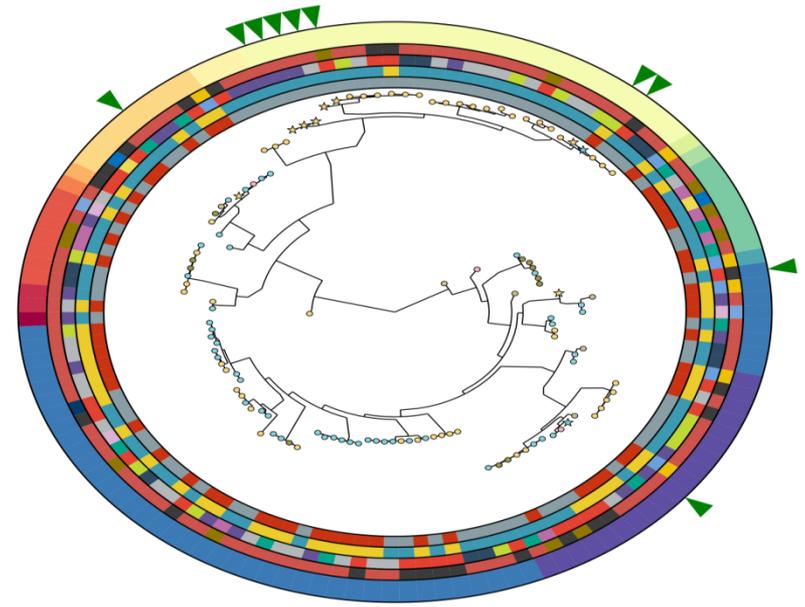
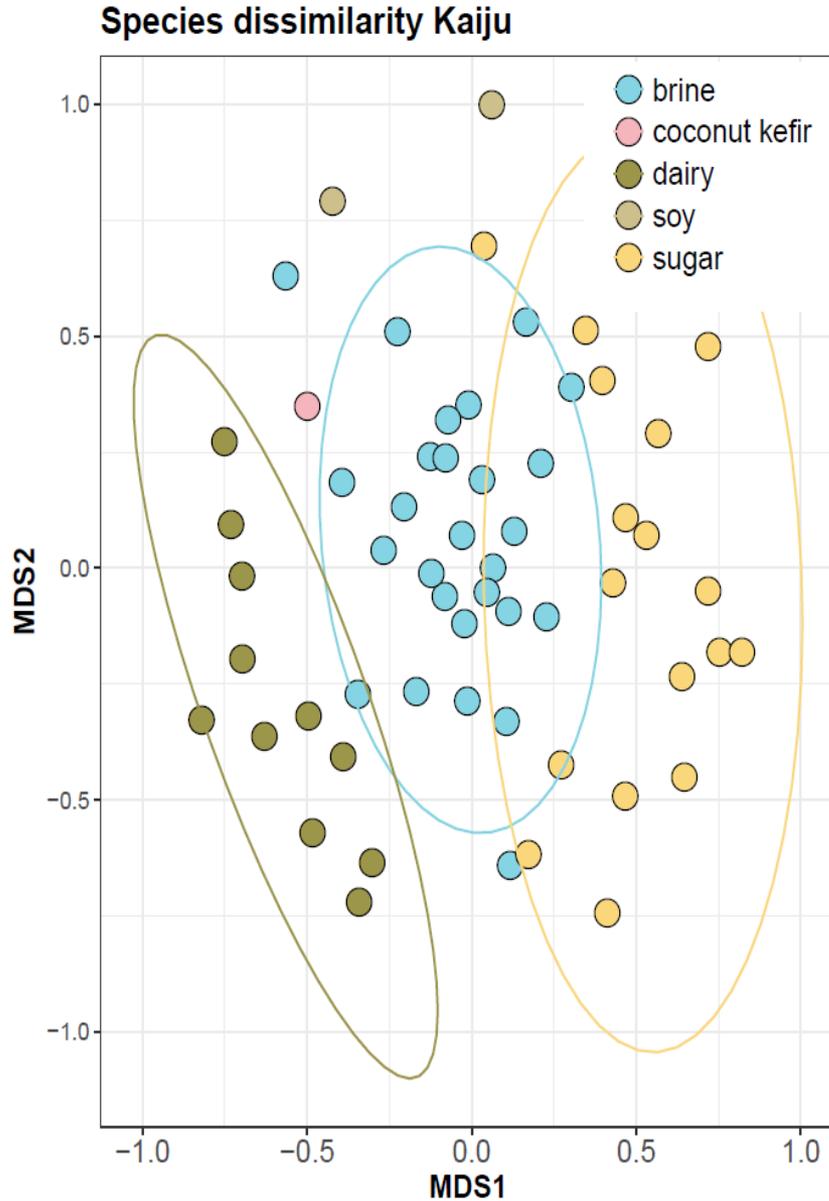
# Global Fermented Food Initiative



