Emergent Science on Fiber-Bound Polyphenols and the Gut Microbiome

Presenter: Brendan J. Kesler

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Agenda:

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1. Background and Definitions
2. Dietary Consumption
3. Metabolism
4. Health Benefits
5. Research Examples

Background on Fiber-Bound Polyphenols

1. Historic polyphenol research focused exclusively on polyphenols able to be extracted from plants using organic solvents.[5] I.e., "extractable polyphenols (EPP)".
2. However, new research has revealed a significant % of polyphenols are not extractable via organic solvents and, thus, remain associated with dietary fiber.[5] I.e., "non-extractable polyphenols (NEPP)".

❖ The discovery of NEPP within dietary fiber leads to the question of what role NEPP has in the health benefits historically ascribed to fiber alone?

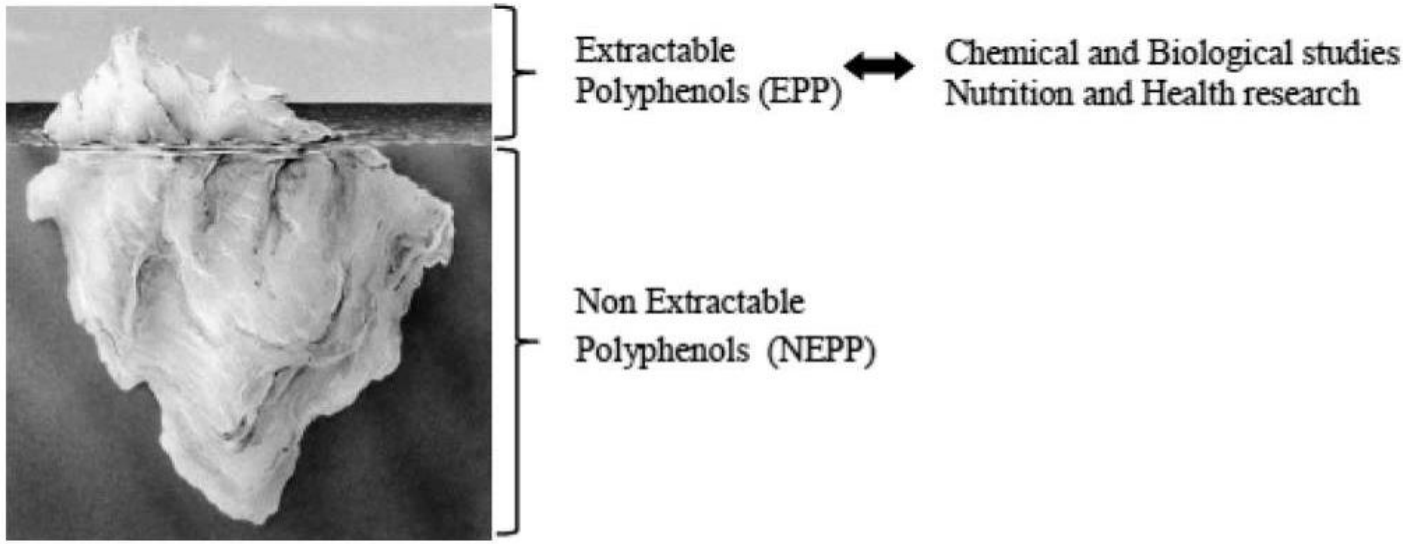


Figure 1. Known and missing dietary polyphenols.

Origin of the NEPP Concept. The concept of NEPP emerged to elucidate a paradoxical result of the analysis of dietary fiber (DF) performed in carob pods.[11] The content of DF in this leguminous plant, determined by using the official AOAC method, was 40.4% (dw), and according to the traditional definition of DF, this amount must correspond to nonstarch polysaccharides and lignin. However, specific analysis of polysaccharides and lignin showed that the actual amount of these compounds accounted for only 18.9% (dw). That is to say, there was a gap of 21.5% that was identified as polymeric proanthocyanidins, a major type of NEPP. Similar paradoxical results were later observed in other plant foods.[4,12–14]

Image and Quote from: (Sauro-Calixto, 2012)[5]

Definition: What are fiber-bound polyphenols?

