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# What Are Prebiotics & Why Should I Care?

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In previous articles, I spoke about the different kinds of fiber and their effects, and the potential risks of taking probiotics without also consuming prebiotic soluble fiber (PSF) in foods and/or supplements [see August & October 2016 issues]. That naturally raises the question of what PSF is and what scientific evidence supports the health effects of consuming it.

The concept of prebiotics was originally proposed by Gibson and Roberfroid in 1995, and defined as follows: "A non-digestible food ingredient that beneficially affects the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon, and thus improves host health."[1]

Over the ensuing years, as the science progressed, the definition of prebiotics matured, with the most recent definition from the 6th Meeting of the International Scientific Association of Probiotics and Prebiotics stated as, "A dietary prebiotic is a selectively fermented ingredient that results in specific changes, in the composition and/or activity of the gastrointestinal microbiota, thus conferring benefit(s) upon host health."[2]

Health Benefits

Many studies show positive health effects from prebiotic fiber supplementation, including the following:

- Improvements in the number and metabolic activity of healthful bacteria, primarily bifidobacteria and lactobacillus species
- Improvements in immune function and regulation
- Improvements in gastrointestinal disorders, including irritable bowel syndrome (IBS), inflammatory bowel disease (IBD) and decreased risk of colorectal cancer
- Improvement in mineral absorption, including calcium and magnesium, and increased bone density
- Decreased appetite and improved weight management in overweight subjects
- Improved glucose and lipid homeostasis

Let's take a stroll through the literature and explore the evidence for the first three above-mentioned health benefits, with the balance covered in a future article.

Improvements in Number and Metabolic Activity of Healthful Bacteria

All health benefits start with "the prebiotic effect" — changes in the composition and/or metabolic activity of certain bacteria that have been shown to positively influence the health of the host. Beneficial effects can be related to their metabolism (i.e., fermentation profiles and end products), capacity for producing vitamins, antioxidants (reduction equivalents), bacteriocins against potentially harmful competitors, exchange of molecular signals between the different genera / species, but also with the eukaryotic epithelial cells.[3] The mechanism for those changes was shown

diagrammatically in an article in Nature Biotechnology, March 10, 2014.[4]

All types of prebiotic soluble fiber show certain characteristics:[5] resistance to gastric acidity, hydrolysis by mammalian digestive enzymes and GI absorption; fermentation by intestinal microflora; and selective stimulation of the growth and/or activity of one or a limited number of intestinal bacteria beneficially associated with health and well-being.

Many animal and human studies show that supplementation with a variety of types of dietary soluble fibers results in increases in bifidobacteria, lactobacillus or both.[6-14] Those and other healthful bacteria improve host health through a variety of metabolic intermediaries. They ferment dietary oligosaccharide soluble fiber, their primary food substrate, increasing in number and metabolic activity, yielding short-chain fatty acids (SCFA) butyrate, propionate and acetate, vitamins, antioxidants, and bacteriocins – narrow-spectrum natural antibiotics that help keep their competition at bay while simultaneously inhibiting some human colonic pathogens.

Butyrate serves as the primary food substrate for colonic epithelial cells (enterocytes), helping to keep them healthy and thus supporting the colonic epithelium's barrier function; and regulates enterocyte cell growth and differentiation – factors that may contribute to butyrate's role in reducing the risk of colon cancer.[15] Acetate and propionate, however, are mostly absorbed and transported to the liver, where they favorably affect glucose metabolism.[16] Propionate also appears to inhibit cholesterol synthesis and regulate adipose tissue deposition.[17-18]

Improvements in Immune Function and Regulation

The immune system is comprised of multiple, functionally different cell types, yielding a spectrum of immunomodulating molecules.[19] Although no single immune marker accurately reflects overall immune function, looking at many markers in different situations can paint a picture of immune function and modulation in both hyper-immune conditions (e.g., autoimmune disorders) and hypo-immune ones (e.g., infection.)

The interactive coexistence of the microbiota and the immune system is particularly clear in the colon, where gut-associated lymphoid tissue (GALT) has evolved to provide both defense against pathogens and tolerance of dietary and self-antigens. Colonic enterocytes are key intermediaries that convey signals from the intestinal lumen to the GALT.[20-21]

Non-breast-fed infants receiving prebiotic supplementation show a significantly higher concentration of fecal secretory IgA (sIgA) antibodies,[22-23] while in elderly adults, there is increased natural killer (NK) cell activity, increased production of anti-inflammatory cytokine IL-10, and decreased production of pro-inflammatory cytokines 1ß, IL-6 and TNF. In infants with a high risk of allergies, prebiotic supplementation reduces plasma levels of total IgE, and IgG1, 2 and 3, and lowers the incidence of atopic dermatitis.[24]

Experimental data from prebiotic supplementation animal studies show increased sIgA in the intestinal lumen, increased B cell numbers in Peyer's patches, enhanced production of anti-inflammatory IL-10, and decreased production of pro-inflammatory cytokines.[25-26] Additionally, in a review article, Lomax notes that many animal and human studies suggest some aspects of innate and adaptive immunity of the gut and systemic immune systems are positively modified by prebiotic supplementation, and a number have shown benefits in infectious outcomes.[27]

This body of work, along with other studies, taken together, strongly suggests prebiotic supplementation results in immunomodulation, improving the body's response to certain infections and improving inflammatory conditions.

Improvements in GI Disorders and Decreased Risk of Colorectal Cancer

IBS is a functional bowel condition of unknown etiology. Patients experience chronic, recurring abdominal pain or discomfort coinciding with diarrhea, constipation or both. In subjects with IBS, prebiotic supplementation has been shown to significantly reduce the incidence and severity of symptoms while increasing ratings of quality of life.[28-30]

IBD, on the other hand, is a chronic, relapsing disorder characterized by intestinal inflammation, ulceration and stricturing resulting from alterations in the balance of proinflammatory and immunoregulatory cytokines within the mucosal immune system. Symptoms include diarrhea, fecal urgency and incontinence, severe abdominal pain and rectal bleeding, and can have a profound negative impact on nutritional status and quality of life.

Studies on prebiotic supplementation in patients with ulcerative colitis (IC) have shown significant reductions in inflammation, with increased mucosal bifidobacteria and decreased pro-inflammatory TNF and IL-10;[31-32] and similar changes in Crohn's disease patients accompanied by a significant reduction in disease activity, with 40 percent of the treated patients entering disease remission.[33]

Evidence from a wide variety of sources implicates alterations in the colonic microbiota in the etiology of colon cancer.[34-35] Therefore, it follows that improving the number and activity of healthful gut microbes may interfere with the process of carcinogenesis. Animal studies on prebiotic supplementation have shown decreased pre-cancerous lesions[36-39] and decreased tumor incidence.[40-42] For human intervention trials, cancer is an impractical end point in terms of number of subjects, study duration, cost and ethical considerations. Human studies, therefore, rely on changes in biomarkers of colon cancer such as DNA damage and cell proliferation in colonic mucosa.[43]

A randomized, double-blind, trial of prebiotic supplementation in patients with resected polyps or colon cancer showed favorable changes in multiple colon cancer biomarkers.[44] This body of work, along with other studies, taken together, strongly suggest prebiotic supplementation helps prevent or ameliorate multiple colonic conditions, including IBS, IBD and colorectal cancer.

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