Benefits of Functional Oligosaccharides (FOS) in treating Functional Bowel Disorders (FBD) and low caloric substitutes for diabetics.

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Abstract: *Flourishing IT culture has led to not only in the technical but also financial advancements. However, this advancement has become the root cause for sedentary lifestyle and its associated diseasesor disorders related to the gut microbiota. Functional Bowel Disorders(FBD) describe problems relative toworking or functioning of the stomach and bowel movements. The common types of FBD are IBS/IBD and FD which are observed even in infants. Irritable Bowel Syndrome (IBS) is identified with a group ofsymptoms which include bloating, constipation and/or diarrhoea, whereas Functional Dyspepsia (FD) is acondition wherein pain above belly button, bloating, nausea which is often without vomiting is observed. FBD disturbs the gut health and hence functional oligosaccharides are effective to restore it. Functional Oligosaccharides are intermediate between monosaccharides and polysaccharides, well known for theirprebiotic effect as they benefit the host by selectively stimulating healthy bacteria in the intestine,especially the bifidobacteria and lactobacillus species. These Functional Oligosaccharides have low molecular weight and are commercially or naturally found in Fructo-Oligosaccharides (FOS) and Galacto-Oligosaccharides (GalOS). They are recommended as safe by the FDA, GRAS. Some countries like the USA, UK, Australia have already been using it as a dietary supplement. Adding to that, functional oligosaccharides are even approved for infant formulation and treating FBD as the dominating prebiotic produces SCFAs i.e Short Chain Fatty Acids which is beneficial for gut microbiota. Moreover, FOS gives 1.5-2Kcal/g which is half of sucrose. Hence, it is a natural, low calorie sweetener,totally non-carcinogenic which can be effectively used for diabetics and weight management as well.*

Keywords: Non-carcinogenic, Prebiotic, Functional Bowel Disorders, Short Chain Fatty Acids, Fructo-Oligosaccharides, Galacto-Oligosaccharides, Gut microbiota.

Introduction:

Functional Bowel Disorders

These are the disorders which are only identified with symptoms, a symptom based classification is very necessary for clinical diagnosis, management and further research. These functional gastrointestinal disorders are mainly seen in the middle or the lower gastrointestinal tract. According to a few researches in order to separate the chronic conditions of FBD, they must have occurred for the first time before 6 months before the patient comes for testing. The patients will be stated as FBD patients if they show these symptoms

1) **Irritable Bowel Syndrome**
   It is a functional disorder in which abdominal pain or discomfort is seen with a change in the defecation or bowel habit.
   Other researches also show that there is abnormal stool frequency (less than three bowel movements a week) or even abnormal stool lumps (very watery stool or very lumpy/hard stool)
   Sometimes even there is a feeling of urgency or also feeling of incomplete bowel movement.
   In some cases even bloating is observed.
   Some researches even showed a case of pseudo diarrhoea. It was even observed in some women who reported of excessive pelvic pain and IBS symptoms during menstruation

2) **Functional Constipation**
   It is the disorder that shows persistently difficult or seemingly incomplete defecation or bowel movement. Many researches show that patients show a pattern of straining, hard stools, unproductive calls (want to but cannot behaviour), prolonged but whole colonic transit etc. It is a recurrent sensation of abdominal detention that may or may not be associated with any other functional or gastrointestinal disorder

3) **Functional Diarrhoea**
It is a continuous or recurrent syndrome characterized by the passage of loose (mushy) or watery stools without any abdominal discomfort. Some researches show that soft stools are 85% water and watery stools are 90% water which shows as to how much electrolytes a person is losing.

Relation between obesity and Functional Bowel Disorders
Obesity-related comorbodities include a variety of severe chronic diseases which also involve FBD.
According to a research, the study showed that almost 40% suffered from gastrointestinal problems like reflux, celiac disease, bowel surgery and even congenital heart defect

Sucrose related Oligosaccharides:

Fructooligosaccharides (FOS)

Short-Chain Fructooligosaccharides and Oligofructose are called Fructooligosaccharides (FOS). Structurally FOS are short-chain fructans consisting of β1→2 bond. Various studies indicate that this bond makes them indigestible and selectively fermentable by a limited number of bacteria, especially bifidobacteria, in the large intestine. And due to the indigestibility and selective fermentation, they have been estimated to yield half the calories of sucrose, i.e. 1.5 to 2 kcal/gram.