1. Key components of definitions from peer-reviewed literature:
   - **Part I** - Dietary fiber that is associated (or formed into a complex) with polyphenols.[1, 2]
   - **Part II** – Polyphenols that are not significantly released from food in the stomach or small intestine but exert their main biological action in the colon where they are acted upon by the gut microbiome.[4, 5]
2. Examples of bound, non-extractable polyphenols include high-molecular weight proanthocyanins, hydrolysable tannins, and flavonoids and can be found widely in fruits, vegetables, legumes, grains, and seeds.[1]

❖ A key reason why bound polyphenols are so intriguing is related to the global fiber gap: if we are under-consuming dietary fiber, we are likely also missing the benefits of fiber-bound polyphenols!

❖ The complexes formed between fiber and bound polyphenols makes research into their unique MOAs difficult.

Illustration of How Polyphenols are Bonded to Fiber

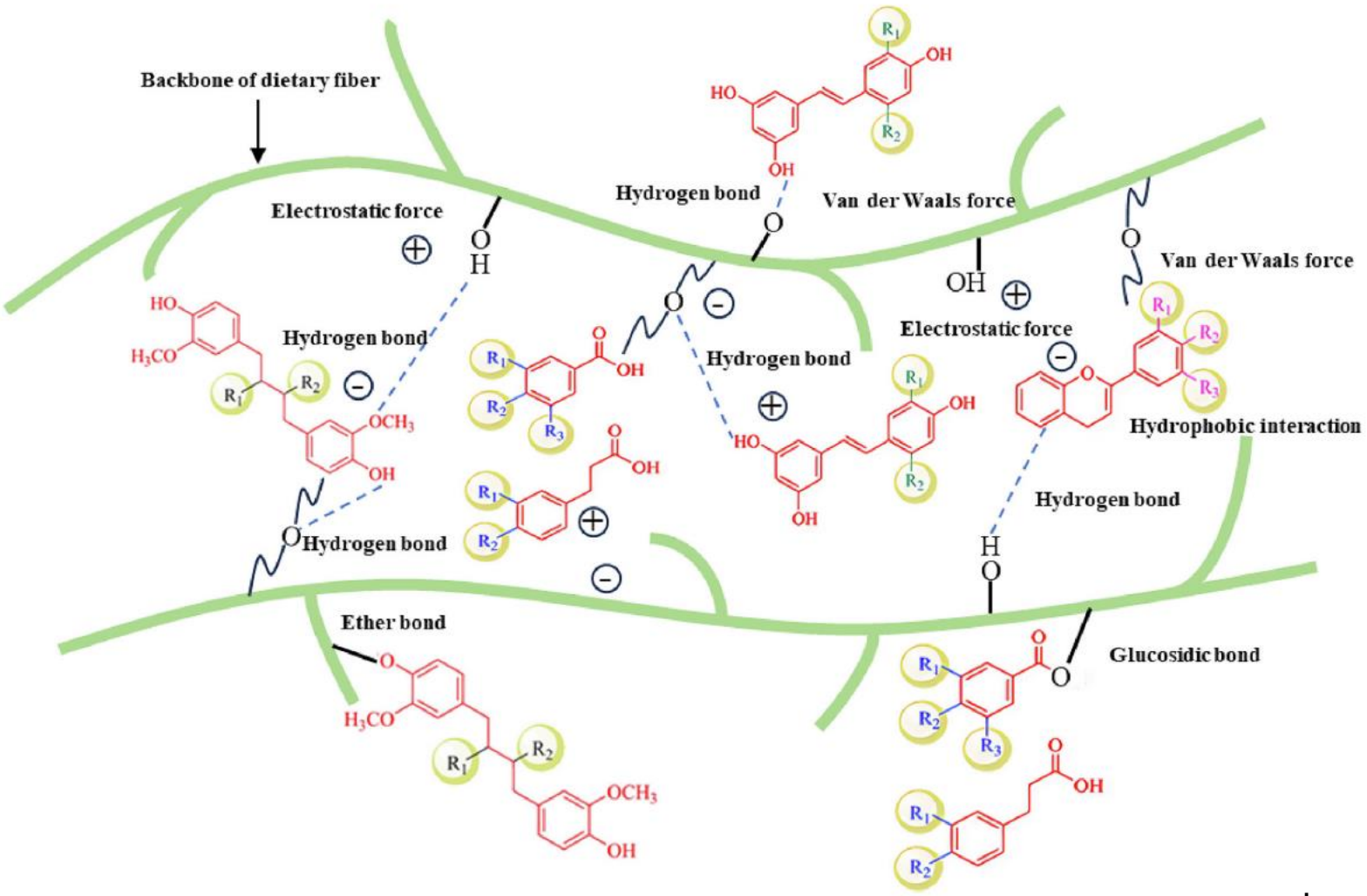


Fig. 1. Schematic illustration of the interactions between phenolic compounds and dietary fiber.

