Detailed Study Notes: Episode 450

Megan Rossi, PhD, RD – Diet For a Healthy Gut: Diversity, Fiber Types & Gut Health Pseudoscience

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Introduction to this Episode

With the advances in understanding the importance of the gut (including its bacterial contents) for human health, much interest and attention has been placed on how to eat to promote positive 'gut health'. This has led to many exciting research questions and labs doing fascinating work.

However, on the opposite side, it has led to a spike in opportunistic quacks to jump on the wave of enthusiasm and promote diets, supplements, testing kits and products that don't reflect the current evidence base.

It has been long recognised that high-fiber diets are, in general, positive for gut health and reduce risk of several chronic diseases, for example colon cancer. But when it comes to getting enough fiber, we should perhaps think beyond just total intake, and instead what fiber subtypes we are consuming, as each can have differential effects in the body.

Similarly, consumption of vegetables, whole grains, legumes, and other plant foods have been at the center of recommendations for a healthy dietary pattern. But how much does the diversity of different plants we are consuming matter?

Connection to Previous Episodes

Previous podcast episodes that connect to the topics discussed in the present episode include:

- #351: Prof. Glenn Gibson – Human Gut Bacteriology, Prebiotics & Probiotics
- #105: Prof. John Cryan – How Gut Bacteria Affect the Brain & Behaviour
- #422: Psychobiotics – Can Probiotics Improve Mood-related Disorders?
- #412: Eirini Dimidi, PhD – Diet, Chronic Constipation and the Gut
- #383: Irritable Bowel Syndrome (IBS) & Diet
- #442: Are Vegetables Detrimental to Health?
- #439: Prof. David Jenkins – Lipid-Lowering Diets
- #291: Gab Fundaro, PhD – Gut Microbiome, Bacterial Diversity & the Impact of Diet & Probiotics

Diversity of Plants in the Diet

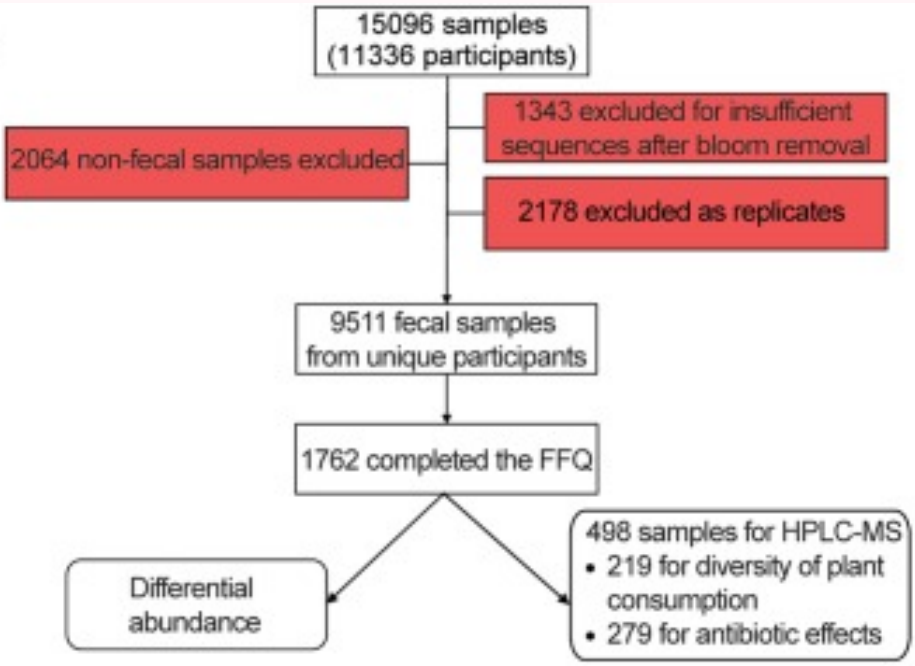
The number of **"30 plant different plants per week"** is based on the American Gut Project. This was a cohort of more than 10,000 "citizen scientists", who shipped in their samples.

This study looked at data from participants primarily in the United States (n = 7,860), but also the United Kingdom (n = 2,518) and Australia (n = 321), plus 42 other countries or territories making up the rest.

