Fermented plant-based foods and cardiometabolic health - Does fermentation matter?

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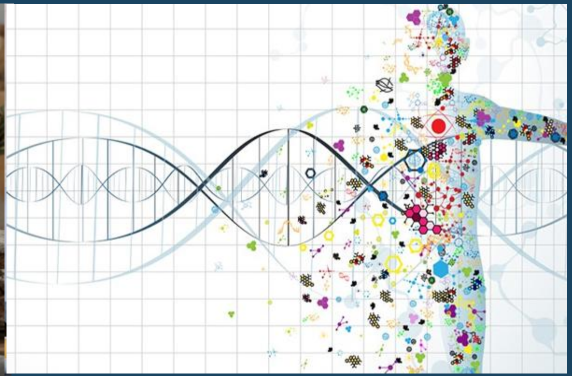
HealthFerm Final conference August 25-26, Leuven Belgium



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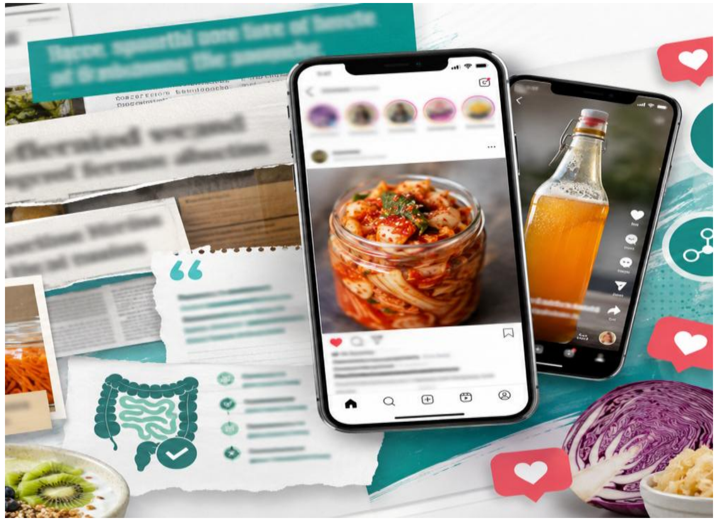
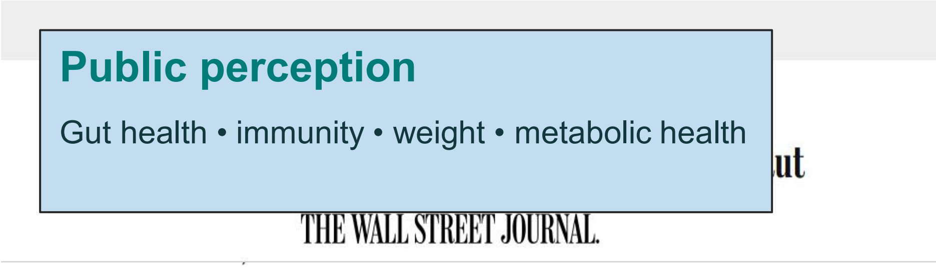
Fermented foods are having a moment now!





Public perception

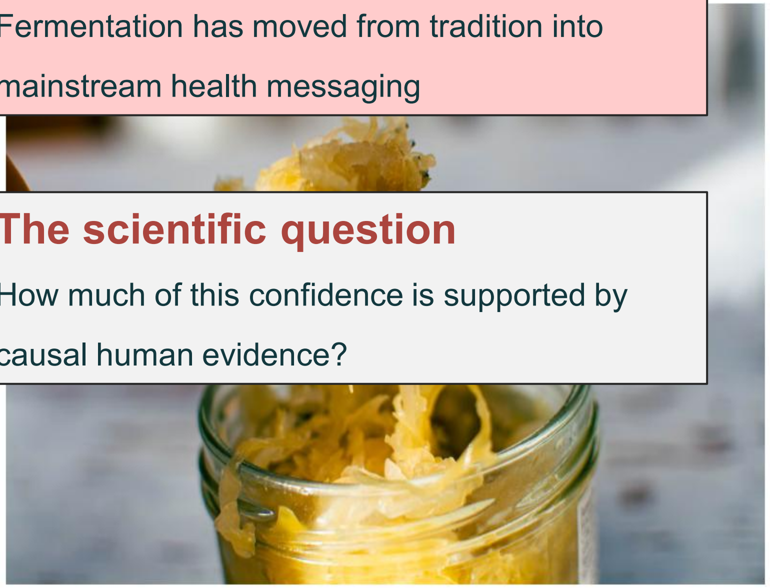
Gut health • immunity • weight • metabolic health

Policy & media

Fermentation has moved from tradition into mainstream health messaging

The scientific question

How much of this confidence is supported by causal human evidence?



What could fermentation add?

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LIVE MICROBES

Transient exposure
community interactions

TRANSFORMED MATRIX

Bioavailability
reduced antinutrients

MICROBIAL PRODUCTS

Organic acids
peptides • metabolites

HOST RESPONSE

Gut barrier
immune & metabolic signalling

Plausible mechanisms ≠ demonstrated cardiometabolic benefit

Fermented foods are entering dietary guidelines – but health claims remain limited

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THEN

Fermented foods have historically received little explicit attention in food-based dietary guidelines.

Marco et al., Nat Rev Gastroenterol Hepatol 2021

NOW – USA 2026

US Dietary Guidelines explicitly link fermented foods – including sauerkraut, kimchi, kefir and miso – to a diverse gut microbiome- *which* ***may be*** *beneficial for health*.

Dietary Guidelines for Americans 2025–2030, p. 2

EU CLAIMS

Only one EU-authorised health claim specifically involves live microorganisms: live yoghurt cultures improve lactose digestion.

European Commission, EU Register of Health Claims, ID 1143

DIETARY GUIDANCE IS MOVING AHEAD – BUT HOW STRONG IS THE EVIDENCE?

Microbial content of common fermented foods- “fermented foods” are not all the same