Image from: (Hou et al., 2025)[2]

Consumption of Fiber-Bound Polyphenols

1. Foods contain significant amounts of NEPP and, in many cases, more NEPP than EPP. [4,6]
2. As an example, in some fruit products NEPP content is more than 60% of the total, while in whole grains such value could be as high as 60–85%, with a maximum percentage of 96%.[2]

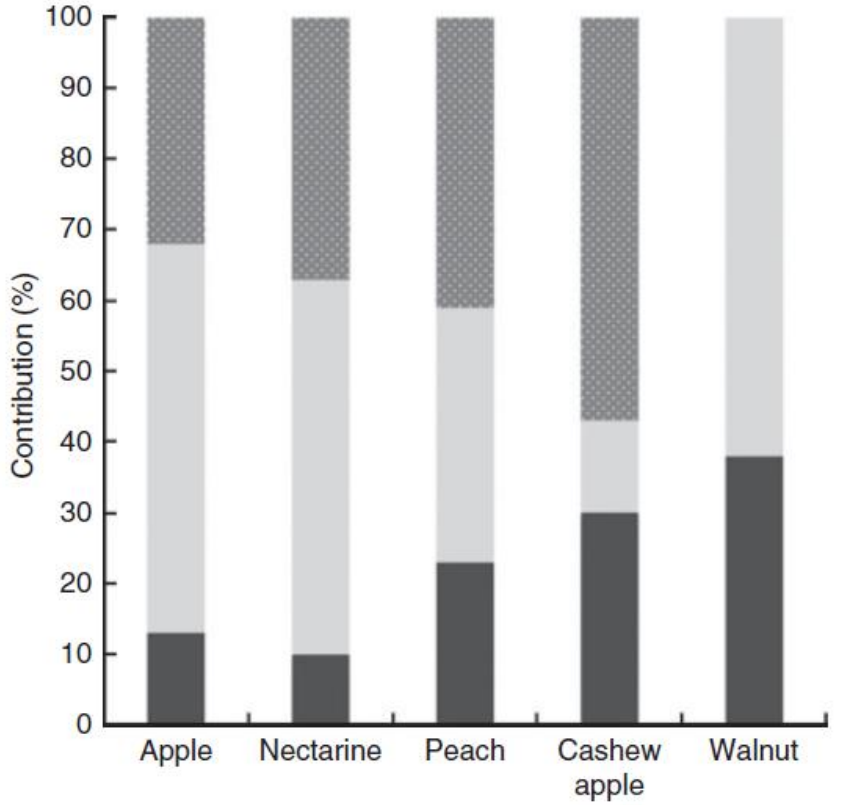


Fig. 2. Contribution of the different classes of non-extractable polyphenols to total polyphenol content in different foods[29,41,57]. ■, Non-extractable proanthocyanidins; ■, hydrolysable phenolics; ■, extractable polyphenols.

Image from: (Perez-Jimenez et al., 2013)[4]

Consumption of Fiber-Bound Polyphenols

1. Study on the Mediterranean Diet in Spain estimated:

    - NEPP intake (day/person) of 942 mg.
    - EPP intake (day/person) of 258 mg.
    - Fruits and vegetables (746 mg) are the major contributors to the total PP intake (1201 mg).[6]