The researchers focused their primary investigative efforts on a "healthy adult" subset (n = 3,942) of:

- individuals aged 20 to 69 years
- body mass indexes (BMIs) ranging between 18.5 and 30 kg/m2
- no self-reported history of inflammatory bowel disease (IBD), diabetes, or antibiotic use in the past year

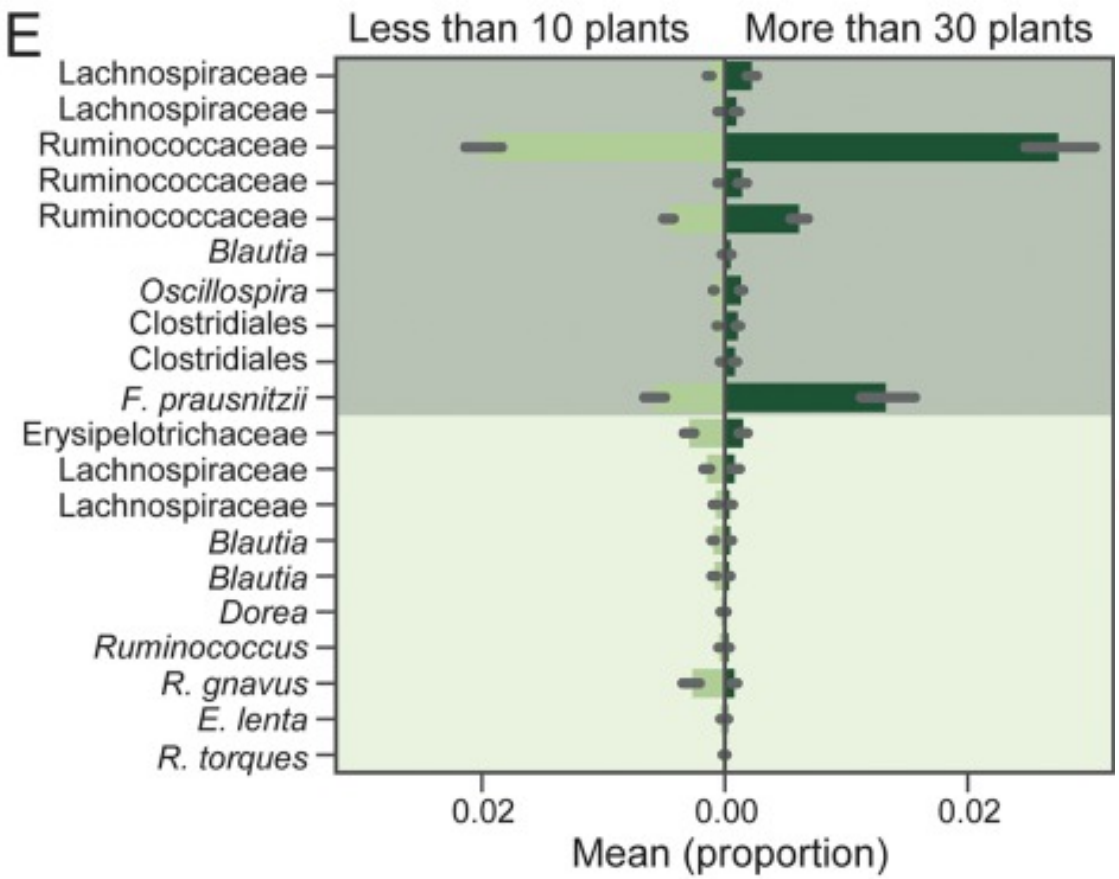
14.8% of participants completed a validated picture-based food frequency questionnaire (FFQ)



From: McDonald et al., mSystems. 2018 May 15;3(3):e00031-18

The self-reported dietary data suggested that the number of unique plant species that a subject consumes is associated with microbial diversity, rather than self-reported categories such as “vegan” or “omnivore”.

