Promoting a Healthy Microbiome with Food and Probiotics

Definitions

- **Prebiotic:** The food that probiotics need to sustain themselves (e.g., fructooligosaccharides)
- **Probiotic:** A living organism that benefits the health of the host (e.g., bacteria and yeast)
- **Synbiotic:** A supplement that contains both a prebiotic and a probiotic
- **Postbiotic:** A metabolic byproduct of probiotics (e.g., n-butyrate from fermentation of fiber and bacteria)

Nutrition: The Ultimate Prebiotic

Although a person's population of bacteria originates at the time of birth, most of the microbiome is established in the human gut with the introduction of food. Breast milk includes milk oligosaccharides (MOS) that provide bacteria with nutrients to grow, particularly *Bifidobacteria*. Diets that contain the most fiber, fruit, and vegetables are known to engender the most diversity and richness of bacteria growth in the gut. Healthy bacteria produce short-chain fatty acids, such as n-butyrate, that support the health of the intestinal lining.[1]

Foods rich in choline and carnitine (e.g., red meat and eggs) are metabolized by the intestinal microbiota to form the gas trimethylamine (TMA). TMA is converted by the liver to trimethylamine oxide (TMAO). This substance (an unhealthy postbiotic) has been strongly linked to the development of atherosclerosis and coronary artery disease.[2]

Eating a diet low in red meat and animal fat and rich in fibrous plants has been found to support bacteria in the gut that can reduce how much energy the body stores; our gut's microbiome can influence one's risk of obesity.[3] When humans were hunters and gatherers, it was harder to kill wild game, so eating meat and animal fat was less common. It may have been advantageous in the past to have a gut that contained bacteria able to maximize energy storage when such foods were available. Unfortunately, in modern times, when animal-based foods are easy to obtain, it may be that our gut bacteria increase our risk of obesity.

The number of studies investigating associations between our gut microbiome and various health conditions continues to grow exponentially. Positive changes in our gut flora have now been associated with improvements in conditions ranging from acne, nonalcoholic fatty liver disease, and chronic kidney disease,[4-6] to the conditions listed in Table 1, below.

Unfortunately, only 5% of Americans consume recommended amounts of daily fiber (21-38 gm per day depending on sex and age), as the average daily American intake is only 16.2 gm. "Whole grains" are often considered by consumers to be a surrogate for fiber, though the fiber content of whole grains various widely by grain and type of processing.[7]

A good rule of thumb to optimize one's fiber intake is to examine food labels and determine the "total carbohydrate to fiber ratio." A ratio of less than 10 is good, and a ratio of less than 5 is ideal. For example, if a serving of cereal has 20 gm of total carbohydrates and 4 gm of fiber, this ratio would be 20/4=5; this would be an excellent choice.

Nutrition is the main therapeutic tool to positively influence the microbiome. A diet rich in fiber, vegetables, and fruit helps establish a diverse and rich microbiome that promotes the health of the host.

Prebiotic foods: *Asparagus, artichokes, bananas, oatmeal, leeks, chicory root, red wine, honey, and beans. Soluble fiber, such as guar gum and psyllium, is also a good prebiotic.*

Food Sources of Probiotics

Fermentation occurs when a food interacts with a microorganism or enzyme and undergoes anaerobic biochemical change. This process can prolong the shelf life, promote the growth of healthy bacteria, enhance taste, and improve digestibility of the food. Microbes that promote fermentation can produce postbiotics that suppress the growth of harmful bacteria that could otherwise cause spoilage and disease. An example of this is *Lactobacillus. Lactobacillus* species produce lactic acid, which facilitates the digestion of lactose in milk. Fermentation produces antimicrobial substances such as acids, carbon dioxide, and alcohol. It is one of the oldest methods for preserving food and an excellent way to populate the gut with healthy bacteria. The byproducts of probiotic fermentation maintain a balanced ecosystem while also supporting digestion.

Fermentation is self-limited, based on the amount of bacteria found in a given food. Take wine, for example. When the sugar in the grape is fermented, alcohol is produced, reducing the amount of bacteria in the wine.