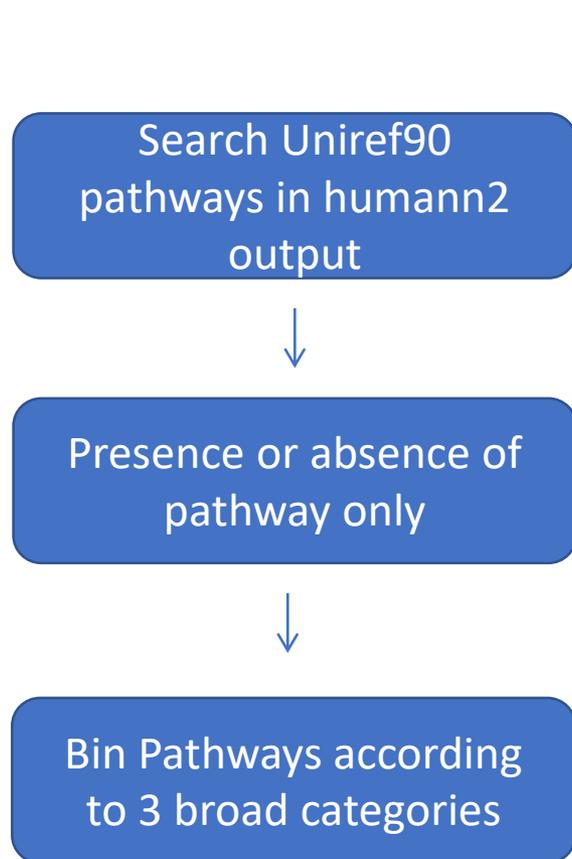
id	Sample N	Name	Type	Origin	id	Sample N	Name	Type	Origin
1FS00a_2016	Wagashi	Cheeses, Dairy product	Benin	21FS20_2017	Black Garlic	Condiment, Pickeld vegetables	England		
2FS01_2016	Bread Kvass	Beverage	Russia	22FS21_2017	Papouis Halloumi Cheese	Cheeses, Dairy product	Cyprus		
3FS02_2016	Carrot Kimchi	Fermented Vegetable	UK	23FS22_2017	Raw Sauerkraut & Juniper berries	Cabbage	Ireland		
4FS03_2016	Boza	Beverage	UK	24FS23_2017	Brown rice amazake	Brown Rice	Japan		
5FS04_2016	Lemon	Preserve	UK	25FS24_2017	Beetroot Kvass	Beetroot	Ireland		
6FS05_2016	Turnip	Fermented Vegetable	UK	26FS25_2017	Kefir and fennel soup	Dairy Soup	Ireland		
7FS06_2016	Orange	Preserve	UK	27FS26_2017	Mead	Fermented honey	Ireland		
8FS07_2016	Krauthehi	Fermented Vegetable	Germany	28FS27_2017	Saurkraut	Cabbage	Ireland		
9FS08_2016	Tepache	Beverage	Mexico	29FS28_2017	Dill dearg	saurkraut	Ireland		
10FS09_2016	Ginger Beer	Beverage	UK	30FS29_2017	Kimchi	cabbage	Ireland		
11FS10_2016	Tempoh	Fermented Grain	UK	31FS30_2017	Golden child	Saurkraut	Ireland		
12FS11_2016	Cucumber	Fermented Vegetable	UK	32FS31_2017	Water Kefir Hibiscus	Beverage	Ireland		
13FS12_2016	Milk Kefir	Beverage	UK	33FS32_2017	Water Kefir lemon	Beverage	Ireland		
14FS13_2016	Water Kefir	Beverage	UK	34FS33_2017	Water Kefir Ginger	Beverage	Ireland		
15FS14_2017	Sushi Ginger	Condiment, Pickled vegetables	China	35FS34_2017	Kombucha Vinegar	Liquid condiment	Ireland		
16FS15_2017	Fukujin Zuke	Condiment, Pickled radish & vegetables	China	36FS35_2017	RYAZHENKA	beverage	Russia		
17FS16_2017	Tofu Chilli	Fermented condiment	China	37FS36_2017	Agousha	beverage	Russia		
18FS17_2017	Daikon	Fermented condiment	China	38FS37_2017	ROSTAGROËKPORT VOROŽNyJ	Snack	Russia		
19FS18_2017	Pickled Bamboo	Condiment, Pickeld vegetables	China	39FS38_2017	RUŽ'A	Cheeses, Dairy product	Russia		
20FS19_2017	Pickled vegetables	Condiment	China	40FS39_2017	Raw Milk Kefir	Beverage	Ireland		