Differential abundances of bacterial species between those who eat fewer than 10 plants per week and those who eat over 30 per week:



From: McDonald et al., mSystems. 2018 May 15;3(3):e00031-18

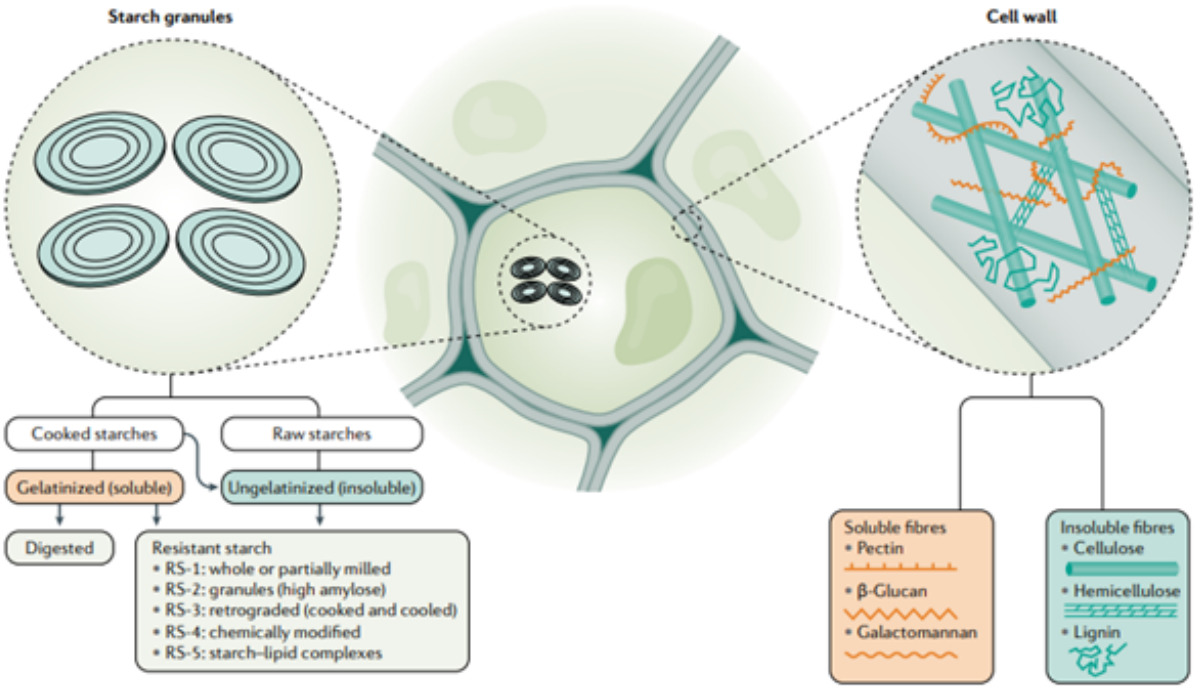
It’s important to note that this cohort is crowdsourced and self-selected (and paying for the cost of processing a sample), and therefore are not representative of the general population (i.e. this cohort has lower rates of smoking and obesity, and higher income and education).

Dietary Fiber & Sub-types

Benefits of high-fiber diets:

- High-fiber diets lead to lower risk of heart disease, diabetes and colorectal cancer
- High-fiber intakes can treat or prevent constipation
- Certain fiber types (beta-glucans) can lower LDL-C
- Prebiotic fibers can benefit intestinal health and the gut microbiome

Typically, when referring to carbohydrates that cannot be digested, we can categorize them as indigestible starches (e.g. raw or resistant starch) or fiber (with one sub-categorisation being soluble and insoluble).



From: Gill, S.K., Rossi, M., Bajka, B. et al., Nat Rev Gastroenterol Hepatol 18, 101–116 (2021)
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However, fiber is a much more multifaceted class of substances than suggested if only classified as either 'soluble' or 'insoluble'.

Fiber has a number of important physicochemical characteristics that need to be considered.