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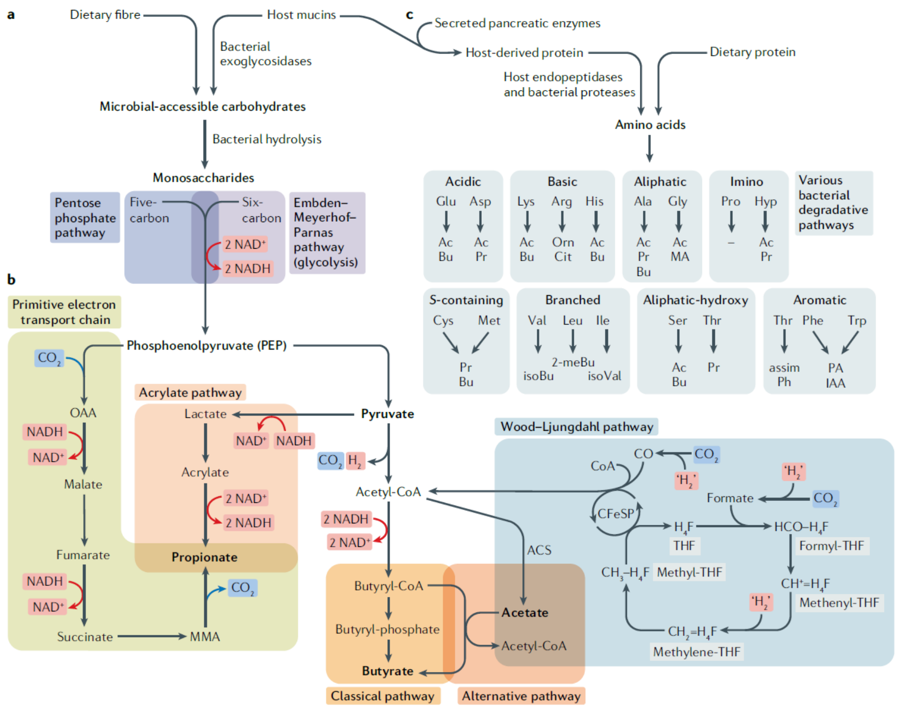
Name	Description	Region of Origin	Source of Microorganisms	Microorganisms Identified in Final Product *
Kefir	Fermented milk beverage	Caucasus	Starter culture	*Lactobacillus kefiri, Lactobacillus paracasei, Lactobacillus parabuchneri, Lactobacillus casei, Lactobacillus lactis, Lactococcus lactis, Acetobacter lovaniensis, Kluyveromyces Lactis, Saccharomyces cerevisiae*
Kombucha	Fermented tea beverage	China	Starter culture	*Komagataeibacter xylinus, Saccharomyces cerevisiae, Zygosaccharomyces bailii. Brettanomyces bruxellensis, Acetobacter pasteurianus, Acetobacter aceti, Saccharomyces cerevisiae, Zygosaccharomyces bailii, Brettanomyces bruxellensis, Acetobacter xylinum, Zygosaccharomyces* spp., *Acetobacter, Gluconacetobacter*
Sauerkraut	Fermented cabbage	China	Spontaneous	*Lactobacillus sakei, L. plantarum, Candidatus accumulibacter phosphatis, Thermatoga* spp., *Pseudomonas rhizosphaerae, L. hokkaidonensis, L. rhamnosus, Leuconostoc carnosum, Clostridium saccharobutyrilicum, Rahnella aquatillis, Citrobacter freundii, Enterobacter cloacae, Bifidobacterium dentium, Enterococcus faecalis, Lactobacillus casei, Lactobacillus delbrueckii, Staphylococcus epidermidis, Lactobacillus curvatus, Lactobacillus brevis, Weissella confusa, Lactococcus lactis, Enterobacteriaceae, Leuconostoc* spp., *Yarrowia brassicae*
Tempeh	Fermented boiled and dehulled soybeans	Indonesia	Starter culture (*Rhizopus oligoporus*)	*Enterococcus faecium, Rhizopus oryzae, Rhizopus oligoporus, Mucor indicus, Mucor circinelloides, Geotrichum candidum, Aureobasidium pullulans, Alternaria alternata, Cladosporium oxysporum, Trichosporon beigelii, Clavispora lusitaniae, Candida maltosa, Candida intermedia, Yarrowia lipolytica, Lodderomyces elongisporus, Rhodotorula mucilaginosa, Candida sake, Hansenula fabiani, Candida tropicalis, Candida parapsilosis, Pichia membranefaciens, Rhodotorula rubra, Candida rugosa, Candida curvata, Hansenula anomola*
Natto	Fermented soybean	Japan	Starter culture (*Bacillus subtilis* natto)	Data not available
Miso	Fermented soybean paste	Japan	Starter culture (*Aspergillus oryzae*)	*Bacillus subtilis, Bacillus amyloliquefaciens, Staphylococcus gallinarum, Staphylococcus kloosii, Lactococcus* sp. GM005
Kimchi	Fermented vegetable dish	Korea	Spontaneous, Addedcommercially	*Leuconostoc gasicomitatum, Leuconostoc gelidum, Leuconostoc mesenteroides, Weissella koreensis, Weissella confuse, Lactobacillus sakei, Lactobacillus plantarum, Lactobacillus curvatus, Trichosporon domesticum, Trichosporon loubieri, Saccharomyces unisporus, Pichia kluyveri*
Sourdough bread	Bread made from longer ferment	Middle East and Europe	Spontaneous or backslopping	Data not available

Dimidi et al. (2019)

Products of gut microbial fermentation of **carbohydrates**, protein and **dietary polyphenols**

Metabolite	Pathway	Genera or species
Acetate	Pyruvate decarboxylation to acetyl-CoA	*Akkermansia muciniphila*, *Bacteroides* spp., *Bifidobacterium* spp., *Prevotella* spp., *Ruminococcus* spp.
	Wood–Ljungdahl pathway	*Blautia hydrogenotrophica*, *Clostridium* spp., *Streptococcus* spp.
Propionate	Acrylate pathway	*Coprococcus catus*, *Eubacterium hallii*, *Megasphaera elsdenii*, *Veillonella* spp.
	Succinate pathway	*Bacteroides* spp., *Dialister* spp., *Phascolarctobacterium succinatutens*, *Veillonella* spp.
	Propanediol pathway	*Roseburia inulinivorans*, *Ruminococcus obeum*, *Salmonella enterica*
Butyrate	Classical pathway via butyrate kinase	*Coprococcus comes*, *Coprococcus eutactus*
	Alternate pathway using exogenous acetate	*Anaerostipes* spp., *C. catus*, *E. hallii*, *Eubacterium rectale*, *Faecalibacterium prausnitzii*, *Roseburia* spp.
Short-chain fatty acids and branched-chain fatty acids	Amino acid fermentation through various dissimilatory proteolytic reactions	*Acidaminococcus* spp., *Acidaminobacter* spp., *Campylobacter* spp., Clostridia spp., *Eubacterium* spp., *Fusobacterium* spp., *Peptostreptococcus* spp.
'Kynurenines' (kynurenine and its derivatives)	Various bacterial enzymes homologous to mammalian enzymes of the kynurenine pathway	*Lactobacillus* spp., *Pseudomonas aeruginosa*, *Pseudomonas fluorescens*
		Putative: *Pseudomonas* spp., *Xanthomonas* spp., *Burkholderia* spp., *Stenotrophomonas* spp., *Shewanella* spp., *Bacillus* spp., members of Rhodobacteraceae, Micrococcaceae and Halomonadaceae families
Indole	Hydrolytic β-elimination of tryptophan to indole (tryptophanase)	*Achromobacter liquefaciens*, *Bacteroides ovatus*, *Bacteroides thetaiotamicron*, *Escherichia coli*, *Paracolobactrum coliforme*, *Proteus vulgaris*
Indole derivatives	Multiple	*Bacteroides* spp., *Clostridium* spp. (*Clostridium sporogenes*, *Clostridium cadaveris*, *Clostridium bartlettii*), *E. coli*, *Lactobacillus* spp., *E. hallii*, *Parabacteroides distasonis*, *Peptostreptococcus* spp. (*Peptostreptococcus anaerobius*)
Tryptamine	Decarboxylation of tryptophan	*C. sporogenes*, *Ruminococcus gnavus*
Serotonin	Induction of host synthesis[a]	Indigenous spore-forming bacteria, dominated by *Clostridium* spp. and *Turicibacter* spp.
Histamine	Decarboxylation of histidine (histidine decarboxylase (HDC))	*E. coli*, *Morganella morganii*, *Lactobacillus vaginalis*
		Putative: *Fusobacterium* spp.
Imidazole propionate (ImP)	Non-oxidative deamination of histidine to urocanate followed by reduction of urocanate to ImP by urocanate reductase (UrdA)	*Aerococcus urinae*, *Adlercreutzia equolifaciens*, *Anaerococcus prevotii*, *Brevibacillus laterosporus*, *Eggerthella lenta*, *Lactobacillus paraplantarum*, *Shewanella oneidensis*, *Streptococcus mutans*
Dopamine	Decarboxylation of levodopa (L-DOPA) via tyrosine decarboxylase (TyrDC)	*Enterococcus* spp. (*Enterococcus faecalis*, *Enterococcus faecium*, 77 human isolates of *Enterococcus* spp.), *Lactobacillus brevis*, *Helicobacter pylori*
p-Cresol	From tyrosine or phenylalanine via two pathways: direct cleavage of the Cα–Cβ bond in tyrosine to yield p-cresol by tyrosine lyase; and a series of reactions involving transamination, deamination and decarboxylation of tyrosine or phenylalanine via formation of the cresol precursor phenylacetic acid	Assay proven: *Blautia hydrogenotrophica*, *Clostridioides difficile*, *Olsenella uli*, *Romboutsia lituseburensis*
		Predicted: *Acidaminococcus fermentans*, *Anaerococcus vaginalis*, *Anaerostipes* spp., *Bacteroides* spp., *Bifidobacterium infantis*, *Blautia* spp., *Citrobacter koseri*, *Clostridium* spp., *Eubacterium siraeum*, *Fusobacterium* spp., *Klebsiella pneumoniae*, *Lactobacillus* spp., *M. elsdenii*, *Roseburia* spp., *Ruminococcus* spp., *Veillonella parvula*
Phenylacetylglutamine (PAGln) and phenylacetylglycine (PAGly)	Synthesized during host hepatic phase II metabolism via conjugation of either glutamine or glycine to phenylacetic acid, an intermediate in microbial fermentation of phenylalanine	Conjugation of phenylacetic acid to glutamine or glycine occurs in the host liver; see p-cresol (above) for information about its precursor, phenylacetic acid