According to a study conducted on Fructooligosaccharides, it has been shown that they offer health benefits like dietary fibre in curing constipation and traveller's diarrhoea. Additionally, FOS is fermented in the colon to produce Short Chain Fatty Acids which are an excellent fuel source for colonocytes, promote beneficial colonic bacterial growth, maintain the colonic pH, enhance the release of Insulin promoting Incretins, regulate cholesterol metabolism via communication with the liver, enhance mineral absorption, decrease phospholipids and decrease triglycerides. More recently, FOS got approved by the European Union for use in infant formulas in combination with galactooligosaccharides. They are also considered safe for food applications and pharmaceutical drug formulation by Generally Recognised as Safe (GRAS), Food and Drug Administration (FDA) and other worldwide regulatory agencies.

Due to the bountiful benefits, FOS is commonly used as a low-calorie sweetener and a nutritional-value enhancing agent in various diabetic products and yoghurts, nutrition bars & other food products, respectively.

They have a rich natural presence in higher plants such as various fruits and vegetables mentioned below:

Blue Agave

Garlic

Onion

Chicory root

Asparagus

Jerusalem artichokes

Leeks

Tomatoes

Banana

Wheat and Barley

Fructooligosaccharides from the above sources can be eaten up to a quantity of 20 grams/ day by adults and 4.2 grams/ day by infants of less than one year old. Beyond this daily intake, individuals may experience bloating, stomach cramps, diarrhoea, and intestinal gas (flatus).

Apart from side effects of higher consumption, patients suffering from Irritable Bowel Syndrome (IBS) and Small Intestinal Bacterial Overgrowth Syndrome (SIBO) may experience the side effects of FOS consumption even at lower quantities.

Lactose Related Oligosaccharides:

Galactooligosaccharides (GalOS) Human milk is one of the earliest known sources of Galactooligosaccharides. Approximately 90% of the carbohydrates profile of Human milk is dominated by 200 different types of lactose related oligosaccharides and lactose itself. The composition of Human milk oligosaccharides is, however, individual to each mother.

The third-largest component of Human milk after lipids and lactose is galactooligosaccharides (5-10 g/L). The gut microbiome of the breastfed infants in their early life is also partly shaped by the human milk oligosaccharides, the Galactooligosaccharides. Even Colostrum is rich in Galactooligosaccharides, approximately 24% of the total Colostrum carbohydrates.

The pleasant taste, texture, mouthfeel, moisture-retaining capacity and thermostability during food processing of GOS captivated their commercial usage as a low carcinogenic replacement for the high carcinogenic sugars. Not only this, but Galactooligosaccharides also offer various health benefits like relieving constipation symptoms, improving stool frequency, enhancing immune response and stimulating the growth of beneficial colonic bacteria - Bifidobacteria and Lactobacillus.

The natural presence of GOS in Human milk, yoghurt, human intestinal tract and animal intestinal tract attracted the attention and safety recognition of GRAS, FDA and various other worldwide regulatory agencies.

To leverage fully on GOS, a daily intake of 0.3-0.4 g/kg body weight is recommended. Consumption beyond this is associated just with transient osmotic diarrhoea.

Lactose-Sucrose:

Lactose-sucrose is a rare oligosaccharide composed of three types of sugar units namely glucose, galactose and fructose. It occurs naturally, but in low concentrations, in yoghurt made from lactose and sucrose containing milk. Commercially, it is enzymatically produced with lactose and sucrose substrates. The degree of sweetness of Lactose-sucrose has been estimated to be similar to sucrose and its functional properties have been found to be similar to that of functional oligosaccharides.

This functional oligosaccharide is considered safe for the formulation of functional food products and foods by GRAS, FDA and other worldwide regulatory agencies. Additionally, it is also promoted as a prebiotic which selectively stimulates the growth of beneficial colonic bacteria, especially of the bifidobacteria species.

Lactose-sucrose has a wide range of uses since it is a non-digestible, non-carcinogenic and intestinal mineral absorption enhancer. It has application in various pharmaceuticals and cosmetic formulations. Some studies claim its benefit to patients suffering from Inflammatory Bowel Diseases (IBD). While some patents highlight it as an active ingredient in drugs for the prevention of skin diseases.

It can be added to low-calorie food products and can be used as an additive in food products like baked goods, ice-creams, candies, infant formula, juices and mineral water.

To benefit from lactose-sucrose, a daily intake of 3 g/day is recommended for adults.