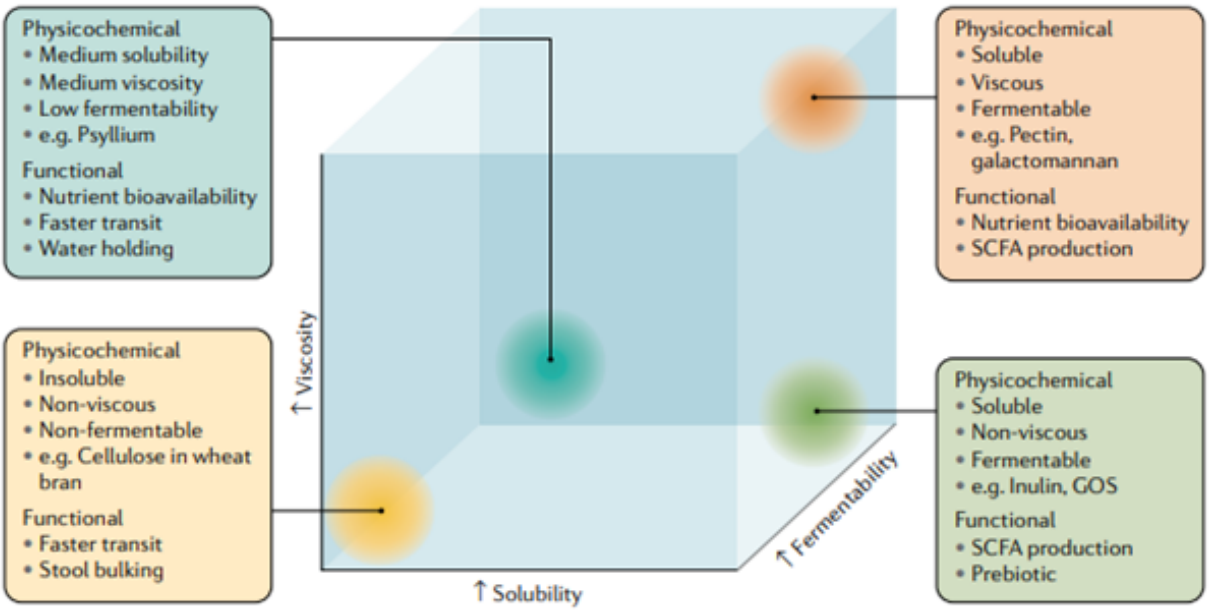
Dietary fiber has physicochemical characteristics that determine its functionality in the gastrointestinal tract, including its effects on, for example, micronutrient availability, gut transit time, stool formation and microbial specificity.

Such physicochemical characteristics include:

1. Solubility
2. Viscosity
3. Fermentability

Rather than think of fiber as either 'soluble' or 'insoluble', we need to instead recognise that there are several physicochemical characteristics by which fibers differ, and for each of these they exist along a spectrum.

This is illustrated well by Gill *et al.* (2021), showing how fibers can be placed at different points on a 3-dimensional plot of solubility, viscosity and fermentability:



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Based on this, we can therefore have a whole range of different types of fiber that will vary in their characteristics and, therefore, their effects in the body:

Table 1 | **Physicochemical characteristics of common dietary fibres**

Fibre type	Common sources	Physicochemical characteristics[a]		
		Solubility	Viscosity	Fermentability
Cellulose	All green plant cell walls	Insoluble	Non-viscous	Low
Lignins	All green plant cell walls	Insoluble	Non-viscous	Low
Arabinoxylans	Wheat, psyllium[b]	Low to medium	Medium	High[b]
β-Glucans	Oat, barley, fungi	Low to medium	Medium to high	High
Galactomannans	Guar gum, fenugreek	Medium to high	Medium to high	High
Pectins	Fruits, vegetables, legumes	High	Medium to high	High
Inulin	Cereals, fruits, vegetables	Medium to high	Low to high	High
Galacto-oligosaccharides	Pulses (e.g. beans, peas, lentils)	High	Low	High
Dextrins	Cereals (e.g. wheat dextrins)	High	Non-viscous to low	High
Alginate	Seaweed	High	High	Low
Methylcellulose	Synthesized	High	High	Non-fermentable
Resistant Starch				
RS-1 (physically inaccessible)	Whole grains, legumes, raw fruits, vegetables	Insoluble	Non-viscous	High
RS-2 (starch conformation)	Cereals, raw legumes, raw fruits, vegetables	Low	Non-viscous	High
RS-3 (retrograded)	Cooking and cooling of any starch source	Low	Non-viscous to low	High
RS-4 (chemically modified)	Synthesized (e.g. acylated starches)	Low to high	Low to medium	High
RS-5 (starch–lipid complex)	Synthesized (e.g. amylose and stearic acid)	Low	Low	Low

From: Gill, S.K., Rossi, M., Bajka, B. et al., Nat Rev Gastroenterol Hepatol 18, 101–116 (2021)

Fiber Recommendations

The Dietary Guidelines for Americans (2020 - 2025) sets a target **average daily intake** for best health outcomes at **≥ 14 g/ 1,000 kcal**.