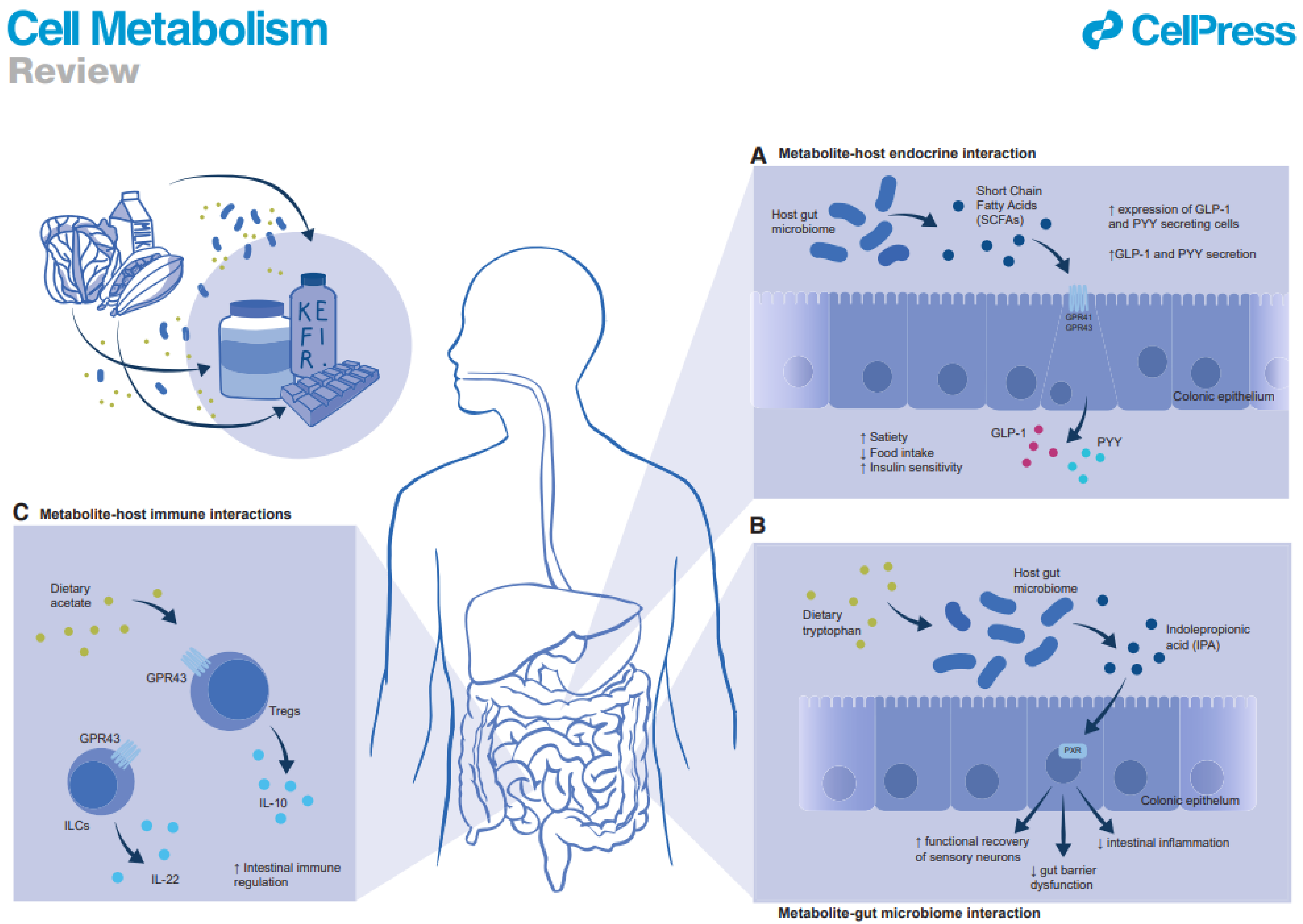
Diverse set-up of metabolites formed during fermentation



Mediators of health-effects?

Krautkrame et al. (2021) Nature Reviews

Effects of fermented food microbes and metabolites



Caffrey et al. (2024) Cell Metabolism

The extended microbiome: a metabolic paradigm linking fermented food-derived metabolites to health

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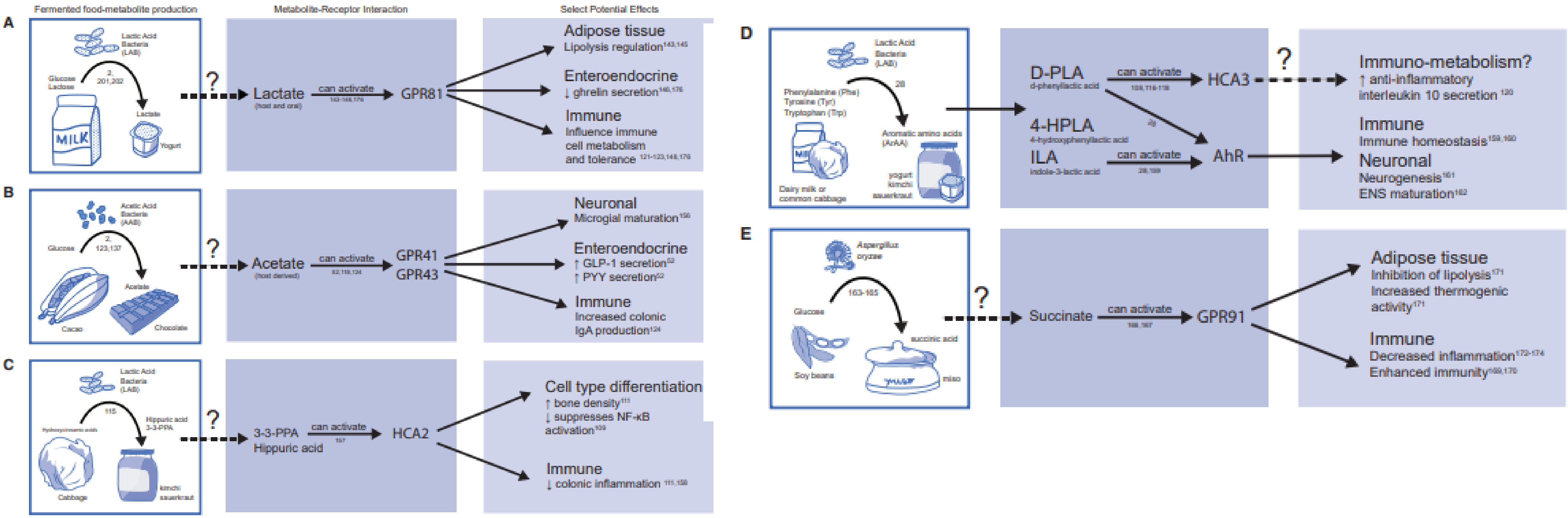

Caffrey et al. (2024) Cell Metabolism

Cardiometabolic health-benefits of fermented foods

- Little is known
- Observational studies, few intervention trials
- Yoghurt

Żółkiewicz et al. (2020) Nutrients

Fermented foods and cardiometabolic health- what does epidemiology tell us?

