Beta-glucan

β-Glucans (**beta-glucans**) comprise a group of β-D-glucose polysaccharides naturally occurring in the cell walls of cereals, bacteria, and fungi, with significantly differing physicochemical properties dependent on source. Typically, β-glucans form a linear backbone with 1-3 β-glycosidic bonds but vary with respect to molecular mass, solubility, viscosity, branching structure, and gelation properties, causing diverse physiological effects in animals.

Various studies have examined the potential health effects of β-glucan. Oat fiber β-glucan at intake levels of at least 3 g per day can decrease the levels of saturated fats in the blood and may reduce the risk of heart disease. Some studies have suggested that cereal-derived β-glucan may also have immunomodulatory properties. Yeast- and medicinal mushroom-derived β-glucans have been investigated for their ability to modulate the immune system. β-glucans are further used in various nutraceutical and cosmetic products, as texturing agents, and as soluble fiber supplements, but can be problematic in the process of brewing.

History

Cereal and fungal products have been used for centuries for medicinal and cosmetic purposes; however, the specific role of β-glucan was not explored until the 20th century. β-glucans were first discovered in lichens, and shortly thereafter in barley. A particular interest in oat β-glucan arose after a cholesterol lowering effect from oat bran reported in 1981.

In 1997, the FDA approved of a claim that intake of at least 3.0 g of β-glucan from oats per day decreased absorption of dietary cholesterol and reduced the risk of coronary heart disease. The approved health claim was later amended to include these sources of β-glucan: rolled oats (oatmeal), oat bran, whole oat flour, oatrim, whole grain barley and barley beta-fiber. An example of an allowed label claim: Soluble fiber from foods such as oatmeal, as part of a diet low in saturated fat and cholesterol, may reduce the risk of heart disease. A serving of oatmeal supplies 0.75 grams of the 3.0 g of β-glucan soluble fiber necessary per day to have this effect. The claim language is in the Federal Register 21 CFR 101.81 Health Claims: Soluble fiber from certain foods and risk of coronary heart disease (CHD).

Structure

Glucans are arranged in six-sided D-glucose rings connected linearly at varying carbon positions depending on the source, although most commonly β-glucans include a 1-3 glycosidic link in their backbone. Although technically β-glucans are chains of D-glucose polysaccharides linked by β-type glycosidic bonds, by convention not all β-D-glucose polysaccharides are categorized as β-glucans. Cellulose is not typically considered a β-glucan, as it is insoluble and does not exhibit the same physicochemical properties as other cereal or yeast β-glucans.

Some β-glucan molecules have branching glucose side-chains attached to other positions on the main D-glucose chain, which branch off the β-glucan backbone. In addition, these side-chains can be attached to other types of molecules, like proteins, as in polysaccharide-K.

β-glucan types

β-glucans form a natural component of the cell walls of bacteria, fungi, yeast, and cereals such as oat and barley. Each type of beta-glucan comprises a different molecular backbone, level of branching, and molecular weight which effects its solubility and physiological impact. One of the most common sources of β(1,3)D-glucan for supplement use is derived from the cell wall of baker's yeast (*Saccharomyces cerevisiae*). The β(1,3)D-glucans from yeast are often insoluble. However, β(1,3)(1,4)-glucans are also extracted from the bran of some grains, such as oats and barley, and to a much lesser degree in rye and wheat. Other sources include some types of seaweed, and various species of mushrooms, such as reishi, *Ganoderma applanatum*, shiitake, Chaga and maitake.

Cereal β-Glucans

Cereal β-glucans from oat, barley, wheat, and rye induce a variety of physiological effects that positively impact health. Barley and oat β-glucans have been studied for their effects on blood glucose regulation in test subjects with hypercholesterolemia.

Oats and barley differ in the ratio of trimer and tetramer 1-4 linkages. Barley has more 1-4 linkages with a degree of polymerization higher than 4. However, the majority of barley blocks remain trimers and tetramers. In oats, β-glucan is found mainly in the endosperm of the oat kernel, especially in the outer layers of that endosperm.

Mushroom β-glucans

β-D-glucans form part of the cell wall of certain fungi,
especially *Aspergillus* and *Agaricus* species. Mushroom beta-glucans are linked by 1,3 glycosidic bonds with 1,6 branches.

Yeast β-Glucans

β-Glucans found in the cell walls of yeast contain a 1,3 carbon backbone with elongated 1,6 carbon branches. A series of human clinical trials in the 1990s evaluated the impact of PGG-glucan on infections in high-risk surgical patients. In these studies, PGG-glucan significantly reduced complications. Orally administered yeast-glucan was reported to decrease the levels of IL-4 and IL-5 cytokines responsible for the clinical manifestation of allergic rhinitis, while increasing the levels of IL-12.

β-Glucan absorption

Enterocytes facilitate the transportation of β(1,3)-glucans and similar compounds across the intestinal cell wall into the lymph, where they begin to interact with macrophages to activate immune function. Radiolabeled studies have verified that both small and large fragments of β-glucans are found in the serum, which indicates that they are absorbed from the intestinal tract. M cells within the Peyer's patches physically transport the insoluble whole glucan particles into the gut-associated lymphoid tissue.

(1,3)-β-D-glucan medical application

An assay to detect the presence of (1,3)-β-D-glucan in blood is marketed as a means of identifying invasive or disseminated fungal infections. This test should be interpreted within the broader clinical context, however, as a positive test does not render a diagnosis, and a negative test does not rule out infection. False positives may occur because of fungal contaminants in the antibiotics amoxicillin-clavulanate, and piperacillin/tazobactam. False positives can also occur with contamination of clinical specimens with the bacteria *Streptococcus pneumoniae*, *Pseudomonas aeruginosa*, and *Alcaligenes faecalis*, which also produce (1→3)β-D-glucan. This test can aid in the detection of Aspergillus, Candida, and Pneumocystis jirovecii. This test cannot be used to detect Mucor or Rhizopus, the fungi responsible for mucormycosis, as they do not produce (1,3)-beta-D-glucan.

The most common forms of β-glucans are those comprising D-glucose units with β-1,3 links. Yeast and fungal β-glucans contain 1-6 side branches, while cereal β-glucans contain both β-1,3 and β-1,4 backbone bonds. The frequency, location, and length of the side-chains may play a role in immunomodulation. Differences in molecular weight, shape, and structure of β-glucans dictate the differences in biological activity.