Based on approximate, average calorie needs by age and sex, that would mean adults should ideally be consuming between 22 - 34 grams of dietary fiber per day:

Daily Nutritional Goals, Ages 2 and Older

MACRONUTRIENTS, MINERALS & VITAMINS		Age-Sex Groups												
		M/F 2-3	F 4-8	F 9-13	F 14-18	F 19-30	F 31-50	F 51+	M 4-8	M 9-13	M 14-18	M 19-30	M 31-50	M 51+
Calorie Level Assessed	Source of Goal[a]	1,000	1,200	1,600	1,800	2,000	1,800	1,600	1,400	1,800	2,200	2,400	2,200	2,000
Macronutrients														
Protein (% kcal)	AMDR	5-20	10-30	10-30	10-30	10-35	10-35	10-35	10-30	10-30	10-30	10-35	10-35	10-35
Protein (g)	RDA	13	19	34	46	46	46	46	19	34	52	56	56	56
Carbohydrate (% kcal)	AMDR	45-65	45-65	45-65	45-65	45-65	45-65	45-65	45-65	45-65	45-65	45-65	45-65	45-65
Carbohydrate (g)	RDA	130	130	130	130	130	130	130	130	130	130	130	130	130
Fiber (g)	14g/ 1,000 kcal	14	17	22	25	28	25	22	20	25	31	34	31	28
Added Sugars (% kcal)	DGA	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Total lipid (% kcal)	AMDR	30-40	25-35	25-35	25-35	20-35	20-35	20-35	25-35	25-35	25-35	20-35	20-35	20-35
Saturated Fatty Acids (% kcal)	DGA	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

In the US, 90% of women and 97% of men do not meet these recommended intakes (USDA Dietary Guidelines 2020 - 2025)

In the UK, dietary fiber figures recommended by government dietary guidelines are based on the SACN Carbohydrate and Health report (2015).

This recommended target is **30 g/d of dietary fiber** for all adults:

Age (years)	**19 - 64**		**65 - 74**		**75+**	
Gender	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**
Energy(MJ/day)	10.5	8.4	9.8	8.0	9.6	7.7
Energy (kcal/day)	2500	2000	2342	1912	2294	1840
Macronutrients						
Protein (g/day)	55.5	45.0	53.3	46.5	53.3	46.5
Fat (g/day) [Less than]	97	78	91	74	89	72
Saturated fat (g/day) [Less than]	31	24	29	23	28	23
Polyunsaturated fat (g/day)	18	14	17	14	17	13
Monounsaturated fat (g/day)	36	29	34	28	33	27
Carbohydrate (g/day) [At least]	333	267	312	255	306	245
Free sugars (g/day) [Less than]	33	27	31	26	31	25
Salt (g/day) [Less than]	6.0	6.0	6.0	6.0	6.0	6.0
Dietary fibre (g/day)	30	30	30	30	30	30

Plant-based Diet Index (PDI)

