Health Benefits of Prebiotic Dietary Fiber

Jennifer Erickson, Ph.D., RD

Objectives
- Provide some background on dietary fiber
- To define the term "prebiotic dietary fiber"
- To discuss potential health effects of prebiotic dietary fibers
- To identify food sources of prebiotic dietary fibers

Dietary Fiber
- "Dietary fiber is the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine... Dietary fiber includes polysaccharides, oligosaccharides, lignin, and associated plant substances." AACC
Dietary Fiber

Soluble
- Beta glucans
- Wheat dextrin
- Psyllium
- Inulin

Insoluble
- Cellulose
- Lignin

Viscous
- Pectins
- B-glucans
- Psyllium

Non-viscous
- Polydextrose
- Wheat dextrin
- Inulin

Fermentable
- Wheat dextrin
- Beta-glucans
- Guar gum
- Inulin

Non-Fermentable
- Cellulose
- Lignin
Health Benefits of Dietary Fiber

- 430 BC Hippocrates documented the effect of coarse wheat compared to refined wheat on regularity of bowel movements.

- Cardiovascular disease
- Glycemic control
- Laxation
- Appetite control/Body weight
- Cancer
- Prebiotic effects

Consumption of fibers in US

- Fiber recommendations:
  - 14g/1000 calories
  - 25g/day for adult females
  - 38g/day for adult males
- Average intakes are approximately 17g/day
  - Only 5% of the population meets the Adequate Intake!
The new Nutrition Facts Panel will affect dietary fiber too.

Changing Fiber Regulations by the FDA.
Changing Fiber Regulations by the FDA

- Fiber definition will now require each isolated and synthetic fibers to have a proven health benefit.
  - Qualifying health benefits include:
    - Lowering blood glucose and cholesterol levels
    - Lowering blood pressure
    - Increase in frequency of bowel movements (improved laxation)
    - Increased mineral absorption in the intestinal tract
    - Reduced energy intake
    - Fermentability as indicated by the production of beneficial metabolites or specific changes in GI taxa are not considered a direct health benefit.

FDA approved isolated and synthetic fibers

- Beta-glucan soluble fiber
- Psyllium husk
- Cellulose
- Guar gum
- Pectin
- Locust bean gum
- Hydroxypropylmethylcellulose

Fibers not included on this list will need to be approved as a fiber by the FDA through a citizens petition process reviewing the health effects of the fiber.

Health Canada’s Fiber Definition

- "Dietary fibre consists of:
  - Carbohydrates with a DP1 of 3 or more that naturally occur in foods of plant origin and that are not digested and absorbed by the small intestine; and
  - Accepted novel fibres."

*Accepted novel fibres have at least one physiological effect demonstrated by generally accepted scientific evidence.
Accepted Physiologic Effects for Health Canada

- Improves laxation or regularity by increasing stool bulk
- Reduces blood total and/or low-density lipoprotein cholesterol levels
- Reduces post-prandial blood glucose and/or insulin levels
- Provides energy-yielding metabolites through colonic fermentation

List of dietary fibers accepted by Health Canada

- Barley beta-glucan concentrate
- Barley bran
- Corn bran
- Oat bran
- Wheat bran
- Fructooligosaccharides
- Inulin
- Galactooligosaccharides
- Isomaltooligosaccharides
- Resistant starches
- Oat beta-glucan concentrate
- Oat hull fibre
- Partially hydrolyzed guar gum
- Pea hull fibre
- Polydextrose
- Psyllium seed husk
- Resistant maltodextrins

Prebiotic Dietary Fibers
Why are we seeing this increasing interest in Prebiotics?

The gut microbiome!

Probiotics vs Prebiotics

Probiotics
- Live microorganisms

Prebiotics
- Fuel source for the microorganisms in your gut

Prebiotic Dietary Fibers
- Specific, microbiota-shaping compounds that function as a carbon source for growth of beneficial taxa, thus delivering a specific or selective change that influences host health related to its metabolism.