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TYPE 2 DIABETES

↓ risk

Most consistent signal (particularly yoghurt / fermented dairy)

CARDIOVASCULAR HEALTH

↓ risk / mortality

Generally favourable associations
but heterogeneous across foods

ADIPOSITY & METABOLIC RISK

favourable signals

Associations with weight and metabolic health are less consistent

The evidence base is dominated by ***food-specific*** analyses rather than ***fermentation*** as an exposure.

PROMISING ASSOCIATIONS — BUT LITTLE EVIDENCE FOR FERMENTATION PER SE

Ahn et al. (2025), *Nutr Rev*
Matalas et al. (2026), *Front Nutr*
Companys et al. (2020), *Adv Nutr*

Health-benefits of fermented foods - yoghurt

Table 2 **Summary of studies**

Area studied	Total no. of studies	Study types	Fermented products studied	Comparators	No. of studies with favorable outcome	No. of studies with no significant effect	No. of studies with unfavorable outcome
Gastrointestinal health and disease	26	RCT=16 RCOT=8 CS=1 NRCT=1	Yogurt, fermented milk, fermented milk drinks, pasteurized yogurt, probiotic yogurt, kefir	Dahi, ultra-heated yogurt, non-fermented dairy product, milk, pasteurized yogurt, acidified milk, yogurt, lactose water, ice	20	6	0
					16	11	1
		CS=8 CH=9		isoenergetic sucrose beverage, low-dairy calcium diet	19	3	0
Cancer	17	RCT=1 CC=5 CH=11	Yogurt, fermented milk	No yogurt	9	5	3
Diabetes	9	RCT=1 RCOT=2 CS=1 CH= 5	Yogurt, probiotic in fermented milk	Sweetened yogurt, skim milk, orange juice, no supplementation, nonfermented milk	7	1	0
Bone health	7	RCT=1 CS=3 CH=3	Yogurt, laban	No yogurt	5	2	0

Abbreviations: CC, case-control (study); CH, onal (study); NRCT, nonrandomized controlled trial; RCOT, randomized crossove trial; RCT, ran omized controlled trial.

CONCLUSIONS
Consistent associations exist between **fermented milk consumption** and **reduced risk of T2D, improved weight maintenance, and improved cardiovascular, health**.

Savaiano and Robert W. Hutkins (2020) Nutrition Reviews

Associations between yoghurt and reduced risk of:

- Type 2 diabetes
- Improved weight management
- Improved inflammatory markers, and cardiovascular health

Savaiano, 2020, *Nutrition Reviews*
SaeidiFard, 2019, *Clinical Nutrition ESPEN*
Baruah, 2022, *Journal of Applied Microbiology*

Plant-based fermented foods: intervention evidence

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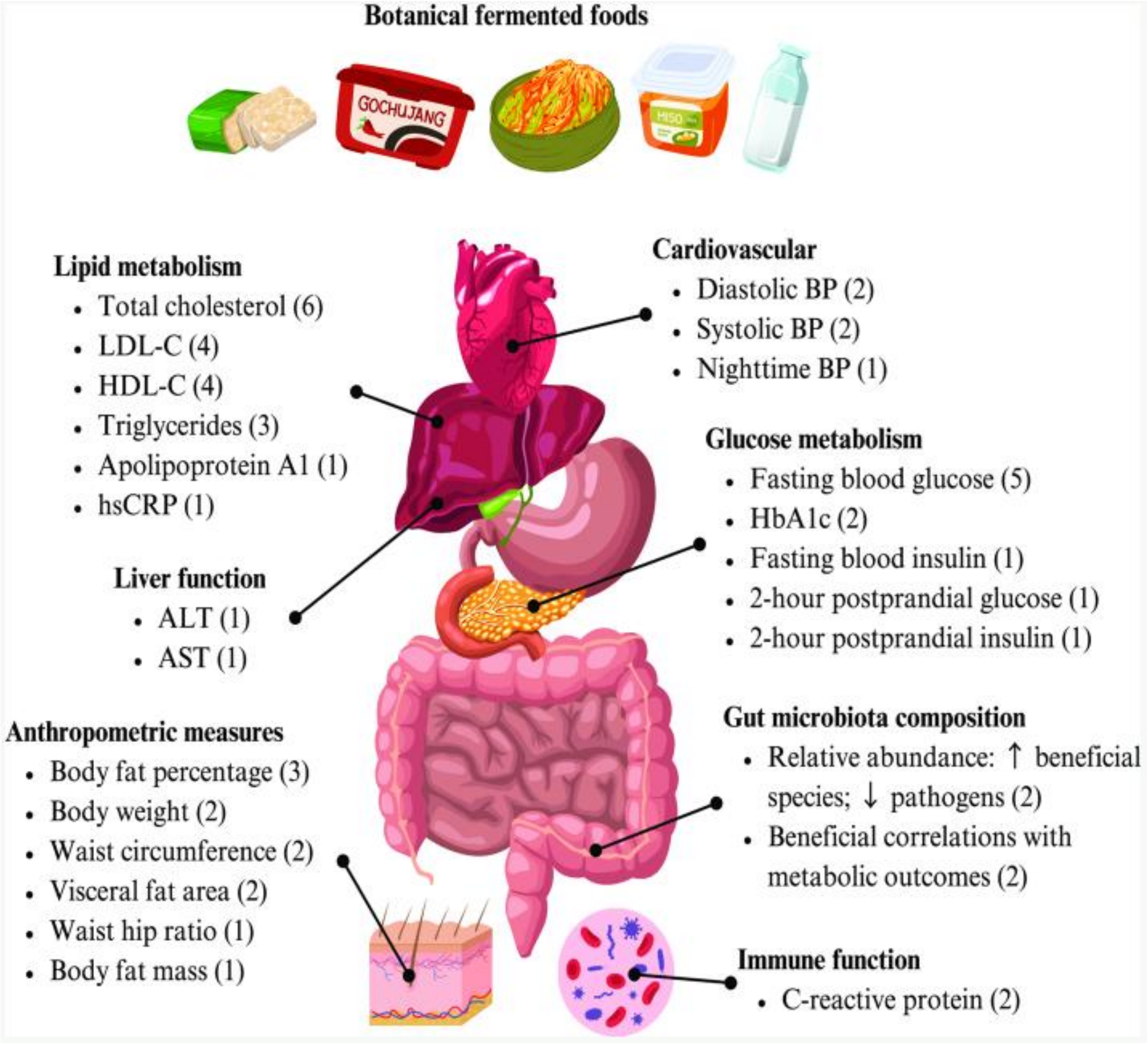