Red wine is a good prebiotic. A 2012 study of 10 men given 9 oz (270 ml) of red wine daily found that their fecal microbiome was altered. There was more growth of species of *Bifidobacteria, Bacteroides,* and *Enterococcus*. The increase in *Bifidobacteria* was linked to lower levels of cholesterol and changes in C-reactive protein, a marker of inflammation levels. Benefits were attributed to the polyphenols (e.g., resveratrol) found in wine.[8]

Fermented foods contain a broad spectrum of beneficial bacteria, supporting overall microbiome health. Eating fermented foods has been showed to enhance immune function, metabolic health, and improve intestinal permeability. Studies have provided positive associations with improvements in metabolic syndrome, colon cancer incidence, depression, stress hormones, anxiety, and even anger.[9]

Common Probiotic Foods

The following list includes types of probiotics and which foods they can be found in. Unfortunately, the high temperatures involved in pasteurization kills probiotics. Look for labeling that says, “contains live cultures” or “contains active cultures.”

Plants

- **Probiotics*:*** *Lactobacillus, Leuconostoc, Pediococcus*
- **Foods:** Sauerkraut (cabbage), miso (soy paste), tempeh (soy), pickles (cucumber)
- **Notes:** Avoid pickling with vinegar as this can reduce the growth of bacteria.

Dairy

- **Probiotics*:*** *Lactobacillus, Streptococcus, Saccharomyces* (yeast)
- **Foods:** Yogurt, milk, kefir
- **Notes:** Yogurt with live cultures is one of the most accepted methods to obtain probiotics.

Tea

- **Probiotics:** *Lactobacillus, Pediococcus**,** Acetobacter**,** Saccharomyces* (yeast)**,** *Brettanomyces* (yeast)
- **Foods:** Kombucha
- **Notes**: Although the tea leaf is a plant, kombucha is mentioned separately because it is a good source of a variety of probiotics. Also, it is important to be mindful of the added sugar content (often from adding juice after fermentation) of many commercially available products.

Probiotic Supplements

Note: Supplements are not regulated with the same degree of oversight as medications, and it is important that clinicians keep this in mind. Products vary greatly in terms of accuracy of labeling, presence of adulterants, and the legitimacy of claims made by the manufacturer.

Prescribing probiotics can be challenging, as there are thousands of products, each claiming superiority over the other. Many products have a “special recipe,” a patented strain, or a mixture of multiple different organisms (a sort of microbiologic shotgun approach). It is difficult to say whether one probiotic type is superior to another. Studies indicate that certain microorganisms work better for different illnesses, but it may just be a matter of which probiotics have been studied and which ones have not.

The goal is to populate the gastrointestinal ecosystem with a healthy balance of microorganisms that optimally supports the host. At this time, it is not clear what that balance should be. In fact, it is probably highly individualized, based on geographic location, food choices, and even the company one keeps.

What to Look for in a Probiotic

First, look at what genus, species, and strain(s) are in the product. Probiotics’ names have three parts, usually listed in order. The first part is the name of the genus, the second part is the species, and the third part is the name of the strain. For example, *Lactobacillus rhamnosus* GG

is from the genus *Lactobacillus* and has the species name *rhamnosus*. GG is the name of the strain. Different companies patent different strains that they develop.

Lactobacillus is usually abbreviated with an *L*, and *Bifidobacterium* is usually abbreviated with a *B*. *Lactobacilli* work in the small intestine, and *Bifidobacteria* work in the large intestine. Because antibiotics can kill the bacteria along the entire intestinal tract, it is important to add back both of these types of bacteria for people who have just taken antibiotics.

A general rule of thumb is to make sure the product you recommend contains species from both *Lactobacilli* and *Bifidobacteria*. The yeast *Saccharomyces boulardii* has also shown benefit for a number of conditions.

Some of the most-researched probiotics are:

- *Lactobacillus rhamnosus* GG (available as the brand Culturelle)
- *Bifidobacterium lactis* BB12 (abbreviated as *B. lactis* BB12)
- *L. acidophilus* NAS (sometimes just called Acidophilus)
- *L. bulgaricus* LB-51
- *L. gasseri*
- *L. plantarum*
- *B. bifidum* Malyoth strain
- *B. longum*
- *L. acidophilus* DDS1
- *Saccharomyces boulardii*—this is actually a yeast that has been found to have several benefits

Others, which have been studied less but are often taken, are *L. johnsonii, L. reuteri, L. rhamnosus, B. breve, B. infantis, E. faecalis,* and *Streptococcus salivarius*.