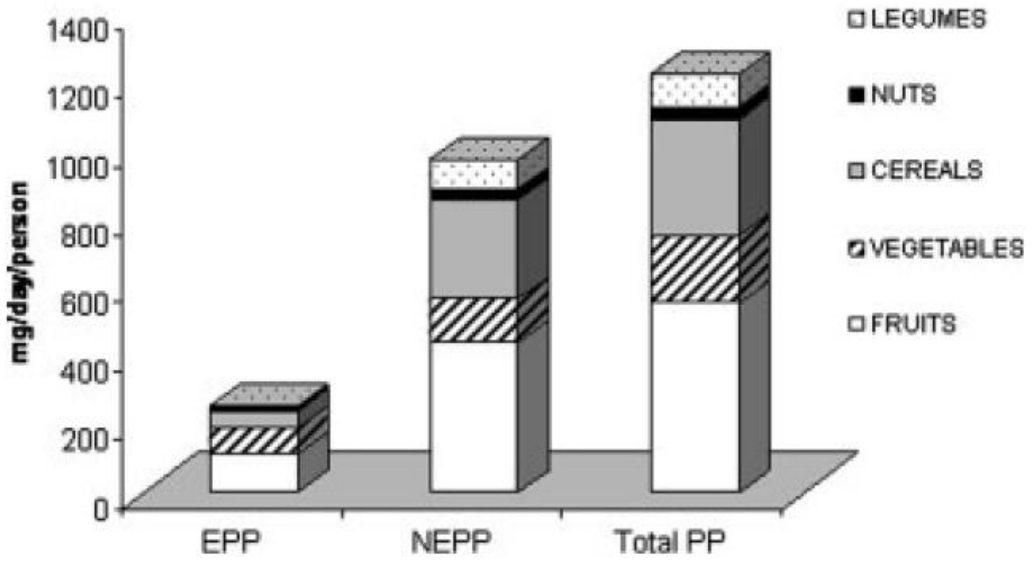


Figure 3. Intake of PP from plant-derived foods in the Spanish diet (EPP; NEPP including hydrolyzable PP and nonextractable PA and total PP).

Image from: (Arranz et al., 2010)[6]

Metabolism of Fiber-Bound Polyphenols

1. NEPP are not significantly released from food either by mastication, acid pH in the stomach or action of digestive enzymes, reaching the colon primarily intact.[1, 4]
    - Research estimates only 5-10% of NEPP can be partially released prior to reaching the colon.[1, 4]
2. Within the colon, fiber-bound polyphenols are released by the action of gut microbes and some intestinal enzymes (e.g., esterases).[1, 4]
3. Polyphenols may be released by microbes in-tact or microbes can transform polyphenols into absorbable metabolites.[1, 4]
4. Once freed in the gut, polyphenols and their metabolites can act within the gut or pass through the colon mucosa and be absorbed into the bloodstream.[1]

❖ Additionally, many researchers propose a synergistic effect of dietary fiber and bound-polyphenols most likely stemming from sustained and increased overall bacterial fermentation.[3, 5]

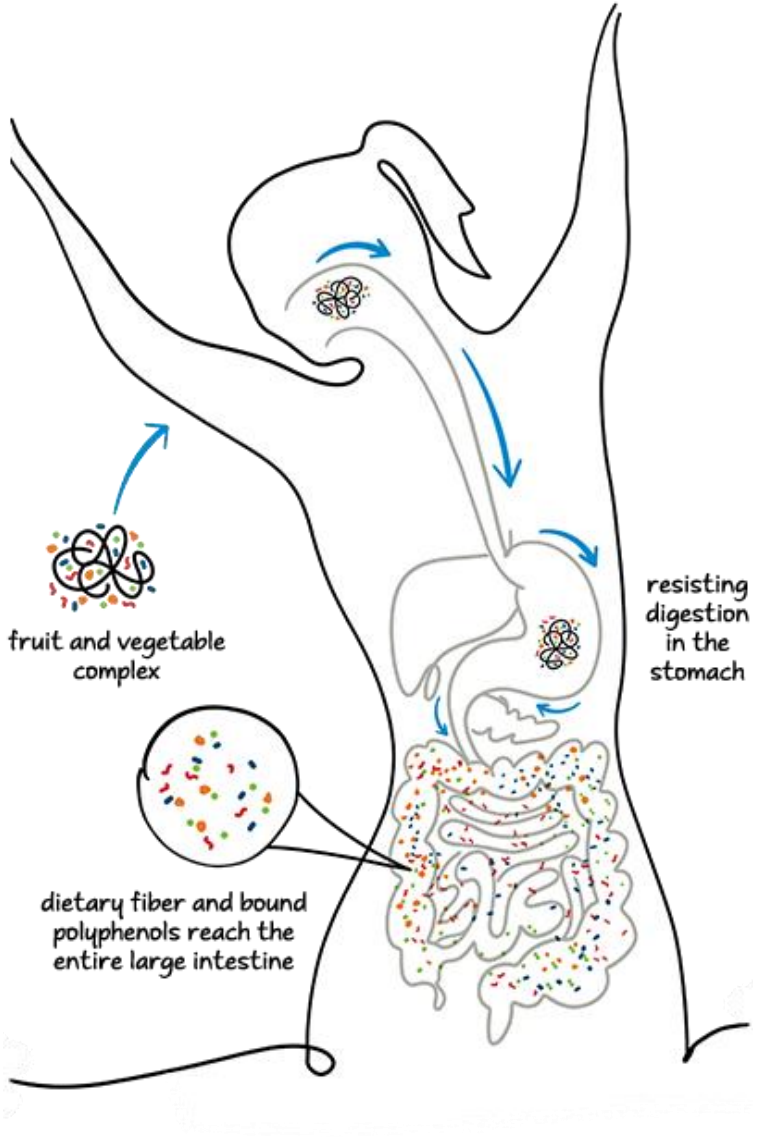


Illustration of Fiber-Bound Polyphenol Digestion from Nemzer et al. (2025)[3]

