Fructooligosaccharide and Diarrhea

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The outstanding of fructooligosaccharide as a nondigestible dietary fiber has been proved for the prevention of hypercholesterolemia, overgrowth of pathogen bacteria, colon cancer, and enhancement of mucosal immune response. The primary function of beneficial intestinal microflora is to protect the intestinal tract from the proliferation of infection or harmful bacteria. *Bifidobacterium bifidum* produces volatile fatty acids, which provide important metabolic energy, and acidifies the bowel, which inhibits the growth of harmful bacteria, including *Salmonella*, *Shigella*, *Clostridium*, *Campylobacter jejuni*, and *Escherichia coli*. When the population of beneficial microflora decreases the gastrointestinal environment makes a subtle chemical shift, which allows harmful bacteria such as *Clostridium perfringens* and *E. coli* to proliferate. One clinical manifestation of this imbalance is diarrhea. In developing countries, diarrhea is still the most important cause of child morbidity and mortality with an estimation of 1.3 billion episodes each year in children under 5 years old. FOS acts like an efficient intestinal "fertilizer" by feeding beneficial intestinal microflora and helping them to reproduce. The improvement in the intestinal microflora was followed by a relief of constipation, or loose stool; decreased formation of putrefactive products in the large intestine, improved serum lipids in hyperlipidemia; and reduced total cholesterol, triglycerides, blood glucose, and blood pressure. Studies show that the duration of diarrhea in children who ingested FOS were shorter than in those who ingested a placebos (2.62 days versus 4.24 days). The pH of stool in children who ingested FOS was significantly lower than in children who did not.

Key words: microflora; fructooligosaccharides; diarrhea; children

INTRODUCTION

The study regarding gastrointestinal disorder and its relation to the effects of fructooligosaccharide have recently been pursued worldwide after findings of the remarkable biofunctions and usefulness of fructooligosaccharide on gastrointestinal flora balance. Many nutrition and food factories competed to produce many kinds of fructooligosaccharide in various preparations. They promoted the benefits of the consumption of fructooligosaccharide on human health.

The outstanding of fructooligosaccharide as a nondigestible dietary fiber has been proved to be a prevention of hypercholesterolemia, overgrowth of pathogen bacteria, and colon cancer and to enhance mucosal immune response. Nondigestible oligosaccharide passes through the small intestine without digestion and reach the colon, which has many microorganisms such as *Bifidobacterium bifidum*, and *Lactobacillus* utilizes oligosaccharide. These microorganisms produce acetic acid and lactic acid from these saccharides, and the short-chain fatty acids (SCFA) lower the intestinal pH and protect from an overgrowth of harmful bacteria (6).

In a clinical view, it has been shown that the administration of prebiotic *in vitro* can protect pig from infectious *E. coli* (1). In this paper we would like to review the relation between the administration of oligosaccharides on children who have diarrhea.

DIARRHEA IN CHILDREN

In developing countries, diarrhea is still the most important cause of child morbidity and mortality with an estimated 1.3 billion episodes each year in children under 5 years old. In Indonesia, every child suffers from diarrhea an average of 1.6 to 2 times every year. Diarrhea there mostly occurs in the first 2 years of life with a peak incidence in children that are 6 to 11 months old (4).

Intestinal microflora balance is among the factors that influence diarrhea in children. The normal intestines consist of 100 trillion bacteria comprising 100 different species of beneficial bacteria (*Bacteroides*, *Eubacteria*, *Bifidobacteria*) and potentially harmful ones (*Clostridium perfringens*, *Staphylococcus aureus*, *Proteus*, *Pseudomonas aeruginosa*) in a delicate balance. This balance is needed to maintain digestive functions of the intestine. These microflora also play a critical role in every aspect of immunological responses, ei-
ther by helping to build resistance to infection or by becoming pathogenic (5). The primary function of beneficial intestinal microflora is to protect the intestinal tract from the proliferation of infection or from harmful bacteria. *Bifidobacterium bifidum* produce volatile fatty acids, which provide important metabolic energy, and acidify the bowel, which inhibits the growth of harmful bacteria, including *Salmonella*, *Shigella*, *Clostridium*, *Campilobacter jejuni*, and *E. coli*. When the population of beneficial microflora decreases, the gastrointestinal environment makes a subtle chemical shift, which allows harmful bacteria such as *Clostridium perfringens* and *E. coli* to proliferate (7). One clinical manifestation of this imbalance is diarrhea.