Dosing

Usually $1x10^9$, or 1 billion, colony-forming units (CFUs) is a good daily dose. For Crohn's disease or irritable bowel, $1x10^{11}$, or 100 billion, CFUs is recommended daily by some experts. For treating bacterial infections in the vagina, vaginal suppositories with 1 billion CFUs of lactobacillus organisms are typically used. Many experts recommend taking probiotics on an empty stomach, when there is less stomach acid present. Children are often given doses in the $1x10^8$ range. Many products that are tailored to infants or young children are available.

Guidelines for Prescribing Probiotics

- Take on an empty stomach.
- Heat-dried formulations should be kept refrigerated. Lyophilized ones can handle room temperature.
- Most doses range from 1 to 10 billion (10^8-10^9) CFUs 1-2 two times daily.

If taking with antibiotics, separate the antibiotic and the probiotic dosing time by 2 hours.

Duration of Treatment

This is controversial. Some would say that once a healthy gut ecosystem is established, continued use of probiotics is not necessary and would be similar to seeding an already seeded garden. But others argue that the therapeutic benefit of the bacteria may be beneficial after the microbiome is established. The focus should always be on improving the whole ecosystem so the individual is not dependent on bacteria in pill form.

Various sources recommend taking probiotics daily anywhere from 2 weeks to 2 months to fully recolonize the bowel's healthy bacteria. After the initial course, it may be possible to back off to 2-3 doses per week. In Crohn's disease or irritable bowel syndrome (IBS), people often need daily doses for longer time periods. Improvement in symptoms can help guide this decision. Many of the studies, where probiotics were given to prevent diarrhea after antibiotic treatment, had subjects take them at the same time as the antibiotic. It is best to take them 2 hours apart from each other and continue the probiotic for 1-2 weeks after the antibiotic course is completed.

What to Treat?

Table 1 lists conditions that have the strongest evidence in support of using probiotics for prevention and treatment. For more information, check out the Probiotics Chapter in Rakel's *Integrative Medicine* textbook, which is available through the national VA Library.[10]

Table 1. Conditions with the Strongest Evidence for Benefit from Probiotics

Indication	Bacteria Strains Used	Comments	Key Study
Prevention of upper respiratory infection (URI) in children	*Lactobacillus acidophilus* +/- *Bifidobacteria animalis*	Benefits seen with *Lactobacillus* alone or combined with *Bifidobacteria* given twice daily for 6 months.	[11]
Prevention of colic, reflux, and constipation in infants	*Lactobacillus reuteri* DSM 17938 during the first 3 months of life	Mean duration of crying time was 38 minutes for the probiotic group versus 71 minutes in the placebo group ($P < .01$).	[12]
Prevention of diarrhea in preschoolers	*Lactobacillus reuteri* DSM 17938 1 x 10^8 CFUs given daily for 3 months	Not only reduces the incidence and duration of diarrhea but also reduced the incidence of URI.	[13]
Prevention of atopic dermatitis in infants	*Lactobacillus rhamnosus* strain GG (Culturelle)	When this was given to mothers prenatally and then to their offspring for 6 months, the benefit persisted after a 4-year follow-up.	[14]

Indication	Bacteria Strains Used	Comments	Key Study
Ability to store fat	Bacteria from human twins (overweight and normal weight) were transplanted into sterile mice.	Bacteria from overweight twin caused mice to gain more weight. Eating a high-fiber, low-fat diet negated the effect.	3
Irritable bowel syndrome	*Bifidobacteria infantis* 35624	The dose of 1 x 10^8 CFUs worked best in this study of women. The available data supports *bifidobacteria* to be more effective than *lactobacillus* at reducing gas and bloating.	15, 16
C. difficile colitis	Donor stool infusion Single-strain probiotic (no clear recommended species)	Significant benefits have resulted in this becoming the therapy of choice for drug-resistant cases. >50% reduction among hospitalized individuals if started[17] within 2 days of antibiotic initiation	18

Resource Links

- Passport to Whole Health: https://wholehealth.wiscweb.wisc.edu/wp-content/uploads/sites/414/2018/09/Passport-to-Whole-Health-3rd-Edition-2018.pdf

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