Known Health Benefits of Fiber-Bound Polyphenols

1. Providing a slow and continuous release of polyphenols and their metabolites (improving bioacessibility and bioactivity).[1]
2. Reducing local oxidative stress and boosting anti-inflammatory mechanisms and immunity in the gut.[1]
3. Modifying microbiota composition.[1, 3] I.e., a "prebiotic" effect.
4. Suppressing pathogenic bacteria.[1, 3] I.e., a "duplibiotic" effect.
5. Being transformed into bioactive metabolites.[1, 3]
6. Enhancing production of short-chain fatty acids (SCFA).[1] Enhancing lipid excretion.[5]
7. Modulating gene expression.[5]

❖ Many of the health benefits of fiber-bound polyphenols may reach beyond the gut and influence overall health.

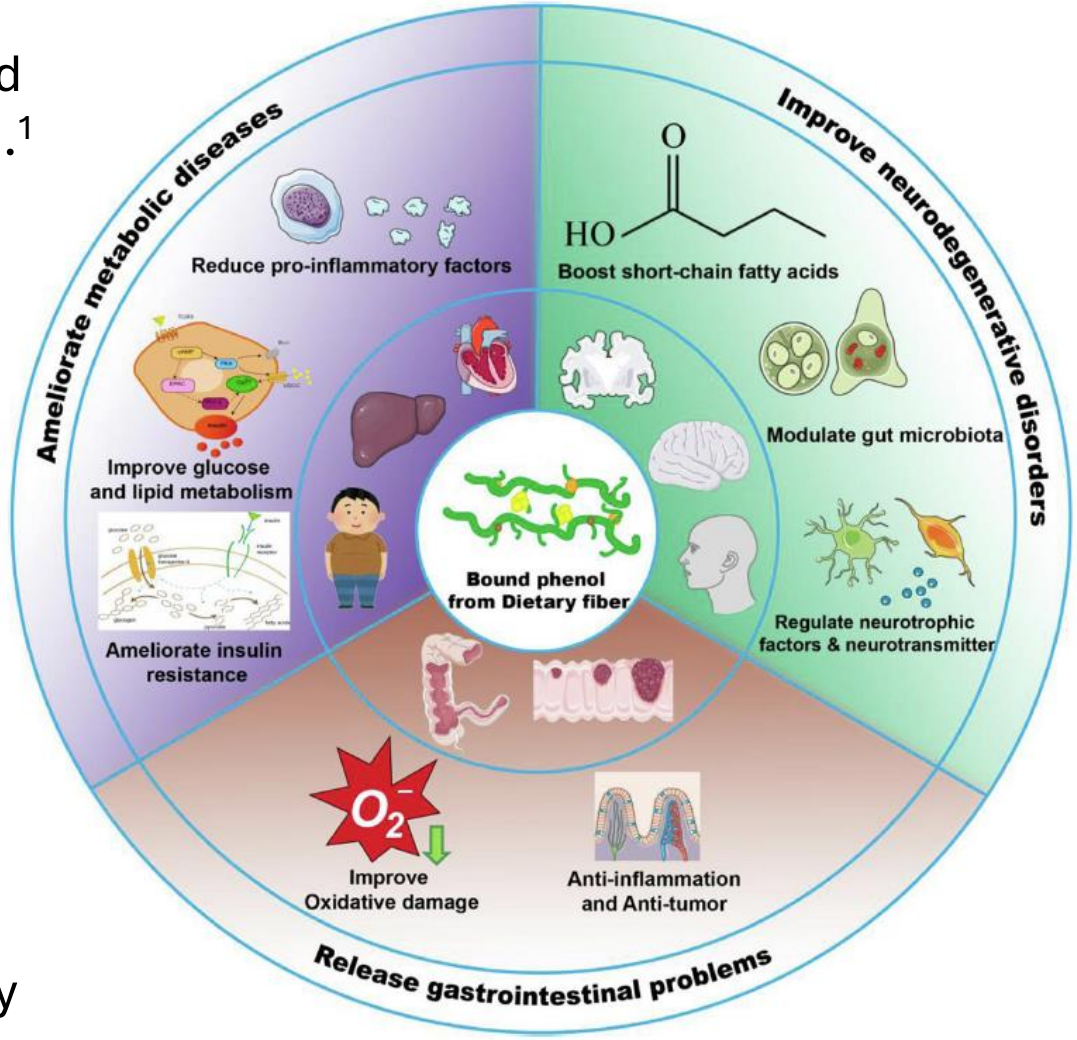


Fig. 2. The synergistic activities of BPs in dietary fiber.