EFSA J. 2010
A prebiotic must:
- Resist digestion
- Be fermentable by the microflora
- Promote the production of beneficial bacteria

Physiologic Effects of Prebiotic Dietary Fiber
- Gas production
- SCFA production
- Lower pH
- Depends largely on sources for fermentation

Potential Health Effects of Prebiotic Dietary Fibers
1. Effects on Hind Gut Bacteria Composition
2. Change in Pathogenic Bacteria Populations
3. Metabolite Production
4. Effect on Mineral Absorption
5. Effect on Protein Fermentation
6. Effect on Allergy Risk
7. Effects on Gut Barrier Permeability
8. Effects on Immune System Defense
**Effect on Gut Microbiota**

- Promotion of beneficial bacteria
  - Lactobacilli and Bifidobacteria
- Reduction in pathogenic bacteria populations
  - Lower colonic pH
  - Competition
  - Inhibitory peptides
  - Improved immune function

**Allergy Risk**

- Decreased Bifidobacteria and Lactobacilli associated with development of allergies
- Supplementation of oligosaccharides may have allergy protective effects
  - Reduced eczema in infants
- Mechanism unknown

**Metabolite Production**

- Short chain fatty acids
  - Acetate, propionate, butyrate
  - Source of metabolizable energy
  - Negatively correlated with presence of GI disorders, cancers and obesity
  - High degree of individual variation


*Cochrane Database Syst Rev. 2013 Mar 28 (3).*

Gut Barrier Permeability

- Leaky Gut
- When tight junctions between the intestinal epithelial cells are compromised due to inflammation

Addition of SCFA to the walls of rat intestines can improve intestinal barrier function.

Mice fed fiber supplemented diets had reduced paracellular permeability in the distal colon.

Supplementation of prebiotics promotes Bifidobacteria growth and increases in GLP-2 production in mice.

Immune System

- Prebiotic fermentation influences many immune cells including TREG, T cells, B cells and natural killer cells
- Exact mechanism not known
- Butyrate has been shown to effect number of macrophages, T cells and dendritic cells
Mineral Absorption

- Distal intestine is a primary site for mineral absorption
  - Calcium, magnesium and zinc
  - Improved absorption of calcium and magnesium have been observed
  - Overall results are mixed in human studies

J Nutr. 2007 Mar;137(3 Suppl):838S-46S

Protein Fermentation

- Without sources of fermentable carbohydrates, the gut bacteria will ferment protein
  - Production of harmful metabolites
  - Supplementation of prebiotic dietary fibers shown to reduce fecal and/or urinary ammonia levels and p-crestol levels


Common Sources of Prebiotic Dietary Fibers
Beta-glucan

- Soluble fiber found in the cell walls of grain endosperm
- Oats and barley are the two largest sources of beta-glucans
  - Other foods like mushrooms and algae also contain beta-glucan

Oligosaccharides

- Fructooligosaccharides, galactooligosaccharides, xylooligosaccharides and isomaltooligosaccharides
  - Non-digestable carbohydrates with chain lengths of 2-20 monomers
  - Strong bifidogenic effects
  - Chain length influences its prebiotic effects
  - Common food sources: wheat and rye, legumes, onions, garlic, asparagus, broccoli, etc.

Resistant starches and maltodextrins

- Starches that are not digestible by enzymes in the small intestine and are fermented in the colon by microbiota

<table>
<thead>
<tr>
<th>Type of Resistant Starch</th>
<th>Description</th>
<th>Food Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>RS1</td>
<td>Starch that is physically inaccessible due to cell walls</td>
<td>Whole grains, seeds, legumes</td>
</tr>
<tr>
<td>RS2</td>
<td>Starch with highly crystalline structure</td>
<td>Raw potatoes, green bananas</td>
</tr>
<tr>
<td>RS3</td>
<td>Retrograded nongranular starch</td>
<td>Cooked and retrograded starchy foods</td>
</tr>
<tr>
<td>RS4</td>
<td>Chemically modified starches</td>
<td>Functional foods with added RS4</td>
</tr>
</tbody>
</table>

*(Starch, 2013; 66(1-2), 102-144)*
Prebiotic Consumption

- Consumption of prebiotics is difficult to quantify
- No analytic test
- Found in a wide range of foods
- No universal definition or list of accepted ingredients

Dietary trends limited in prebiotic dietary fibers

- Restrictive carbohydrate diets like low FODMAP, ketogenic diet, Atkins, etc.
- Important to encourage individuals following restrictive diets to ensure that they are consuming adequate fiber.
- Variety is important for a healthy gut microbiota
Summary

- Prebiotic dietary fiber is an evolving area of research in nutrition
- Current evidence indicates various health impacts associated with the consumption of prebiotic dietary fiber
- Each prebiotic source provides a unique carbon source for fermentation
- A varied diet, rich in fiber is recommended to achieve these health benefits

Thank you!