- **26 RCTs**

  31 reports; adults with metabolic syndrome components or T2D

- **73% reported ≥1 between-group improvement**

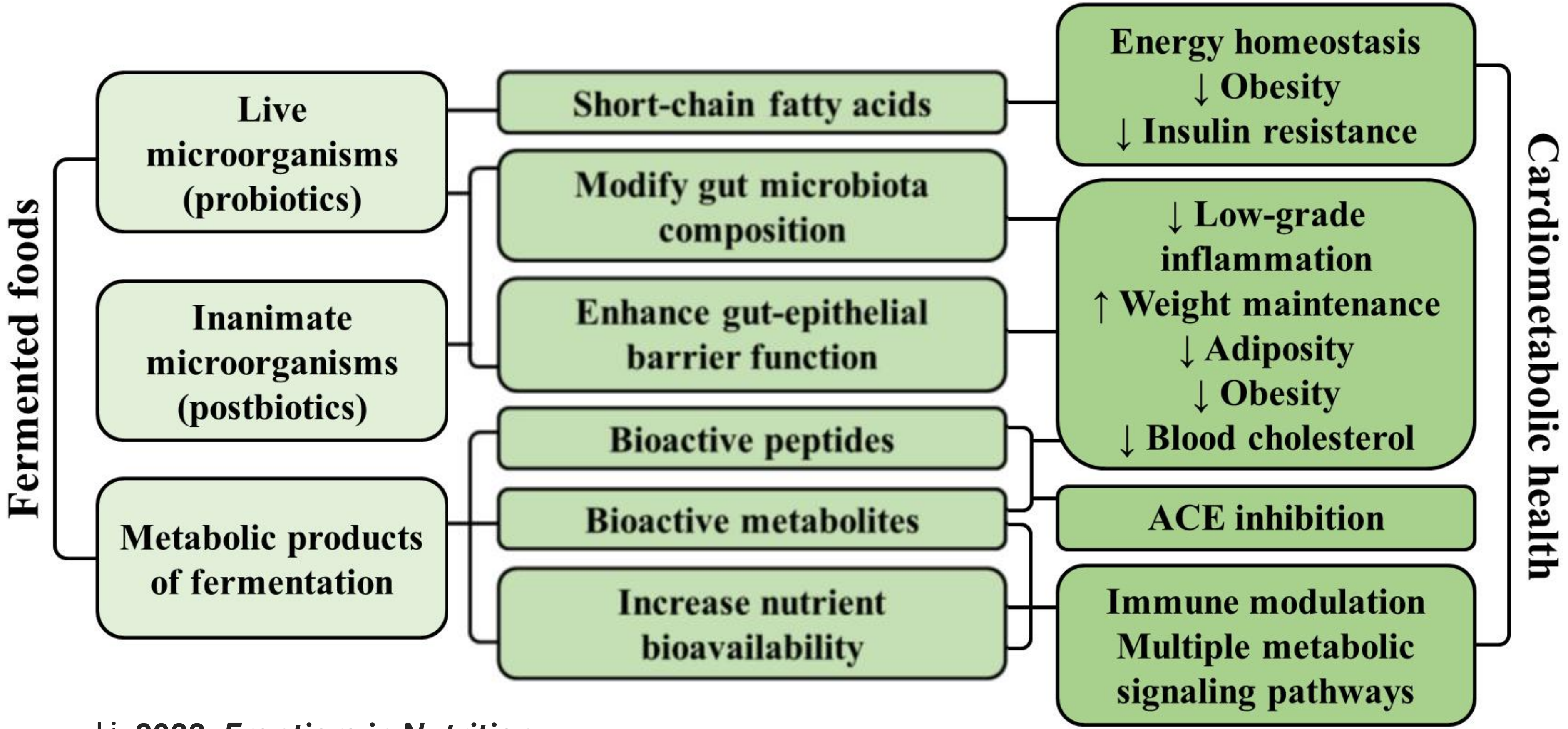
  Signals across glucose, lipids, blood pressure, adiposity and CRP

- **But evidence remains heterogeneous**

  Foods, populations and comparators differed; microbiota assessed in only 4 studies

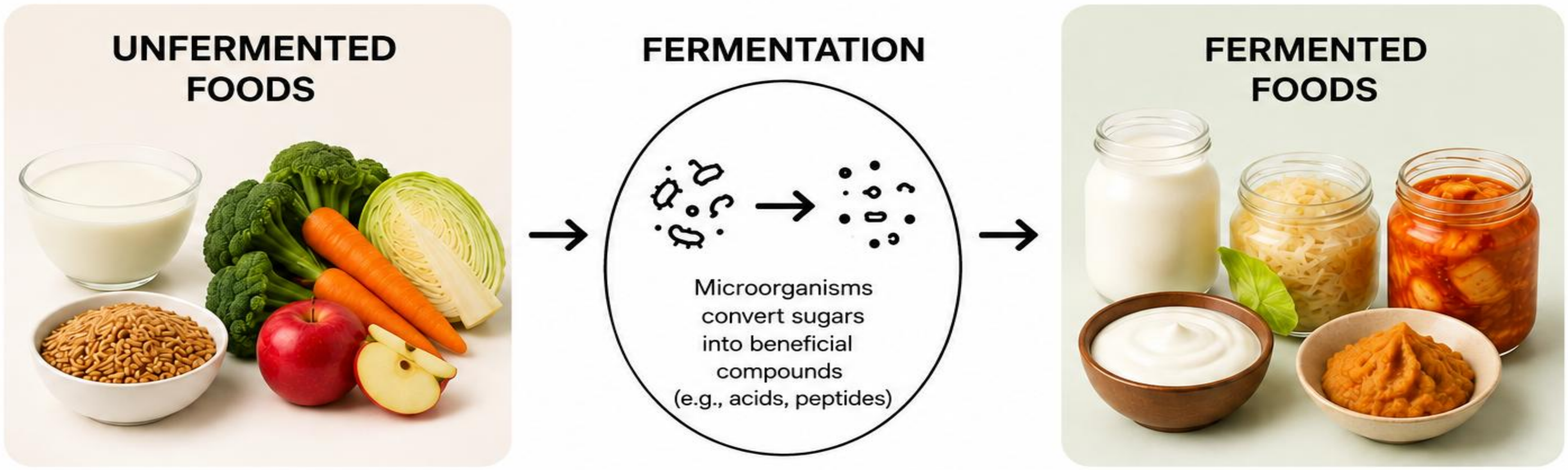
Chan et al. (2024), Nutr Res Rev
Ahn et al. (2025), *Nutr Rev*

Fermented foods and cardiometabolic health – proposed mechanisms



Li, **2022**, ***Frontiers in Nutrition***

Are fermented foods healthy — or healthier because they are fermented?



What is the role of **fermentation itself** in determining the health effects of fermented foods?