- Researchers have developed the plant-based diet index (PDI), which is a way of scoring the data collected from FFQs
- This has two subcomponents:
    a. The healthy plant-based diet index (hPDI)
    b. The unhealthy plant-based diet index (uPDI)
- It takes the foods assessed in a food frequency questionnaire (FFQ) and breaks foods into three general groups:
    a. **Healthy plants:** whole grains, fruits, vegetables, nuts, legumes, vegetable oils, and tea/coffee
    b. **Unhealthy plant foods:** fruit juices, sugar-sweetened beverages, refined grains, potatoes, and sweets/desserts
    c. **Animal food groups:** animal fats, dairy, eggs, fish/seafood, meat (poultry and red meat), and miscellaneous animal-based foods.
- So for example, a higher hPDI score reflects higher intake of healthy plant-based foods and lower intake of animal products and unhealthy plant-based food.
- Examples of its use:
    a. Satija et al., 2017 - Healthful and Unhealthful Plant-Based Diets and the Risk of Coronary Heart Disease in U.S. Adults
    b. Li et al., 2021 - Plant-Based Diet Index and Metabolic Risk in Men: Exploring the Role of the Gut Microbiome
        - *… "categorized these 18 food groups (servings/day) into quintiles, and each quintile was assigned a score between 1 and 5.*
        - *Participants receive a score of 1–5 (1 for lowest quintile and 5 for highest quintile) for each healthy plant food group; for animal food groups and unhealthy plant food groups, we reversed the score so that higher intake received a lower score (1 for highest quintile and 5 for lowest quintile).*
        - *We then summed the scores across the 18 food groups to derive the hPDI score, which has a theoretical range of 18 (lowest possible score) to 90 (highest possible score)."*
- What this means for practice:
    a. Simply knowing someone eats a plant-based diet or not doesn't really inform us as to what the actual health impact is.
    b. Need to know what foods/products are making up bulk of the dietary pattern.
    c. Same as with macronutrient profiles (e.g. knowing if a diet is 'low-fat' or 'low-carb' alone is meaningless).

Fermented Foods

- Fermented foods are defined as "foods or beverages produced through controlled microbial growth, and the conversion of food components through enzymatic action"
- There are two main methods through which foods are fermented:
    a. Fermented naturally (often referred to as "wild ferments" or "spontaneous ferments") - The microorganisms are present naturally in the raw food or processing environment.
        - E.g. sauerkraut, kimchi, and certain fermented soy products
    b. Fermented via the addition of starter cultures (known as "culture-dependent ferments")
        - E.g. example kefir, kombucha and natto
- Includes foods/products such as:
    a. Kefir, kombucha, sauerkraut, tempeh, natto, miso, kimchi and sourdough bread.
- From Dimidi et al., 2019:
    a. "There are no RCTs investigating the impact of kombucha, miso, kimchi or tempeh in gastrointestinal health."
    b. There is very limited clinical evidence for the effectiveness of most fermented foods in gastrointestinal health and disease.
    c. Lead author Dr. Eirini Dimidi was on the podcast in episode 412.

Overview of trials to date:

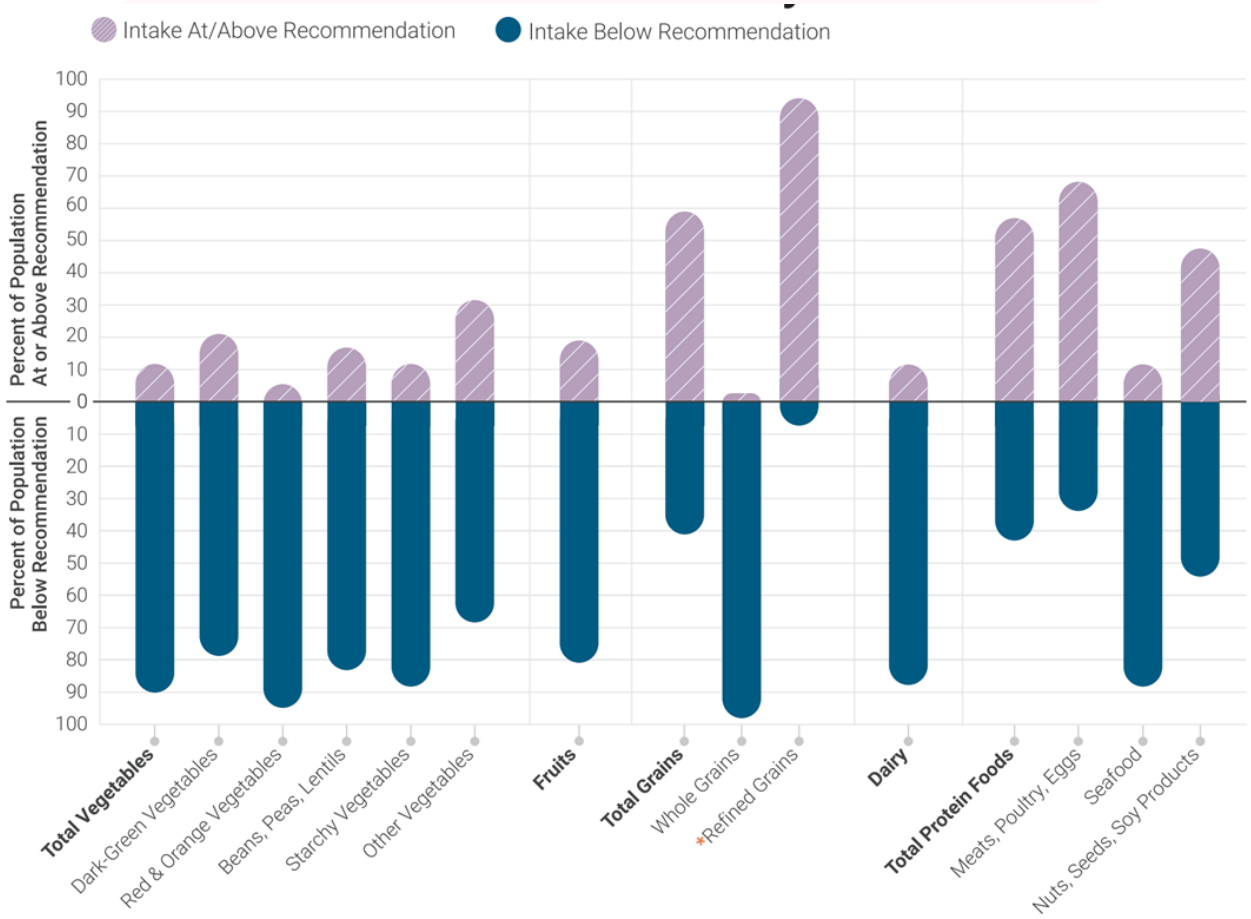
1. Fujisawa et al., 2006 – natto/miso – open-label uncontrolled trial – 200ml miso soup per day for 2 weeks = Higher Bifidobacteria and Bacilli, Lower Enterobacteriaceae
2. Kil et al, 2004 – 300g kimchi vs. 60g kimchi – 4 week Non-randomised trial - Increased Lactobacillus and Leuconostoc - H. pylori not eradicated in any participants
3. Mitsui et al., 2006 - 50 g/day Natto for 2 weeks - Increased ratio of stool Bifidobacteria:total bacteria
4. Nielsen et al., 2018 – 58 person RCT – IBS patients – 75 g/d sauerkraut for 6 weeks - No significant effects of either unpasteurised or pasteurised sauerkraut on microbiota composition - Lower IBS-SSS score

Practical Application

At a population level, relative to dietary guidelines, people tend to massively under consume:

- Fruit and vegetables
- Whole grains
- Legumes
- Nuts and seeds

In the US population, this is shown nicely in the most recent Dietary Guidelines for Americans. This chart shows the percentage of the population eating at/above the recommended amount (purple) or below the recommended amount (blue) of each of the food groups shown.



Source: [USDA, 2020-2025 Dietary Guidelines for Americans]

So, as one example, 98% fall below recommendations for whole grains.

Sources of fiber in the diet:

Food Source	Typical Serving Size	Carbohydrate Amount per Serving (g)	Fiber Amount per Serving (g)
Lentils	36 g (3 tablespoons, uncooked)	23	4
Wholegrain Bread	2 slices (80 g/ 2.8 oz)	32	4
Kidney beans (canned)	150 g	22	7
Pinto beans (canned)	150 g	30	8
Chickpeas (Garbanzo beans)	120 g	27	8
Broccoli	91 g (one cup, chopped)	6	2.5
Chia seeds	15 g / 0.5 oz	6	5
Spinach	90 g (3 cups)	3	2
Apple	1 medium apple (180 g)	25	4.5

What counts towards the theoretical "30 plants per week"?

- One "point" out of the target 30 is given for a single portion of any fruit, vegetable, wholegrain, legume (beans and pulses), nut, seed.
- 1/4 point given to each herb or spice used.

Other practical poins:

1. Consumer microbiome testing is a waste of money, time and effort.
2. Consumer food intolerance testing is a waste of money, time and effort.
3. Beyond this, such testing can actually lead to more harm as it leads people to follow dietary or supplemental practices that are at best, unnecessary, and at worst, dangerous.