# Microbial diversity across a range of fermented foods



# Health Associated Gene Clusters



## Example of Colonising Pathways

- tad
- exopolysaccharide
- eps
- bacteriocins

## Example of Survival Pathways

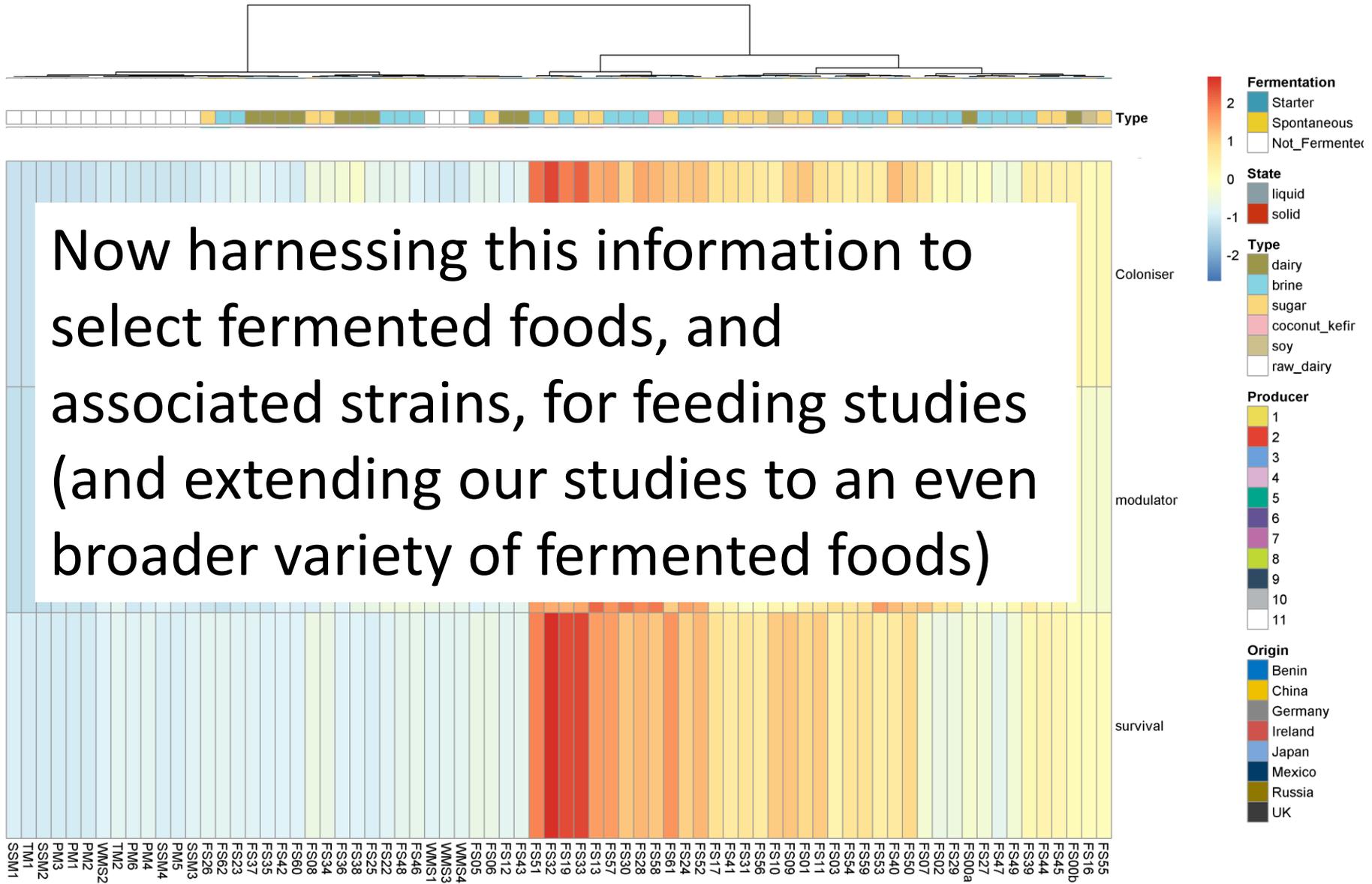
- Glutamate decarboxylase beta
- D-alanine--poly(phosphoribitol)
- Cyclic di-GMP phosphodiesterase

## Example of Modulation Pathways

- Lipoteichoic acid synthase
- D-lactate dehydrogenase
- D-alanine--poly(phosphoribitol)

**fermented foods contained considerably more clusters than the non-fermented substrates**

# Larger number of HAGCs were found in brine- and sugar-foods



# Conclusion

- There are quite a number of health-promoting fermented foods on the market but the science underlying the associated claims can often be poor
- This can be addressed through a more rigorous examination and harnessing of the microorganisms present, and the compounds that they produce
- ....thereby ensuring that the increased consumption of fermented foods is not just a short-term trend



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