Starch related oligosaccharides:

Starch is a homopolymer of glucose. It acts as an energy store in the vast majority of plants. The two major components of starch are *amylose* and *amylopectin*.

Amylose and Amylopectin act as substrates for enzymatic reaction to produce starch related oligosaccharides. There are various types of starch related oligosaccharides which are being produced over enzymatic reactions of these two types of

starch. The common known starch oligosaccharides are maltoligosaccharides, trehalose, isomaltooligosaccharides, cyclodextrins, nigerooligosaccharides and gentio oligosaccharides.

Maltooligosaccharides:

Current studies indicate that maltooligosaccharides are digestible natural sweetner along with additional benifits such as low sweetness, low in calories and have low osmotic pressure. This mouth feeling characteristic interest food industries to incorporate these maltooligosaccharides in processing of bevarages, dairy products, juices, jams, cakes and several functional foods. Maltooligosaccharides are usually vended in the form of syrups and powders.

They have numerous health benifits like reducing tiredness, improving peristalsis of intestines and in preventing constipation. One more application of maltooligosaccharide is being observed in clinical chemistry as an alternative for measuring blood glucose levels.

Iso-maltooligosaccharides:

This study explains that iso-maltooligosaccharide are composed of 3 to 6 glucose units linked together with indigestible 1-6 glycosidic bonds and are being manufactured commercially. Moreover, they are found naturally at low concentrations in honey and fermented food stuffs like soy sauce.

Iso-maltooligosaccharides have significant benefits in the term of low calories and mild sweet in taste. They act as bulking agent for addition of fiber into the food products. Furthermore, iso-maltooligosaccharides fuse with intensive zero calorie sweetners such as saccharine, aspartame,stevia,sucralose andacesulfame-k to obscure their unpleasant taste.

The main advantage of iso-maltoligosaccharides is that it acts as a prebiotic which promotes the growth of essential bacteria in the colon. They unexpectedly help in loweing blood cholesterol and triglyceride levels and supports in absorption of minerals from foods.

As said, every advantage has its disadvantage, excess intake of iso-maltooligosaccharide may lead to gastrointestinal symptoms like flatulence, bloating, soft stools and diarrhoea.

Soy- oligosaccharides:

Soy- oligosaccharides , which are isolated from soybean seeds, are well-established prebiotics.Soy-oligosaccharides are a group of soluble oligosaccharides found in soy or other legumes and consist primarily of raffinose, stachyose, and sucrose.In the intestine, soy-oligosaccharides can be fermented by certain bacteria, such as lactobacilli and bifidobacteria.

They have varoius health benifits like prevention of constipation, improving absorption of calcium and other minerals, elevation of microbial metabolite of short chain fatty acids which in result help in reducing the risk of colon cancer, and decrease toxic metabolites production that effect the liver.

The current average daily intake of soy-oligosaccharide is 4.0 grams. It is important to draw attention towards over consumption of soy- oligosaccharides which may lead to abdominal bloating,excessive gas and diarrhoea.

The chemical structure of soy-oligosaccharide having linked alpha 1-6 bonds is unbreakable due to lack of the enzyme known as *alpha galactosidase* in human digestive system.

Conclusion:

FBD includes IBS, IBD, dyspepsia, bloating, constipation and diarrhea. Studies have observed that obesity and FBD have a correlation. To relieve the FBD symptoms and discomforts, functional oligosaccharide FOS is helpful as it is fermented in the colon to produce Short Chain Fatty Acids which act as an excellent fuel source for colonocytes, promotes beneficial colonic bacterial growth, maintains colonic pH, enhances the release of Insulin promoting Incretins, regulates cholesterol metabolism via communication with the liver, enhances mineral absorption, decreases phospholipids and decreases triglycerides. The indigestibility and selective fermentation is responsible for yielding half the calories of sucrose, i.e. 1.5 to 2 kcal/gram. FOS sources (i.e. Blue Agave, garlic, onion, chicory root, asparagus, Jerusalem, artichokes, leeks tomatoes, banana, wheat and barley) can be consumed around 20 grams/day by adults and 4.2 grams/ day by infants who are less than one year old.

These can also be used as a natural low caloric substitute for diabetics and weight management as healthy gut helps in balancing hunger and appetite hormones.

Human milk is one of the earliest known sources of Galacto-oligosaccharides. Therefore, Human milk or exclusive breast feeding is recommended for infant upto 6 months. GalOS offer various health benefits like relieving constipation symptoms, improving stool frequency, enhancing immune response and stimulating the growth of beneficial colonic bacteria - Bifidobacteria and Lactobacillus. A daily intake of 0.3-0.4 g/kg body weight is recommended. Consumption beyond this is associated just with transient osmotic diarrhoea.