A landmark trial: high-fermented vs. high-fiber diets

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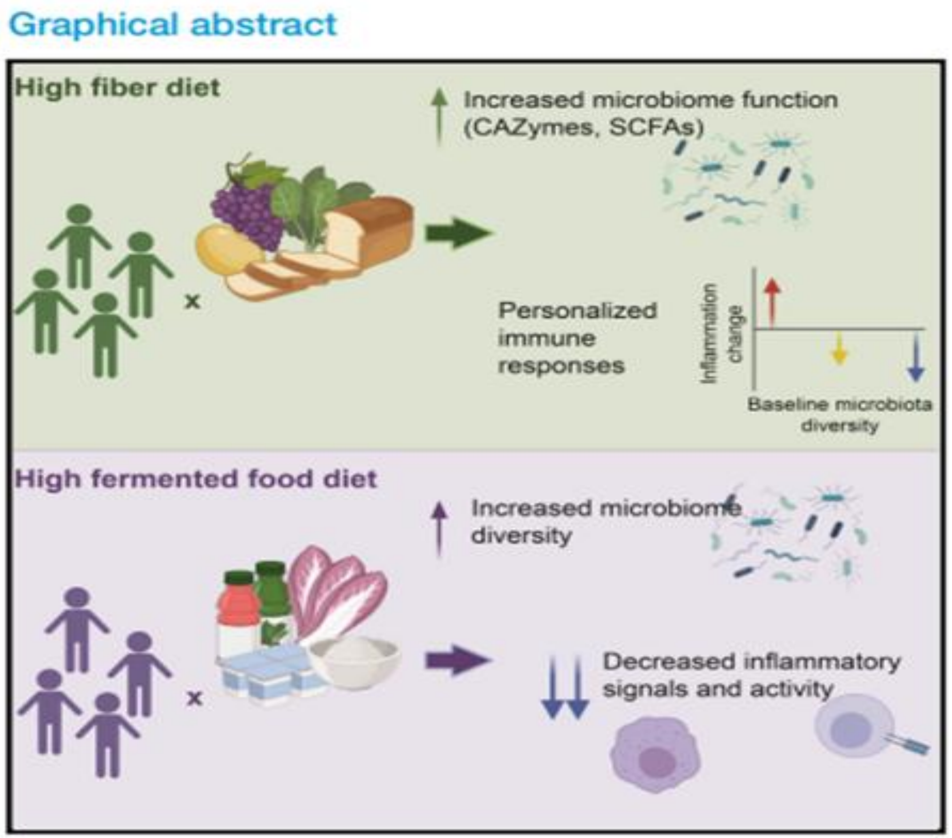

Cell
CellPress

Article

Gut-microbiota-targeted diets modulate human immune status

Hannah C. Wastyk,[2,7] Gabriela K. Fragiadakis,[1,7] Dalia Perelman,[3] Dylan Dahan,[1] Bryan D. Merrill,[1] Feiqiao B. Yu,[5] Madeline Topf,[1] Carlos G. Gonzalez,[4] William Van Treuren,[1] Shuo Han,[1] Jennifer L. Robinson,[3] Joshua E. Elias,[5] Erica D. Sonnenburg,[1,6,*] Christopher D. Gardner,[3,*] and Justin L. Sonnenburg[1,5,8,*]

Highlights

- Diet intervention with systems profiling reveals link: microbiome-immune axis
- High-fiber diet changes microbiome function and e personalized immune responses
- Fermented-food diet increases microbiome diversit decreases markers of inflammation

- Small exploratory trial: n = 18/arm
- ↑ Microbiome diversity and ↓ inflammatory markers with fermented foods
- No effects on glucose, insulin, lipids, BP or waist circumference

Wastyk et al. (2021), Cell

17-week randomized prospective study in generally healthy adults

High fermented-food intake: microbiome and immune effects

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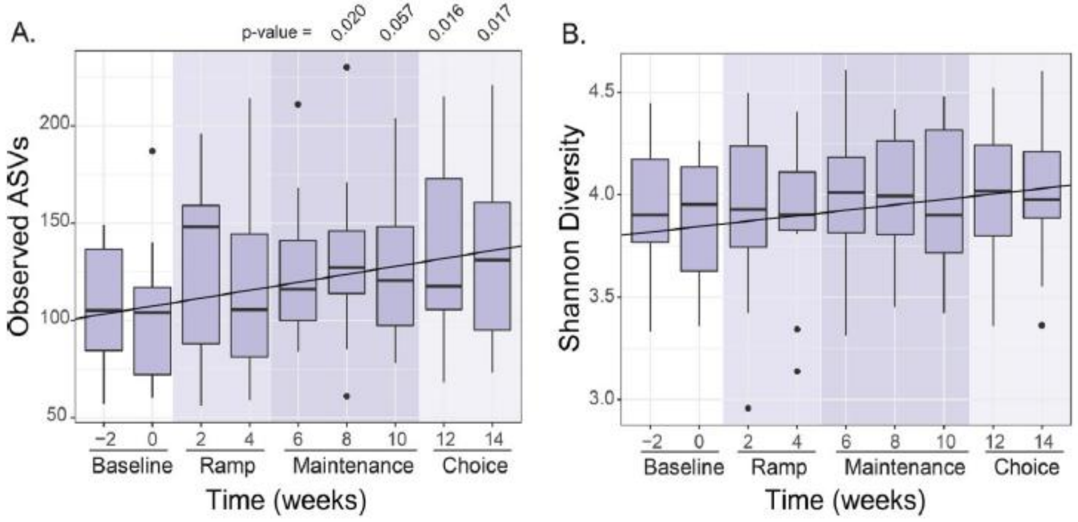
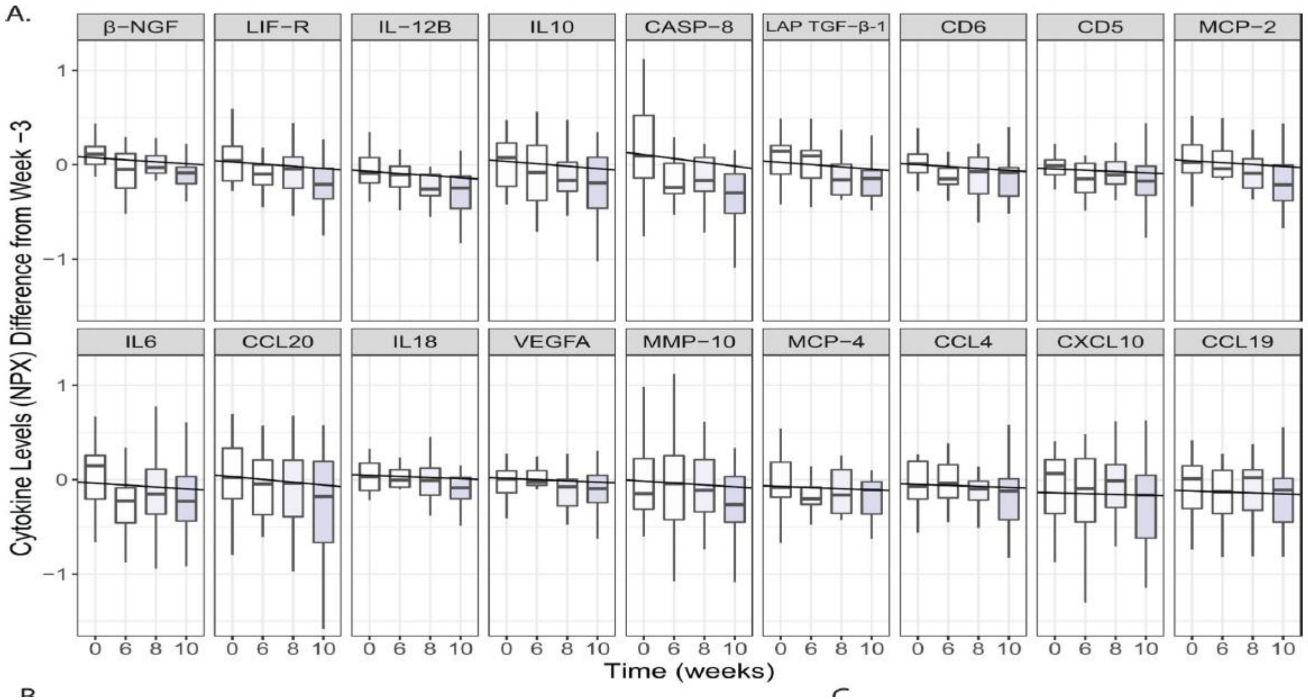
↑ Gut microbiota diversity