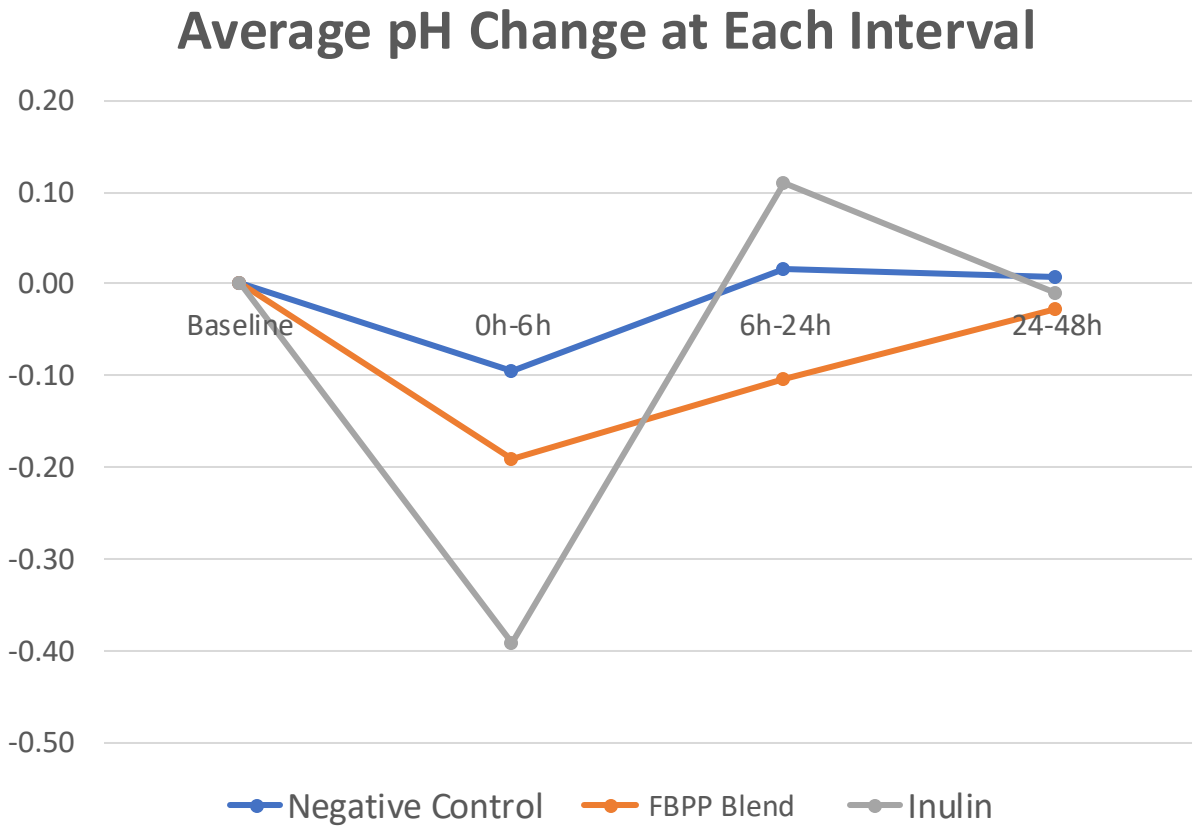
Image from: (Hou et al., 2025)[2]

New Research on Fiber-Bound Polyphenols

1. Researched compared effect of 1 gram of fiber from a purified source (Inulin) compared with a mix of natural fruit and vegetable fibers rich in bound-polyphenols (FBPP Blend).

2. Fiber and polyphenol blend demonstrated a slow, sustained fermentation profile that aligns with previously cited literature.