**FRUCTOOLIGOSACCHARIDE (FOS)**

Fructooligosaccharides (FOS) are $1^f(1\beta$-fructofuranosyl)$_{n-1}$ sucrose oligomers, where $n$ may vary from 2 to 4 (14). They consist of sucrose molecules to which one, two, or three additional fructose units have been added by a $\beta(2\beta)-$glycosidic linkage to the fructose unit of sucrose (2). The common sugars such as GF$_2$ (1-kestose), GF$_3$ (nystose), and GF$_4$ (1$^f\beta$-fructofuranosynystose) are found in a variety of edible plants that for many years have been used as human and animal food sources, including banana, barley, garlic, honey, onion, rye, brown sugar, tomato, asparagus root, Jerusalem artichoke, wheat, and triticale (3).

**BENEFIT OF FOS**

The FOS is not hydrolyzed in the rat or in the human by digestive enzymes such as disaccharidases of intestinal mucosa and $\alpha$-amylase of pancreatic homogenates. Human intestinal bacteria, predominantly *Bifidobacterium* species, can utilize FOS; however, harmful bacteria such as *Clostridium perfringens*, *Clostridium difficile*, and *E. coli* (11) cannot utilize them. A study of senile in-patients who ingested FOS 8 g/day for 2 weeks showed a significant increase of the *Bifidobacterium bifidum* number in the feces, without increasing the other putrefactive bacteria (5). Another study shows that the improvement of beneficial effect of dietary FOS is because of the proliferation of Bifidobacteria and subsequent improve the intestinal microflora. FOS acts like an efficient intestinal "fertilizer" by feeding the beneficial intestinal microflora and helping them to reproduce. Another benefit of FOS is its low caloric utilization by man 1.5 kcal/g (8). FOS consumption includes the production of volatile fatty acids (5), an increase in Bifidobacteria and other microorganisms in the intestine (12, 13), a lowering of intestinal pH, and a decreased production of putrefactive substances in the intestine (5). Other effects of FOS are the reduction of constipation, the amelioration of antibiotic-associated diarrhea, and a reduction in serum triglycerides and cholesterol (13, 16, 17).

Some studies have shown that FOS has many non-immune and immune effects on the intestines. It has two characteristic properties, nondigestibility and selective utilization by intestinal bacteria. The beneficial effects of FOS on humans and animals are thought to derive from these two properties (5). The nondigestible saccharides are used as nutrients by beneficial bacteria in the large intestine, and this selective utilization results in an increase in bifidobacteria followed by the production of short-chain fatty acids, lowered pH in the large intestine, and suppression of putrefactive substances (5). The improvement in the intestinal microflora was followed by relieved constipation, or loose stool; decreased formation of putrefactive products in the large intestine; improved serum lipids in the hyperlipidemia; and reduced total cholesterol, triglycerides, blood glucose, and blood pressure (5, 13). A study on the *Min* rat showed that a significantly higher number of microscopically detectable lymphoid nodules were noted in the small intestine with an sc-FOS diet (15). A study of neonatal pig showed that with a FOS diet, the cell proliferation of the epithelial mucosa was greater along the entire length of the large bowel (9).

**EFFECT OF FOS ON ACUTE DIARRHEA**

A randomized control trial study was done in Yogyakarta, Indonesia, and it involved 119 children in an age range of 1 to 14 years that had acute diarrhea from various causes. Ninety-three children ingested 2.5 to 5 g/day FOS, depending on age. Twenty-five children consumed placebos.

Duration of diarrhea: This study showed that the duration of diarrhea in children who ingested FOS was shorter than in the placebo category children, either in all age groups or in a specific age group (Tables 1 and 2, Fig. 1) (10). It is indicated that the ingestion of FOS influence on the duration of diarrhea in children with acute diarrhea, FOS can probably stimulate the growth of beneficial bacteria in the intestine. The beneficial bacteria inhibit the ongoing growth of harmful bacteria. A study in adults showed that the effects of FOS in different doses results in an increasing number of Bifidobacteria in all groups (5). No side effects such as an increase of diarrhea or prolonged diarrhea were found (10) (Fig. 2), but same were in another study.

A decrease in the production of putrefactive sub-
stances in the intestines in children who ingested FOS was found in this study. The pH of stool in children who ingested FOS was significantly lower than in children who did not ingest it (Table 3, Fig. 3) (10). The solid low percent and amount of putrefactive products indicate that when the number and or ratio of bifidobacteria is high, putrefaction in the gut is effectively suppressed.

**THE FUTURE OF FOS**

According to the results of the studies, either *in vitro* or *in vivo* FOS has many beneficial functions. Clinical observation showed that FOS also benefits in shorter on duration of diarrhea in children. These data indicate that FOS is beneficial not only for healthy human, but also for humans with gastrointestinal problem. Besides being a healthful nutrition, FOS is also good as therapy nutrition.

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Fig. 3. pH of stool before, during, after administration of FOS.

REFERENCES