↓ Inflammatory markers



No detectable changes in glucose, insulin, lipids, blood pressure or waist circumference

Wastyk et al. (2021), Cell

Fermented Plant-based Portfolio Diet 4 Metabolic Health (FermDiHealth)

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Randomized controlled crossover study

Individuals aged 20-70 y with sign of metabolic syndrome/increased risk of CVD, n=100

Fermented plant-based foods

Non-fermented plant-based foods

Habitual diet

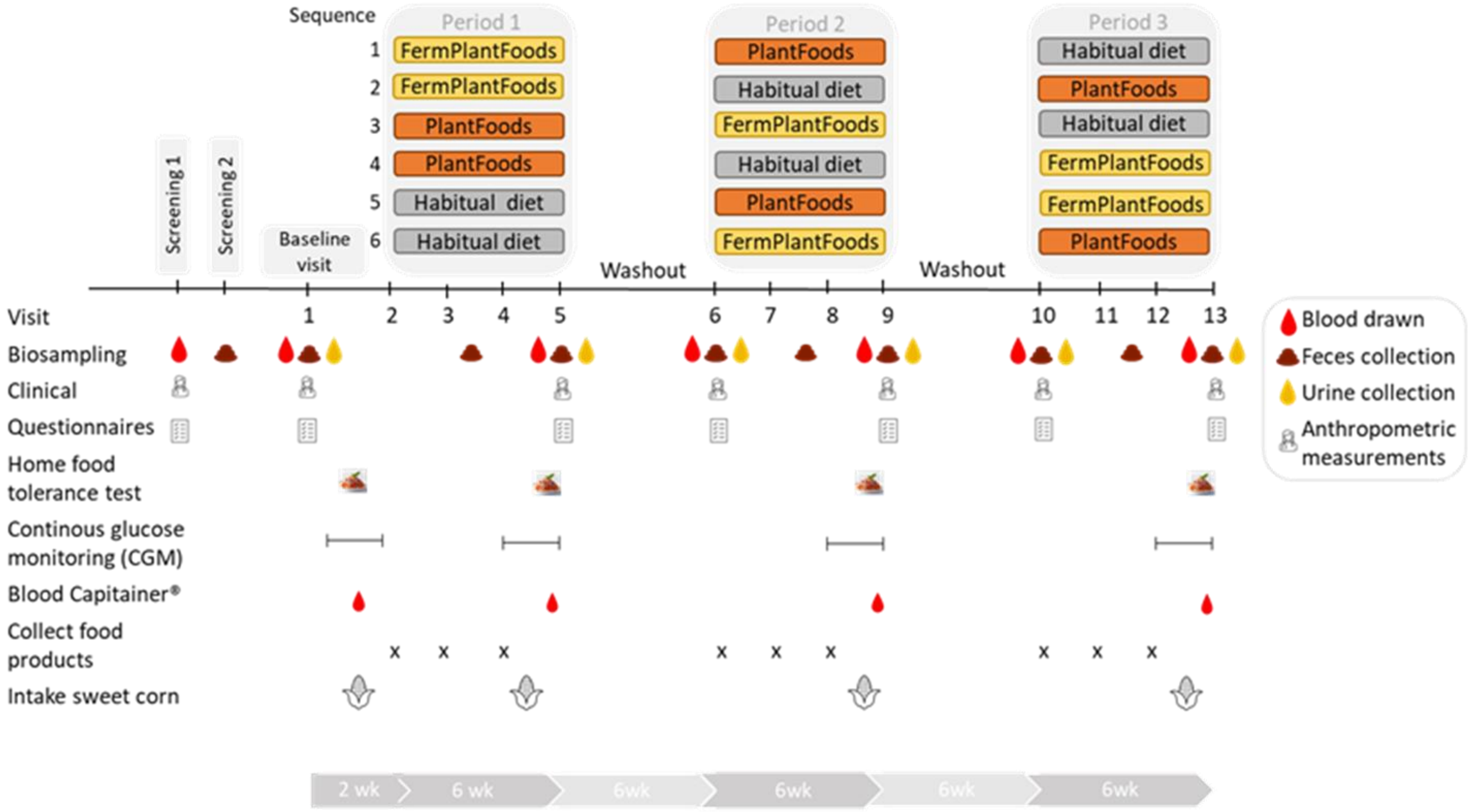
Inclusion criteria:

BMI between 25-35, and waist circumference

>102 cm (men)/88 cm (women) and at least **one of the following**:

- High density lipoprotein (HDL) ≤1.0 mmol/L (men) / HDL ≤1.3 mmol/L (women)
- Triglycerides ≥ 1,7 mmol/L
- Blood pressure ≥130/85 mmHg
- Fasting blood glucose ≥5.6 mmol/L
- Low density lipoproteins (LDL) ≥4.1 mmol/L

Fermented Plant-based Portfolio Diet 4 Metabolic Health (FermDiHealth)



Fermented Plant-based Portfolio Diet 4 Metabolic Health (FermDiHealth)

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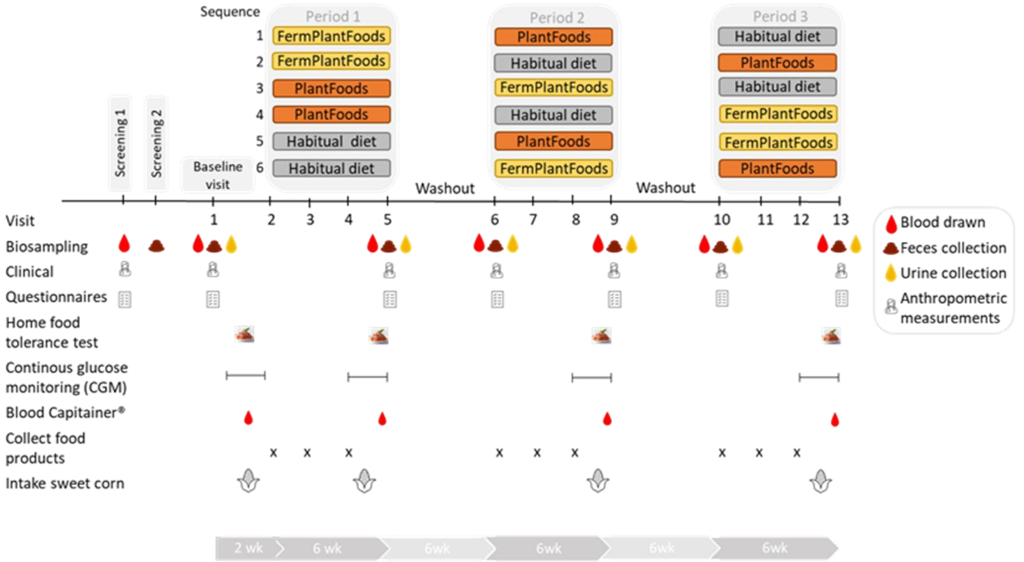
Primary aim: Difference in the inflammatory biomarker hsCRP

Secondary aims: Lipid profile, glucose and insulin levels, blood pressure, glycaemic variability, microbiota, metabolome, (stratification – low/high prevotella), saliva microbiome

Questionnaires: 24 h recall method ”Riksmaten Flex” (22 d in total), cognitive test ”Mindmore” – online
GI symptoms GSRS and Rome IV IBS and FD module, physical activity, stress (PPS), general wellbeing (PGWB), general health (SF36_v2), medical history + follow up

Qualitative assessment (N=15)



Preliminary results

Screened
N=199

Not meeting inclusion criteria N=80 (too healthy, recent intake of antibiotics, too unhealthy)
Declined to participate N=30