All data is from Govaert et al. (2025)[7]



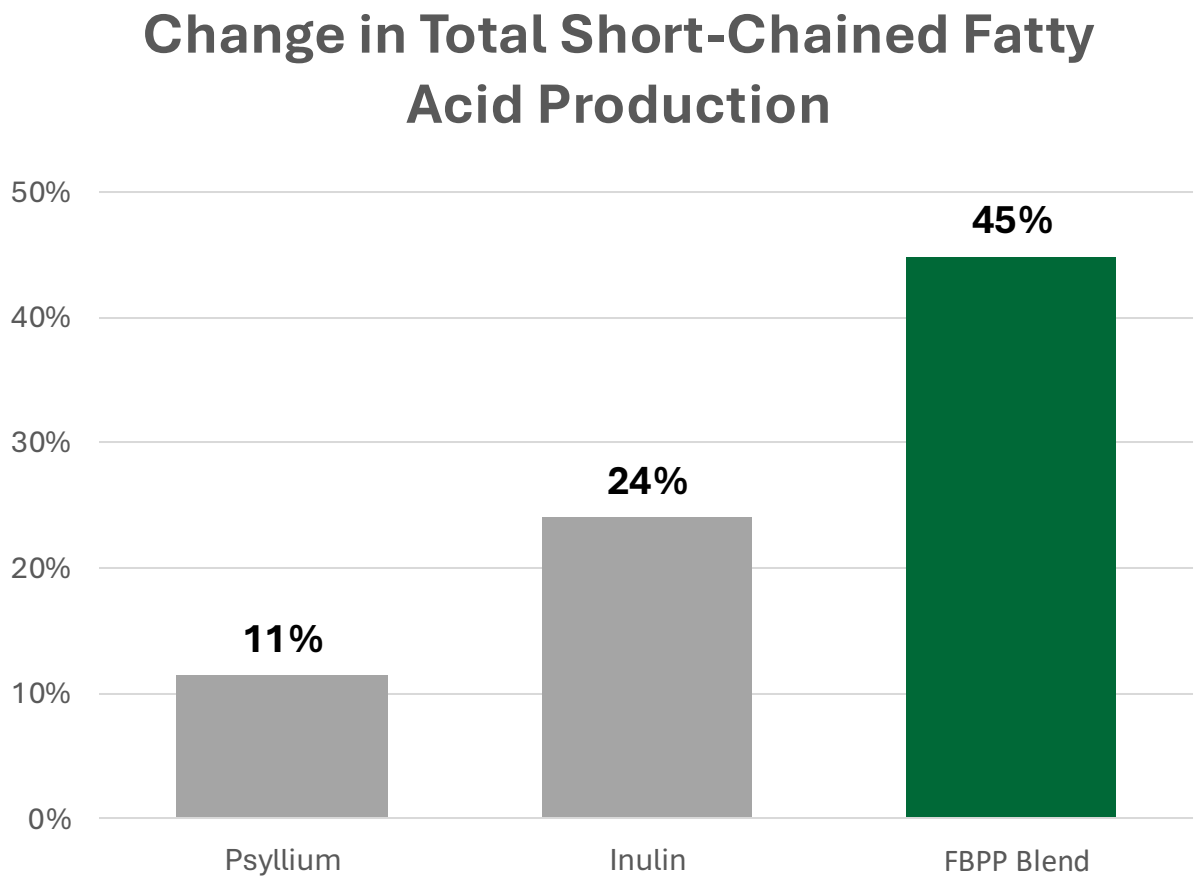
"FBPP" = Fiber-Bound Polyphenol Blend

New Research on Fiber-Bound Polyphenols

1. Researched compared effect of 1 gram of fiber from a purified source (Inulin) compared with a mix of natural fruit and vegetable fibers rich in bound-polyphenols (FBPP Blend).

2. Produced significantly more total SCFA compared to control, Psyllium, and Inulin ($p=<0.05$) and led in all SCFA sub-categories.

All data is from Govaert et al. (2025)[7]



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New Research on Fiber-Bound Polyphenols

1. Researched compared effect of 1 gram of fiber from a purified source (Inulin) compared with a mix of natural fruit and vegetable fibers rich in bound-polyphenols (FBPP Blend).