Lactose-sucrose is a rare oligosaccharide composed of three types of sugar units namely glucose, galactose and fructose. The recommended daily intake for adults is 3 g/day. This functional oligosaccharide is considered safe for the formulation of food products by GRAS, FDA and other worldwide regulatory agencies. Additionally, it is also promoted as a prebiotic which selectively stimulates the growth of beneficial colonic bacteria, especially that of the bifidobacteria species. Lactose-sucrose has a wide range of uses since it is a non-digestible, non-carcinogenic and intestinal mineral absorption enhancer. Moreover, it has an application in various pharmaceuticals and cosmetic formulations

Amylose and Amylopectin act as substrates for enzymatic reaction to produce starch related oligosaccharides.

Malto-oligosaccharides have several health benefits like reducing tiredness, improving intestinalperistalsis and hence preventing constipation. Moreover, it is being observed in clinical chemistry as an alternative for measuring blood glucose levels.

Iso-maltooligosaccharides are low in calories and have mild sweet taste. They act as bulking agent and also as a prebiotic promoting the growth of essential colonic bacteria. They are also beneficial in lowering blood cholesterol and triglyceride levels and in the absorption of minerals from foods.

Soy-oligosaccharides are a group of soluble oligosaccharides found in soy or other legumes which primarily consist of raffinose, stachyose and sucrose. They have several health benefits like preventing constipation, improving absorption of calcium and other minerals, elevation of microbial metabolite of short chain fatty acids which in result help in reducing the risk of colon cancer, and decreasing toxic metabolites production that affect the liver. The current average daily intake of soy-oligosaccharide is 4.0 grams. Over consumption may lead to abdominal bloating, excessive gas and diarrhoea. So, oligosaccharides are considered as the functional foods needed to be consumed in right quantity to get the maximum benefits and handle the growing problems of various Functional Bowel Disorders. Nevertheless they are beneficial as natural Low Calorie Sweetener for diabetes too.

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Refrences.

Sources from google and some related articles.

1. Saito YA, Schoenfeld P, Locke GRI. The epidemiology of irritable bowel syndrome in North America: a systemic review. Am J Gastroenterol 2002;97:1910–1915.

2. Gwee K-A. Irritable bowel syndrome in developing countries—a disorder of civilization or colonization? Neurogastroenterol Motil 2005;17:317–324. 1488 LONGSTRETH ET AL GASTROENTEROLOGY Vol. 130, No. 5

3. Longstreth GF. Definition and classification of IBS: current consensus and controversies. Gastroenterol Clin North Am 2005;34: 173–187.

4. Whitehead WE, Paulsson O, Jones KR. Systematic review of the comorbidity or irritable bowel syndrome with other disorders: what are the causes and implications? Gastroenterology 2002; 122:1140–1156.

5. Wilson A, Longstreth G, Knight K, Wong J, Wade S, Chiou C, Barghout V, Frech F, Ofman J. Quality of life in managed care patients with irritable bowel syndrome. Manage Care Interface 2004;17:24–28.

6. Longstreth GF, Wilson A, Knight K, Wong J, Chiou CF, Barghout V, Frech F, Ofman JJ. Irritable bowel syndrome, health care use, and costs: a U.S. managed care perspective. Am J Gastroenterol 2003;98:600–607.

7. Thompson WG, Longstreth GF, Drossman DA, Heaton KW, Irvine EJ, Muller-Lissner SA. Functional bowel disorders and functional abdominal pain. In: Drossman DA, Corazziari E, Talley NJ, Thompson WG, Whitehead WE, eds. The functional gastrointestinal disorders. 2nd ed. Washington: Degnon, 2000. 8. Thompson WG, Longstreth GF, Drossman DA, Heaton KW, Irvine EJ, Muller-Lissner SA. Functional bowel disease and functional abdominal pain. Gut 1999;45:43–47.

9. O'Donnell LJD, Virjee J, Heaton KW. Detection of pseudodiarrhoea by simple clinical assessment of intestinal transit rate. Br Med J 1990;300:439–440.

10. Heaton KW, Ghosh S, Braddon FEM. How bad are the symptoms and bowel dysfunction of patients with the irritable bowel syndrome? A prospective, controlled study with emphasis on stool form. Gut 1991;32:73–79.

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