Randomized
N=89

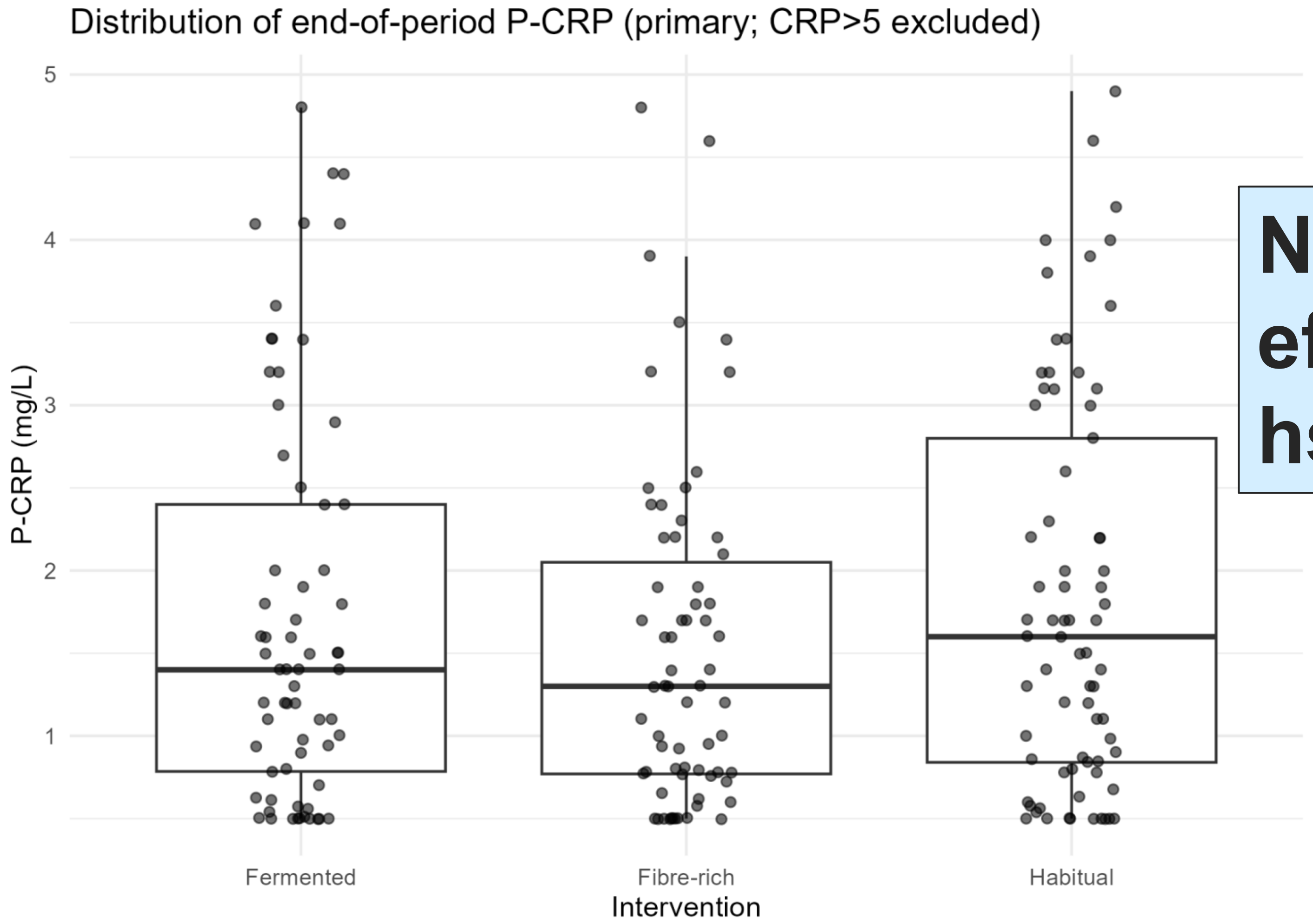
Drop-out N=16

Completed all three interventions N=73

- Fermented diet (A) N=75
- Non-fermented diet (B) N=74
- Habitual diet (C) N=76

Nybacka, Nordin et al. (2026) In preparation

No effects on hs-CRP



No significant treatment effects were observed on hs-CRP.

Nybacka, Nordin et al. (2026) In preparation

Effects on other CMD-factors

Treatment effects after fermented (A), non-fermented (B) and habitual (C) diet period.

Variable	Fermented adj mean (95% CI)	Non-fermented adj mean (95% CI)	Habitual adj mean (95% CI)	Intervention p	p (A vs. B)	p (A vs. C)	p (B vs. C)
Body weight (kg)	87.4 (86.8 to 87.9)	87.4 (86.8 to 88.0)	87.7 (87.1 to 88.3)	0.510	0.994	0.625	0.780
Systolic BP (mmHg)	129.4 (127.1 to 131.6)	130.0 (127.8 to 132.3)	127.3 (125.1 to 129.6)	0.158	0.957	0.424	0.182
Diastolic BP (mmHg)	81.7 (80.6 to 82.9)	82.2 (81.1 to 83.4)	81.4 (80.2 to 82.5)	0.585	0.904	0.964	0.654
Waist circumference (cm)	102.5 (101.7 to 103.4)	103.0 (102.1 to 103.8)	103.0 (102.2 to 103.8)	0.755	0.833	0.828	1.000
P-Cholesterol	5.13 (4.91 to 5.36)	5.26 (5.04 to 5.49)	5.45 (5.23 to 5.68)	**<0.001**	0.114	**<0.001**	**0.007**
P-HDL-Chol	1.38 (1.30 to 1.47)	1.46 (1.38 to 1.54)	1.48 (1.40 to 1.57)	**<0.001**	**<0.001**	**<0.001**	0.364
P-non-HDL-Chol	3.75 (3.55 to 3.95)	3.80 (3.60 to 4.00)	3.99 (3.79 to 4.19)	**<0.001**	0.720	**<0.001**	**0.004**
P-Triglycerides	1.14 (1.02 to 1.26)	1.12 (1.00 to 1.24)	1.15 (1.03 to 1.27)	0.822	0.915	0.978	0.816
B-Hemoglobin	134 (131.9 to 136.5)	135 (132.4 to 137.0)	135 (132.5 to 137.1)	0.735	0.833	0.741	0.985
P-Ferritin	101.9 (78.0 to 125.9)	91.5 (67.5 to 115.4)	99.4 (75.5 to 123.3)	**0.037**	**0.041**	0.829	0.150
B-Eosinophils	0.54 (0.45 to 0.62)	0.26 (0.18 to 0.35)	0.16 (0.08 to 0.25)	**<0.001**	**<0.001**	**<0.001**	0.111

- **No clear effect on hs-CRP, our primary outcome**
- **Cardiometabolic effects were more closely related to fibre intake than to fermentation per se**
- **Potential effects on iron status to be further explored**
- **Multi-omics analyses may reveal mechanisms and individual response patterns**

Nybacka, Nordin et al. (2026) In preparation

Conclusions

1. **Fermented foods are promising — but evidence remains limited**
   Findings vary substantially between foods and studies.

2. **Fermentation changes the food — but added cardiometabolic benefit is uncertain**
   Biologically plausible effects through microbes, metabolites and the gut microbiome.

3. **FermDiHealth: no clear additional cardiometabolic benefit of fermentation**
   No clear effect on hs-CRP; responses appeared more closely related to dietary fibre.

4. **The most interesting biology may lie beyond conventional risk markers**
   Multi-omics may reveal what fermentation adds — and who responds.

Does fermentation matter for cardiometabolic health?

- Based on current evidence- Probably less than the underlying food matrix and fibre

Acknowledgements

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