2. Modulated gut bacteria across all (4) dominant human bacterial phylum.

All data is from Govaert et al. (2025)[7]

% Change in Major Bacterial Phylum

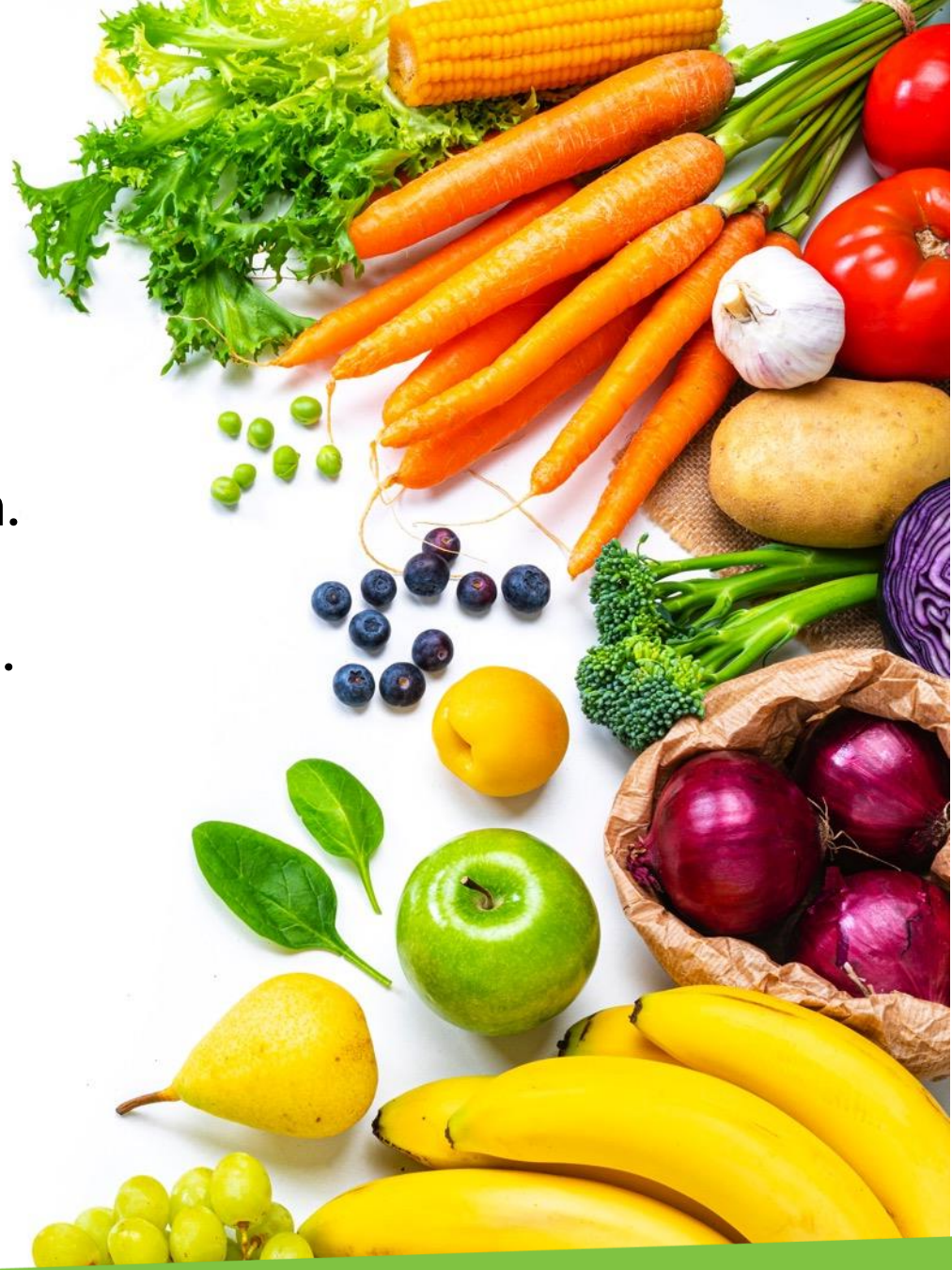
	FBPP Blend	Inulin	Psyllium
Bacteroidetes	112.70%	-0.30%	125.60%
Firmicutes	37.93%	-23.90%	-16.85%
Proteobacteria	54.03%	52.94%	15.95%
Actinobacteriota	91.41%	251.29%	-40.23%
Total Bacteria	**8,707,717,674**	**6,192,348,519**	**7,260,045,747**

"FBPP" = Fiber-Bound Polyphenol Blend

Future Research Directions:

1. Epidemiology of bound polyphenol consumption.
2. Bound polyphenol “duplibiotic effect”.
3. Impact of bound polyphenols on the distal colon.
4. Mapping of polyphenol metabolites.
5. Human RCTs for targeted health effects.

❖ There is MUCH more to learn about the unique behavior of fiber-bound polyphenols!



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Thank You!

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